Overall obesity is leveling off while abdominal obesity continues to rise in a Chinese population experiencing rapid economic development: Analysis of serial cross-sectional health survey data 2002-2010

Running title: Overall and abdominal obesity in southern China

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Conflict of interest statement

We declare there is no conflict of interest

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Abstract

Background

Obesity epidemic is related to industrialization and urbanization, that have lead to changes in nutrition, lifestyle, and socioeconomic status. However, information on the trajectory of the obesity epidemic in populations experiencing rapid economic development is limited. We therefore investigate trends in obesity from 2002 to 2010 in a southern Chinese population experiencing world's fastest economic development

Methods

Between 2002 and 2010 four standardized surveys were conducted in a population of 85 million residents in Guangdong, China. Multistage cluster sampling was adopted to recruit representative samples. Weight, height and waist circumference of the participants were measured in a standardized way. The analysis included residents aged between 18 and 69 years. The number of participants included in the present analysis for Surveys conducted in 2002, 2004, 2007, and 2010 were 13,058, 7,646, 6,441, and 8,575, respectively.

Results

From year 2002 to 2010, the age-standardized BMI insignificantly changed from 21.7 kg/m^2 to 22.3 kg/m^2, and the prevalence of overweight and overall obesity from 15.8% to 16.6% (both $p > 0.05$). The age-standardized waist circumference increased from 73.7 cm to 78.4 cm, and prevalence of abdominal obesity increased from 12.9% to 23.7% (both $p < 0.001$). In urban areas, BMI and overall obesity changed little during the eight-year period (BMI from 22.6 to 22.7 kg/m^2 and overall obesity from 23.7 to 21.4%), whereas there were slight increases in rural areas

(BMI from 20.8 to 22.1 kg/m^2 and overall obesity from 8.2 to 13.3%). Waist circumference and abdominal obesity increased significantly in both areas, but the increase was more pronounced in rural areas (in urban area, waist circumference from 75.1 to 78.5 cm and abdominal obesity from 16.8 to 26.5%; in rural area, waist circumference from 72.2 to 78.3 and abdominal obesity from 8.8 to 22.0%).

Conclusions

BMI and overall obesity in this population, which has experienced the world's fastest economic development over the past three decades, has been leveling off, while waist circumference and abdominal obesity, independent predictors of cardiovascular risk, have continued to rise. Our findings suggest that obesity epidemic transition in rapidly developing populations may be much faster than what has been observed in Western countries.

Key words: Overall obesity, abdominal obesity, trend, transition, Chinese

Introduction

Obesity is an important public health problem worldwide, affecting both rich and poor countries. The World Health Organization (WHO) reported that obesity has nearly doubled worldwide since 1980. In 2008, more than 1.4 billion adults, 20 years or older, were overweight. Of these, over 200 million men and nearly 300 million women were obese [1]. This translates into a huge obesity-related disease burden on society, as obesity is a major determinant of a number of diseases, such as cancer, diabetes, and cardiovascular disease. Understanding the pattern of obesity development and the driving forces behind it is necessary to develop appropriate prevention strategies.

In recent decades, there has been a secular increase in the prevalence of obesity in most countries. This trend is caused by the epidemiological transition resulting from increased industrialization and urbanization. However, in 2007, a slight decline in the prevalence of obesity was reported in Scotland [2]. Since then, several studies have shown that the obesity epidemic has slowed down or even leveled off since the 2000s, especially in regions and countries with high socio-economic status [3]. In the U.S.A., data from the 2009–2010 National Health and Nutrition Examination Survey (NHANES) shows little change from 2003 in the prevalence of obesity both in adults and children, although the reasons for this are not clear [4, 5]. To date, there is little data on the slowing-down or leveling-off of obesity in developing countries. This is partly because there have been relatively few serial standardized health surveys, such as the NHANES, in developing countries, which prevents us longitudinally monitoring the trajectory of the obesity epidemic. Additionally, developing countries may be still in the early stages of the obesity epidemic and hence may obesity continues to rise. However, the contemporary pace of industrialization and

96 urbanization in developing countries is much faster than previously experienced in Western
97 populations, leading to accelerated adverse changes in nutrition, lifestyle, and socioeconomic
98 status. In short, the trajectory of the obesity epidemic and its potential impact may be different
99 for developed and developing countries. Obtaining information about these trends and their
100 causes is important for the development of obesity prevention strategies.

101 China is the world's largest developing country, and it has had the world's fastest growing
102 domestic product (GDP) growth rate over the past three decades. Guangdong province is located
103 in southern China with a population of 85 million. Its GDP growth has been the fastest over the
104 past three decades among all 34 provinces and autonomous regions of China, with an average
105 annual growth rate of 13.6% [6]. Guangdong therefore provides a unique opportunity to observe
106 the changing trend in the prevalence of obesity in response to rapid economic development.
107 These considerations led us to analyze data on the trajectory of obesity from four standardized
108 cross-sectional health surveys conducted in Guangdong between 2002 and 2010. The results of
109 these analyses will help physicians and policy makers develop prevention and intervention
110 programs for populations undergoing rapid economic development and urbanization.

Methods

The Guangdong Health Survey is a series of studies designed to assess the health status of residents of Guangdong province. Approvals were obtained from the Ethics Committee of the China Center for Disease Control, as well as the Ethics Committee of the Guangdong Provincial Center for Disease Control and Prevention. Four standardized health surveys were conducted in 2002, 2004, 2007 and 2010 (hereafter referred to Survey 2002, Survey 2004, Survey 2007 and Survey 2010) [7]. A multistage stratified cluster random sampling method was adopted to recruit representative population samples in these surveys. The response rates for Surveys 2002, 2004, 2007, and 2010 were 89.5%, 91.1%, 90.6%, and 85.3%, respectively. All means of BMI/waist and prevalence of overweight and obesity calculated in this study represented the overall estimates for the corresponding population. The details of sampling have been described elsewhere [7].

A central survey site was set up in each cluster for onsite interviews and health examinations, all of which were conducted following standard protocols by physicians who had received training specifically for the surveys. The survey questionnaires solicited a wide range of information, including demographic characteristics, lifestyle, family, and personal disease histories. Weight and height were measured in the morning before breakfast, with the participants wearing light indoor clothing and no shoes. Waist circumference was measured horizontally around the narrowest circumference between the ribs and the iliac crest. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. As there are differences in the definition of obesity for Caucasians and Asians, classification of participants as "overweight" or "overall obesity" was based on WHO suggestions for Chinese; overweight was defined as BMI $\geq$ 25.0–27.49 kg/m^2 and overall obesity was defined as BMI $\geq$ 27.5 kg/m^2 [8].

Based on the guidelines of the International Diabetes Federation, abdominal obesity was defined as waist circumference ≥ 90 cm in men and ≥ 80 cm in women [9].

We included only the residents between 18 and 69 years of age in the present analysis. This was because (1) Survey 2004 and Survey 2007 recruited only residents who were between these ages and we wanted age levels to be consistent across the four surveys, and (2) the 18 to 69 age group has the greatest susceptibility to changes in BMI and waist circumference due to socio-economic changes. The number of participants included in the present analysis for Surveys conducted in 2002, 2004, 2007, and 2010 were 13,058, 7,646, 6,441, and 8,575, respectively.

All data analyses were performed using SAS software, version 9.2 (SAS Institute, Cary, NC, U.S.A). Because stratified multistage cluster sampling with probability proportional to size was adopted for sampling, design parameters, including weighting, stratum and cluster, were incorporated into all the analyses, as previously described [7, 10-13]. Weightings were derived from the 2000 census data of Guangdong and the associated administrative data. Age-standardized prevalence was calculated based again on the 2000 census using age groups of 18–34 years, 35–49 years, and 50–69 years. Two-sided *p* values of less than 0.05 were considered statistically significant. Data comparing changes in the obesity epidemic over time are presented separately for urban and rural areas. Living in urban or rural area is an index of socio-economic status in China. Urban and rural areas were defined by the Chinese central government in the early 1990s based on their level of economic development at the time [14]. Standard errors are reported for means and prevalence. PROC UNIVARIATE was used for the BMI and waist distribution graphs. Weighting was used in the frequency statement because weighting statement is not available for histogram in PROC UNIVARIATE. PROC GREPLAY was used to consolidate all curves in a single graph for ease of comparison.

Results

The mean ages of this population in years (range 18 to 69) in 2002, 2004, 2007, and 2010 were 44.1, 43.4, 44.9, and 45.2 respectively. The increase in mean age was significant in rural residents, but no significant increase was observed for urban residents. Age group distributions were similar across the surveys. Between 2002 and 2010, this population had fewer women, and became richer, but there were no significant changes in educational levels. The general characteristics of this population were presented in Table 1.

Overall, there were no significant increases in mean BMI as well as in the prevalence of overweight and obesity as defined by BMI, during the eight-year survey period. However, when stratified by areas, significant increases were observed in the rural residents. In urban residents, there was little change in BMI, with the prevalence of overweight and obesity insignificantly changing from 23.7% to 21.4%. Details for BMI are presented in Table 2, and details for BMI-defined overweight and obesity are presented in Table 3. Supplementary Table 1 shows that there were no differences for the prevalence of obesity defined as BMI $\geq$ 27.5 kg/m^2 over the eight-year period stratified by urban/rural residence.

Age-standardized and age-specific waist circumference increased significantly over the survey period, irrespective of area. In line with the increase in waist circumference, abdominal obesity increased significantly over the survey period. Both trends are most obvious for rural and younger residents. Details of the trends for waist circumference and abdominal obesity are presented in Tables 4 and 5.

The changing trends in BMI, overweight and obesity determined by BMI, waist circumference and abdominal obesity stratified by sex are presented in Supplementary Table 2 and in general

mirrored those observed in the combined population. In men, a slight increasing trend in BMI was observed over time but no difference for overweight/obesity determined by BMI was observed. In women, no significant increases in BMI or the prevalence of overweight/obesity as defined by BMI were observed. With regards to waist circumference and abdominal obesity, similar significant increasing trends were observed in both men and women.

Figure 1 shows the trends of BMI and waist circumference distributions stratified by areas. For BMI, there were no meaningful differences over the eight-year period in urban areas (Panel A), but a slight significant increase in rural areas was observed (Panel B). For waist circumference, significant increases in both urban and rural areas were observed (Panels C and D), and the increases were much greater in rural areas.

Discussion

In this population BMI and the overall prevalence of obesity changed very little from 2002 to 2010 slightly increasing from 21.7 to 22.3 kg/m^2, and from 15.8% to 16.6%, respectively. At the same time, waist circumference increased significantly from 73.7 to 78.4 cm, and the prevalence of abdominal obesity almost doubled from 12.9% to 23.7%. These trends differed between urban and rural areas, which is noteworthy because for China, living in urban or rural area can be used as a proxy for socio-economic status [15]. In urban areas, the overall obesity apparently reached a plateau, identified as a standardized BMI of 22.6 kg/m^2. The prevalence of overall obesity remained at 21–23% during the survey period, but the prevalence of abdominal obesity increased significantly from 16.8 to 26.5%, corresponding to an increase in mean waist circumference from 75.1 to 78.5 cm. In rural areas, there was a significant increase in both BMI (from 20.8 to 22.1 kg/m^2) and waist circumference (from 72.2 to 78.3 cm). The prevalence of overall obesity increased from 8.2 to 13.3%, and the prevalence of abdominal obesity increased from 8.8 to 22.0%. Thus, although abdominal obesity continued to increase in both rural and urban areas, the changing magnitudes were more pronounced in rural areas.

The review by Rokholm *et al*. shows a clear tendency towards stabilization of the obesity epidemics in Australia, Europe, Russia and the U.S.A. [3]. In contrast, earlier studies suggest strongly increasing trends in Chinese adults [16-18]. However, these data are generally from before 2000, and hence they may not reflect the latest trends. In addition, some studies used national data, and pooled provinces with different levels of industrialization and urbanization, as well as other characteristics including heterogeneous dietary habits, lifestyle, public resources, and health indicators. Therefore, the trends reported previously might reflect a complex interplay of these factors, whereas trends in each province may not be the same.

There is little information on obesity in Guangdong province before 2000. Although Guangdong was included in two National Nutrition and Health Surveys conducted in 1982 and 1992 [19], the raw data are not available. This precluded our studying a longer period. In addition, we found no data on BMI and obesity in the 1982 survey. However, the 1992 survey shows that in that year the BMI in Guangdong adults age 20-45 was 21.8 kg/m^2 for urban residents and 21.1 kg/m^2 for rural residents. For overweight / obesity (defined as BMI $\geq$ 25 kg/m^2), the prevalence were 14.4% in urban areas and 7.0% in rural areas [20]. The corresponding BMI figures for residents age 20-45 from Survey 2002, which we used in the present study, are 22.5 kg/m^2 for urban areas and 21.2 kg/m^2 for rural areas. The prevalence of obesity was 22.1% in urban areas and 10.1% in rural areas. These figures indicate that during the 1992-2002 period, overall obesity increased significantly in Guangdong, especially among urban residents. There are no data on waist circumference and abdominal obesity in the 1992 survey.

Compared with the increases found in the 1992-2002 period, our present analysis show that between 2002 and 2010, BMI and overall obesity started to stabilize. This leveling-off is more apparent in urban areas, whose socio-economic status higher than in rural areas and in other Chinese provinces. As previous studies have already shown that obesity epidemics are more likely to plateau in areas with high economic status [3], we deduce that BMI and overall obesity may have reached a plateau, especially in the urban areas of Guangdong province. On the other hand, in China as a whole, BMI and overall obesity are most likely continuing to show an upward trend, because China is still a developing country and its average level of socio-economic status is lower than in developed Western countries.

Although BMI and overall obesity have been leveling off in this population, waist circumference and abdominal obesity have continued to rise. It is believed that waist circumference is a better

discriminator of risk of vascular disease and abdominal obesity is associated with an increased risk of death independently of overall obesity [21-23]. No published studies show a leveling off of abdominal obesity so far. Our findings are in line with data from Ford *et al*. showing that abdominal obesity continues to rise in the U.S.A. despite relative stability in the rate of overall obesity [24]. A study in Hong Kong by Ko yielded similar findings [25]. The leveling-off in overall obesity that we found in our study does not imply that the risk of obesity-related diseases will also plateau as abdominal obesity continues to rise. Our previous studies also show a jump in diabetes and a slight increase in hypertension during the survey period of 2002–2010 [7, 13]. Despite a number of studies in different populations consistently showing that waist circumference has increased faster than BMI [24, 26-28], the causes behind the differential trends are unclear. BMI is a construct of fat mass and non-fat mass and most importantly body structure. Although body composition may change over time, body structure which is in part based on skeletal structure is less amenable to change and may thus attenuate potential changes in adults. Additionally, Wells *et al* demonstrated that contemporary children had significantly higher fatness than reference children of two decades ago, despite similar BMI values [29]. Another hypothesis is that central fatness may be related more to physical activity than to energy intake [27]. It is well documented that sedentary lifestyle has increased substantially over the past decades. Nonetheless, further research is warranted to examine the root causes.

Many factors have been driving the changes in obesity epidemic. Epidemiologic transition resulting from the rapid economic development and urbanization probably underlies the obesity trends in our population [30]. Between the 1940s and the late 1970s, the major challenge China faced was to provide its people with sufficient food to meet their basic energy and nutrition requirements. Since 1979, when China began to open up and reform its economy, it has enjoyed

262 the fastest economic development in the world. Moreover, Guangdong is the first province where
263 the Chinese leader Deng Xiao Ping implemented these policies. Guangdong's GDP growth has
264 been the fastest among all the provinces and autonomous regions of China during the past three
265 decades. Statistics show that Guangdong's GDP growth increased from RMB 410 in 1979 to
266 RMB 44,736 in 2010 [6]. Many areas defined as rural areas in the early 1990s are no longer
267 considered rural today. This rapid economic development and urbanization has increasingly
268 promoted a sedentary lifestyle, an elevated consumption of energy-rich foods, and greater
269 psychological stress; all of these factors contribute to increases in obesity. The three nutrition
270 surveys also show that the consumption of animal products increased three-folds from 1982 to
271 2002 in Guangdong [19]. Furthermore, our study shows that the obesity epidemic in Guangdong
272 has slowed down in urban areas, while it has continued to rise at an astonishing clip in rural areas
273 (in contrast to the trend from 1992 to 2002, when increases in overall obesity were more obvious
274 in urban areas than in rural areas). These results are in line with the Epidemiologic Transition
275 Theory, which predicts that in the early stages of a society's economic development, a high
276 prevalence of chronic disease is most apparent among the most educated and wealthy; but this
277 trend slows down or even reverses as people realize the health hazards of poor diet and lifestyle
278 choices. However, in the developed Western countries, it has taken much longer for the leveling
279 off of overall obesity to occur [31]. Our results suggest that the obesity epidemic transition has
280 been accelerating more rapidly in countries with stronger economic development than has been
281 observed in most Western countries, which are already highly developed. Our findings are in line
282 with the rapid health transition in China during the last two decades, as reported by Yang *et al* [32].
283 The United Nations reported that around 5.7 billion (82.2%) of the world's population live in
284 less developed countries [33], where a booming economy has been the top priority. Our findings

indicate that in rapidly developing countries, prevention strategies should be focused most on abdominal obesity, and different intervention strategies should be adopted for rural and urban populations.

A strength of the present study is its focus on a large population that happens to have experienced the world's fastest economic development over the past three decades. Thus, we were able to observe the trajectory of the obesity epidemic under unique circumstances. National representative samples may not have this advantage, because the pace of economic development has varied dramatically in different regions of China. Besides, the relatively homogeneous characteristics of this population minimized the modification effects of other factors. However, one limitation of our study is the relatively short period of monitoring the trajectory of the obesity epidemic. Results from the NHANES show that obesity was relatively stable in the U.S.A. from 1960 to 1980, but its prevalence rose during the 1980s and 1990s [34]. Because the survey period in our study (2002–2010) was relatively short, we cannot conclude whether the leveling off of BMI and overall obesity is temporary or more permanent. Therefore, the continued monitoring of the obesity epidemic trajectory in this population is warranted. Furthermore, because abdominal obesity is more harmful, it is very important to observe whether abdominal obesity will reach a plateau and, if so, when.

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Conflict of interest statement

We declare there is no conflict of interest among the authors.

Supplementary information is available at IJO's website.

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Table 1 Characteristics of the residents of 18–69 years of age in Guangdong, 2002–2010

	Survey 2002 (n = 13,058)	Survey 2004 (n = 7,646)	Survey 2007 (n = 6,441)	Survey 2010 (n = 8,575)	Change from 2002 to 2010	*p* for trend
Age (mean, year)						
All	44.1 (0.77)	43.4 (0.63)	44.9 (0.75)	45.2 (0.94)	1.1 yrs	0.17
Urban	44.6 (1.19)	43.3 (1.30)	43.8 (1.68)	44.8 (1.90)	0.2 yrs	0.89
Rural	43.7 (0.99)	43.4 (0.57)	45.7 (0.53)	45.5 (0.91)	1.8 yrs	0.043
Age group (%)						
18-34	27.9(2.43)	24.7 (1.84)	23.2 (2.44)	22.5 (2.79)	-5.2%	0.13
35-49	38.1 (1.46)	44.6 (0.78)	39.8 (0.96)	39.3 (1.06)	1.2%	0.66
50-69	34.0 (2.21)	30.7 (1.39)	37.0 (2.19)	38.2 (2.91)	4.2%	0.059
Women (%)						
All	56.2 (1.07)	58.1 (1.61)	52.9 (1.21)	51.7 (1.66)	-4.5%	0.0089
Urban	58.1 (1.30)	60.5 (2.21)	56.2 (2.46)	55.9 (2.94)	-2.2%	0.32
Rural	54.5 (1.62)	56.6 (2.22)	50.6 (1.13)	48.9 (1.89)	-5.6%	0.0013
Annual household income (less than RMB15,000, %)*						
All	54.3 (3.09)	59.4 (2.90)	47.4 (4.43)	29.7 (3.45)	-24.6%	0.0024
Urban	32.5 (1.99)	22.4 (6.23)	21.7 (6.85)	17.0 (3.38)	-14.5%	0.010
Rural	73.4 (6.33)	85.9 (2.35)	64.1 (4.93)	39.0 (5.33)	-34.4%	< 0.001
Less than high school (%)						

All	70.1 (3.48)	76.1 (3.16)	76.3 (3.12)	72.4 (1.95)	2.3%	0.81
Urban	54.4 (6.40)	57.4 (7.34)	56.8 (7.36)	52.6 (4.00)	-1.8%	0.82
Rural	84.1 (2.85)	88.8 (1.95)	89.8 (1.56)	86.2 (2.15)	2.1%	0.62

Values were presented in mean (standard error), or percentage (standard error)

* 1 US$ = 6·36 RMB.

Table 2 Trends in the age-standardized and age-specific mean of body mass index (BMI, kg/m^2) among the residents of 18–69 years of age in Guangdong, 2002–2010

		Survey 2002	Survey 2004	Survey 2007	Survey 2010	Change from 2002 to 2010	*p* for trend
All:							
	Age- standardized	21.7 (0.33)	21.7 (0.16)	21.9 (0.13)	22.3 (0.13)	0.6	0.062
	18–34	21.2 (0.27)	21.3 (0.13)	21.4 (0.10)	21.8 (0.12)	0.6	0.034
	35–49	22.2 (0.15)	22.2 (0.14)	22.5 (0.14)	23.0 (0.13)	0.8	0.014
	50–69	22.4 (0.19)	22.2 (0.22)	22.4 (0.16)	22.8 (0.21)	0.4	0.32
Area:							
Urban	Age- standardized	22.6 (0.14)	22.3 (0.12)	22.2 (0.13)	22.7 (0.17)	0.1	0.92
	18–34	21.8 (0.16)	21.6 (0.12)	21.5 (0.12)	22.0 (0.14)	0.2	0.33
	35–49	23.3 (0.22)	23.1 (0.13)	23.0(0.21)	23.5 (0.22)	0.2	0.64
	50–69	23.9 (0.09)	23.5 (0.35)	23.4 (0.17)	23.7 (0.38)	-0.2	0.56
Rural	Age- standardized	20.8 (0.28)	21.2 (0.17)	21.6 (0.16)	22.1 (0.14)	1.3	< 0.001
	18–34	20.6 (0.46)	21.1 (0.19)	21.3 (0.15)	21.7 (0.20)	1.1	0.017
	35–49	21.3 (0.21)	21.6 (0.21)	22.1 (0.18)	22.6 (0.17)	1.3	< 0.001
	50–69	20.9 (0.33)	21.3 (0.25)	21.8 (0.22)	22.3 (0.20)	1.4	< 0.001

Table 3 Trends in the age-standardized and age-specific prevalence of overweight and overall obesity (BMI ≥ 25 kg/m^2) among the residents of 18–69 years of age in Guangdong, 2002–2010

		Survey 2002 (%, SE)	Survey 2004 (%, SE)	Survey 2007 (%, SE)	Survey 2010 (%, SE)	Change from 2002 to 2010 (%)	*p* for trend
All:							
	Age- standardized	15.8 (2.63)	13.7 (1.34)	13.1 (1.26)	16.6 (1.63)	0.8%	0.82
	18–34	11.4 (1.34)	11.4 (0.98)	8.0 (0.89)	11.6 (1.67)	0.2	0.72
	35–49	19.4 (1.23)	17.9 (1.11)	18.1 (1.60)	21.3 (1.78)	1.9	0.53
	50–69	23.2 (1.20)	18.9 (1.85)	19.4 (1.83)	23.0 (2.12)	-0.2	0.93
Area:							
Urban	Age- standardized	23.7 (1.22)	19.3 (1.34)	16.3 (1.73)	21.4 (2.09)	-2.3	0.29
	18–34	16.1 (1.03)	13.7 (1.52)	8.2 (1.78)	15.3 (2.66)	-0.8	0.28
	35–49	29.7 (2.06)	26.6 (1.40)	23.4 (2.95)	28.0 (2.68)	-1.7	0.48
	50–69	36.2 (1.32)	28.9 (3.14)	28.2 (2.22)	32.5 (3.75)	-3.7	0.37
Rural	Age- standardized	8.2 (1.36)	10.0 (1.39)	11.3 (1.36)	13.3 (1.93)	5.1	0.026
	18–34	6.9 (2.26)	9.7 (1.26)	7.9 (0.56)	8.8 (2.23)	1.9	0.71
	35–49	11.2(1.28)	12.5 (1.60)	14.6 (1.68)	16.8 (2.55)	5.6	0.026
	50–69	10.0 (1.02)	11.9 (2.11)	14.2 (2.43)	16.5 (2.06)	6.5	0.0058

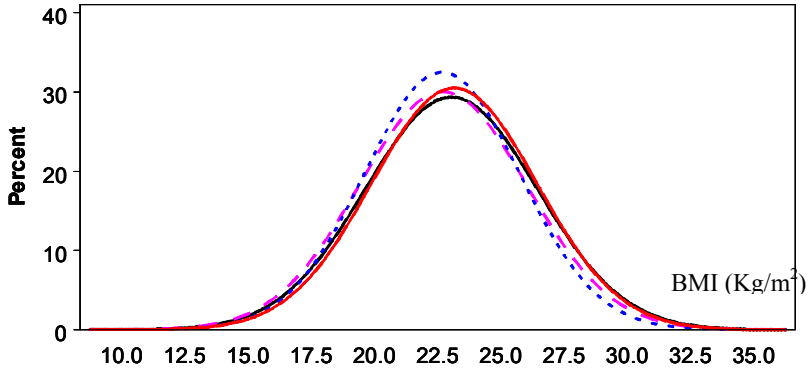
Table 4 Trends in the age-standardized and age-specific mean of waist circumference (cm) among the residents of 18–69 years of age in Guangdong, 2002–2010

		Survey 2002 (Mean, SE)	Survey 2004 (Mean, SE)	Survey 2007 (Mean, SE)	Survey 2010 (Mean, SE)	Change from 2002 to 2010 (cm)	*p* for trend
All:							
	Age- standardized	73.7 (0.67)	75.8 (0.65)	76.9 (0.53)	78.4 (0.44)	4.7	< 0.001
	18–34	71.1 (0.65)	74.3 (0.71)	75.5 (0.45)	77.6 (0.47)	6.5	< 0.001
	35–49	75.1 (0.38)	77.0 (0.66)	78.6 (0.57)	79.7 (0.44)	4.6	< 0.001
	50–69	77.3 (0.55)	78.9 (0.72)	79.1 (0.61)	80.7 (0.62)	3.4	0.003
Area:							
Urban	Age- standardized	75.1 (0.63)	77.3 (0.62)	77.9 (0.42)	78.5 (0.67)	3.4	< 0.001
	18–34	72.0 (0.71)	74.8 (0.71)	75.7 (0.42)	77.3 (0.77)	5.3	< 0.001
	35–49	77.0 (0.77)	79.0 (0.65)	80.2 (0.50)	80.3 (0.59)	3.3	0.003
	50–69	80.2 (0.79)	82.1 (1.10)	81.9 (0.75)	82.5 (1.09)	2.5	0.086
Rural	Age- standardized	72.2 (0.62)	74.8 (0.92)	76.3 (0.85)	78.3 (0.61)	6.1	< 0.001
	18–34	70.3 (1.03)	73.9 (1.12)	75.4 (0.79)	77.9 (0.57)	7.6	< 0.001
	35–49	73.6 (0.50)	75.7 (0.99)	77.6 (0.87)	79.4 (0.64)	5.8	< 0.001
	50–69	74.2 (0.84)	76.7 (0.88)	77.5 (0.92)	79.6 (0.84)	5.4	< 0.001

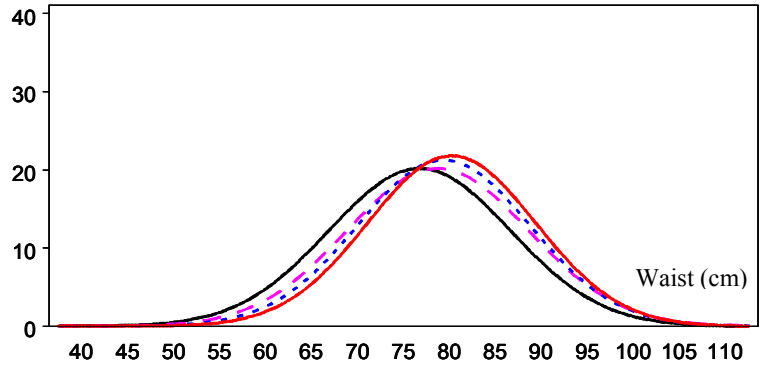
Table 5 Trends in the age-standardized and age-specific prevalence of abdominal obesity (waist ≥ 90 for men and waist ≥ 80 for women) among the residents of 18–69 years of age in Guangdong, 2002–2010

		Survey 2002 (%, SE)	Survey 2004 (%, SE)	Survey 2007 (%, SE)	Survey 2010 (%, SE)	Change from 2002 to 2010 (%)	*p* for trend
All:							
	Age- standardized	12.9 (1.91)	20.1 (1.96)	21.3 (1.85)	23.7 (2.15)	10.8	< 0.001
	18–34	7.2 (1.10)	13.8 (2.01)	16.3 (1.50)	18.7 (2.50)	11.5	< 0.001
	35–49	16.5 (1.37)	24.5 (2.08)	25.9 (2.17)	28.5 (2.04)	12.0	< 0.001
	50–69	24.7 (1.90)	31.6 (2.64)	31.6 (2.52)	33.9 (2.88)	9.2	0.055
Area:							
Urban	Age- standardized	16.8 (2.23)	25.5 (1.56)	25.2 (1.50)	26.5 (2.32)	9.7	0.0086
	18–34	8.8 (0.98)	15.1 (1.51)	17.2 (0.99)	20.5 (2.30)	11.7	< 0.001
	35–49	22.0 (3.04)	31.1 (2.15)	31.1 (2.89)	32.1 (2.85)	10.1	0.032
	50–69	34.5 (3.5)	44.9 (4.45)	42.4 (3.66)	42.8 (4.39)	8.3	0.18
Rural	Age- standardized	8.8 (1.04)	16.5 (2.73)	18.9 (2.92)	22.0 (3.22)	13.2	< 0.001
	18–34	5.8 (1.83)	12.9 (3.35)	15.5 (2.83)	17.3 (4.07)	11.5	0.011
	35–49	12.1 (1.09)	20.3 (3.09)	22.4 (2.97)	26.1 (2.94)	14.0	< 0.001
	50–69	14.6 (1.80)	22.2 (2.74)	24.9 (3.52)	27.9 (3.90)	13.3	< 0.001

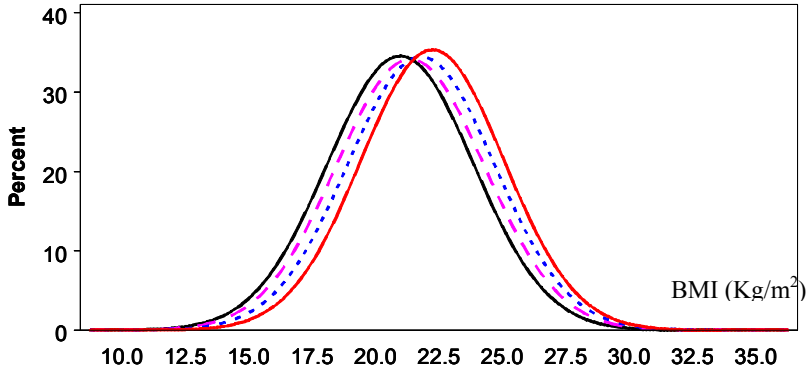
Figure 1 Distributions of BMI and waist circumference among residents age 18-69 years in Guangdong stratified by areas, 2002-2010.



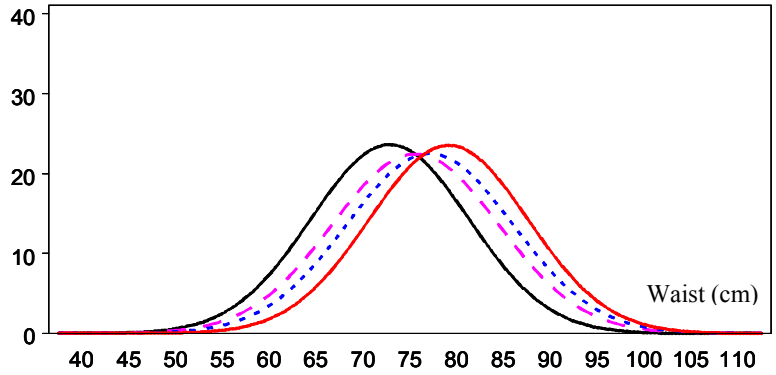
A: Distribution of body mass index in urban residents from 2002 to 2010



C: Distribution of waist circumference in urban residents from 2002 to 2010



B: Distribution of body mass index in rural residents from 2002 to 2010



D: Distribution of waist circumference in rural residents from 2002 to 2010