Waist circumference and waist-to-height ratio percentiles of Thai school-aged children

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Abstract

Introduction: Waist circumference (WC) and waist-to-height ratio (WHTR) are used to screen the central obesity and identify metabolic syndrome. These parameters are dependent on sex, age and ethnicity, thus requiring specific values in each country. The study aims to develop age and gender specific WC and WHTR percentile curves for Thai youth.

Method: This is a cross-sectional study based on the nutrition survey of schoolhood Thai children. Height, weight and WC are measured among 1,877 children. Smoothed age- and gender- specific percentile curves of WC and WHTR are calculated by the LMS method.

Results: WC increases with age in both genders and boys have higher WC than girls at each age. WHTR is similar between genders and tends to decrease with age.

Conclusion: These reference curves represent the first WC and WHTR percentile for Thai children. We encourage the use of these values to evaluate central fatness in this population.

Key words: Central obesity, child, Thailand, waist circumference, waist-to-height ratio

Introduction

Prevalence of obesity and overweight in childhood is increasing worldwide. Diagnostic criteria to determine obesity are the body mass index and the body weight that are not informative about fat distribution.[1] Indeed, rather than obesity, metabolic complications are related to central fat distribution.[2] Visceral adipose tissue has been correlated to an increased risk of cardiovascular disease (CVD) and waist circumference is a better predictor of CVD than the body mass index (BMI), generally used to define the obesity.[1] Then, waist circumference has been compared with dual-energy X-ray absorptiometry and validated as the simplest and most valuable measure of visceral adipose tissue.[3] Some differences between gender, ethnicity and age have been reported in several papers[4-6], suggesting the importance to generate waist circumference percentile curves for each country in order to assess central obesity and fat distribution in the specific ethnic contest.[4]

The waist to height ratio has been reported as an alternative tool to determine the central obesity and is correlated to visceral fat too. Thus, we present in this paper the first working set of waist circumference percentiles and waist to height ratio percentiles obtained from data collected in Thailand.

Material and Methods

The data used were cross-sectionally collected from the Nutrition Survey among school children in Ongkhaluck, Nakorn Nayok province, Thailand in 2008. Subjects measured in this survey were aged from 6.0 to 12.9 years and a total number of 1877 children were included in the study. A written informed consent and assent were obtained from parents and children. The study was approved by the Ethic committee of Faculty of Medicine, Srinakharinwirot University.

Anthropometric parameters were assessed by a trained staff: height was measured at the nearest 0.1 cm, while weight was evaluated at the nearest 0.1 kg by an electronic scale (Tanita BF 680W, Japan). Waist circumference was determined at the nearest 0.1 cm at the midpoint between the lower margin of the last palpable rib and the top of iliac crest by a non-elastic tape. The measurement was taken at the end of normal expiration in standing position. The BMI was calculated from weight (kg) divided by the square of height (m), while the waist to height ratio was obtained by dividing waist circumference (cm) by the height (cm).

Descriptive analysis was performed by using SPSS (version 11.0, SPSS, Chicago, IL). Differences between each age group, described as a whole- year age (e.g. 6.00-6.99 years) and gender were tested by student t-test. A p- value < 0.05 was considered as statistically significant.

Smoothed age and gender specific percentile curves were calculated by the LMS method using R's VGAM package version 0.8-7. The LMS method summarizes the change of distribution by three curves representing the mean (M), coefficient of variation (S), and skewness (L). In order to compare data from the present study with other previous studies from various ethnicities, the 50^{th} percentile curves were plotted on the same graph with ggplot 2 version 0.9.1.

Results

Table 1 summarizes all anthropometric parameters measured and calculated from data collected among the children included in this study. Of 1877 children, 964 (51.4%) were boys. Height and weight trended to be similar between gender at all ages except for 10, 11 and 12 years when girls are taller and weightier than boys. However, only for height at 10 and 12 years this difference was significant. Waist circumference and WHTR were larger in boys than in girls and reached a significant difference when children are 9 years old. It was found that waist circumference increased with age in both genders, from 52.3 cm (6 years old) to 63.5 cm (12 years old) and from 52.0 cm to 62.6 cm for boys and girls, respectively. In contrast, WHTR trended to decrease from 0.45 to 0.43 in boys and from 0.45 to 0.42 in girls. The age- and gender- specific waist circumference at the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles are presented in Table 2 and Figure 1, while Table 3 and Figure 2 show the age- and gender- specific waist to height ratio percentiles. A comparison between 50^{th} percentile of waist circumference from previous studies and our data is proposed in figure 3.

Discussion

This study provides the first curves of WC and WHTR percentiles for 6 to 12-year-old Thai children. The waist circumference has been accepted as the anthropometric parameter that better defines central fat distribution and is considered as the simplest and most acceptable method to determine body composition in children.[7] However, some discrepancies are evident about the point of measurement of waist circumference. As it has been done in the present study, the waist circumference can be measured at the midpoint between the lower margin of the last palpable rib and the top of iliac crest or, alternately, just above the uppermost lateral border of the right ileum.[8] The lack of studies aimed to compare the different points of measurement avoids to define which point is more convenient to correctly describe the WC. However, it has been reported that measurement at the umbilicus tends to underestimate the true waist circumference[9] and the WHO STEPwise approach to surveillance instructs that the measurement should be made at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest.[10] As presented in Figure 3 the waist circumference of Thai children is smaller than other countries, if compared with the studies in which the WC has been measured at the same point.[4-6, 11-14] In the same country it is possible to evaluate significant difference in standard WC values in different ethnic groups, as shown in figure 3. In US, Mexican- American children aged between 2 and 18 years demonstrated higher WC and faster rate of increase than European- American or African- American children.[8] In China, five regional groups have been classified in order to describe the national distribution of waist circumference.[12] In the present study, we have evaluated a sample from central Thailand that should be representative of overall country, considering that Thai children share almost the same ethnicity. However, further studies to refine Thai standard values should be appreciable. Furthermore, few data are available about South- East Asia population, indicating the need to collect data in this world area.

We have proposed also the waist to height ratio percentile curves of Thai children. WHTR tends to decrease with age in both genders till 50th percentile, as reported in literature,[6] whereas at higher percentiles especially in boys curves tend to be irregular and increase. We found that WHTR in Thai children do not differ among age and sex. We suggest the opportunity of further studies to better point the cut off values and the risk of CVD in association to WHTR.

Conclusion

This is the first report of waist circumference and waist to height ratio reference percentiles and smoothed percentile curves of Thai children. Thus, we provide a criterion to classify metabolic syndrome related to cardiovascular disease in Thai children and we encourage the use of these values to evaluate central fatness in Thailand. Future studies will be aimed to explore the direct correlation between WC and WHTR and cardiovascular disease risk in Thai children. Furthermore, considering that the ethnicity is determinant to assess the correct WC in association to age and sex, we also propose the use of these values to generate international reference curves.

List of abbreviation

BMI Body mass index

CVD	Cardiovascular disease
WC	Waist circumference
WHTR	Waist to height ratio

Author Contributions

The work presented here was carried out in collaboration between authors. Both authors defined the research theme. LR designed methods and experiments, carried out the experiment, analyzed the data, interpreted the results and wrote the paper. SR co-designed methods and experiments, and co-worked on associated data collection, interpretation and wrote the paper. Both authors have contributed to, seen and approved the manuscript.

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Conflict of Interest: The authors have no conflict of interest to report.

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Table 1: Means (standard deviations) of weight, height, body mass index, waist circumference and waist to height ratio of the study population by age and gender

	Age[1] (years)	n	Weight (kg)	Height (cm)	BMI (kg/m^2)	WC (cm)	WHTR
Boys	6	82	22.6 (5.4)	116.1 (5.5)	16.6 (3.1)	52.3 (6.4)	0.45 (0.05)
	7	115	24.6 (7.8)	119.7 (6.4)	16.9 (4.1)	54.1 (8.9)	0.45 (0.06)
	8	126	26.1 (7.7)	125.2 (7.1)	16.3 (3.1)	54.2 (8.6)	0.43 (0.05)
	9	154	30.8 (9.2)	132.1 (7.4)	17.4 (3.8)	58.3[2] (9.3)	0.44[2] (0.06)
	10	165	33.3 (11.5)	135.8[2] (7.6)	17.7 (4.3)	59.3 (10.6)	0.44 (0.06)
	11	164	37.3 (12.2)	142.2 (8.6)	18.1 (4.2)	60.8 (10.8)	0.43 (0.06)
	12	158	41.4 (11.9)	146.9[2] (8.9)	19.0 (4.3)	63.5 (12.3)	0.43(0.08)
Girls	6	82	21.4 (5.3)	115.4 (5.8)	15.9 (2.9)	52.0 (6.9)	0.45 (0.05)
	7	104	24.7 (7.0)	120.6 (6.4)	16.8 (3.4)	54.3 (8.6)	0.45 (0.06)
	8	111	24.1 (6.3)	124.9 (7.2)	16.0 (2.8)	53.4 (6.7)	0.43 (0.04)
	9	130	29.7 (10.4)	131.8 (7.3)	16.8 (4.3)	55.8 (9.4)	0.42 (.0.06)
	10	145	34.0 (10.4)	138.0 (8.0)	17.6 (4.0)	58.7 (9.3)	0.42 (0.06)
	11	192	38.1 (11.4)	143.3 (8.4)	18.3 (3.9)	60.7 (9.5)	0.42 (0.05)
	12	149	43.9 (11.5)	149.4 (7.6)	19.5 (4.1)	62.6 (9.1)	0.42 (0.05)

[1]Age: a whole year age, e.g. 6 years = 6.0-6.99 years; [2]$p<0.05$ for the difference between gender

Table 2: Waist circumference percentiles by age and gender

	Age[1] (years)	5th	10th	25th	50th	75th	90th	95th
Boys	6	45.0	46.0	49.0	51.0	55.0	61.4	64.9
	7	44.0	46.0	49.0	52.0	56.0	69.4	75.2
	8	45.0	46.0	49.0	53.0	56.3	66.3	71.3
	9	49.0	50.0	52.0	56.0	61.3	74.0	77.3
	10	49.0	50.0	53.0	56.0	61.0	76.0	85.0
	11	50.0	51.0	54.0	57.0	65.0	76.0	86.8
	12	51.0	52.0	55.0	60.0	69.0	80.0	85.1
Girls	6	42.3	44.3	48.0	51.0	54.0	63.4	67.9
	7	45.0	46.0	48.0	52.0	56.8	57.8	75.3
	8	44.0	46.0	49.0	53.0	56.0	60.8	68.2
	9	46.3	47.1	49.8	53.0	58.3	68.0	73.9
	10	49.0	50.0	52.0	56.0	63.0	71.8	77.4
	11	50.0	51.0	54.0	57.0	66.0	74.7	80.4
	12	50.0	53.0	56.0	61.0	68.0	73.0	80.5

[1]Age: a whole year age, e.g. 6 years = 6.0-6.99 years

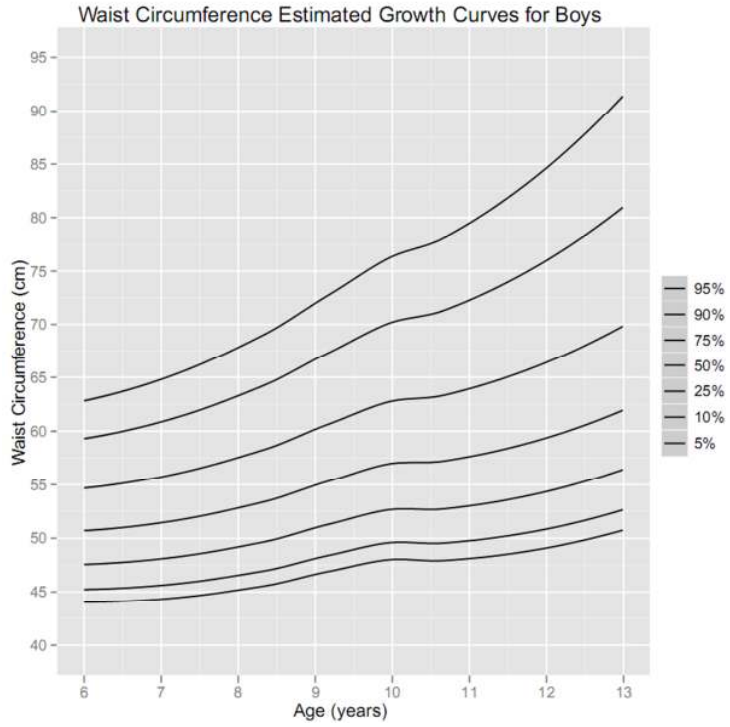
Table 3: Waist to height ratio percentiles by age and gender

	Age[1] (years)	5th	10th	25th	50th	75th	90th	95th
Boys	6	0.39	0.40	0.42	0.44	0.47	0.51	0.53
	7	0.38	0.39	0.41	0.44	0.48	0.54	0.59
	8	0.38	0.38	0.40	0.42	0.45	0.50	0.53
	9	0.38	0.39	0.40	0.42	0.46	0.53	0.58
	10	0.37	0.38	0.39	0.42	0.45	0.53	0.59
	11	0.36	0.37	0.39	0.41	0.46	0.53	0.56
	12	0.36	0.37	0.39	0.41	0.46	0.54	0.58
Girls	6	0.39	0.40	0.41	0.44	0.48	0.53	0.57
	7	0.38	0.39	0.41	0.44	0.47	0.54	0.59
	8	0.36	0.38	040	0.43	0.45	0.49	0.53
	9	0.36	0.37	0.39	0.41	0.44	0.50	0.53
	10	0.36	0.37	0.38	0.41	0.45	0.52	0.54
	11	0.35	0.36	0.38	0.41	0.45	0.50	0.53
	12	0.35	0.36	0.38	0.41	0.45	0.50	0.52

[1]Age: a whole year age, e.g. 6 years = 6.0-6.99 years

Figure 1: Smoothed waist circumference percentile curves of Thai primary school boys (1A) and girls (1B)

1A



1B

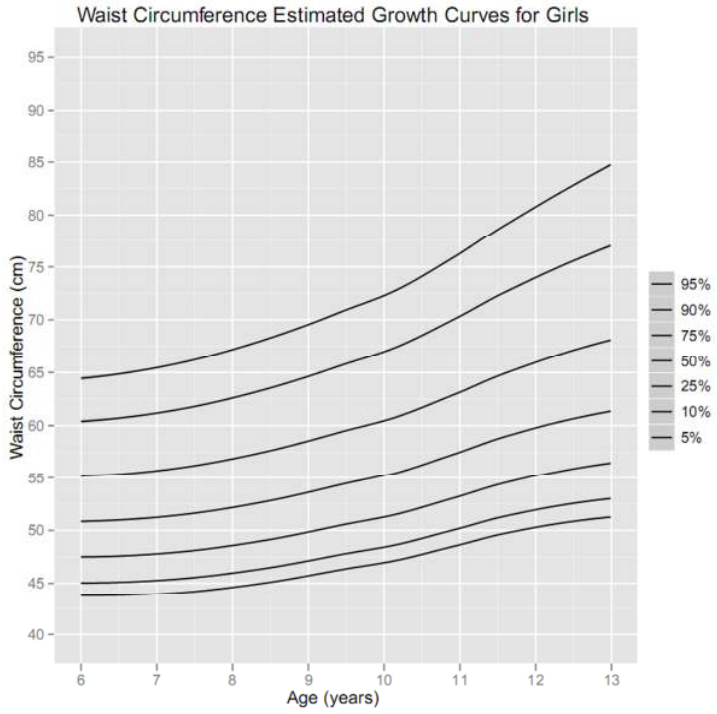
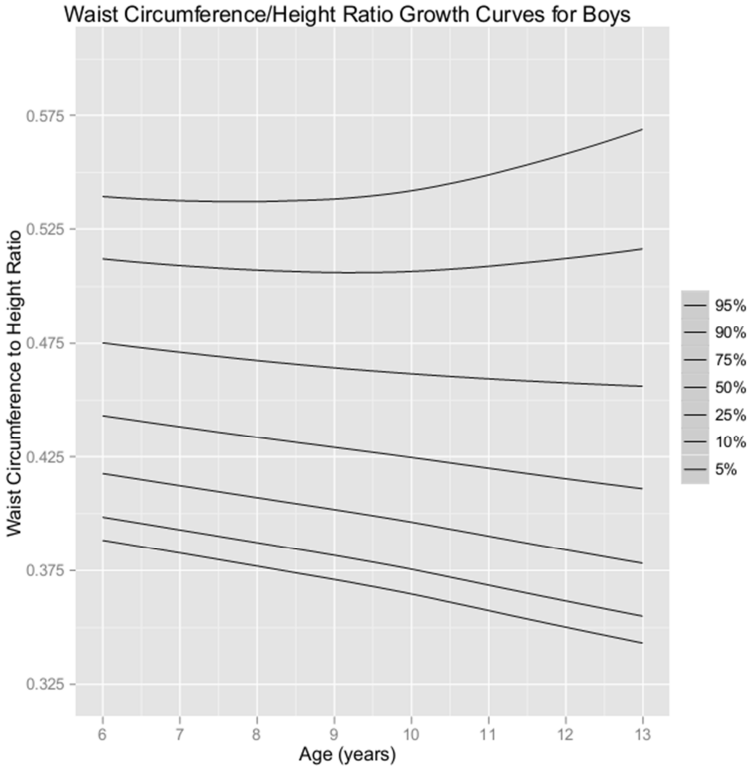


Figure 2: Smoothed waist to height ratio percentile curves of Thai primary school boys (2A) and girls (2B)

2A



2B

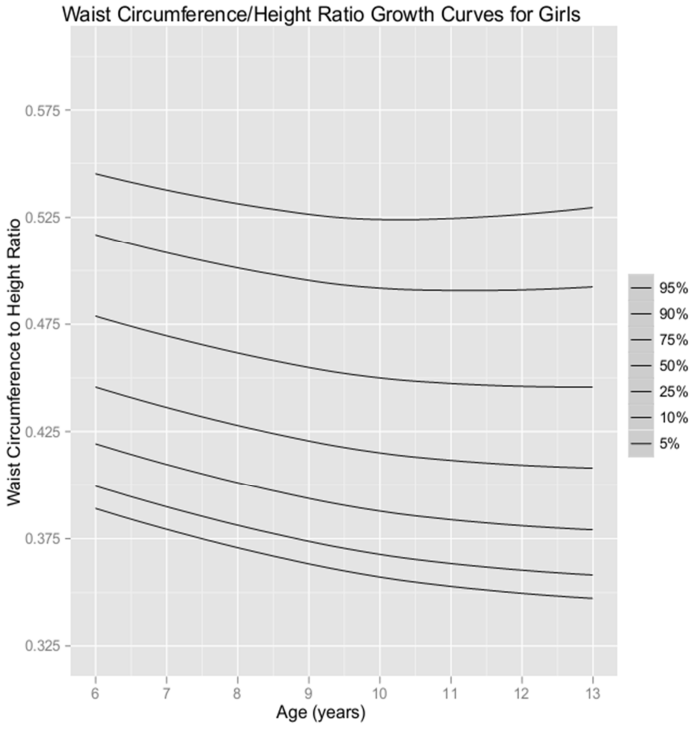
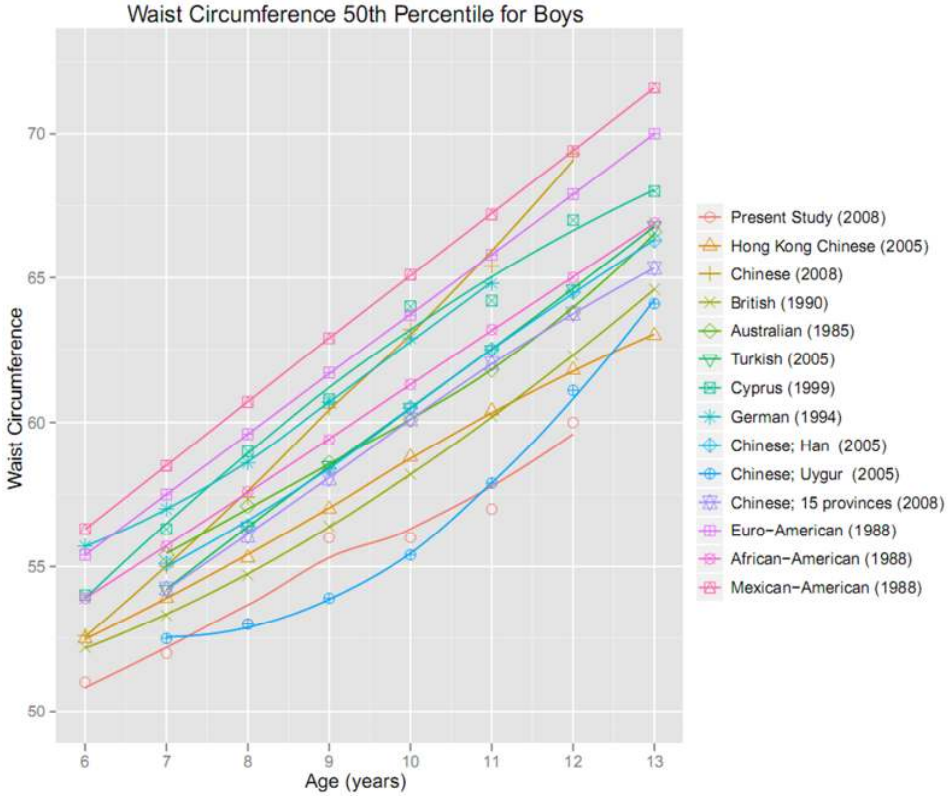
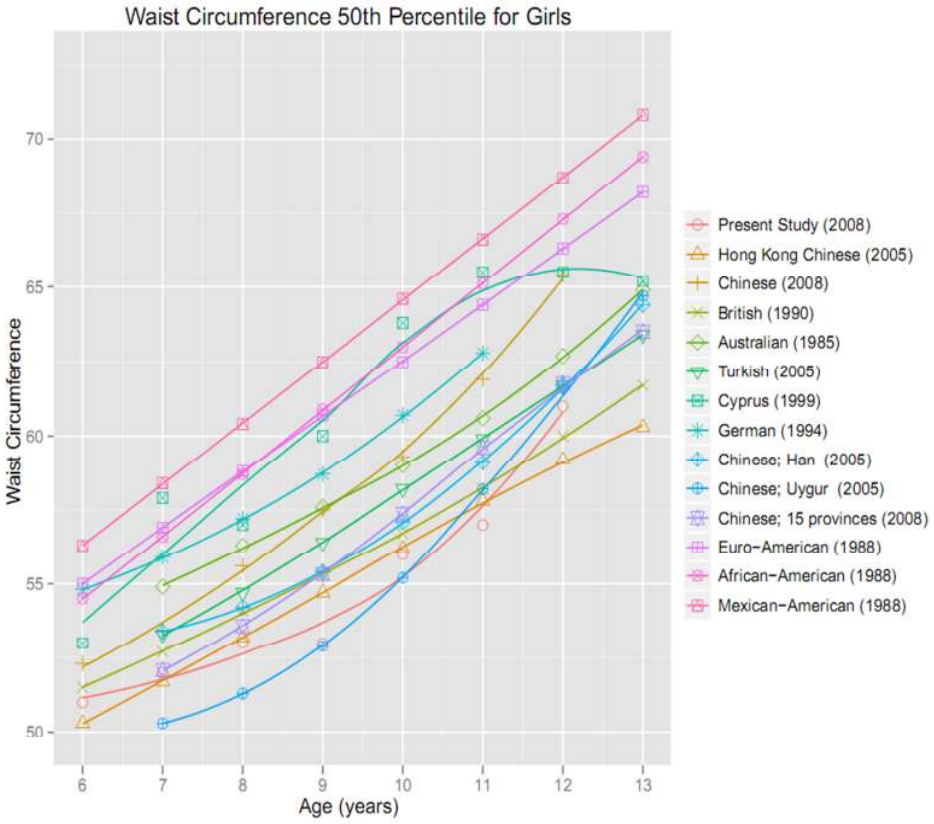


Figure 3: Comparison of the 50th waist circumference percentile curves of Thai primary school boys (3A) and girls (3B) with previous studies from American children[8]; Australian children[15]; British children [4]; Chinese children[12, 13, 16]; Cypriot children[17]; German children[14]; Hong Kong Chinese children[6] and Turkish children[11]

3A



3B


Waist Circumference 50th Percentile for Girls
Waist Circumference
70
65
60
55
50
6
7
8
9
10
11
12
13
Age (years)
Present Study (2008)
Hong Kong Chinese (2005)
Chinese (2008)
British (1990)
Australian (1985)
Turkish (2005)
Cyprus (1999)
German (1994)
Chinese; Han (2005)
Chinese; Uygur (2005)
Chinese; 15 provinces (2008)
Euro-American (1988)
African-American (1988)
Mexican-American (1988)