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Obesity and cardiometabolic risk factors in a representative population of Iranian adolescents and adults in comparison to a Western population: the Isfahan Healthy Heart Programme

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Abstract

Objective: The aim of the present study was to develop reference data for the Iranian population for anthropometric values and cardiometabolic data in comparison with those in Americans, as representative of a Western population.

Design: The present cross-sectional survey, conducted as part of the baseline survey of a community-based interventional study (the Isfahan Healthy Heart Programme), used a two-stage clustering design and was conducted in 12 600 randomly selected adults (≥19 years of age) and 2000 adolescents (aged 11–18 years) living in three cities in the central part of Iran. For comparison with a Western population, comparable data for Americans were derived from the data sets of the Second and Third National Health and Nutrition Examination Surveys (NHANES II and NHANES III).

Results: Iranian women had significantly higher mean BMI, waist circumference (WC), hip circumference (HC) and waist:hip ratio (WHR) than Iranian men and American women; but the mean BMI of Iranian men was lower than that of American men. The mean serum TAG level of Iranian men was significantly higher than that of Iranian women, whereas the mean serum total cholesterol (TC), LDL cholesterol (LDL-C) and HDL cholesterol (HDL-C) levels were significantly higher in Iranian women than in men. The Iranian population had lower mean TC, LDL-C and TAG levels than the Americans, but such difference was not documented for HDL-C. Iranian adolescents had significantly lower mean BMI and higher mean TAG than did American adolescents.

Conclusions: Our findings provide serious evidence for health professionals and policy makers about the very high prevalence of generalized and abdominal obesity in Iran. Controlling this emerging health problem, notably in women, should become a national priority in Iran and necessitates comprehensive public health programmes.

Keywords
Anthropometric indices
Lipid profile
Ethnicity
Gender differences

Chronic non-communicable diseases (NCD) have become the leading causes of mortality worldwide[1]. CVD accounts for an estimated 16·6 million or one-third of total global deaths, 80 % of which occur in middle- and low-income countries[2]. In contrast to the trends in Northern Europe and America[3], 1999 data showed that mortality from CVD is increasing in Iran[4].

The *World Health Report 2002* has identified obesity as one of the ten leading risk factors affecting global health. Conventionally, BMI has been used to explore the association between obesity and disease[5,6]. However, this index cannot distinguish fat from muscle mass, nor can it represent the fat distribution. This overall obesity index may not be the most appropriate in predicting chronic NCD risk. Given that abdominal or upper-body fat carries an increased risk for metabolic complications, waist circumference (WC) and waist:hip ratio (WHR) are considered as useful anthropometric measures for abdominal obesity in different ethnicities[7,8].

Interest in childhood precursors to chronic NCD is increasing because it is well documented that both behavioural and biological risk factors of such diseases

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persist from childhood into adulthood, and that several risk factors track from childhood to adult life[9]. Consequently, in addition to the adult population, adolescents should be studied as well.

It is well documented that the relationship between percentage body fat and BMI differs in various ethnic groups[10]. Moreover, it appears that the metabolic consequences of obesity such as dyslipidaemia and dysglycaemia are manifested at lower absolute amounts of total body fat in South Asians than in whites[11]. Obesity is common in Iran[12] but little is known about fat distribution and lipid levels, particularly in comparison with a Western population. Therefore the first purpose of the present study was to develop reference data for the Iranian population for key anthropometric values, as well as baseline associated cardiometabolic data. The second purpose was to compare these results with those in Americans, as representatives of a Western population.

Methods

Participants

The present cross-sectional study was conducted in the year 2000 as the baseline survey of a longitudinal, community-based, quasi-experimental interventional programme called the Isfahan Healthy Heart Programme (IHHP). Details of the IHHP have been published previously[13,14]. In brief, a representative sample of 12 600 adults aged ≥19 years was randomly selected using a two-stage cluster sampling design from urban and rural areas in three districts, Isfahan, Najaf-Abad and Arak, all in the central part of Iran (and used as a representative sample of the Iranian population). Isfahan (population of 1 895 856) was divided into ninety-three clusters, Najaf-Abad (population of 275 084) into forty-seven clusters and Arak (population of 668 531) into sixty clusters. Each cluster had approximately 1000 households. Initially, census blocks based on data of the Ministry of Health were randomly selected from each district with the probability of selection proportional to the expected number of households. Within households, single age-eligible subjects were selected at random. The adolescents studied consisted of 2000 students (1000 girls, 1000 boys), aged 11–18 years, who were selected by multistage random cluster sampling from fifty-six middle and high schools of different urban and rural areas in the three aforementioned districts.

Data collection

Informed consent was obtained when an adult participant arrived at the clinic and from parents of students after a full explanation of the procedures involved. Participants were asked to fast for 12 h prior to the examinations and to bring all medical records, prescription and non-prescription drugs used regularly to the clinic. In adults, blood pressure (BP) was measured in duplicate in a seated position with a random-zero sphygmomanometer and using an appropriately sized cuff after a 5 min rest. The average of two measures of the first and fifth Krotkoff phase was recorded as systolic and diastolic BP (SBP and DBP), respectively.

Height was measured to the nearest 0·5 cm using a secured metal ruler while weight was measured in light clothing using a calibrated scale to the nearest 200 g. BMI was computed as weight divided by the square of height (kg/m^2). WC was taken as the smallest circumference at or below the costal margin and hip circumference (HC) at the level of the greater trochanter. Venepuncture of the left antecubital vein was performed and blood collected into citrate or fluoride monovettes. The blood samples were transferred to the laboratory at Isfahan Cardiovascular Research Center (ICRC). Serum total cholesterol (TC) and TAG were measured using enzymatic colorimetric methods. HDL cholesterol (HDL-C) was determined after dextran sulfate–magnesium chloride precipitation of non-HDL-C. LDL cholesterol (LDL-C) was derived from the Friedewald equation in those individuals with TAG < 400 mg/dl[15]. All parameters other than WC, HC and fasting blood glucose (FBG) were measured with the same methods in adolescents.

For quality control, the ICRC central laboratory meets the evaluation criteria of the National Reference Laboratory of the Ministry of Health in Teheran (a WHO Collaborating Centre). An external standardization programme with the central laboratory of the University Hospital of Leuven in Belgium was also in place.

Data analysis

Statistical analyses were performed using the SPSS for Windows statistical software package version 11·5 (SPSS Inc., Chicago, IL, USA). The significance level was set at $P < 0{\cdot}05$. The data were analysed separately in adolescents and adults. Mean values were compared between genders by the *t* test. The physical and metabolic risk factors of the American population (as a representative of a Western population with available valid data) were derived from the results of the Second and Third National Health and Nutrition Examination Surveys (NHANES II, 1976–80 and NHANES III, 1988–94)[16,17]. In order to make comparisons possible, the age groups of our study participants were reclassified according to the American data.

Results

The first set of comparisons was done between Iranian men and women (48·7 % and 51·3 % of the population, respectively). The mean age was not different in terms of gender (39·7 (SD 14) years in men *v.* 39·3 (SD 15) years in women). The anthropometric measures for the Iranian men and women are shown in Tables 1 and 2. Iranian women had

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Table 1 Obesity indices in women aged 20 years and over in Iran

				Percentile				
	n	Mean	SD	10th	25th	50th	75th	90th
Height (cm)								
20 years and over	5490	156·7	7·2	148·5	152·0	157·0	161·0	165·0
20–29 years	1595	159·0	6·5	151·0	155·0	159·0	163·0	167·0
30–39 years	1647	157·3	6·8	150·0	153·5	158·0	161·0	165·0
40–49 years	1025	156·1	6·8	148·0	152·0	156·0	160·0	164·0
50–59 years	556	154·4	7·2	145·8	150·0	154·0	159·0	163·0
60–69 years	482	153·2	7·8	145·0	150·0	153·0	158·0	162·0
70–79 years	166	150·2	6·9	142·0	147·0	150·5	155·0	158·0
80 years and over	19	149·8	8·1	139·5	144·0	150·0	154·0	164·0
Weight (kg)								
20 years and over	5490	65·3	12·5	50·0	56·0	64·5	73·0	81·5
20–29 years	1595	61·5	11·8	48·0	53·0	60·0	69·0	78·0
30–39 years	1647	66·8	12·3	51·9	58·0	66·0	75·0	82·0
40–49 years	1025	68·7	12·4	53·9	60·0	68·0	76·0	84·0
50–59 years	556	67·6	12·2	52·0	59·0	67·0	75·0	84·0
60–69 years	482	65·0	12·0	50·0	56·0	64·0	72·2	81·0
70–79 years	166	59·7	10·7	47·5	53·0	59·0	65·0	72·3
80 years and over	19	52·7	8·3	42·0	45·0	55·0	60·0	63·0
BMI (kg/m^2)								
20 years and over	5490	26·67	5·38	20·31	22·88	26·27	29·72	33·24
20–29 years	1595	24·40	4·95	18·98	20·95	23·73	27·26	30·46
30–39 years	1647	27·03	5·16	21·23	23·53	26·56	30·02	33·32
40–49 years	1025	28·28	5·45	22·03	24·76	28·01	31·21	34·20
50–59 years	556	28·36	5·01	22·25	24·81	28·17	31·48	34·56
60–69 years	482	27·78	5·52	21·77	24·29	27·39	30·49	33·77
70–79 years	166	26·44	4·42	21·09	23·59	26·22	28·26	31·67
80 years and over	19	23·52	3·64	17·70	20·82	23·61	26·28	28·53
WC (cm)								
20 years and over	5490	92·8	13·9	75·0	70·0	93·0	102·0	110·0
20–29 years	1595	86·5	13·0	71·0	77·0	86·0	95·0	104·0
30–39 years	1647	92·9	13·5	75·0	84·0	93·0	101·0	110·0
40–49 years	1025	96·3	13·0	80·0	89·0	97·0	105·0	112·0
50–59 years	556	98·4	12·8	81·7	90·0	99·0	107·0	114·3
60–69 years	482	98·6	13.2	82·0	91·0	99·0	107·0	115·0
70–79 years	166	96·0	13·0	81·4	88·0	95·0	103·0	112·3
80 years and over	19	92·5	9·7	77·0	85·0	95·0	99·0	104·0
HC (cm)								
20 years and over	5490	102·6	11·2	90·0	96·0	102·0	110·0	116·0
20–29 years	1595	99·5	11·0	88·0	93·0	99·0	107·0	112·0
30–39 years	1647	103·8	10·7	91·0	97·0	104·0	110·0	116·0
40–49 years	1025	104·5	11·3	92·0	98·0	104·0	111·0	117·0
50–59 years	556	104·5	10·6	92·0	98·0	105·0	111·0	119·0
60–69 years	482	102·8	10·8	90·0	95·0	103·0	110·0	116·0
70–79 years	166	100·2	12·0	88·0	93·3	99·0	107·0	114·0
80 years and over	19	97·5	8·2	86·0	90·0	98·0	103·0	107·5
WHR								
20 years and over	5490	0·905	0·097	0·786	0·850	0·909	0·963	1·010
20–29 years	1595	0·869	0·093	0·761	0·809	0·871	0·925	0·971
30–39 years	1647	0·895	0·096	0·783	0·846	0·901	0·950	0·990
40–49 years	1025	0·923	0·088	0·816	0·872	0·926	0·979	1·018
50–59 years	556	0·942	0·092	0·825	0·896	0·951	0·990	1·039
60–69 years	482	0·959	0·091	0·856	0·905	0·960	1·010	1·063
70–79 years	166	0·959	0·083	0·874	0·904	0·957	1·009	1·064
80 years and over	19	0·950	0·080	0·854	0·898	0·941	1·020	1·073

WC, waist circumference; HC, hip circumference; WHR, waist:hip ratio.

significantly higher mean and median levels of BMI, WC, HC and WHR compared with Iranian men. It is noteworthy that all obesity indices were greater up to 60 years of age and thereafter the differences were less prominent.

Tables 3 and 4 present the cardiometabolic risk factors in the Iranian population. FBG did not differ significantly between Iranian women and men (83·3 (SD 32·1) *v.* 82·9 (SD 29·3) mg/dl, respectively). Men had significantly higher mean TAG than did women (162·4 (SD 77·4) *v.* 152·8 (SD 75·1) mg/dl, respectively, $P < 0·05$). Moreover, the median and the 75th percentile of TAG were higher in men than in women. TAG increased constantly up to 60 years of age and then decreased; after the age of 50 years, it was higher in women than in men.

Mean TC was significantly higher in women than in men (203·19 (SD 47·6) *v.* 195·5 (SD 49·7) mg/dl, respectively,

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Table 2 Obesity indices in men aged 20 years and over in Iran

				Percentile				
	n	Mean	SD	10th	25th	50th	75th	90th
Height (cm)								
20 years and over	5085	170·8	8·2	161·0	166·0	171·0	176·0	180·0
20–29 years	1602	174·1	7·5	165·0	170·0	174·0	179·0	183·0
30–39 years	1354	171·5	7·5	163·0	167·0	171·1	176·0	180·0
40–49 years	867	169·8	7·7	162·0	166·0	170·0	175·0	179·0
50–59 years	561	168·4	7·6	160·0	164·0	168·0	173·0	178·0
60–69 years	449	165·7	7·8	156·0	161·0	166·0	170·0	175·0
70–79 years	233	164·2	8·0	153·7	159·0	165·0	169·0	174·0
80 years and over	19	160·1	5·5	154·0	155·0	160·0	164·0	170·0
Weight (kg)								
20 years and over	5085	71·4	12·3	56·0	62·0	70·0	79·0	88·0
20–29 years	1602	69·6	12·2	56·0	61·0	68·0	76·0	86·0
30–39 years	1354	72·7	12·2	58·0	64·0	72·0	80·0	89·5
40–49 years	867	73·6	12·3	58·0	65·0	73·0	81·0	90·0
50–59 years	561	74·1	12·2	58·0	65·0	74·0	82·0	90·0
60–69 years	449	68·8	11·4	55·0	60·7	69·0	76·0	85·0
70–79 years	233	66·1	11·2	52·0	57·0	65·0	74·0	82·0
80 years and over	19	60·2	12·7	41·0	51·7	62·0	69·0	76·0
BMI (kg/m^2)								
20 years and over	5085	24·52	4·56	19·57	21·45	24·13	27·08	29·72
20–29 years	1602	22·99	4·34	18·61	20·19	22·26	24·93	28·06
30–39 years	1354	24·75	4·10	19·94	21·79	24·48	27·31	29·71
40–49 years	867	25·63	5·28	20·50	22·77	25·09	27·74	30·42
50–59 years	561	26·14	4·06	20·99	23·42	25·95	28·73	31·15
60–69 years	449	25·13	4·62	20·17	22·47	24·77	27·46	30·46
70–79 years	233	24·48	3·52	20·10	22·08	24·34	26·70	29·01
80 years and over	19	23·44	4·96	16·01	21·79	23·79	25·03	31·22
WC (cm)								
20 years and over	5085	88·4	11·8	73·0	80·0	88·0	97·0	104·0
20–29 years	1602	82·8	10·5	71·0	75·0	82·0	90·0	96·0
30–39 years	1354	88·1	10·5	74·0	80·0	88·0	96·0	102·0
40–49 years	867	91·6	11·2	77·0	83·0	92·0	100·0	106·1
50–59 years	561	94·5	11·9	79·0	86·5	96·0	103·0	108·0
60–69 years	449	93·2	11·3	78·0	86·0	94·0	100·0	108·0
70–79 years	233	92·6	12·1	75·0	85·0	93·0	100·0	107·0
80 years and over	19	89·4	13·1	75·0	80·0	91·0	95·0	114·0
HC (cm)								
20 years and over	5085	98·4	9·4	88·0	93·0	98·0	104·0	110·0
20–29 years	1602	96·7	9·4	87·0	91·0	96·4	102·0	108·0
30–39 years	1354	98·7	8·6	88·2	94·0	99·0	104·0	109·0
40–49 years	867	99·6	9·8	90·0	94·0	100·0	105·0	110·0
50–59 years	561	100·9	9·4	91·0	96·0	101·0	107·0	110·0
60–69 years	449	98·7	9·6	88·0	93·5	99·0	104·0	110·0
70–79 years	233	97·7	9·5	88·0	92·0	98·0	103·5	109·6
80 years and over	19	91·2	8·2	79·0	86·0	91·0	98·0	101·0
WHR								
20 years and over	5085	0·898	0·080	0·804	0·846	0·894	0·945	0·989
20–29 years	1602	0·856	0·073	0·777	0·810	0·852	0·894	0·935
30–39 years	1354	0·892	0·066	0·810	0·850	0·892	0·931	0·964
40–49 years	867	0·920	0·072	0·837	0·876	0·920	0·958	1·000
50–59 years	561	0·936	0·076	0·844	0·892	0·942	0·980	1·020
60–69 years	449	0·946	0·079	0·862	0·901	0·941	0·982	1·030
70–79 years	233	0·946	0·077	0·846	0·894	0·949	0·990	1·040
80 years and over	19	0·977	0·086	0·867	0·919	0·951	1·030	1·130

WC, waist circumference; HC, hip circumference; WHR, waist:hip ratio.

$P < 0·05$), as was mean LDL-C (124·3 (SD 40·3) *v.* 117·0 (SD 39·9) mg/dl, respectively, $P < 0·05$). LDL-C tended to increase up to about 70–80 years of age and then decreased. Women had significantly higher mean HDL-C (48·2 (SD 10·2) mg/dl) than men (45·1 (SD 10·7) mg/dl, $P < 0·05$). The median of HDL-C was 47 mg/dl in women and 44 mg/dl in men. TC:HDL-C ratio was significantly higher among Iranian men than women. Its median was 4·19 and 4·29 mg/dl and the 75th percentile was 5·11 and 5·22 mg/dl for women and men, respectively.

Table 5 presents the adolescents' data. Mean age was not significantly different between girls and boys (14·5 *v.* 15·1 years, respectively). Boys had significantly higher height and weight than did girls; however, BMI was significantly higher in girls than in boys. The mean TAG level was significantly higher in boys than in girls (121·5

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Table 3 Blood pressure and metabolic values in women aged over 20 years in Iran

				Percentile				
	n	Mean	SD	10th	25th	50th	75th	90th
SBP (mmHg)	5490	115·1	20·3	90·0	100·0	110·0	120·0	140·0
DBP (mmHg)	5490	75·3	11·9	60·0	70·0	75·0	80·0	90·0
FBG (mg/dl)	5490	83·3	32·1	67·0	71·0	78·0	86·0	97·0
TAG (mg/dl)	5490	152·8	75·1	73·0	96·0	136·0	194·2	256·0
TC (mg/dl)	5490	203·1	47·6	146·0	169·0	198·0	232·0	266·0
HDL-C (mg/dl)	5490	48·2	10·2	36·0	41·0	47·0	55·0	62·0
LDL-C (mg/dl)	5609	124·3	40·3	75·0	95·0	120·0	149·0	178·0
TC:HDL-C	5687	4·37	1·30	2·86	3·45	4·19	5·11	6·08

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol.

Table 4 Blood pressure and metabolic values in men aged over 20 years in Iran

				Percentile				
	n	Mean	SD	10th	25th	50th	75th	90th
SBP (mmHg)	5085	116·4	18·1	100·0	105·0	115·0	120·0	140·0
DBP (mmHg)	5085	75·7	10·7	60·0	70·0	80·0	80·0	90·0
FBG (mg/dl)	5085	82·9	29·3	66·0	72·0	78·0	86·0	96·0
TAG (mg/dl)	5085	162·4	77·4	80·0	105·0	147·0	205·0	271·0
TC (mg/dl)	5085	195·5	49·7	141·0	163·0	191·0	222·0	254·0
HDL-C (mg/dl)	5222	117·0	39·9	69·0	89·0	113·0	140·0	169·0
LDL-C (mg/dl)	5085	45·1	10·7	34·0	38·0	44·0	51·0	59·0
TC:HDL-C	5687	4·48	1·40	2·94	3·53	4·29	5·22	6·19

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol.

(SD 51·6) *v.* 116·8 (SD 48·2) mg/dl, respectively, $P<0·05$). Mean TC level was higher in girls than in boys (168·2 (SD 32·8) *v.* 161·6 (SD 44·7) mg/dl, respectively, $P<0·05$). This was also the case for mean levels of LDL-C and HDL-C (LDL-C: 96·3 (SD 28·5) *v.* 90·4 (SD 30·2) mg/dl, respectively, $P<0·05$; HDL-C: 49·6 (SD 13·1) *v.* 46·7 (SD 10·8) mg/dl, respectively, $P<0·05$). Girls had lower levels of both SBP and DBP compared with boys (SBP: 101·1 (SD 13·2) *v.* 110·4 (SD 13·4) mmHg, respectively, $P<0·05$; DBP: 60·8 (SD 10·9) *v.* 68·9 (SD 9·0) mmHg, respectively, $P<0·05$).

Figure 1 compares median obesity indices in Iranian and American adults. BMI was higher in Iranian women than in American women; whereas the BMI of American men was higher than that of Iranian men. Iranian women had higher WC, HC and WHR compared with American women; while American men had higher WC in comparison to Iranian men. HC was almost the same in the men of the two populations; however, WHR was higher in American than in Iranian men. Our results showed a slightly higher level of BMI as well as HC in Iranian women compared with American men; WC was the same until the age of 50 years and thereafter was slightly higher in American men than in Iranian women. WHR was higher among American men than in Iranian women. In summary, Iranian women were clearly more obese than American women whereas American men were more obese than Iranian men.

Median LDL-C was lower in Iranian than in American adults of both genders; whereas median TAG was lower in Americans than in Iranians (data not shown). Median HDL-C was higher in American women than in Iranian women; but the HDL-C level at the 5th percentile in American and Iranian women and also the HDL-C level in American and Iranian men at the 5th and 50th percentile were almost in the same range. Median TC was higher in Americans than in Iranians of both genders and this difference became more significant after the age of 50 years. The median TC:HDL-C ratio was higher in American men compared with Iranian men; however, it was greater in Iranian women than in American women (data not shown).

Figure 2 compares obesity indices and metabolic values among Iranian and American adolescents. Median BMI was higher in American than in Iranian adolescents. Median TC in Iranian boys was similar to that in American boys; whereas it was higher in Iranian girls than in American girls at 12–15 years, then almost the same from 16 to 19 years of age. TC level was higher in Iranian boys and girls at the 75th percentile; however, it was higher in American girls at the age of 16–19 years. Median and 75th percentile TAG levels were higher in Iranian than in the American adolescents. HDL-C levels were in the same range in Iranian and American adolescents from 12 to 15 years, but at age 16–19 years the HDL-C level increased among American in comparison to Iranian adolescents.

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Table 5 Obesity indices and metabolic values in adolescents aged 11–19 years in Iran

				Percentile				
	n	Mean	SD	10th	25th	50th	75th	90th
Weight (kg)								
Girls	1140	49·0	11·1	35·0	42·0	48·0	55·0	63·0
Boys	1078	53·9	13·7	36·0	44·0	54·0	62·0	70·0
Total	2218	51·3	12·7	35·0	42·0	50·0	59·0	67·0
Height (cm)								
Girls	1140	155·7	8·8	145·0	151·0	157·0	161·0	165·0
Boys	1078	164·1	13·8	145·0	156·0	167·0	175·0	180·0
Total	2218	159·7	12·2	145·0	152·0	160·0	168·0	176·0
BMI (kg/m^2)								
Girls	1140	20·11	3·76	15·80	17·52	19·60	22·18	25·10
Boys	1078	19·79	3·60	15·77	17·35	19·22	21·63	24·50
Total	2218	19·95	3·68	15·80	17·44	19·47	21·90	24·69
SBP (mmHg)								
Girls	1140	101·1	13·2	90·0	90·0	100·0	110·0	120·0
Boys	1078	110·3	13·4	100·0	100·0	110·0	120·0	130·0
Total	2218	105·5	14·1	90·0	100·0	100·0	110·0	120·0
DBP (mmHg)								
Girls	1140	60·8	10·9	50·0	50·0	60·0	70·0	80·0
Boys	1078	68·9	9·0	60·0	60·0	70·0	75·0	80·0
Total	2218	64·7	10·8	50·0	60·0	60·0	70·0	80·0
TAG (mg/dl)								
Girls	1140	116·8	48·2	64·0	82·0	109·0	143·0	183·0
Boys	1078	121·5	51·6	65·0	86·0	112·5	148·0	190·0
Total	2218	119·1	50·0	64·0	83·8	110·0	146·0	186·0
TC (mg/dl)								
Girls	1140	168·2	32·8	129·0	146·0	166·0	188·0	210·0
Boys	1078	161·6	44·7	124·0	139·0	156·0	180·0	203·0
Total	2218	165·0	39·2	127·0	141·0	161·0	184·0	207·0
LDL-C (mg/dl)								
Girls	1140	96·3	28·5	61·0	77·0	94·0	114·0	134·0
Boys	1078	90·4	30·2	55·0	70·0	87·0	109·0	130·0
Total	2218	93·4	29·5	58·0	72·0	90·0	112·0	132·0
HDL-C (mg/dl)								
Girls	1140	49·6	13·1	36·0	41·0	48·0	55·0	64·9
Boys	1078	46·7	10·8	35·0	39·0	45·0	52·0	60·0
Total	2218	48·2	12·2	36·0	40·0	47·0	54·0	62·0

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol.
The mean age of the girls and boys in the study was 14·59 years and 15·13 years, respectively.

Discussion

The present study provides current national data on the pattern of obesity and cardiometabolic risk factors in Iranian adults and adolescents, describing these distributions by age and sex, and additionally comparing them with those obtained in Americans of the same age groups. By every criterion of the anthropometric indices, Iranian women were more obese than American women, whereas the opposite was the case for the men. Moreover, Iranian women had higher BMI and larger HC than American men. The same differences appear to hold if Iranians are compared with Finns[18]. Our data indicate that abdominal obesity is more prominent in Iranian women than in Americans or Europeans and should raise considerable concern for the cardiovascular health of Iranian women[7]. Overall, it seems that in Middle Eastern populations a particular type of obesity, the so-called Middle Eastern pattern of obesity, is highly prevalent. This pattern makes them more susceptible to cardiometabolic risk factors. The major feature of this pattern of obesity is central adiposity and enlarged waist, particularly among women. More than half of adult women in these countries are abdominally obese. This might be explained by the different dietary pattern in this part of the world as compared with elsewhere[19]. Such a higher prevalence of abdominal adiposity would result in higher prevalence of cardiometabolic risk factors among women[20].

Our findings are qualitatively consistent with a comparative study of men and women of European origin and South Asians in London. In South Asian men, both BMI and WC were marginally lower while the visceral fat compartment was larger than in Europeans. However, in South Asian women, BMI and WC were slightly higher and visceral fat much greater than in European women[21].

Iranian adolescents had a lower BMI than Americans. In similar research conducted in Wuhan and Los Angeles, BMI was higher in American adolescents than in their Chinese counterparts but, in contrast to our study, BMI

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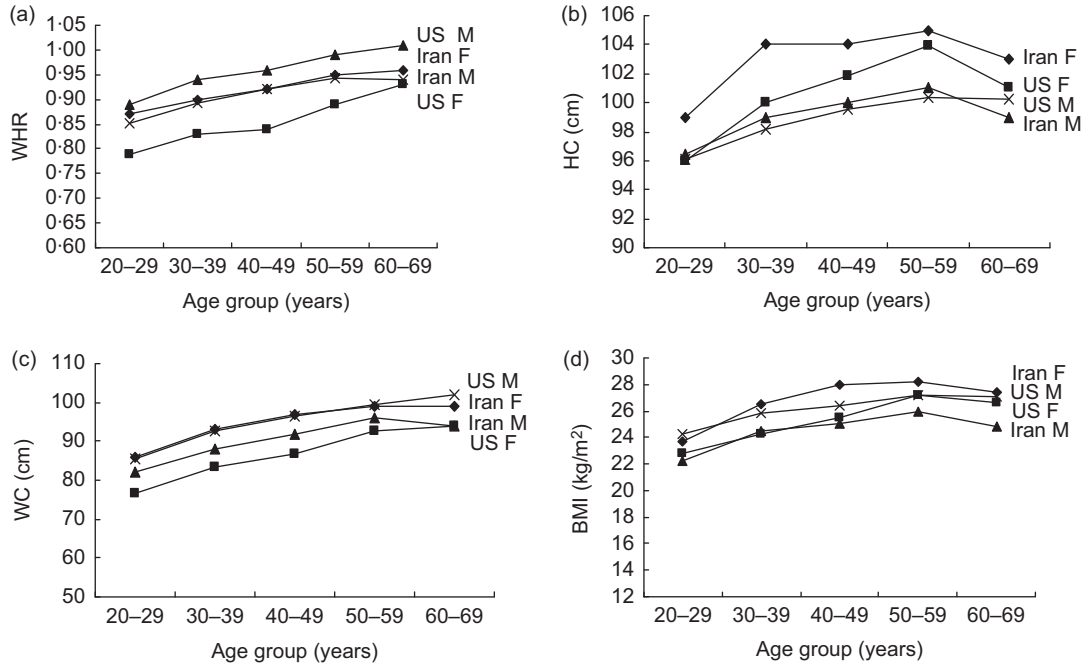

Fig. 1 Comparison of obesity indices: (a) waist:hip ratio (WHR), (b) hip circumference (HC), (c) waist circumference (WC) and (d) BMI, between Iranian and American adults (M, males; F, females)

was higher in Chinese boys in comparison to girls. Our findings may be related to the lower physical activity among Iranian girls[22].

Although BMI is the most easily measured index for obesity, there is now considerable evidence that markers of abdominal obesity are better predictors of outcome than BMI[23,24]. This appears to be particularly important in multi-ethnic studies[25]. Specifically, a WHO Expert Consultation has determined that the metabolic complications of obesity occur at lower BMI in Asian populations than in Europeans[26]. Also compared with Europeans, South Asians have increased abdominal fat at comparable levels of BMI. These data all indicate that reliance on BMI alone will underestimate vascular risk in South Asians[27–29].

Other studies in Iran also confirmed the larger BMI and WC in Iranian women compared with men and have related it to the limited outdoor physical activity and less attention to a healthy diet in Iranian women, particularly if they are of a lower social class[30,31].

Abdominal obesity was more marked in Iranian women than in any of the other major subgroups. Of special concern in the context of our study was the lack of evidence about excessive dysglycaemia in the Iranian women. In general, plasma TAG was higher, and HDL-C was lower, in Iranians than in Americans. Furthermore, LDL-C was higher in Americans than in Iranians, and no significant difference was evident for the median or 75th percentile of TC:HDL-C ratios in women. Previous reports have shown that Caucasian women have higher TAG levels than African-American women but their TC, LDL-C and HDL-C levels are reported to be almost in the same range[32].

Previous reports have shown that each biological parameter has specific cut-off points in different populations; for example, a cut-off of the 75th percentile for LDL-C is considered high in a population and the 50th percentile is considered the average value[33]. Therefore, it seems that LDL-C cut-off points for the Iranian population could be lower, while TAG cut-offs could be higher, than in Americans.

Interestingly, our results reveal that at all ages, including adolescence, TAG levels are higher in Iranians than in a Western population[34], but again the explanations remain to be determined. There is evidence, however, that the average energy intake in the Iranian population is higher than in the Finnish and American populations. In addition, it has been shown in Iran that carbohydrate intake is higher and fat intake is lower than reference values[35,36]. This could explain in part the high TAG and low LDL-C levels in our community.

In both Iranian and American populations, all obesity indices increased until the age of about 60 years and then were less pronounced. These age-related differences have been documented in other studies as well[18,37,38]. The decrease in obesity indices and lipid levels in older age groups could be due to low energy intake, which in turn might be because of low-fat and -carbohydrate diets consumed in these age groups[12]. In the present study TAG and TC levels were higher in Iranian men than in Iranian women until the age of about 50 years, but thereafter this association was reversed, perhaps reflecting hormonal changes in women after the age of 50 years.

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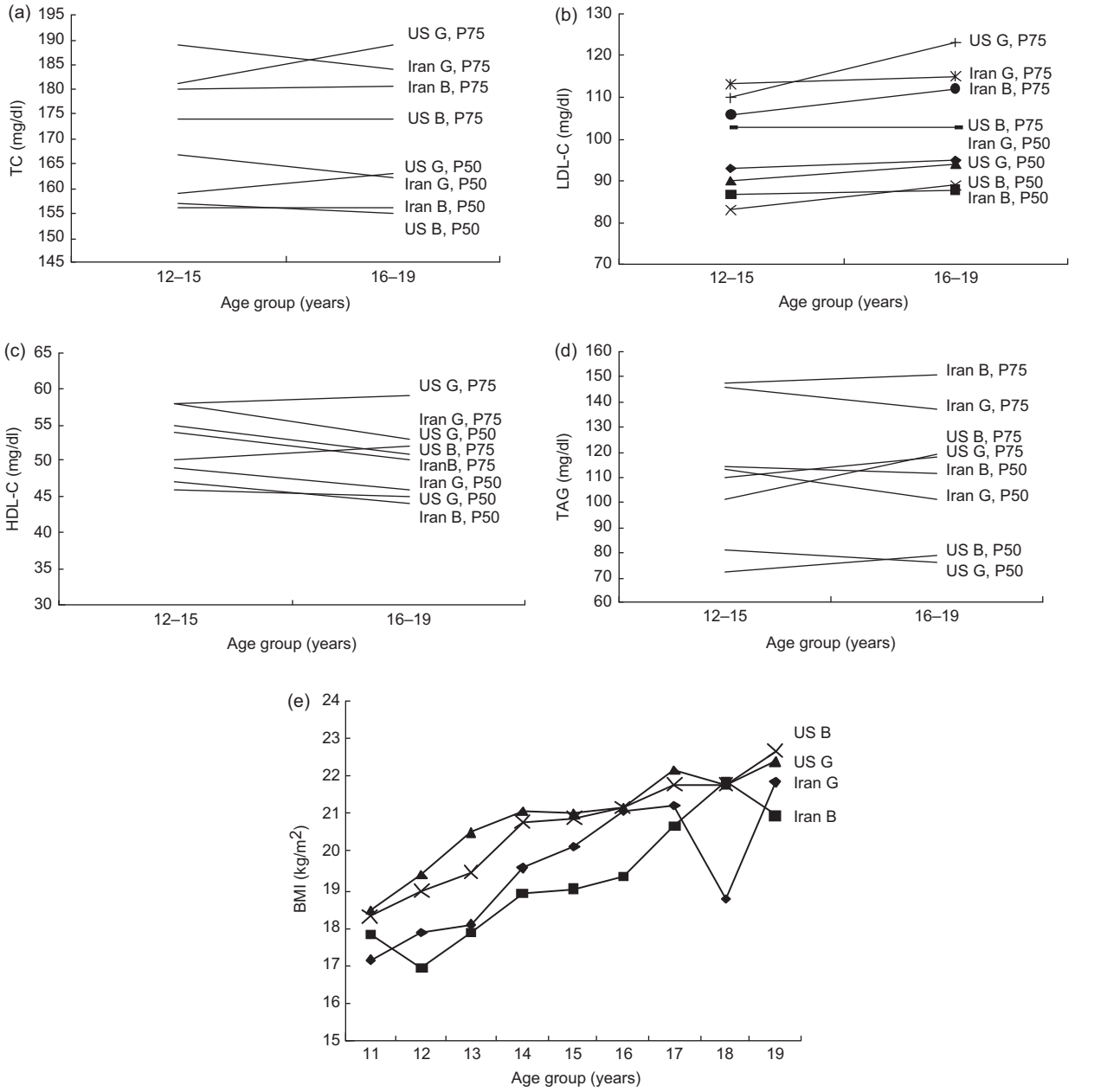

Fig. 2 Comparison of metabolic values and obesity indices: (a) total cholesterol (TC), (b) LDL cholesterol (LDL-C), (c) HDL cholesterol (HDL-C), (d) TAG and (e) BMI, between Iranian and American adolescents (B, boys; G, girls; P75, 75th percentile; P50, median)

The strength of the present research is that we studied risk factor levels between different age groups of Iranian adults and adolescents that could be used as a reference for our population; however, our limited access to the whole data of the American population led to limited comparisons between both populations.

Conclusion

The findings of our study provide alarming evidence for health professionals and policy makers about the very high prevalence of generalized and abdominal obesity in Iran, notably in women. Public health interventions and a national strategy to tackle the contributors to excess weight gain and its cardiometabolic consequences at population level and in different age groups should become a national health priority in Iran. Considering the higher TAG and lower HDL-C levels in Iranian adults and adolescents compared with their American counterparts, we suggest that the current guidelines for screening and control of lipid disorders, which are based on cholesterol, should be modified to consider such ethnic differences.

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