Trends in cardiovascular disease risk factors in children and adolescents: Tehran Lipid and Glucose Study

S. Moradi[1] and F. Azizi[2]

اتجاهات عوامل اختطار الأمراض القلبية الوعائية لدى الأطفال والمراهقين: دراسة طهران للشحوم والغلوكوز

صديقه مرادي، فريدون عزيزي

الخلاصة: أظهرت الدراسات أن عوامل اختطار الأمراض القلبية الوعائية، مثل البدانة ومستويات شحوم الدم، تبدأ منذ الطفولة، وأن بعضها آخذ في الازدياد لدى الأطفال. وتُعَد المعطيات حول الاتجاهات ذات أهمية من أجل التعرف على وجود المشكلة. وفي هذه الدراسة التي هي جزء من دراسة طهران للشحوم والغلوكوز، تمّ تحديد معدلات انتشار زيادة الوزن وما يرتبط بها من عوامل الاختطار، ومقارنتها لدى 2555 طفلاً ومراهقاً في طهران عام 2000، ولدى 1329 منهم عام 2003، ولدى 1158 منهم عام 2006. وقد قسم الباحثون المشاركين في الدراسة إلى ثلاث مجموعات عمرية هي 3-6 سنوات، و7-12 سنة، و13-17 سنة. وقاس الباحثون القياسات الجسمية، وضغط الدم، وسكر الدم على الريق (الصيامي)، والكوليسترول والغليسريدات الثلاثية. واتضح للباحثين أن المعدل الإجمالي لانتشار البدانة بين الأطفال والمراهقين في طهران قد ازداد زيادة يُعْتَد بها إحصائياً من عام 2000 إلى عام 2006، وأن ضغط الدم ومستويات شحوم المصل قد تناقصت. ويرى الباحثون أنه ينبغي تقييم أسباب نقص ضغط الدم ومستويات شحوم المصل، وأن زيادة معدل انتشار البدانة بين الأطفال والمراهقين في طهران أمر يدعو للقلق ويتطلَّب مواصلة الرصد.

ABSTRACT Studies have shown that cardiovascular risk factors, such as obesity, blood lipid levels, start early in childhood and some are on the rise in children. Data on trends are important in order to identify if there is a problem. This study, part of the Tehran Lipid and Glucose Study, determined and compared the prevalence of overweight and its associated risk factors in 2 555, 1 329 and 1 158 Tehran children and adolescents in 2000, 2003 and 2006 respectively. The participants were categorized into age groups 3–6, 7–12 and 13–17 years. Body mass index measurements were taken and blood pressure, fasting blood glucose, cholesterol and triglycerides measured. Overall the prevalence of obesity in Tehran children and adolescents increased significantly from 2000 to 2006 while blood pressure and serum lipid concentrations decreased. The causes for the decreased blood pressure and serum lipid concentrations should be evaluated. The increased prevalence of obesity in Tehran children and adolescents is of concern and requires monitoring.

Tendances des facteurs de risque des maladies cardiovasculaires chez l'enfant et l'adolescent : étude sur le glucose et les lipides réalisée à Téhéran

RÉSUMÉ Des études ont démontré que les facteurs de risque cardiovasculaires tels que l'obésité et une hyperlipidémie s'installaient de manière précoce dans l'enfance et certains étaient en augmentation chez l'enfant. Des données sur les tendances sont importantes afin de repérer l'émergence d'un problème. Le présent essai fait partie de l'étude sur le glucose et les lipides réalisée à Téhéran. Il vise à déterminer et comparer la prévalence du surpoids et des facteurs de risque associés chez 2 555, 1 329 et 1 158 enfants et adolescents de Téhéran en 2000, 2003 et 2006 respectivement. Les participants ont été répartis par tranches d'âge de 3 à 6 ans, de 7 à 12 ans et de 13 à 17 ans. Des évaluations de l'indice de masse corporelle ont été réalisées et la pression artérielle, la glycémie à jeun, le taux de cholestérol et des triglycérides ont été mesurés. Globalement, la prévalence de l'obésité chez l'enfant et l'adolescent à Téhéran a nettement augmenté entre 2000 et 2006 alors que la tension artérielle et les concentrations sériques de lipides ont diminué. Les causes de la diminution de la pression artérielle et des concentrations sériques de lipides doivent être évaluées. La prévalence accrue de l'obésité chez l'enfant et de l'adolescent à Téhéran est préoccupante et appelle une surveillance.

[1]Endocrine Research Center (Firouzgar), Institute of Endocrinology and Metabolism, Tehran University of Medical Sciences Tehran, Islamic Republic of Iran (Correspondence to S. Moradi: s-moradi@tums.ac.ir).
[2]Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic of Iran.

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Introduction

The increasing prevalence of obesity in recent years is a serious concern worldwide, in both developed and developing countries [1]. It is estimated that over 22 million children worldwide under the age of 5 years are overweight [2]. Occurring simultaneously with increasing numbers of overweight and obese children is an increase in the prevalence of metabolic syndrome, which consists of a set of risk factors for cardiovascular disease [3]. In a study involving obese children, the prevalence of metabolic syndrome was 35% in the obese group and 44% in the severely obese group [4].

In developed countries, the increase in cardiovascular risk factors is inversely related to socioeconomic status; however, in developing countries, where changes are occurring in welfare and nutritional status, this is reversed [5,6]. A study, conducted in America using national surveys from 1963 to 2002 in children 8–17 years old, found that high blood pressure and pre-high blood pressure in children and adolescents were on the rise [7]. In addition to general obesity, as described by body mass index (BMI), the increase in abdominal fat, based on waist circumference, is a better index for metabolic disorders and cardiovascular risk factors in all ages [8].

During the period 1993–1999 in the Islamic Republic of Iran, the obesity prevalence in children and adolescents doubled [9]. In a study performed in a group of females 14–17 years old, overweight and obesity rates were 21.9% and 5.3%, respectively [10]. In a study involving children 7–12 years old, more than 12% showed waist circumferences above the 90th percentile [11]. Another study conducted in children between 10–19 years old in Tehran city reported a metabolic syndrome prevalence of 10.1% [12].

The Islamic Republic of Iran experienced a nutrition transition in the past decade and there was a lack of information on changes in cardiovascular risk factors in children and adolescents over this period of time in our capital city (Tehran). Therefore the aim of this study was to compare cardiovascular risk factors in children and adolescents in 2000, 2003 and 2006 in Tehran.

Methods

This study was conducted as a part of the Tehran Lipid and Glucose Study, and the details have been published previously [13]. This consisted of was 3 cross-sectional studies over 3 time periods: 2000, 2003 and 2006 in which 2 555, 1 329, 1 158 children and adolescents (3–17 years old) participated respectively. Briefly, the children and adolescents recruited were residents of district No. 13 of Tehran (one of the 22 districts of the city) and were under the coverage of three medical health centres. A total of 15 005 individuals aged 3 years and over were selected using multistage cluster random sampling method. All members of each family, including those not having risk factors, were invited for baseline measurements to be followed every 3 years. The age distribution and socioeconomic status of the population in district No. 13 is representative of overall population of Tehran.

In each phase of the study, a questionnaire was completed, which included past medical record, family history of noncommunicable diseases, amount of physical activity and cigarette smoking. A short physical examination was performed which included height and weight measurements to calculate body mass index (BMI), waist circumference and blood pressure measurements. Weight was measured without shoes and with just underwear. Height measurements were performed using a standard method [13]. Waist circumference was measured about the naval, and the hip circumference was also recorded at the highest point of the hip with a meter measuring tape. BMI was calculated by dividing the weight (kg) by height squared (m^2). Blood pressure was recorded in a sitting position after 15 minutes of rest in two 5-minute intervals. These measurements were done with a standard mercury sphygmomanometer on the right arm, and the mean of the two-recorded measurements was used for comparison.

A venous blood sample was taken from each subject in a sitting position between 07:00 and 09:00 following 12–14 hours of fasting. Total cholesterol and triglyceride levels were measured by an enzymatic method and chromatography (Kit Pars Test, Islamic Republic of Iran) was measured after lipoprotein precipitations containing apolipoprotein-B. LDL was calculated with the Friedewald formula [14]. Glucose was measured by an enzymatic assay and with chromatography by a glucose oxidase method. Inter- and intra-assay coefficients of variation were 2.2% for glucose, 2% and 0.5% for total cholesterol and 1.6% and 0.6% for triglycerides, respectively.

The methods for clinical and laboratories measurements were the same in the 3 phases of the study.

Definitions

Overweight and obesity were defined according to the international percentile in each sex for 2–18 years [15]. Cholesterol concentrations of ≥ 200 mg/dL were considered high and those of 170–200 mg/dL were considered borderline high. LDL concentrations > 130 mg/dL were considered high and those 110–130 mg/dL considered borderline high. Triglyceride levels > 150 mg/dL and HDL levels < 35 mg/dL were considered abnormal [16].

Statistical analyses

Subjects were divided into three age groups (3–6, 7–12, and 13–17 years old) in each of the 3 study phases. The mean and standard deviation of

each variable were calculated for each temporal period for all participants and in each age group for both sexes. ANOVA was used to compare the variable means in the defined time periods and between different age groups and sexes. If the ANOVA test was significant, a multiple comparison test was used to evaluate the groups. $P < 0.05$ was considered statistically significant.

Results

In 2000, 2003, and 2006, 2 555, 1 329, 1 158 children participated in the study respectively. Their mean ages and the number of subjects in each age group are shown in Table 1.

Changes in cardiovascular risk factors for girls and boys are shown in Tables 2 and 3 respectively. BMI significantly increased from 2000 to 2006 in both genders in the 13–17 years age group. Waist circumference increased significantly in all age groups for boys in 2006, compared with 2000. Blood pressure decreased significantly in all age groups of girls from 2000–2006.

Table 4 shows the data on the abnormality in risk factors in the 3 intervals in the study. The overweight prevalence in boys in the 13–17 years age group was greater compared to the other groups in all 3 periods.

An abnormal waist circumference was defined as being greater than the 70% percentile for that gender and age. The boys in all age groups showed increased waist circumferences in the second and third periods; however, no increases were observed in the girls in any age group.

In 2000, total cholesterol values were high in 41% of the boys. Of these, 27% had cholesterol values between 170 and 200 mg/dL, and 14% had cholesterol values > 200 mg ($P = 0.0001$). In 2003, 27% of the boys had increased cholesterol levels, 20% of whom had values between 170 and 200 mg/dL and 7% had values > 200 mg ($P = 0.01$). In 2006, 23.8% of the boys had increased cholesterol levels, of whom 17.8% had values between 170 and 200 mg/dL and 6.0% had values > 200 mg ($P = 0.01$)

In 2000, 48.7% of the girls had high cholesterol levels, of whom 17.8% had levels between 170 and 200 mg/dL and 29.9% had levels > 200 mg. In 2003, 32.7% of the girls had high cholesterol levels, of whom 23.6% had levels between 170 and 200 mg/dL and 9.1% had levels > 200 mg ($P = 0.0001$). In 2006, 32.4% of the girls had increased cholesterol levels, 23.6% of whom had levels between 170 and 200 mg/dL and 8.8% had levels > 200 mg/dL ($P = 0.01$).

The high triglyceride levels in both boys and girls decreased significantly during the 3 periods. In 2000, LDL levels were high in 37.2% of the boys in all age groups, of whom 23.4% had levels between 110 mg/dL and 129 mg/dL and 13.8% had levels > 130 mg/dL. In 2003, LDL levels in 21% of the boys were between 110 mg/dL and 129 mg/dL and in 13.8% they were higher than 130 mg/dL ($P = 0.04$). In 2006, LDL levels were high in 26.3% of boys, of whom 15.4% had levels between 110 mg/dL and 129 mg/dL and 10.9% had levels > 130 ($P = 0.006$). In 2000, LDL in 24% of the total number of girls was between 110 mg/dL and 129 mg/dL and in 17.4% it was > 130 mg/dL. In 2003, LDL in 21.6% of the girls was between 110 mg/dL and 129 mg/dL and in 14.7% was > 130 mg/dL ($P = 0.01$); In 2006 these figures were 13.2% and 9.0% respectively ($P = 0.001$).

Table 1 Age distribution of children in the 3 periods of study

Age group (years)	No.	Mean age (SD) (years)
	2000	
3–6	430	4.8 (1.0)
7–12	1030	9.8 (1.7)
13–17	1095	15 (1.4)
	2003	
3–6	204	5 (0.9)
7–12	485	9.7 (1.7)
13–17	640	15 (1.4)
	2006	
3–6	172	5 (1.0)
7–12	456	9.5 (1.7)
13–17	530	15 (1.4)

SD = standard deviation.

Discussion

This study showed that indices of general and abdominal obesity increased but blood pressure and lipidaemia decreased in children and adolescents in Tehran, Islamic Republic of Iran, which is undergoing a nutrition transition. This study is the first epidemiological survey the country to compare the cardiovascular risk factors among children in 6-year intervals. The findings are important because Iran has undergone some rapid changes in recent years in the following categories: nutritional status and physical activities in children and adolescents, reproduction and mortality rates, and urbanization status. Overweight and obesity can help predict cardiovascular disease development in the future. Additionally, high waist circumference (as an index of abdominal obesity) and decreased HDL increase the risk of noncommunicable diseases in adulthood, which can be triggered at a lower age.

Table 2 Cardiovascular risk factors in Tehran girls aged 3–17 years in 2000, 2003 and 2006, by age group

Variable	2000		2003		P^a	2006		P^b	P^c
	No.	Mean (SD)	No.	Mean (SD)		No.	Mean (SD)		
Age group 3–6 years									
SBP (mm/Hg)	205	97.3 (0.8)	95	87.6 (1.1)	0.0001	68	88.3 (1.4)	0.9	0.0001
DBP (mm/Hg)	204	66.8 (0.7)	95	56.8 (1.1)	0.0001	68	58.7 (1.1)	0.9	0.0001
BMI (kg/m^2)	213	15 (0.1)	93	15.3 (1.7)	0.5	66	15.6 (0.2)	0.9	0.1
WC (cm)	132	51.4 (0.4)	61	0.87 (0.6)	0.9	46	51.4 (0.6)	0.9	0.9
WC/HC ratio	132	0.86 (0.004)	61	0.87 (0.006)	0.4	46	0.86 (0.007)	0.4	0.9
FBS (mg/dL)	175	82 (0.6)	83	83 (0.8)	0.9	66	80.5 (0.9)	0.2	0.8
Total chol (mg/dL)	175	173 (2)	83	165 (3.3)	0.1	66	167 (3.6)	0.9	0.5
Triglycerides (mg/dL)	175	89 (2.7)	83	83.5 (3.7)	0.6	66	78.8 (3.4)	0.9	0.1
HDL-chol (mg/dL)	169	44.4 (0.7)	81	41.4 (1)	0.09	63	46.4 (1.4)	0.01	0.5
LDL-chol (mg/dL)	169	111 (1.9)	83	108 (3)	0.9	60	105 (3.5)	0.9	0.4
Age group 7–12 years									
SBP (mm/Hg)	507	101 (0.4)	249	95 (0.5)	0.0001	223	92.7 (0.7)	0.03	0.0001
DBP (mm/Hg)	507	7 (0.4)	249	64.4 (0.5)	0.0001	223	60.8 (0.6)	0.0001	0.0001
BMI (kg/m^2)	509	17 (0.001)	243	17.5 (0.2)	0.2	224	18 (0.2)	0.2	0.001
WC (cm)	509	60.4 (0.4)	242	61 (0.6)	0.9	224	61.2 (0.6)	0.9	0.9
WC/HC ratio	509	0.82 (0.002)	242	0.82 (0.003)	0.9	224	0.80 (0.003)	0.001	0.001
FBS (mg/dL)	500	87 (0.3)	244	88.4 (0.4)	0.06	231	86.8 (0.4)	0.1	0.9
Total chol (mg/dL)	500	176 (1.5)	244	166 (1.9)	0.001	231	163 (2)	0.5	0.0001
Triglycerides (mg/dL)	500	105 (2.2)	244	106 (3.4)	0.9	231	98.2 (3)	0.2	0.1
HD-chol (mg/dL)	499	45 (0.5)	243	42 (0.6)	0.001	230	45.5 (0.7)	0.001	0.9
LDL-chol (mg/dL)	499	109 (1.4)	243	103 (1.7)	0.02	218	96.2 (1.7)	0.02	0.02
Age group 13-17 years									
SBP (mm/Hg)	570	105 (0.4)	329	101 (0.6)	0.001	250	100 (0.6)	0.8	0.0001
DBP (mm/Hg)	570	72 (0.3)	329	69 (0.5)	0.001	250	66.3 (0.5)	0.001	0.0001
BMI (kg/m^2)	569	21 (0.1)	317	21.6 (0.2)	0.006	245	22.1 (0.2)	0.4	0.006
WC (cm)	569	71 (0.3)	317	72.5 (0.5)	0.9	245	70.8 (0.5)	0.07	0.9
WC/HC ratio	569	0.76 (0.002)	317	0.78 (0.003)	0.001	245	0.75 (0.003)	0.0001	0.1
FBS (mg/dL)	573	87.7 (0.3)	324	87.9 (0.4)	0.004	254	85.7 (0.4)	0.003	0.004
Total chol (mg/dL)	573	170 (1.2)	324	153 (1.4)	0.001	254	154 (1.7)	0.9	0.3
Triglycerides (mg/dL)	573	113 (2.5)	324	102 (2.6)	0.03	254	103 (3.4)	0.9	0.3
HDL-chol (mg/dL)	573	42.9 (0.4)	324	39.4 (0.4)	1	253	43 (0.6)	0.0001	0.9
LDL-chol (mg/dL)	571	154 (1)	324	93.7 (1.3)	0.001	243	90.4 (1.5)	0.3	0.0001

[a]Comparison between 2000 and 2003; [b]Comparison between 2003 and 2006; [c]Comparison between 2000 and 2006.
SPB = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index; WC = waist circumference; HC = hip circumference; FBS = fasting blood sugar; Chol = cholesterol; HDL-chol = high-density lipoprotein cholesterol; LDL-chol = low-density lipoprotein cholesterol.

Although unexpected, favourable changes in blood pressure and serum lipid concentrations were observed in this study, despite increases in general and abdominal obesity. These results are probably due to the national programme that is designed to decrease salt and lipid consumption. This programme consists of consumption of more unsaturated fat and replacement of lipid oil for solid oil and educating the public on proper nutrition, exercise and diet through the media. None of these subjects were receiving anti-hypertensive or anti-lipid drug treatments.

The high prevalence of low HDL is probably due to specific genetic backgrounds as it has been previously reported in Iranian adults [12]. High prevalence of low HDL has also been reported in other Middle Eastern countries, such as Turkey and Oman [17,18]. Along with genetic background, what is eaten in childhood, such as diets with high levels of solid hydrogenated oils that contain transacids and/or saturated fats, can also cause HDL cholesterol and triglyceride increases [19].

An NHANES study found that the overweight prevalence increased from

Table 3 Cardiovascular risk factors in Tehran boys aged 3–17 years in 2000, 2003 and 2006, by age group (Tehran Lipid and Glucose Study)

Variable	2000		2003		P^a	2006		P^b	P^c
	No.	Mean (SD)	No.			No.	Mean (SD)		
Age group 3–6 years									
SBP (mm/Hg)	380	98.7 (0.5)	196	88.6 (0.7)	0.001	162	89.1 (0.8)	0.9	0.0001
DBP (mm/Hg)	378	67.8 (0.4)	196	59 (0.7)	0.001	162	58.5 (0.6)	0.9	0.0001
BMI (kg/m^2)	414	15 (0.09)	195	15.3 (0.1)	0.01	159	16.3 (0.8)	0.1	0.06
WC (cm)	246	51 (0.3)	117	52 (0.4)	0.03	112	52.4 (0.4)	0.9	0.001
WC/HC ratio	114	0.87 (0.004)	56	0.89 (0.006)	0.01	66	0.91 (0.005)	0.1	0.0001
FBS (mg/dL)	330	61.8 (0.5)	175	83 (0.6)	0.8	153	82.4 (0.6)	0.9	0.2
Total chol (mg/dL)	330	171 (1.5)	175	161 (2.3)	0.001	153	160 (2.4)	0.9	0.004
Triglycerides (mg/dL)	330	86.5 (1.9)	175	80 (2.3)	0.005	153	76 (2)	0.8	0.07
HDL-chol (mg/dL)	317	45 (0.5)	175	41 (0.7)	0.9	148	46 (0.8)	0.001	0.9
LDL-chol (mg/dL)	317	107 (1.4)	175	103 (2)	0.004	142	99 (2.2)	0.3	0.02
Age group 7–12 years									
SBP (mm/Hg)	996	102 (0.3)	474	96 (0.5)	0.001	437	93 (0.5)	0.001	0.0001
DBP (mm/Hg)	996	70 (0.3)	474	64.3 (0.4)	0.001	437	61 (0.4)	0.001	0.0001
BMI (kg/m^2)	1005	16.8 (0.1)	460	17.4 (0.1)	0.001	439	17.8 (0.1)	0.5	0.2
WC (cm)	1005	59 (0.2)	459	61.8 (0.4)	0.001	439	62.4 (0.5)	0.9	0.0001
WC/HC ratio	496	0.84 (0.002)	217	0.89 (0.02)	0.001	215	0.88 (0.006)	0.9	0.003
FBS (mg/dL)	980	87.5 (0.2)	466	89 (0.3)	0.9	440	87 (0.3)	0.001	0.9
Total chol (mg/dL)	980	174 (1)	466	164 (1.3)	0.001	440	161 (1.3)	0.4	0.0001
Triglycerides (mg/dL)	978	100 (1.5)	466	100 (2.4)	0.004	440	91 (1.9)	0.01	0.01
HDL-chol (mg/dL)	972	46.5 (0.3)	465	42.5 (0.4)	0.9	439	46.8 (0.5)	0.001	0.0001
LDL-chol (mg/dL)	969	107 (0.9)	463	101 (1)	0.004	420	95 (1)	0.004	0.0001
Age group 13-17 years									
SBP (mm/Hg)	1069	106 (0.3)	631	103 (0.4)	0.001	509	102.7 (0.5)	0.9	0.02
DBP (mm/Hg)	1069	71.9 (0.2)	631	68.4 (0.3)	0.001	509	66.7 (0.3)	0.005	0.0001
BMI (kg/m^2)	1073	21 (0.1)	616	21.4 (0.1)	0.001	513	22 (0.2)	0.02	0.0001
WC (cm)	1073	71 (0.3)	616	74.4 (0.4)	0.001	513	75 (0.5)	0.7	0.0001
WC/HC ratio	504	0.82 (0.003)	299	0.85 (0.003)	0.001	268	0.86 (0.004)	0.04	0.0001
FBS (mg/dL)	1061	90 (0.3)	618	89.6 (0.5)	0.005	519	87 (0.3)	0.001	0.1
Total chol (mg/dL)	1061	167 (1)	618	152 (1)	0.001	519	151 (1.2)	0.9	0.0001
Triglycerides (mg/dL)	1061	114 (2)	618	105 (2))	0.005	519	103 (2.4)	0.9	0.1
HDL-chol (mg/dL)	1056	42.5 (0.3)	618	38.6 (0.3	0.6	517	41.8 (0.4)	0.001	0.2
LDL-chol (mg/dL)	1048	101 (0.8)	616	93 (1)	0.001	490	88 (1)	0.01	0.0001

[a]Comparison between 2000 and 2003; [b]Comparison between 2003 and 2006; [c]Comparison between 2000 and 2006.
SD = standard deviation.
SPB = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index; WC = waist circumference; HC = hip circumference; FBS = fasting blood sugar; Chol = cholesterol; HDL-chol = high-density lipoprotein cholesterol; LDL-chol = low-density lipoprotein cholesterol.

4% to 6% in 1976–1980 and to 16% in 1999–2002 [20,21]. In this study, high blood pressure, low HDL cholesterol and triglycerides were raised in children who were overweight but there was no relationship between overweight, total cholesterol and LDL cholesterol [22].

In a study conducted in Korea in 3-year intervals for children 10–18 years old, overweight prevalence increased from 5.4% to 11.6%. Triglyceride levels were significantly increased in the second period, and the LDL, HDL, and blood pressure measurements improved [23]. In our study, waist circumference and body weight significantly increased during the three defined periods. These findings are similar to a study performed in the United States in children ages 2–17 years and from the third period of NHANES to 2000. The BMI and waist circumference increased, but triglyceride and

Table 4 Frequency of abnormal of risk factors for cardiovascular disease among Tehran children and adolescents aged 3–17 years in 2000, 2003 and 2006, according to sex (Tehran Lipid and Glucose Study)

Variable	2000	2003	*P* [a]	2006	*P* [b]	*P* [c]
	No. (%)	No. (%)		No. (%)		
Fasting blood sugar > 100 mg%						
Boys	77 (6.1)	46 (4.1)	0.01	46 (7.6)	0.001	0.1
Girls	82 (3.7)	36 (3.30)	0.1	31 (4.8)	0.1	0.1
Total cholesterol > 170 mg%						
Boys	462 (41.1)	166 (27.3)	0.001	134 (23.8)	0.01	0.0001
Girls	608 (48.7)	213 (32.7)	0.0001	179 (32.4)	0.04	0.01
LDL-chol > 110 mg%						
Boys	204 (37.2)	560 (34.8)	0.04	482 (26.3)	0.006	0.001
Girls	167 (41.6)	427 (36.3)	0.01	325 (22.2)	0.0001	0.0001
Triglyceride >150 mg%						
Boys	148 (13.2)	63 (10.3)	0.001	43 (7.6)	0.0001	0.0001
Girls	190 (15.2)	80 (12.2)	0.07	62 (11.2)	0.006	0.0001
HDL-chol < 35 mg%						
Boys	844 (76.5)	370 (60.9)	0.001	446 (80)	0.0001	0.0001
Girls	931 (75)	402 (62)	0.08	540 (80.4)	0.1	0.3
Overweight						
Boys	148 (29.8)	102 (39.1)	0.001	97 (43.5)	0.1	0.001
Girls	188 (37.7)	101 (41.3)	0.7	104 (49.7)	0.05	0.001
Obese						
Boys	73 (15.5)	38 (13.2)	0.6	54 (23.3)	0.001	0.001
Girls	42 (8.8)	34 (15.2)	0.001	31 (15)	0.1	0.001
WC increase > 70% percentile						
Boys	149 (78)	135 (89)	0.001	171 (86)	0.2	0.01
Girls	200 (49)	127 (64)	0.001	91 (51)	0.01	0.1

[a]Comparison between 2000 and 2003; [b]Comparison between 2003 and 2006; [c]Comparison between 2000 and 2006.
SD = standard deviation.
LDL-chol = low-density lipoprotein cholesterol; HDL-chol = high-density lipoprotein cholesterol; WC = waist circumference.

glucose levels, which are associated with obesity, decreased during this time. Total cholesterol, LDL cholesterol, HDL cholesterol, and haemoglobin A1C showed no differences between the two periods [24].

It is now known that BMI does not show the body lipid percentage and is not a good prognostic factor for determining cardiovascular disease in children; therefore, waist circumference is used for estimating abdominal fat [25]. In our study, waist circumference was an important factor for developing metabolic syndrome; however, the waist-to-hip ratio was not. Our study is in accordance with previous studies that showed high waist circumference as an important characteristic in metabolic syndrome in children and adolescents [10].

There are some limitations in our study. As a cross-sectional study, the causative factors could not be evaluated and the length of the follow-up was short. Additionally, one cannot predict the future changes that may occur in this population as adults. It should also be noted that the most recent data pertain to about 6 years ago and changes in life style have continued since then which may affect the risk factors evaluated. There is a need therefore to follow up on the children and adolescents who were included in TLGS in the future.

To conclude, this study showed increasing prevalences of general and abdominal obesity in Tehran children and adolescents. These increases may cause serious public health problems in this country. The causes of blood pressure and serum lipid concentration decreases should be further evaluated.

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References

1. Lobstein T, Frelut M-L. Prevalence of overweight among children in Europe. *Obesity Reviews*, 2003, 4:195–200.
2. Lobstein T, Baur L, Uauy R; IASO International Obesity Task Force. Obesity in children and young people: a crisis in public health. *Obesity Reviews*, 2004, 5(Suppl. 1):4–104.
3. Freedman DS et al. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*, 1999, 103:1175–1182.
4. Serdula MK et al. Do obese children become obese adults? A review of the literature. *Preventive Medicine*, 1993, 22:167–177.
5. Manios Y et al. Cardiovascular disease risk factors among children of different socioeconomic status in Istanbul, Turkey: directions for public health and nutrition policy. *Lipids in Health and Disease*, 2004, 3:11–18.
6. Okosun IS et al. Trends in abdominal obesity in young people: United States 1988–2002. *Ethnicity & Disease*, 2006, 16:338–344.
7. Din-Dzietham R et al. High blood pressure in children and adolescents in national surveys, 1963 to 2002. *Circulation*, 2007, 116:1437–1439.
8. McCarthy HD. Body fat measurements in children as predictors for the metabolic syndrome: focus on waist circumference. *Proceedings of the Nutrition Society*, 2006, 65:385–392.
9. Kelishadi R et al. Obesity and associated modifiable environmental factors in Iranian adolescents: Isfahan Healthy Heart Program – Heart Health Promotion from Childhood. *Pediatrics International*, 2003, 45:435–442.
10. Maddah M. Overweight and obesity among Iranian female adolescents in Rasht: more overweight in the lower social group. *Public Health Nutrition*, 2006, 10:450–453.
11. Hamidi A et al. Obesity and associated cardiovascular risk factors in Iranian children: a cross-sectional study. *Pediatrics International*, 2006, 48:566–571.
12. Esmaillzadeh A et al. High prevalence of the metabolic syndrome in Iranian adolescents. *Obesity (Silver Spring, Md.)*, 2006, 14:377–382.
13. Azizi F et al. Tehran Lipid and Glucose Study: rationale and design. *CVD prevention*, 2000, 3:242–247.
14. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry*, 1972, 18:499–502.
15. Cole TJ et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ (Clinical Research Ed.)*, 2000, 320:1240–1243.
16. Franklin FA Jr, Dashti N, Franklin CC. Evaluation and management of dyslipoproteinemia in children. *Endocrinology and Metabolism Clinics of North America*, 1998, 27:641–654.
17. Kozan O et al. Prevalence of the metabolic syndrome among Turkish adults. *European Journal of Clinical Nutrition*, 2007, 61:548–553.
18. Al-Shafaee MA et al. Prevalence of metabolic syndrome among prediabetic Omani adults: a preliminary study. *Metabolic Syndrome and Related Disorders*, 2008, 6:275–279.
19. Kelishadi R et al. Dietary fat intake and lipid profiles of Iranian adolescents: Isfahan Healthy Heart Program? Heart Health Promotion from Childhood. *Preventive Medicine*, 2004, 39:760–766.
20. Ogden CL et al. Prevalence and trends in overweight among US children and adolescents, 1999–2000. *Journal of the American Medical Association*, 2002, 288:1728–1732.
21. Hedley AA et al. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *Journal of the American Medical Association*, 2004, 291:2847–2850.
22. Thompson DR et al. Childhood overweight and cardiovascular disease risk factors: the National Heart, Lung, and Blood Institute Growth and Health Study. *Journal of Pediatrics*, 2007, 150:18–25.
23. Kim HM et al. Obesity and cardiovascular risk factors in Korean children and adolescents aged 10–18 years from the Korean National Health and Nutrition Examination Survey, 1998 and 2001. *American Journal of Epidemiology*, 2006, 164:787–793
24. Ford ES, Mokdad AH, Ajani UA. Trends in risk factors for cardiovascular disease among children and adolescents in the United States. *Pediatrics*, 2004, 114:1534–1544.
25. Maffeis C et al. Waist circumference and cardiovascular risk factors in prepubertal children. *Obesity Research*, 2001, 9:179–187.