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Waist Circumference in Children and Adolescents from Different Ethnicities

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1. Introduction

In their Bulletin 2001; 79 the World Health Organisation (WHO) had published: "The last two decades have witnessed the emergence and consolidation of an economic paradigm which emphasizes domestic deregulation and the removal of barriers to international trade and finance. If properly managed, such an approach can lead to perceptible gains in health status."
Globalization in the last two decades influenced lifestyle and especially food patterns all over the world (Bauchner H, 2008 and Hu FB, 2008). In a "Nutrition transition" the consumption of dietary fat and/ or high -caloric meals and sweetened drinks has been increased, in developed countries as well as in developing ones (Hawkes C, 2006). At the same time overweight and obesity just as increased and diet- related chronic diseases like diabetes mellitus II, hypertension or lipid disorders or cardiovascular diseases known from elder adults are observed in children and adolescents.
Waist circumference (WC) is a generally accepted measure of central obesity that is a traditional risk factor for cardiovascular disease (CVD). A worldwide standardization of WC is warranted because of considerable differences between different ethnicities. For adults pragmatic ethnic-specific cut-off values for WC were defined between >85 cm and >94 cm for men and between >80 cm and >90 cm for women (Alberti et al., 2005). For children and adolescents from different ethnicities no uniform definition of WC cut-offs exists because of physiological growth and development.
The aim of this study is to develop age- and gender-specific reference curves of WC for German children and adolescents, to define cut-off values, to collect percentile curves from other ethnicities, and to compare global findings. Calculation of our cut-off values is based on conventional anthropometric and non-anthropometric cardiovascular risk factors.
WC is obligate for the definition of the metabolic syndrome already in youths. Early detection and intervention by lifestyle change are mandatory to prevent adult adiposity and its multiple complications. Thus, precise diagnosis is prerogative for the estimation of the worldwide prevalence of the metabolic syndrome and global intervention.

2. Subjects and methods

For the PEP Family Heart Study representative samples of 3531 German children (1788 boys, 1743 girls) aged 3-11 years and of 3024 German adolescents (1633 males, 1391 females) aged 12–18 years participating in yearly cross-sectional surveys between 1994 and 2004

respectively between 2000 and 2007 were studied (Schwandt et al., 2008; Haas et al., 2011). The CASPIAN Study was performed in 2003-2004 and contributes representative samples of 1616 Iranian children (757 boys and 859 girls) and of 2608 Iranian adolescents (1216 males and 1392 females) in these age groups. The Belo Horizonte Heart Study contributes 464 Brazilian children (241 boys and 223 girls) and 545 Brazilian adolescents (255 males and 290 females) to this large data set of the BIG study consisting of 11,788 youths from three continents. All the three studies followed the Declaration of Helsinki and the same methodology.

The ethical committee of the medical faculty of the Ludwig- Maximilians- University Munich, the Bavarian Ministry of Science and Education, and the local school authorities approved the Prevention Education Program (PEP). Written informed consent together with oral consent from children and adolescents was obtained from all parents, assessment of the pubertal status was not accepted. Exclusion criteria of the PEP Family Heart Study were non-German ethnicity **(**2.6% of children from 17 non-German ethnicities to avoid ethnic bias), incomplete data sets, apparent cardiovascular, metabolic, endocrine and malignant diseases, extreme physical activities, special nutrition habits and taking any medication**.**

Continuously trained research assistants performed all measurements along the study manual as previously described (Schwandt et al., 1999, 2009, 2010). Physical examination included measurements of weight, height, body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR), skin fold thickness (SFT), percent body fat (%BF) and blood pressure (BP). Lipids, lipoproteins and glucose were measured in fasting venous blood samples, processed and stored at -20°C every year during November and December. Definition of risk factors is shown in Table 1.

Overweight:	85th to 95th percentile of BMI (kg/m²)
General obesity:	≥95th percentile of BMI (kg/m²)
Central obesity:	WC≥ 90th and/or waist to height ratio ≥0.5
Hypertension: SBP and/or DBP	≥95th percentile
Fasting hyperglycemia:	≥100 mg/dL plasma glucose
Hypertriglyceridemia:	≥150 mg/dL
Increased LDL-Cholesterol:	≥130 mg/dL
Decreased HDL-Cholesterol:	<40 mg/dL
Increased Non HDL-Cholesterol:	≥123 mg/dL
Increased ratio of LDL-C/HDL-C:	≥ 3.0
Increased ratio of TG/HDL-C	≥3.5

Table 1.

Statistical analyses were performed with PASW 17.0 version for Windows (SPSS, Illinois, USA) according to a predefined analysis plan and program. Continuous variables are presented as the mean ± standard deviation (SD). Smoothed age- and gender-specific curves were constructed for WC, WHtR, SFT and BMI (Schwandt et al., 2008; Haas et al., 2011) using the software package LMS Chart Maker Pro, version 2.3. The associations between anthropometric measurement and cardiovascular risk factors were calculated by multivariate logistic regression using the backward Likelihood Quotient Model. All of the tests were 2-sided, and p values of <0.05 were considered to be statistically significant.

3. Results

3.1 Age- and gender-specific percentiles of waist circumference in German children and adolescents

The anthropometric characteristics of healthy German children are demonstrated in Table 2

Age (years)	Number (n)	Weight (kg)	Height (cm)	WC (cm)	BMI (kg/m³)	HC (cm)	WHR	WHtR
Boys								
3	95	15.7±2.19	100.61±4.61	50.93±3.24	15.44±1.35	55.37±3.51	0.92±0.05	0.51±0.03
4	164	17.86±2.14	107.31±4.46	52.85±2.82	15.50±1.51	57.58±3.45	0.92±0.05	0.50±0.03
5	101	19.59±3.11	113.18±5.30	53.57±4.28	15.22±1.58	59.58±4.86	0.90± 0.05	0.50±0.03
6	670	23.77±4.17	122.40±5.42	56.55±4.98	15.79±1.96	64.23±5.36	0.88± 0.05	0.46±0.04
7	447	25.12±4.37	125.30±5.34	57.81±5.60	15.93±2.10	65.60±5.87	0.88±0.08	0.45±0.04
8	80	29.09±5.23	132.24±6.45	59.79±6.50	16.61±2.86	68.68±6.23	0.87±0.04	0.45±0.05
9	104	31.69±5.55	138.68±6.25	61.13±5.47	16.39±2.09	71.45±5.64	0.86±0.04	0.44±0.03
10	77	37.75±8.18	144.60±5.53	65.69±8.00	17.93±3.04	76.30±7.74	0.86±0.06	0.45±0.05
11	60	38.95±8.37	147.27±6.75	65.67±7.63	17.85±2.88	77.18±7.03	0.85±0.05	0.45±0.04
Total	1788	24.74±7.32	123.33±11.87	57.19±6.66	15.98±2.28	64.84±7.76	0.88±0.06	0.47±0.04
Girls								
3	91	14.58±1.60	99.09±4.56	49.88±2.74	14.84±1.21	54.87±3.07	0.91±0.05	0.50±0.03
4	133	17.23±2.53	106.53±5.61	52.00±4.31	15.16±1.73	57.43±3.64	0.91±0.06	0.49±0.04
5	98	19.64±2.78	112.45±4.70	53.71±3.93	15.60±1.77	60.18±4.12	0.89±0.04	0.48±0.03
6	702	23.10±3.79	121.43±5.40	55.45±4.74	15.60±1.82	64.28±5.38	0.86±0.04	0.46±0.03
7	410	24.82±4.67	124.27±5.25	56.63±5.63	15.99±2.30	66.23±6.13	0.86±0.05	0.46±0.04
8	87	29.29±6.12	132.63±6.69	58.72±6.46	16.54±2.61	69.94±6.74	0.84±0.05	0.44±0.04
9	90	30.93±6.20	137.13±6.57	58.98±6.13	16.32±2.23	71.66±6.38	0.82±0.05	0.43±0.04
10	77	36.86±9.29	143.96±7.11	62.70±8.06	17.65±3.52	76.78±7.92	0.82±0.06	0.44±0.05
11	55	41.18±8.78	149.09±7.69	64.36±7.69	18.41±3.10	81.27±6.88	0.80±0.06	0.43±0.05
Total	1743	24.31±7.21	122.53±12.05	56.02±6.04	15.88±2.23	65.25±7.81	0.86±0.05	0.46±0.04

Table 2. Weight, height, waist circumference (WC), hip circumference (HC), body mass index (BM), waist to hip ratio (WHR) and waist to height ratio (WHtR) by age and sex in 3531 German boys and girls (mean± SD) (Schwandt et al 2008)

Among boys and girls, WC increased continuously from 3 years to 11 years at all percentiles, steepest at the 97th percentile in both genders (Figure 1). At the 50th percentile, this corresponds to an increase of WC by 14 cm in boys and by 13 cm in girls from age 3 years to age 11 years (Table 2). However, in adolescents WC increased less, by 11 cm in males and only by 5 cm in females with even slight decreases between 15 years and 18 years (Table 3).

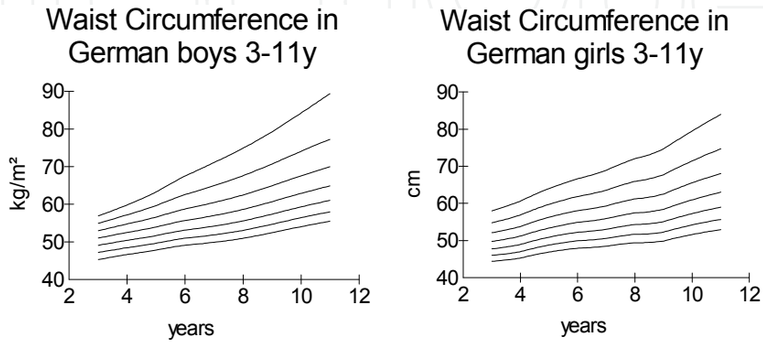


Fig. 1. Smoothed reference curves for the 3rd, 10th, 25th, 50th, 75th and 97th percentiles for waist and body mass index in 3 years to 11-years old German boys and girls (Schwandt et al. 2008)

Age	n	3rd	10th	25th	50th	75th	90th	97th
Boys								
3	95	45.4	47.2	49.0	50.9	52.9	54.9	57.0
4	154	46.7	48.5	50.4	52.5	54.8	57.2	60.1
5	101	47.9	49.7	51.7	54.0	56.7	59.8	63.6
6	670	49.1	51.0	53.1	55.7	58.8	62.6	67.6
7	447	49.9	51.9	54.2	57.0	60.5	64.9	71.0
8	80	50.9	53.1	55.6	58.6	62.5	67.5	74.6
9	104	52.5	54.7	57.4	60.7	65.0	70.6	79.0
10	77	54.1	56.6	59.4	62.9	67.6	74.0	84.0
11	60	55.5	58.0	61.0	64.8	69.8	77.1	89.2
Girls								
3	91	44.2	45.8	47.5	49.7	52.1	55.0	58.5
4	133	45.4	47.2	49.1	51.4	54.1	57.3	61.3
5	98	46.8	48.7	50.8	53.3	56.2	59.6	64.1
6	702	47.9	49.9	52.2	54.8	58.0	61.8	66.7
7	410	48.6	50.7	53.1	55.9	59.4	63.7	69.2
8	87	49.3	51.5	54.1	57.2	61.0	65.8	72.1
9	90	50.2	52.6	55.4	58.7	62.9	68.2	75.4
10	77	51.5	54.1	57.1	60.7	65.3	71.3	79.7
11	55	52.9	55.6	58.8	62.8	67.9	74.7	84.6

Table 3. Age- and sex-specific WC percentile values (cm) for German children 3-11 years of age in the PEP Family Heart Study (Schwandt et al. 2008)

The prevalence of severe obesity (WC>97th percentile) was significantly ($p<0.05$) higher in boys than in girls (4.1% vs. 2.8%) corresponding to similar gender differences for BMI >97th percentile (6.3% vs. 4.9%) in this cohort children.

Age (y)	n	Weight (kg)	Height (cm)	Waist (cm)	BMI (kg/m²)	Hip (cm)	WHR	WHtR
Boys								
12y	361	46.4±9.8	155.3±7.6	69.3 ±8.4	19.1±3.0	82.0±7.8	0.84*±0.05	0.44*±0.05
13y	317	51.8±10.6	162.0±8.1	71.3 ±8.2	19.6±3.1	85.2±7.6	0.84*±0.05	0.44±0.05
14y	277	58.2*±11.0	169.1*±8.2	73.8*±8.7	20.3±3.0	89.2±7.7	0.83*±0.05	0.44±0.05
15y	222	64.4*±11.4	174.7*±7.7	70.1 ±8.9	21.0±2.9	92.1±7.4	0.83*±0.05	0.44±0.05
16y	186	68.6*±10.7	177.9*±6.6	77.6*±8.6	21.6±2.9	94.6±6.9	0.82*±0.05	0.44±0.05
17y	162	70.8*±11.8	178.8*±7.0	79.1*±8.4	22.1±3.3	96.2±7.5	0.82*±0.05	0.44±0.05
18y	108	72.3*±12.0	179.5*±8.2	80.4*±8.6	22.3±2.9	97.0±7.2	0.83*±0.05	0.45±0.04
Total	1633	58.5*±14.2	168.1*±11.8	74.0*±9.3	20.5±3.2	89.0±9.2	0.83*±0.05	0.44±0-05
Girls								
12y	315	47.4*±10.4	156.5*±7.4	68.0±8.9	19.2±3.4	84.9*±8.5	0.80±0.06	0.43±0.05
13y	269	52.6±10.6	161.0±6.8	70.2±8.9	20.2±3.6	89.4* ±8.0	0.78±0.06	0.44±0.05
14y	231	54.8±8.8	163.9±6.7	70.9±8.5	20.4±2.9	91.6*±6.6	0.77±0.06	0.43±0.05
15y	197	58.5±11.2	165.7±6.5	73.5*±9.8	21.3±3.7	94.3*±7.6	0.78±0.07	0.44±0.05
16y	144	58.7±11.9	165.6±6.5	73.9±8.3	21.1±2.8	95.0 ±7.9	0.78±0.06	0.45*±0.05
17y	131	59.2±8.7	166.3±6.4	74.4±8.0	21.4±2.9	95.3±6.4	0.78±0.06	0.45±0.05
18y	104	58.9±7.0	166.1±6.2	73.7±8.1	21.4±2.4	95.3±5.6	0.77±0.07	0.44±0.05
Total	1391	54.3±11.0	162.5±7.7	71.4±9.2	20.5±3.4	91.0*±8.5	0.78±0.06	0.44±0.05

Table 4. Age dependent mean values (SD) of waist circumference, body mass index, hip circumference, waist-to-hip ratio and waist-to-height ratio in male (n=1633) and female (n=1391) adolescents aged 12-18 years; *$p<0.05$ between genders

Females were significantly taller and heavier than males at age 12 y, whereas from age 14 to 18 years males were significantly taller and heavier than females. Female adolescents reached their maximal weight and height at age 17 years one year earlier than males.
As demonstrated in **Table 5** the increase of WC in males was twice of that in females (11.4 cm respectively 6.0 cm)

Males (n=1634)	Age	-2.0001 3 rd	-1.3334 10th	-0.6667 25th	0 50th	0.6667 75th	1.3334 90th	2.0001 97th
	12	56.6	59.7	63.4	67.8	73.3	80.4	90.2
	13	58.9	62.0	65.7	70.1	75.7	82.9	92.7
	14	61.0	64.2	67.9	72.5	78.1	85.3	95.0
	15	62.8	66.1	70.0	74.6	80.3	87.4	96.7
	16	64.3	67.7	71.7	76.4	82.1	89.1	98.0
	17	65.9	69.3	73.3	78.0	83.7	90.6	99.5
	18	67.2	70.6	74.6	79.2	84.9	91.8	100.8
Females (n=1392)								
	12	51.4	57.0	62.6	68.2	73.8	79.4	85.0
	13	52.8	58.5	64.3	70.0	75.8	81.5	87.2
	14	53.7	59.5	65.4	71.2	77.0	82.9	88.7
	15	54.9	60.9	66.8	72.8	78.8	84.7	90.7
	16	55.6	61.7	67.7	73.8	79.8	85.9	91.9
	17	55.8	61.8	67.9	74.0	80.0	86.1	92.2
	18	55.3	61.3	67.3	73.3	79.3	85.4	91.4

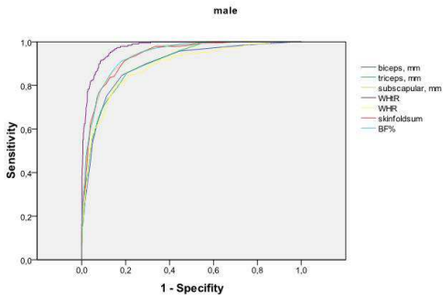
Table 5. Percentile values of waist circumference in 3026 German adolescents aged 12-18 years

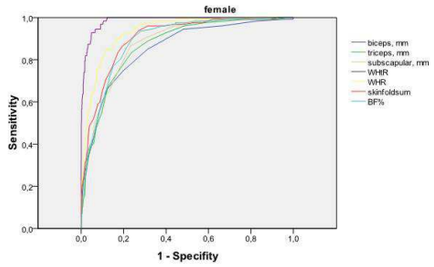
3.2 Cut-off points of waist circumference in adolescents

Since the International Diabetes Federation (IDF) proposed that the metabolic syndrome should not be diagnosed in children younger than age 10 years (Zimmet et al. 2007) we calculated cut-off points only for the group of adolescents.

3.2.1 Cut-off points in terms of seven anthropometric variables

Receiver operating characteristic (ROC) curves were calculated from <90th percentiles of skin fold thickness (SFT) from biceps, triceps and sub-scapular areas, SFT sum, percent body fat, waist-to-height ratio and waist-to-hip ratio. In both genders WHtR at the >90th percentile was closest to 1 in terms of an area under the curve (AUC) of 0.974 in males and 0.986 in females, followed by BF% (0.937) in males respectively by WHR (0.935) in females. (**Figure 2**).





AUC (Waist Circumference >90th percentile)

Variables	area	SE	Significance asymptotic	CI 95% (asymptotic) Lower Limit	Upper Limit
Biceps SFT, mm	.896	.012	.000	.872	.920
Triceps SFT, mm	.903	.010	.000	.883	.924
Subscapular SFT, mm	.936	.008	.000	.921	.952
Sum SFT, mm	.934	.008	.000	.918	.950
WHtR	.974	.004	.000	.966	.982
WHR	.885	.013	.000	.859	.912
BF%	.937	.008	.000	.922	.953

AUC (Waist Circumference >90th percentile)

Variables	area	SE	Significance asymptotic	CI 95% (asymptotic) Lower Limit	Upper Limit
Biceps SFT, mm	.853	.018	.000	.818	.888
Triceps SFT, mm	.868	.015	.000	.839	.898
Subscapular SFT, mm	.884	.013	.000	.858	.910
Sum SFT, mm	.903	.013	.000	.878	.928
WHtR	.986	.003	.000	.981	.991
WHR	.935	.009	.000	.917	.954
BF%	.891	.013	.000	.865	.916

Fig. 2. ROC curves and AUC values calculated at and above the 90th percentile in 3026 German adolescents

3.2.2 Cut-off points in terms of eight non-anthropometric CVD risk factors

The WC cut-off points in children were 93.5 cm for hypertension, increased LDL-Cholesterol, low HDL-Cholesterol, increased triglycerides (TG), non-HDL-Cholesterol and TG/ HDL-Cholesterol ratio and not different for boys and girls except for fasting hyperglycaemia and an increased LDL-Cholesterol/HDL-Cholesterol ratio (Table 6). However, in adolescents the age-adjusted cut-off values were much more different between males and females than among children..

	Boys 6 – 11y	Girls 6 - 11 y	Boys 12 – 18y	Girls 12 – 18 y
Hypertension ≥ 95th percentile	93,5	93,5	93,5	82,5
LDL ≥ 130 mg/dL	93,5	93,5	93,5	62,5
HDL ≤ 40 mg/dL	93,5	93,5	93,5	93,5
TG ≥ 150 mg/dL	93,5	93,5	82,5	93,5
Non HDL ≥ 123 mg/dL	93,5	93,5	62,5	93,5
Glucose ≥ 150 mg/dL	62,5	93,5	82,5	93,5
Increased LDL/HDL-C ratio ≥ 3.0	82,5	62,5	82,5	62,5
Increased LDL/HDL-C ratio ≥ 3.0	93,5	93,5	93,5	93,5

Table 6.

3.3 Comparison with other ethnicities

3.3.1 Iranian and German children

The study population comprised 2076 (991 boys) Iranian and 1721 (851 boys) German children aged 6-11 years (Kelishadi et al 2008). Except height, the Iranian children had higher anthropometric measures than German children did (Table 7).

	Girls		Boys	
	Iranian	German	Iranian	German
Height (cm)	123.15±10.45	124.90±11.35	124.57±11.54	125.62±11.48
Weight (kg)	26.81 ±7.64	25.29±7.29	27.08 ± 7.12	25.51±7.03
Body mass index (kg/m²)	17.28±2.81	15.93±2.28	17.35± 2.84	15.89±2.08
Waist circumference (cm)	58.14 ±8.32	56.55±6.19	58.72± 8.34	57.46±6.20
Hip circumference (cm)	69.25± 9.12	66.17±7.78	68.81± 9.8	65.53±7.30
Waist-to-hip ratio	0.86±0.05	0.72± 0.06	0.88±0.07	0.71± 0.006

Table 7.

The age-specific reference curves of WC demonstrate a continuous increase in Iranian children from 6 years to 11 years whereas at 9 years the increase levelled off in German children (Figure 3).

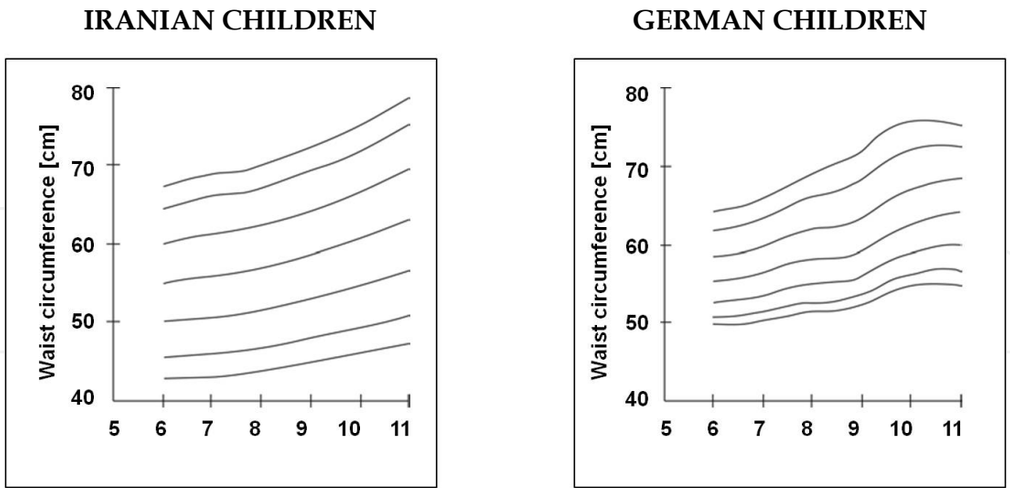


Fig. 3. LMS percentile curves of Iranian and German children (age 6-11)

The comparison of increased WC in German and Iranian adolescents mean age 12.2± 1.7 respectively 12.6±1.7 years reveals a significantly ($p<0.05$) higher prevalence in Iranian subjects than in German adolescents (Table 8).

Accordingly, the prevalence of the metabolic syndrome as defined by IDF was higher in Iranian (2.1%) adolescents than in German adolescents (0.5%).

German Total	n 3647	High WC	Iranian Total	n 2728	High WC
10 y	742	6.1	10 y	215	4.4
11 y	715	5.7	11 y	237	6.8
12 y	677	3.5	12 y	273	9.4
13 y	586	4.3	13 y	254	11.6
14 y	508	4.3	14 y	281	15.9
15 y	419	4.8	15 y	225	16.9

Table 8. Prevalence (percentage) of increased waist circumference in German and Iranian adolescents

3.3.2 Comparisons of Bazilian Iranian and German (BIG study)

The Brazilian-Iranian-German (BIG) Study compared 4473 children (6 to <10 years) and 6800 adolescents (10 to <16 years) participating in the Belo Horizonte Heart Study in Brazil, the CASPIAN Study in Iran and the PEP Family Heart Study in Germany (Schwandt et al. 2010). Table 9 shows the mean values of WC and the prevalence of increased WC (>90th percentile) for males and females of these age groups. Males from the three countries had higher mean values of WC than females. Iranian children and adolescents had lower mean values compared with Brazil and Germany. The prevalence of increased WC was lowest in Brazilian children but highest in Brazilian adolescents.

	Brazil		Iran		Germany	
	Males	Females	Males	Females	Males	Females
Age 6-<10 y						
N	241	223	757	859	1220	1173
Mean age	7.9±1.0	7.9±0.9	7.7±1.0	7.7±1.0	7.6±1.1	7.7±1.1
Mean WC cm	59.2±7.2	58.0±6.8	58.6±7.3*	57.0±7.2	59.3±6.0*	58.3±6.2
WC >90th percentile	4.4%*†	0.9%†	10.9*¶	8,0%¶	8,7%†	9.3%†
Age 10-<16 y						
N	255	290	1216	1392	1938	1709
Mean age	13.0±1.7	13.2±1.7	12.6±1.7	12.6±1.7	12.2±1.7	12.2±1.7
Mean WC cm	68.4±10.0*	65.7±8.1	67.5±9.8*	66.3±9.1	69.9±8.9*	68.0±9.1†
WC >90th percentile	16.1%*	8,9%	10.5%¶	9,0%	8.8%	9,7%

Legend *p<0.05 for gender, †p<0.05 for Germany vs. Iran, ¶p<0.05 for Iran vs. Brazil

Table 9. Comparison of WC values and prevalence of increased WC in children and adolescents from Brazil, Iran and Germany

3.3.3 Turkish and German children

Comparing 2473 Turkish and German first graders (mean age 6.4 years) participating in the PEP Family Heart Study in Nuremberg Turkish boys (58.5±8.9 vs. 56.9±6.1) and Turkish girls (57.6±9.2 vs. 55.8±5.8) girls had significantly higher values than German children did although living in the same town. These differences might be due to different lifestyle as well as to genetic factors (Haas et al. 2008).

Age- and gender-specific percentile values are shown in table 10 and table 11 for 320 Turkish (155 boys and 165 girls) and 3531 German (1788 boys and 1743 girls) children participating in the PEP Family Heart Study.

	Age (y)	3rd perc	10th perc	25th perc	50th perc	75th perc	90th perc	97th perc
German Boys	3	45,42125	47,18961	49,02191	50,92029	52,88695	54,92416	57,03426
	4	46,69526	48,46758	50,39043	52,48431	54,77372	57,28811	60,06324
	5	47,85518	49,65204	51,67864	53,98907	56,65722	59,7872	63,53141
	6	49,09508	50,96856	53,13880	55,69791	58,78483	62,62184	67,59351
	7	49,85503	51,85384	54,19979	57,01334	60,48490	64,93884	70,98889
	8	50,92392	53,05610	55,58078	58,64386	62,48325	67,52202	74,61327
	9	52,45929	54,71848	57,41692	60,72932	64,95015	70,62830	78,95486
	10	54,13066	56,50359	59,36617	62,92871	67,56040	73,99220	83,97658
	11	55,52872	57,99448	60,99931	64,79309	69,83402	77,09267	89,19402
Turkish Boys	3	45,13165	46,56837	48,16657	49,95961	51,99147	54,32160	57,03266
	4	46,62536	48,22576	50,02131	52,05606	54,38956	57,10463	60,32063
	5	47,56840	49,31606	51,29320	53,55601	56,18229	59,28349	63,02618
	6	48,74434	50,64942	52,82218	55,33326	58,28282	61,81867	66,17017
	7	49,72113	51,77748	54,14133	56,89969	60,17884	64,17075	69,18511
	8	50,84256	53,05759	55,62350	58,64620	62,28308	66,78065	72,55271
	9	52,21283	54,59960	57,38526	60,69772	64,73153	69,80078	76,45477
	10	53,61329	56,17588	59,18871	62,80458	67,26134	72,95489	80,60757
	11	54,60335	57,32400	60,54554	64,44736	69,31509	75,63903	84,35397

Table 10. Percentiles for waist circumference in 3 – 11 y old boys

	Age (y)	3rd perc	10th perc	25th perc	50th perc	75th perc	90th perc	97th perc
German Girls	3	44,19034	45,79188	47,60676	49,68840	52,11125	54,98302	58,46667
	4	45,43920	47,16375	49,12995	51,40178	54,07009	57,26926	61,20855
	5	46,84072	48,68316	50,79415	53,24795	56,15164	59,66655	64,05009
	6	47,94398	49,90333	52,16059	54,80217	57,95469	61,81306	66,69706
	7	48,59970	50,68025	53,09390	55,94300	59,38086	63,65009	69,16380
	8	49,32377	51,53956	54,12971	57,21650	60,98747	65,74889	72,04508
	9	50,22757	52,59150	55,37626	58,72775	62,87536	68,20625	75,44123
	10	51,51220	54,04821	57,05925	60,71992	65,31187	71,32723	79,72974
	11	52,86370	55,58198	58,83524	62,83172	67,91631	74,71423	84,51890
Turkish Girls	3	43,04967	45,53947	48,01737	50,48407	52,94023	55,38641	57,82314
	4	44,66278	47,35326	50,16913	53,11458	56,19386	59,41132	62,77140
	5	46,14307	48,96775	52,07110	55,49183	59,27567	63,47701	68,16096
	6	46,92607	49,79550	53,07608	56,86617	61,29882	66,55875	72,91049
	7	47,60613	50,46602	53,83657	57,88478	62,86421	69,18208	77,54257
	8	50,24199	53,19411	56,74006	61,11031	66,68391	74,13976	84,85235
	9	52,82375	55,86301	59,55225	64,16765	70,18581	78,52220	91,24661
	10	54,14897	57,17937	60,89252	65,60252	71,87704	80,88622	95,61519
	11	54,88581	57,84137	61,50332	66,22778	72,69708	82,45647	100,2245

Table 11. Percentiles for waist circumference in 3 – 11 y old Girls

The WC differences between Turkish and German boys decreases from age 3 to age 11 whereas the mean differences in girls increases from age 3 to age 11 years.
Figure 4 and Figure 5 demonstrate the importance of choosing the percentile for comparisons. At the 50th percentile the difference of increasing WC between years 3 and 11 in German and Turkish children is only slight whereas the curve in Turkish girls is much more steeper compared with the other three curves.

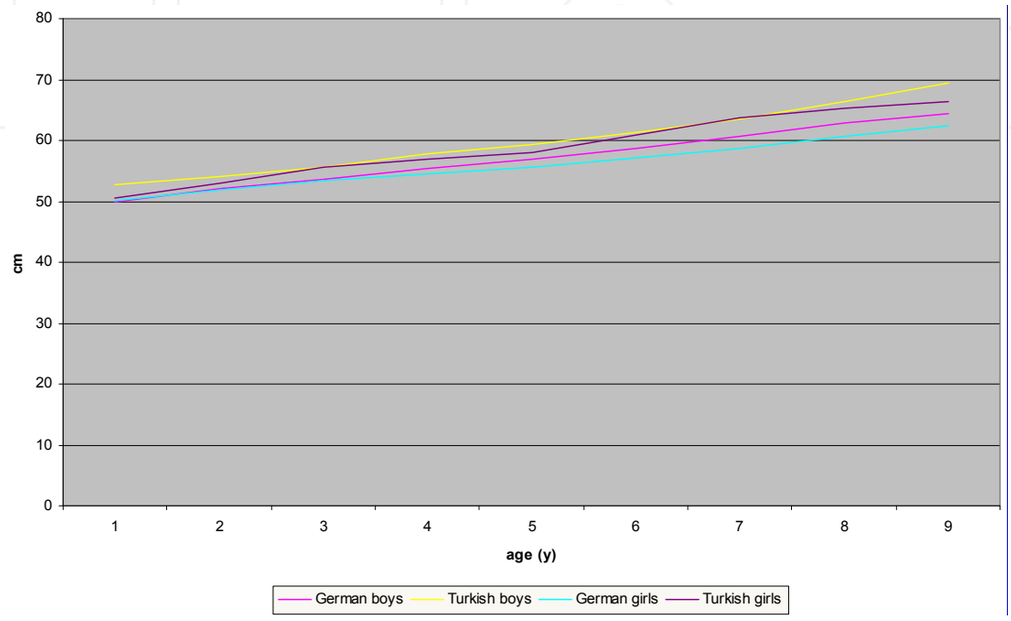


Fig. 4. 50th percentile of LMS waist circumference for German and Turkish children 3 – 11 y

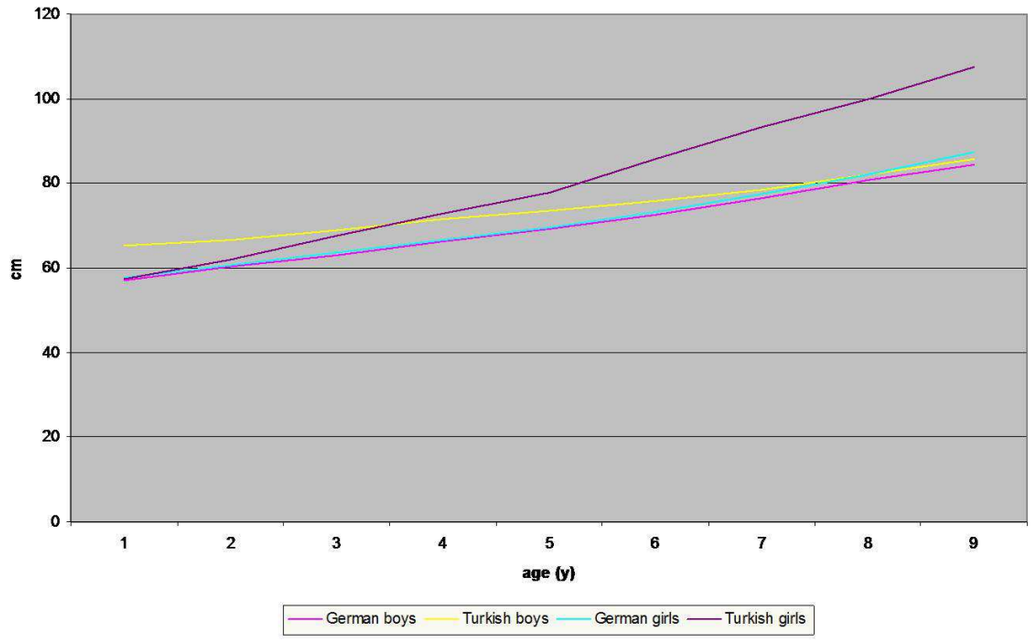


Fig. 5. 90th percentile of LMS waist circumference for German and Turkish children 3 – 11 y

Figure 6 demonstrates these differences at four different percentiles

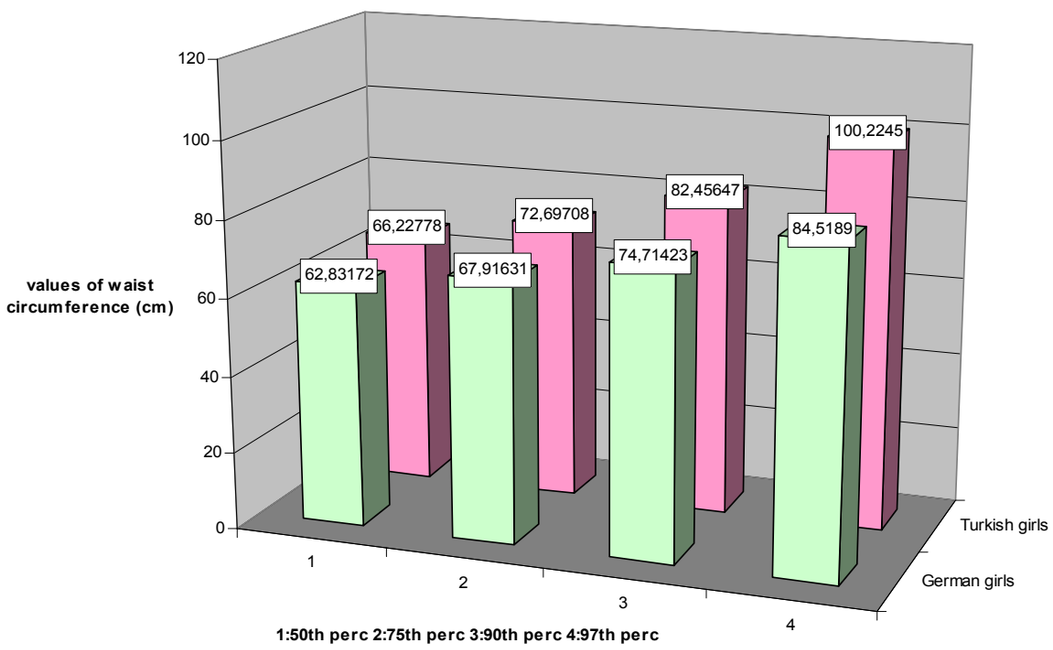
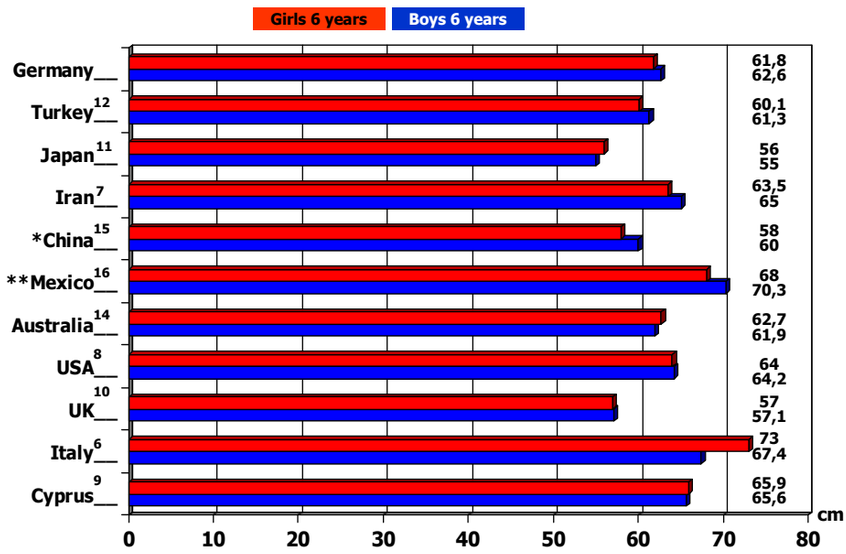


Fig. 6. 50th , 75th , 90th and 97th percentiles of waist circumference in 11 y old Turkish and German girls participatin in the PEP Family Heart Study

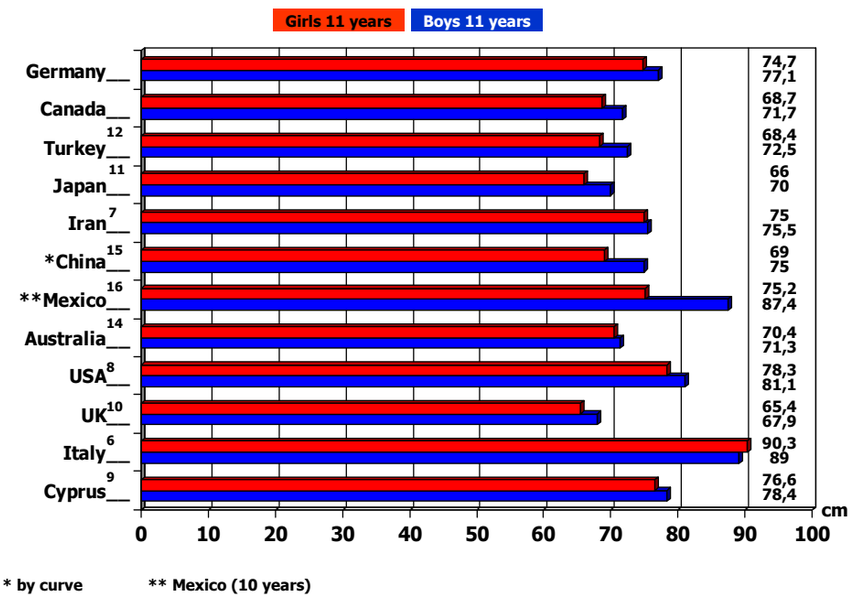
3.3.4 Ethnic comparisons of WC form children from literature

Table 12 and Table 13 compare the mean WC values from 6 respectively 11 years old children from 11 countries in boys and in girls. The continuous increase of waist circumference in these countries is shown in figure 5 and figure 6 (Schwandt et al. 2008).



6. Zannolli R, 1996
7. Kelishadi R, 2007
8. Fernandez JR, 2004
9. Savva SC, 2001
10. McCarthy HD, 2001
11. Inokuchi M, 2007
12. Hatipoglu N, 2007
14. Eisenmann JC: 2005
15. Sung RY, 2007
16. Gómez-Diaz RA, 2005

Table 12. Mean values (cm) of waist circumference in 6 years old children from 11 countries



6. Zannolli R, 1996
7. Kelishadi R, 2007
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9. Savva SC, 2001
10. McCarthy HD, 2001
11. Inokuchi M, 2007
12. Hatipoglu N, 2007
14. Eisenmann JC: 2005
15. Sung RY, 2007
16. Gómez-Diaz RA, 2005

Table 13. Mean values (cm) of waist circumference in 11 years old children from 11 countries

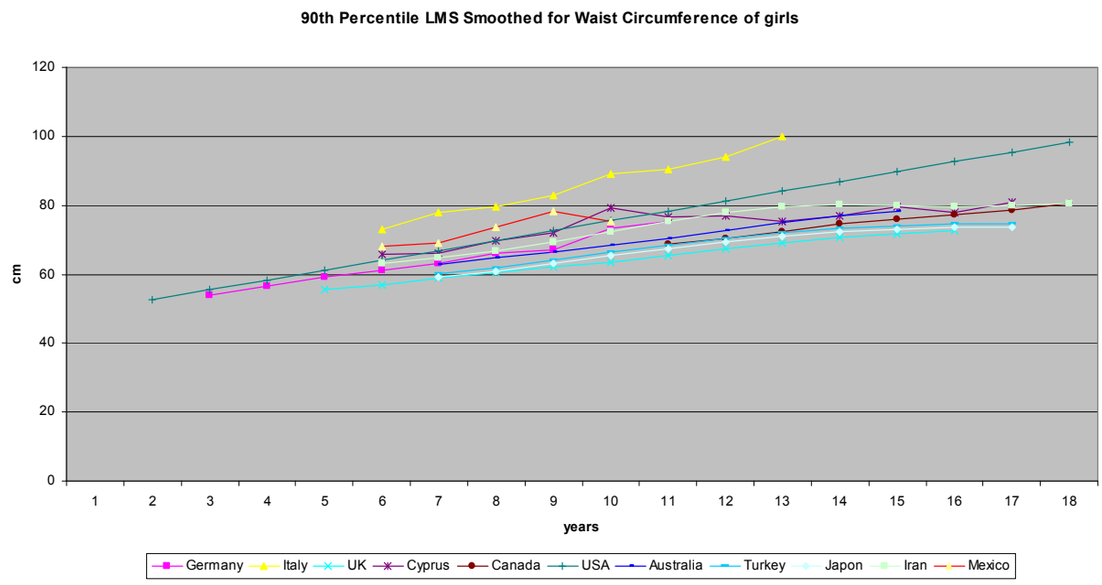

Fig. 7. Waist circumference (cm) at the 90th percentile in girls from 11 countries

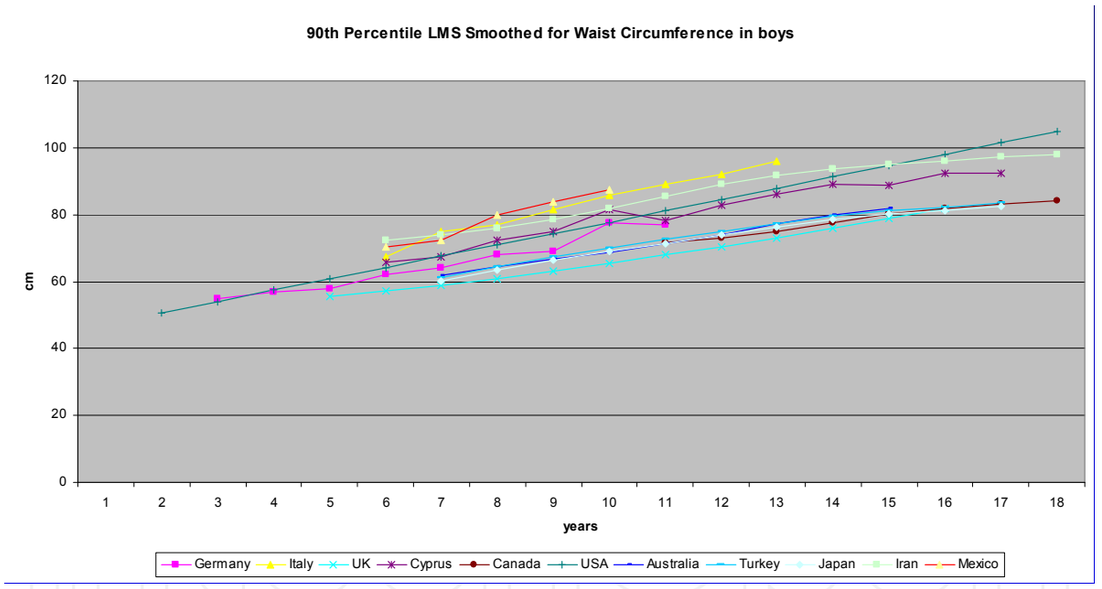

Fig. 8. Waist circumference (cm) at the 90th percentile in boys from 11 countries

4. Conclusions

In 4473 children and 6829 adolescents from Germany, Iran and Brazil the mean prevalence of increased waist circumference (≥ 90th percentile) was 7.0% respectively 10.5%. Increased waist circumference (≥ 90th percentile) is a clinically accessible diagnostic tool and a measure of central obesity that is essential for the global IDF definition of the metabolic syndrome (Zimmet et al. 2007). For adolescents aged 10 years and older increased WC and two or more other features like hypertension, hyperglycaemia, hypertriglyceridemia, and low HDL-Cholesterol are diagnostic.

The relatively homogeneous WC mean values in adolescents of the three different ethnicities in the BIG Study (Schwandt et al., 2010) are far lower than WC mean values of adolescents from USA describing 79.6±12.5 cm in males and 78.8±11.7 cm in females (Jolliffe and Janssen, 2007). These considerable differences between 2906 male and 3116 female US adolescents and 3409 male and 3328 female BIG adolescents might be explained by different age ranges (12-20 years vs. 10-<16 years), different periods of data collection (1988-2002 vs. 2000-2008) and/or different measure points (iliac crest vs. mid-point between lowest rib and iliac crest). Furthermore, heterogeneity of the study populations might have affected the outcome since The National Health and Nutrition Examination Surveys NHANES are nationally representative cross-sectional including Hispanic, Black and White participants.

This comparison of two large cross-sectional studies demonstrates the outstanding importance of comparable design and methodology of the studies. The main strength of the BIG study is that original data of a very large number (11,273) of children and adolescents from Germany, Iran and Brazil of youths from three continents were measured and evaluated by the same methodology. One limitation of the study is that genetic and environmental effects (e.g. physical activity, nutrition and second hand tobacco smoke exposition respectively active smoking) on anthropometric measures are not included.

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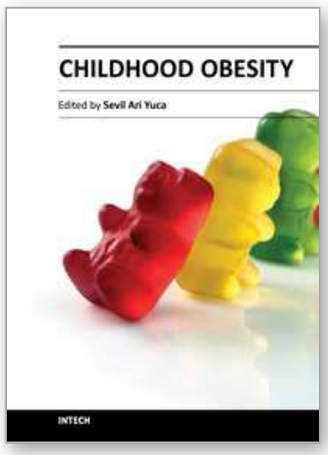

Childhood Obesity

Edited by Dr. Sevil Ari Yuca

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This book aims to provide readers with a general as well as an advanced overview of the key trends in childhood obesity. Obesity is an illness that occurs due to a combination of genetic, environmental, psychosocial, metabolic and hormonal factors. The prevalence of obesity has shown a great rise both in adults and children in the last 30 years. It is known that one third of children who are obese in childhood and 80% of adolescents who are obese in their adolescent years continue to be obese later in life. Obesity is an important risk factor in serious illnesses such as heart disease, hyperlipidemia, hyperinsulinemia, hypertension and early atherosclerosis.

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