

# Dual burden of body weight among Iranian children and adolescents in 2003 and 2010: the CASPIAN-III study

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## Abstract

**Introduction:** Our aim was to compare changes of body mass index (BMI) and waist circumference (WC) curves of Iranian children by comparing the results of two national surveys of a surveillance program, i.e. CASPIAN-I (2003–2004) and CASPIAN-III (2009–2010). The second objective was to evaluate the prevalence of obesity, overweight and underweight among 10–18-year-old Iranian children and adolescents.

**Material and methods:** This study was performed among students who were selected by multistage random cluster sampling from urban and rural areas of 27 provinces of Iran, as part of a national survey of school student high risk behavior entitled CASPIAN-III, conducted in 2009–2010.

**Results:** We evaluated 5088 school students (50.2% boys). In rural areas, underweight was more common in boys and overweight and obesity in girls. In urban areas underweight and obesity were more common in boys, whereas overweight was more common in girls. The highest prevalence of underweight (23.5%) was seen in students aged 13 years and the lowest (11.4%) in those aged 18 years. Underweight was significantly more common in rural than in urban areas (22.1% vs. 15.8%, respectively,  $p < 0.0001$ ) and overweight/obesity was more common in urban than in rural areas. Compared with the findings in 2003–2004, the overall prevalence of elevated body mass index (16.6%) including obesity (9.1%) and overweight (7.5%) as well as underweight (17.5%) increased from 2003 to 2010.

**Conclusions:** In recent years, the double burden of nutritional disorders has increased among Iranian children and adolescents, especially in rural areas. This change may be related to epidemiologic transition, notably in terms of nutrition transition and rapid changes in lifestyle habits. This finding is an important issue for policy-makers for interventional preventive programs.

**Key words:** obesity, underweight, waist circumference, body mass index, pediatric age.

## Introduction

The incidence of obesity in developing countries has been increasing in recent years [1, 2]. According to the World Health Organization (WHO) estimates, it will become the major health problem by the year 2020 [3]. Childhood obesity is a significant risk factor for adult obesity [4], and has many short-term and long-term health impacts such as insulin resistance, hypertriglyceridemia [5], type 2 diabetes [6], microalbuminuria [7], hypertension [8], and even cancers [9]. Abdominal obesity and increased waist circumference as its surrogate marker [10, 11] are risk factors for diabetes, hypertension, hyperlipidemia and ischemic heart disease [12, 13].

Epidemiologic transition, notably in terms of nutrition transition and rapid changes in lifestyle, resulted in the increase in various types of nutritional disorders at the global level. For instance, the prevalence of obesity among Pakistani children aged 5–14 years was 3% in 1994 and rose to 5.7% in 2004, whereas the corresponding figure for underweight decreased from 29.7% to 27.3% in this period [14]. It shows that obesity has been increasing in recent years but underweight is still high. This condition is known as the dual burden of body weight [15, 16]. Such a double burden of nutritional disorders is not limited to developing countries but also is seen in industrialized countries such as Spain [17], Italy [18] and France [19].

The general health status of Iranian children has improved considerably over the last decades; however, rapid lifestyle change, notably a tendency to consume snacks and fast foods with low nutritional value, is a threat to their health [20]. Regarding the rapid change of lifestyle in Iran, we compared the data of two national surveys of a surveillance program entitled “Childhood and Adolescence Surveillance and Prevention of Adult Noncommunicable disease” CASPIAN-III study. Our objective was to compare changes of waist circumference (WC) and body mass index (BMI) curves with the first phase of this study [21, 22] conducted in 2003–2004 and the third survey in 2009–2010 [23]. The second objective was to compare the prevalence of obesity, overweight and underweight based on BMI cut-offs of WHO in Iranian children and adolescents aged 10–18 years in 2003 and 2010.

## Material and methods

The national survey of school student high-risk behavior (2009–2010) was conducted as the third survey of the school-based surveillance system entitled the CASPIAN-III study. We have previously described the methodology of this survey [23] and here we present it in brief.

This school-based nationwide health survey was conducted in Iran with cooperation of the Ministry of Health and Medical Education; the Ministry of Education and Training, Child Growth and Development Research Center, Isfahan University of Medical Sciences; and the Endocrinology and Metabolism Research Institute of Tehran University of Medical Sciences in Iran. The survey was performed among 5088 students aged 10–18 years who were selected by multistage random cluster sampling from urban and rural areas of 27 provinces of Iran. Eligible schools in our study were stratified according to the information bank of the Ministry of Education, and then they were selected randomly. In selected schools, students were also selected randomly and after a complete explanation of the study objectives and protocols for students and their parents, written informed consent was obtained from parents and oral assent from students, then sampling and examinations were begun. A team of trained health care professionals recorded information in a checklist and carried out the examinations under a standard protocol by using calibrated instruments. Based on a standard protocol [24], weight, height and WC were measured and BMI was calculated as weight (kg) divided by height squared ( $m^2$ ). Weight was measured to the nearest 200 g in barefoot and lightly dressed condition. The WC was measured to the nearest 0.5 cm at the end of expiration at the midpoint between the top of the iliac crest and the lowest rib in a standing position. Waist circumference and height were measured using a non-elastic tape.

We used the WHO growth curves to define BMI categories, i.e. underweight as sex-specific BMI  $< -2$  z-score, overweight as sex-specific BMI for age of  $> +1$  z-score, and obesity as sex-specific BMI for  $> +2$  z-score [25].

## Statistical analysis

Findings on continuous variables were expressed as means  $\pm$  standard deviation (SD) and categorical data were expressed as percentage. The Student two-tailed *t* test was applied to compare the mean differences of the variables according to both gender and age.

Statistical analysis was performed using the SPSS for Windows software (version 16.0, SPSS, Chicago, IL), and  $p < 0.05$  was considered as statistically significant.

## Results

Data on 5088 children and adolescents (2556 boys and 2532 girls) with complete information were included in the current study. Table I pres-

**Table I.** Mean and standard deviations (SD) for weight, height, waist circumference and BMI for a nationally representative sample of Iranian children and adolescents: CASPIAN-III Study

Age [years]	Number (n)	Weight [kg]	Height [cm]	Waist [cm]	BMI [kg/m <sup>2</sup> ]
Girls					
10	57	29.00 ±7.02	131.28 ±9.34	58.05 ±6.23	16.86 ±3.84
11	197	31.73 ±7.31	137.55 ±8.53	60.79 ±9.47	16.68 ±3.00
12	372	35.95 ±9.31	141.45 ±9.36	62.62 ±9.15	17.78 ±3.75
13	307	40.78 ±10.33	147.96 ±9.62	64.74 ±8.60	18.55 ±3.90
14	284	46.58 ±11.18	153.43 ±9.98	67.41 ±8.81	19.58 ±3.98
15	376	49.79 ±11.03	156.09 ±8.79	69.26 ±9.02	20.32 ±4.14
16	283	52.68 ±11.61	157.82 ±10.40	71.05 ±9.32	20.97 ±3.91
17	323	54.16 ±10.09	159.19 ±5.96	71.39 ±9.81	21.36 ±3.70
18	338	54.60 ±9.67	159.97 ±8.59	70.93 ±7.97	21.26 ±3.62
Boys					
10	31	29.48 ±6.38	133.45 ±7.53	59.00 ±6.68	16.44 ±2.56
11	161	31.70 ±7.60	136.50 ±7.05	61.10 ±7.93	16.87 ±2.92
12	401	35.40 ±9.40	141.11 ±9.92	63.90 ±9.57	17.55 ±3.47
13	348	38.34 ±10.87	144.64 ±9.92	66.4 ±11.80	18.10 ±4.00
14	300	42.95 ±11.10	150.96 ±13.19	67.54 ±9.30	18.49 ±3.61
15	325	48.98±12.06	158.16 ±12.08	70.05 ±10.57	19.23 ±3.84
16	293	54.49 ±12.94	163.68 ±13.84	72.22 ±10.46	19.87 ±3.81
17	385	60.75 ±14.38	168.72 ±13.69	74.93 ±11.01	20.93 ±4.14
18	316	64.6 ±14.51	172.58 ±11.86	76.97 ±10.75	21.51 ±4.02

BMI – body mass index

ents the means and SD of anthropometric indexes by age and sex. It shows that at all ages, the mean WC was higher in boys than in girls. At all ages, except 11 and 18 years, the mean BMI was higher in girls than in boys. In both genders, WC had an escalating pattern by increasing age.

According to the WHO growth charts for BMI [26], of children and adolescents studied, 17.5% (15.0% of girls and 20.0% of boys) were underweight, 65.9% (68.5% of girls and 63.4% of boys) were normal weight, and 16.6% were overweight or obese, consisting of 7.5% overweight (8.5% of girls and 6.5% of boys) and 9.1% obese (8.1% of girls and 10.0% of boys). It shows that while underweight and obesity both are more common in boys than girls, overweight is more common in girls than in boys.

Among students aged 10–18 years, 1582 (30.8%) lived in rural areas and 3562 (69.2%) in urban areas. In rural areas, underweight was more common in boys (26.8% vs. 17.3%) and overweight (6.6% vs. 3.2%) and obesity (7.0% vs. 4.4%) in girls ( $p < 0.05$ ). In urban areas underweight (17.5% vs.

14.2%) and obesity (12.2% vs. 8.6%) were more common in boys and overweight (9.2% vs. 7.7%) was more common in girls ( $p < 0.05$ ). The highest prevalence of underweight (23.5%) was seen in students aged 13 years and the lowest (11.4%) in those aged 18 years. Underweight was significantly more common in rural than in urban areas (22.1% vs. 15.8%, respectively,  $p < 0.0001$ ) and overweight/obesity was more common in urban than in rural areas.

Tables II and III show the values of BMI and WC percentiles at each age interval for boys and girls, respectively.

Comparisons with the percentiles provided by the CASPIAN-I study showed that after the age of 12, the 5<sup>th</sup> percentile curve for BMI is lower in CASPIAN-III for both genders; but the corresponding figures for WC were higher in this study. The 50<sup>th</sup> percentile curves for BMI and WC were lower in our study than the CASPIAN-I study but in the age group over 13 years, the 95<sup>th</sup> percentiles for BMI and WC were higher in the current study than the first survey.

**Table II.** Age- and gender-specific percentiles of waist circumference: comparison of CASPIAN-I and CASPIAN-III findings

Age [years]	Gender	5 <sup>th</sup>		10 <sup>th</sup>		25 <sup>th</sup>		50 <sup>th</sup>		75 <sup>th</sup>		90 <sup>th</sup>		95 <sup>th</sup>	
		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN	
		I	III	I	III	I	III	I	III	I	III	I	III	I	III
10	Girls	50	51	52	51	56	53	60	57	65	62	71	68	75	70
	Boys	51	51	52	52	56	54	60	58	64	62	72	68	76	78
11	Girls	51	52	54	53	58	55	62	59	67	63	74	70	75	68
	Boys	52	52	54	53	57	56	62	59	68	65	75	73	80	78
12	Girls	53	52	56	53	60	56	65	61	70	66	78	75	82	80
	Boys	53	53	56	55	59	57	64	61	70	68	79	77	83	84
13	Girls	52	53	57	55	61	58	66	64	72	70	78	77	82	80
	Boys	53	54	56	55	61	58	65	63	71	72	80	85	86	90
14	Girls	57	57	60	58	63	61	68	66	72	72	79	80	83	85
	Boys	57	58	60	58	63	61	68	65	74	71	81	82	88	85
15	Girls	57	58	59	59	63	63	68	68	73	74	80	82	85	88
	Boys	54	58	59	60	64	63	69	67	75	75	83	85	89	93
16	Girls	57	59	60	60	64	64	68	69	73	76	80	84	83	91
	Boys	57	59	61	61	66	65	71	70	77	78	84	86	90	93
17	Girls	58	60	60	61	64	64	69	70	74	76	80	84	83	91
	Boys	57	61	61	63	66	68	71	72	78	80	86	91	92	97
18	Girls	60	60	61	62	64	65	70	70	76	76	83	81	86	85
	Boys	52	62	60	65	66	69	72	75	79	84	85	93	91	99

CASPIAN – Childhood and Adolescence Surveillance and Prevention of Adult Noncommunicable disease

Table IV compares the age- and gender-specific mean of WC and BMI between CASPIAN-I and CASPIAN-III findings.

## Discussion

This national study presents the prevalence of weight disorders, and the age- and gender-specific reference curves of WC and BMI for a representative sample of 10–18-year-old Iranian children and adolescents. It shows a high prevalence of both underweight and excess weight. Comparison with the first survey of the CASPIAN Study [24] shows that in the last 8 years, both overweight and underweight have increased among Iranian children and adolescents.

In this CASPIAN-III study, with increasing age, the WC curve tended to plateau in girls but not in boys. This presentation is also reported in other countries [27, 28], and probably is secondary to the earlier beginning of puberty in girls.

Comparing our results with CASPIAN-I [21] showed that weight disorders in terms of under-

weight, overweight, and obesity are all increasing among Iranian children and adolescents. This problem is not limited to Iran but also is seen in some other developing countries such as Vietnam [16], Indonesia [29] and Guinea [30]. Another cross-sectional nationwide survey among 862,433 Iranian children at school entry [31] revealed a prevalence of 19.1% of underweight and 16.2% of overweight and obesity.

Our findings show that the prevalence of obesity and overweight among Iranian adolescents is higher than Indo-Asian children [14, 32], similar to that in China [33] and Japan [34], and far lower than in Spain [17], USA [33], and Italy [18]. However, the prevalence of underweight among Iranian adolescents is lower than Indo-Asian children [14], similar to Chinese, and higher than that in Brazil, USA [33] and Japan [34]. However, it should be acknowledged that these studies have been performed based on different definitions for overweight and underweight.

National surveys in different developing countries reveal that while underweight still persists,

**Table III.** Age- and gender-specific percentiles of BMI: comparison of CASPIAN-I and CASPIAN-III findings

Age [years]	Gender	5 <sup>th</sup>		10 <sup>th</sup>		25 <sup>th</sup>		50 <sup>th</sup>		75 <sup>th</sup>		90 <sup>th</sup>		95 <sup>th</sup>	
		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN		CASPIAN	
		I	III	I	III	I	III	I	III	I	III	I	III	I	III
10	Girls	13	13	13	14	15	14	16	16	18	18	20	21	23	24
	Boys	13	14	14	14	15	15	16	16	18	17	20	20	24	24
11	Girls	13	13	14	13	15	14	17	16	19	18	21	20	24	23
	Boys	14	13	14	14	15	15	16	16	19	18	20	20	24	23
12	Girls	14	13	15	14	16	15	18	17	21	20	22	23	26	25
	Boys	14	14	14	14	16	15	17	16	20	19	22	23	25	25
13	Girls	15	14	15	14	17	16	19	18	21	21	23	24	26	26
	Boys	14	13	15	14	16	15	18	17	20	20	21	24	25	26
14	Girls	15	15	16	16	18	17	20	19	22	22	24	25	27	27
	Boys	15	14	16	15	17	16	19	18	21	20	22	24	26	26
15	Girls	16	15	17	16	18	17	20	20	22	22	24	26	27	28
	Boys	15	15	16	15	17	17	19	18	21	21	23	25	26	27
16	Girls	16	16	17	16	18	18	20	20	22	23	24	27	27	29
	Boys	16	15	17	16	18	17	20	19	22	21	24	25	26	28
17	Girls	17	16	17	17	19	18	21	21	23	24	24	26	27	29
	Boys	16	16	17	17	18	18	20	20	23	23	24	27	27	30
18	Girls	17	17	17	17	19	19	21	21	23	23	24	25	28	28
	Boys	16	16	17	17	19	19	21	21	23	23	25	27	28	30

BMI – body mass index, CASPIAN – Childhood and Adolescence Surveillance and Prevention of Adult Noncommunicable disease

overweight is increasing, i.e. such populations face the double burden of malnutrition [15].

It seems that the double burden of nutritional disorders is present in all age groups of Iranian children and adolescents. In the developing world, the pattern of nutrition is unique and leads to the coexistence of underweight and overweight [35, 36]. Comparing rural and urban areas in this study showed that underweight is significantly higher in rural than in urban children and adolescents (22.1% vs. 15.8%). The higher level of underweight children in rural areas may be secondary to under-nutrition and the higher level of overweight and obese children in urban areas may be indicative of their inadequate physical activity [37, 38] and unhealthy lifestyle [22, 39, 40]. Before a nutritional transition, overweight was concentrated in high socioeconomic status (SES) groups and underweight in low-SES groups, but after the transition, overweight also shifted to the low-SES groups. Thus, low-SES groups face the double burden of nutritional disorders [41]. In recent years, in some industrialized countries such as Italy

[18], Spain [17] and France [19], the prevalence of underweight is increasing. This might be due to more concern about body image among children and adolescents, consuming foods with low nutritional value, more participation in physical activity programs and more education about the risks of obesity for health.

The 5<sup>th</sup> and 50<sup>th</sup> percentile curves for WC in our study are similar to Turkish ones [42], but the 95<sup>th</sup> percentile curve is considerably higher than the Turkish curve. The 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> standard curves of boys in the current study are similar to the findings of the survey on the percentiles of WC among Pakistani primary school children, aged 10–12 years. Among girls, the 5<sup>th</sup> percentile curves of WC of Iranian children are similar to the Pakistani data, but the 50<sup>th</sup> and 95<sup>th</sup> curves of Pakistani girls are higher than Iranian girls [43].

Comparison of the present study with the study conducted in Honk Kong [28] shows that the 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> WC percentile curves of Iranian children are higher than Hong Kong Chinese children. Comparison of WC data from the current study

Table IV. Age- and gender-specific mean of WC and BMI: comparison of CASPIAN-I and CASPIAN-III results

Age [years]	Gender	BMI			WC			
		N (I/III)	CASPIAN		Value of <i>p</i>	CASPIAN		Value of <i>p</i>
			I	III		I	III	
10	Girls (791/57)		16.83 ±3.23	16.86 ±3.84	0.95	60.66 ±8.91	58.05 ±6.23	0.03
	Boys (842/31)		16.87 ±3.52	16.44 ±2.57	0.50	60.58 ±8.95	59.00 ±6.69	0.33
11	Girls (812/197)		17.58 ±3.48	16.68 ±3.00	< 0.001	62.82 ±9.48	60.79 ±9.47	0.007
	Boys (933/161)		17.33 ±3.41	16.88 ±2.92	0.11	63.09 ±9.68	61.10 ±7.93	0.01
12	Girls (1069/372)		18.72 ±3.75	17.79 ±3.75	< 0.001	65.12 ±10.92	62.63 ±9.16	< 0.001
	Boys (1031/401)		18.21 ±3.78	17.55 ±3.47	0.002	65.47 ±10.13	63.91 ±9.57	0.007
13	Girls (899/307)		19.31 ±3.59	18.56 ±3.91	0.002	66.22 ±10.80	64.75 ±8.60	0.31
	Boys (1030/348)		18.35 ±3.43	18.10 ±4.00	0.26	66.75 ±10.36	66.44 ±11.80	0.64
14	Girls (1027/284)		20.17 ±3.57	19.58 ±3.98	0.02	68.12 ±9.80	67.41 ±8.82	0.27
	Boys (1221/300)		19.38 ±3.95	18.49 ±3.61	< 0.001	69.22 ±10.38	67.54 ±9.30	0.01
15	Girls (1042/376)		20.32 ±3.52	20.33 ±4.14	0.95	68.77 ±8.84	69.26 ±9.02	0.36
	Boys (1063/325)		19.71 ±3.48	19.24 ±3.85	0.03	69.67 ±11.15	70.06 ±10.57	0.57
16	Girls (1029/283)		20.65 ±3.68	20.98 ±3.92	0.18	68.79 ±8.29	71.05 ±9.33	< 0.001
	Boys (980/293)		20.41 ±3.31	19.88 ±3.82	0.02	71.38 ±10.64	72.23 ±10.46	0.22
17	Girls (660/323)		21.01 ±3.27	21.36 ±3.70	0.13	69.54 ±7.67	71.40 ±9.81	0.001
	Boys (729/385)		20.93 ±3.56	20.94 ±4.14	0.96	71.94 ±11.78	74.93 ±11.01	< 0.001
18	Girls (290/338)		21.22 ±3.40	21.26 ±3.62	0.88	71.02 ±8.76	70.94 ±7.97	0.90
	Boys (299/316)		21.22 ±3.42	21.52 ±4.03	0.32	72.11 ±11.36	76.97 ±10.75	< 0.001

Data are mean ± SD, BMI – body mass index, WC – waist circumference

with the British study [27] showed that the 5<sup>th</sup> and 50<sup>th</sup> curve of both studies is in close agreement, but the 95<sup>th</sup> percentile curve of Iranian children is higher than the British ones.

Study limitations and strengths: Because of the large sample size studied, we could not determine the pubertal status of participants. Moreover, as a school-based surveillance program, we could not gather detailed information on social determinants of health of participants and similar information related to epidemiological transition at the population level. The strength of the study is studying a large sample size at the national level, considering both urban and rural areas and using the same protocol in different phases of the study.

In conclusion, this study revealed an increase in the dual burden of weight in recent years among Iranian children and adolescents. It may be related to epidemiologic and nutrition transition resulting in rapid changes in lifestyle habits. This finding is an important issue for policy-makers for interventional preventive programs. This study high-

lights the importance of regular monitoring of the growth pattern of children and adolescents, and presenting them to stakeholders and policy-makers for implementation of national health policies.

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