

Cardiovascular disease risk factors, metabolic syndrome and obesity in an Iranian population

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عوامل اختطار المرض القلبي الوعائي، والمتلازمة الاستقلابية، والسمنة، بين السكان الإيرانيين
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الخلاصة: قِيم الباحثون معدّل انتشار عوامل اختطار المرض القلبي الوعائي لدى الإيرانيين المصابين بسمنة معمّمة وبسمنة بطنية كجزء من برنامج صحة القلب في أصفهان، وذلك بإجراء دراسة مستعرضة شملت 3694 شخصاً تزيد أعمارهم على 19 عاماً. وكان 36.6% من الرجال و35.9% من النساء مُتصّفين بزيادة الوزن، كما كان 11.2% من الرجال و28.1% من النساء مصابين بالسمنة، واتضح أن وسطي مُنسب كتلة الجسم ومحيط الخصر ونسبة الخصر إلى الورك يزداد مع تقدّم العمر حتى سن 65 عاماً، أما كوليسترول المصل والجليسيريدات الثلاثية وغلوكوز المصل بعد ساعتين من تناول جرعة تحميل من السكر فتزداد بازدياد مُنسب كتلة الجسم ومحيط الخصر ونسبة الخصر إلى الورك لدى الجنسين. وقد بلغ معدّل انتشار المتلازمة الاستقلابية 19.8% في النساء السويّات من حيث منسب كتلة الجسم، و48.1% في النساء المصابات بزيادة الوزن و63.2% لدى النساء السمنان. أما في الذكور فقد بلغ معدّل انتشار المتلازمة الاستقلابية 3.7% لدى الأسوياء من حيث منسب كتلة الجسم و18.0% لدى المصابين بزيادة الوزن و40.1% لدى السمنان.

ABSTRACT As part of the Isfahan Healthy Heart Program, we evaluated the prevalence of cardiovascular disease risk factors in Iranians with generalized and abdominal obesity. We carried out a cross-sectional study on 3694 participants aged ≥ 19 years. Overall, 36.6% of men and 35.9% of women were overweight; 11.2% of men and 28.1% of women were obese. Mean body mass index (BMI), waist circumference (WC) and waist/hip ratio (WHR) increased with age up to 65 years. Total serum cholesterol, triglycerides and 2-hour post-load plasma glucose increased with BMI, WC and WHR in both sexes. Prevalence of metabolic syndrome was 19.8% in females with normal BMI, 48.1% in overweight females and 63.2% in obese females. In males, corresponding values were 3.7%, 18.0% and 40.1%.

Facteurs de risque de maladie cardio-vasculaire, syndrome métabolique et obésité dans une population iranienne

RÉSUMÉ Dans le cadre du programme de santé cardiaque d'Isfahan, nous avons évalué la prévalence des facteurs de risque de maladie cardio-vasculaire chez des Iraniens présentant une obésité généralisée et abdominale. Nous avons réalisé une étude transversale sur 3694 participants âgés de 19 ans et plus. Globalement, 36,6 % des hommes et 35,9 % des femmes étaient en surpoids ; 11,2 % des hommes et 28,1 % des femmes étaient obèses. L'indice de masse corporelle (IMC), le tour de taille et le rapport taille/hanches augmentaient avec l'âge jusqu'à 65 ans. Cette augmentation s'accompagnait chez les deux sexes d'une élévation des taux de cholestérol sérique total, de triglycérides et de glycémie deux heures après une charge en glucose. La prévalence du syndrome métabolique était de 19,8 % chez les femmes présentant un IMC normal, de 48,1 % chez les femmes en surpoids et de 63,2 % chez les femmes obèses. Chez les hommes, les valeurs correspondantes étaient de 3,7 %, 18,0 % et 40,1 %.

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Introduction

The prevalence of obesity is rapidly increasing in both developed and developing countries [1,2]. The negative effect of obesity on health and longevity is well documented [3,4]. A review on obesity in the World Health Organization (WHO) Eastern Mediterranean Region showed that women had a higher prevalence (35%–75%) than men (30%–60%) [5]. A recent review on the situation in the Islamic Republic of Iran revealed that the prevalence of overweight among urban residents aged 15–39 years and 40–69 years was estimated at about 22% and 40% respectively. Corresponding values in rural areas were 16% and 26% [6].

A simple measure such as body mass index (BMI) is commonly used as a surrogate measure of obesity in epidemiological studies as well as in clinical practice. It does not, however, distinguish between the contribution to body weight of fat tissue and that of muscle, bone and water, nor does it provide any information regarding fat distribution, and there is considerable variability in body composition for any given BMI [7,8].

It is important to distinguish between metabolically obese persons and those who are overweight but metabolically normal. Bearing in mind that the most important clinical issue is not overweight per se, but rather the metabolic consequences of excess adiposity, determining abdominal obesity is important [9]. However, the influence of overweight and obesity on cardiovascular disease (CVD) risk factors and multiple metabolic syndromes may differ between populations [10].

The present study was performed in order to evaluate the CVD risk factors in individuals with generalized and abdominal obesity in an Iranian population studied as part of the baseline survey of a community-based interventional programme (Isfahan Healthy Heart Programme) [11].

Methods

This cross-sectional study was conducted during 2000–2001 in a representative sample of 3562 individuals living in Isfahan, the second largest city in the country, located in the central part of the Islamic Republic of Iran. According to the national population census, the total population in Isfahan was 1 750 000 in 1999.

The methodology used in this study has been described in detail in a previously published study from the Isfahan Healthy Heart Program [11], and is described in brief here. A total of 1770 women and 1924 men aged ≥ 19 years were selected by 2-stage random cluster sampling. All participants were Iranian and mentally competent, and not pregnant in the case of females. All instruments used for anthropometric measurements were standardized before the examination, and the balances and sphygmomanometers were zero-calibrated. To reduce inter-observer variation, we trained the team working on the project, and the supervisor of each team double-checked a sub-sample of the recorded measurements. In order to reduce the potential for variability in measurements, the supervisor of each team closely observed the physical examinations.

Participants were invited to visit the survey centres for risk factor measurements and clinical examination. All participants gave informed consent for the study, which was approved by the ethics committee of Isfahan Cardiovascular Research Centre, Isfahan University of Medical Sciences.

Personal, demographic and lifestyle information were obtained using a standardized questionnaire. Height was measured with participants standing without shoes to the nearest 0.5 cm using a secured metal ruler; weight was measured in light clothing using calibrated scales. Body mass index (BMI) was calculated as weight/height²

(kg/m²). Waist circumference (WC) was measured at a level midway between the lower rib margin and the iliac crest to the nearest 0.5 cm and hip circumference at the level of the greater trochanter; then waist/hip ratio (WHR) was calculated.

Underweight was defined as BMI < 18.5 kg/m², normal weight as BMI 18.5–24.9 kg/m², overweight as BMI 25–29.9 kg/m² and obesity as BMI ≥ 30 kg/m². Abdominal obesity was defined as WC ≥ 102 cm for men and ≥ 88 cm for women. Gender-specific cut-off points of ≥ 0.95 and ≥ 0.80 for WHR were used for men and women respectively.

Blood pressure (BP) was taken on the right arm of the participants, who had been asked to sit for 5 minutes before the measurement. Blood pressure was measured using zero-calibrated sphygmomanometers with appropriate size cuff. The mean of 2 readings for systolic Korotkoff phase and diastolic (Korotkoff phase 5) pressure was recorded.

After measuring BP, venous blood samples were drawn between 07:30 and 09:30 from all participants after 12–14 hours of overnight fasting; these were centrifuged within 30–45 minutes of collection. The 2-hour post-load plasma glucose level (2-hpp) was checked on venous blood samples (in a fasting state and 2 hours after drinking a glucose solution).

Serum total cholesterol (TC) and triglycerides (TG) were measured using enzymatic colorimetric methods. High-density lipoprotein cholesterol (HDL-C) was determined after dextran sulphate–magnesium chloride precipitation of non-HDL-C. Low-density lipoprotein cholesterol (LDL-C) was calculated according to the Friedewald formula in serum samples with TG ≤ 400 mg/dL [12].

All blood samples were analysed in the laboratory of Isfahan Cardiovascular Research Centre, which meets the criteria of the National Reference Laboratory (a WHO collaborating centre) and is under external quality control of the central laboratory of St Rafael University, Leuven, Belgium.

Smoking was assessed by a self-administered questionnaire. Current smoking was defined as persons who had smoked regularly more than once a day on average for ≥ 1 year and who had smoked during the preceding month.

Metabolic syndrome was defined according to the *Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults*, i.e. having ≥ 3 of the following abnormalities: waist circumference > 102 cm in men or > 88 cm in women, serum triglycerides ≥ 150 mg/dL, HDL-C < 40 mg/dL in men and < 50 mg/dL in women, systolic BP ≥ 130 mmHg and/or diastolic BP ≥ 85 mmHg (high BP) or having treatment for hypertension, and fasting serum glucose ≥ 110 mg/dL or having treatment for diabetes [13].

Data were collected for statistical analysis and stored in a database. Recorded information was checked for missing values and data entry errors. All missing data and outliers were rechecked by a trained team. Statistical analyses were performed using SPSS, version 11. The independent *t*-test was used to compare the mean values of variables. The Yates corrected chi-squared test was used to determine the prevalence of different categorical variables. The age-adjusted odds ratio of CVD risk factors according to generalized and abdominal obesity was assessed by logistic regression model.

Results

Overall, 36.6% (705) of men and 35.9% (636) of women were overweight, and 11.2% (217) of men and 28.1% (498) of women were obese. Abdominal obesity was significantly more prevalent in women than in men, 74.2% vs 16.8% respectively ($P < 0.0001$).

Mean and standard deviation of the anthropometric variables are presented in Table 1 and show a progressive increase in mean BMI, WC and WHR with age in both sexes up to 65 years.

There was a significant increase in the serum levels of TC, LDL-C, TG, fasting blood sugar (FBS) and 2-hpp glucose level in both sexes. The prevalence of HDL-C ≤ 40 mg/dL increased with BMI in women but not in men. In addition, in both sexes, prevalence of metabolic syndrome and high BP increased significantly with BMI (Table 2) ($P < 0.0001$).

There was a significant increase in all CVD risk factors with abdominal obesity in both sexes. Prevalence of smoking was lower in men with abdominal obesity. Prevalence of metabolic syndrome was 55.6% in women and 58.6% in men with abdominal obesity (Table 3).

The prevalence of all risk factors except smoking increased significantly with WHR (Table 4).

Age-adjusted odds ratios for CVD risk factors according to generalized and abdominal obesity are presented in Table 5, and show an increasing risk of CVD risk factors with BMI, WC and WHR. The highest odds ratio was found for impaired 2-hpp and high BMI, followed by impaired 2-hpp and high WC. Considering metabolic syndrome, the highest odds ratio was found with WHR.

Discussion

The current study showed a high prevalence of generalized and abdominal obesity in the population studied. In addition, BMI, WC and WHR were significantly related to other major CVD risk factors except smoking.

The positive association between obesity and TC, LDL-C, TG and FBS, and the inverse association with HDL-C are in line with some previous studies in both sexes [14,15]. In the present study, a significant association was shown between generalized and abdominal obesity and FBS and 2-hpp. These findings are consistent with those of

Table 1 Characteristics of participants according to age

Age (years)	No.	Females			No.	Males		
		BMI Mean (SD)	WC Mean (SD)	WHR Mean (SD)		BMI Mean (SD)	WC Mean (SD)	WHR Mean (SD)
19–24	279	23.5 (4.8)	88.4 (11.3)	0.9 (0.1)	272	22.8 (5.8)	84.1 (9.9)	0.9 (0.1)
25–34	592	26.9 (5.8)	95.6 (11.9)	0.9 (0.1)	504	24.9 (5.3)	89.7 (10.0)	0.9 (0.1)
35–44	419	28.3 (5.3)	99.5 (12.9)	0.9 (0.1)	374	26.0 (4.9)	94.5 (10.7)	0.9 (0.1)
45–54	263	29.7 (6.7)	102.9 (11.4)	1.0 (0.1)	233	27.2 (6.8)	98.3 (10.2)	0.9 (0.1)
55–64	148	30.0 (7.8)	104.0 (11.5)	1.0 (0.1)	146	26.8 (6.3)	98.8 (8.8)	1.0 (0.1)
≥ 65	162	27.6 (5.0)	102.2 (13.1)	1.0 (0.1)	170	25.7 (3.8)	98.2 (10.1)	1.0 (0.1)

BMI = body mass index (kg/m^2); WC = waist circumference (cm); WHR = waist to hip ratio. SD = standard deviation.

Table 2 Age-adjusted prevalence of cardiovascular risk factors according to body mass index (BMI)

Risk factor	BMI females (kg/m ²)						BMI males (kg/m ²)									
	< 18.5 (n = 61)		18.5–24.9 (n = 575)		25.0–< 29.9 (n = 636)		≥ 30.0 (n = 498)		< 18.5 (n = 104)		18.5–24.9 (n = 898)		25.0–29.9 (n = 705)		≥ 30.0 (n = 217)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
TC ≥ 240 mg/dL	2	3.3	90	14.4	214	33.6	209	42.0	9	8.6	121	13.5	201	28.5	79	36.4
TG ≥ 200 mg/dL	1	1.6	89	15.5	222	34.9	238	47.8	6	5.7	165	18.4	314	44.5	133	61.3
LDL-C ≥ 160 mg/dL	2	3.3	83	14.4	159	25.0	139	27.9	8	7.7	110	12.2	126	17.8	41	18.9
HDL-C < 40 mg/dL	8	13.1	113	19.6	150	23.5	116	23.3	20	19.2	238	26.5	200	28.3	81	37.3
High blood pressure ^a	8	13.1	70	12.2	146	22.9	157	31.5	5	4.8	94	10.5	145	20.6	65	29.9
FBS > 126 mg/dL	1	1.6	24	4.2	52	8.2	53	10.6	2	1.9	27	3.0	44	6.2	23	10.6
Impaired 2-hpp	0	–	24	4.2	61	9.6	56	11.2	2	1.9	32	3.6	5	0.7	25	11.5
Metabolic syndrome	3	4.9	114	19.8	306	48.1	315	63.2	1	1.0	33	3.7	127	18.0	87	40.1
Smoking	0	–	13	2.3	16	2.5	14	2.8	34	32.7	293	32.6	174	24.6	66	30.4

^aSystolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg.

TC = serum total cholesterol; TG = triglycerides; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; FBS = fasting blood sugar; 2-hpp = 2-hour post-load plasma glucose.

In females P < 0.0001 in all cases except for: LDL-C ≥ 160 mg/dL P = 0.03; HDL-C < 40 mg/dL P = 0.09; FBS > 126 mg/dL P < 0.01; impaired 2-hpp P = 0.006.

In males P < 0.0001 in all cases except for: HDL-C < 40 mg/dL P = 0.007; FBS > 126 mg/dL P = 0.005; impaired 2-hpp P = 0.006.

Table 3 Prevalence of cardiovascular risk factors according to waist circumference (WC)

Risk factor	WC females (cm)				WC males (cm)			
	< 88		≥ 88		< 102		≥ 102	
	(n = 456)		(n = 1314)		(n = 1600)		(n = 324)	
	No.	%	No.	%	No.	%	No.	%
TC ≥ 240 mg/dL	47	10.3	469	35.7	286	17.8	123	37.9
TG ≥ 200 mg/dL	40	8.7	500	38.0	427	26.7	190	58.6
LDL-C ≥ 160 mg/dL	41	8.9	343	26.1	213	13.3	72	22.2
HDL-C < 40 mg/dL	79	17.3	308	23.4	410	25.6	109	33.6
High blood pressure ^a	44	9.6	338	25.7	182	11.4	127	39.2
FBS > 126 mg/dL	9	1.9	122	9.3	59	3.7	37	11.4
Impaired 2-hpp	8	1.7	134	10.2	65	4.1	44	13.6
Metabolic syndrome	10	2.2	731	55.6	58	3.6	190	58.6
Smoking	11	2.4	32	2.4	483	30.2	83	25.6

^aSystolic blood pressure ≥ 30 mmHg and/or diastolic blood pressure ≥ 85 mmHg.

TC = serum total cholesterol; TG = triglycerides; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; FBS = fasting blood sugar; 2-hpp = 2-hour post-load plasma glucose.

P < 0.0001 for all risk factors except for smoking in females, P = 0.1.

Table 4 Prevalence of cardiovascular risk factors according to waist/hip ratio (WHR)

Risk factor	WHR females				WHR males			
	< 0.80		≥ 0.80		< 0.95		≥ 0.95	
	(n = 110)		(n = 1660)		(n = 1445)		(n = 479)	
	No.	%	No.	%	No.	%	No.	%
TC ≥ 240 mg/dL	6	5.5	510	30.7	237	16.4	171	35.7
TG ≥ 200 mg/dL	5	4.5	535	32.2	379	26.2	237	49.5
LDL-C ≥ 160 mg/dL	6	5.5	378	22.8	179	12.4	106	22.1
HDL-C < 40 mg/dL	21	19.1	366	22.0	387	26.8	131	27.3
High blood pressure ^a	11	10.0	371	22.3	136	9.4	173	36.2
FBS > 126 mg/dL	1	0.9	129	7.8	44	3.0	52	10.9
Impaired 2-hpp	1	0.9	141	8.5	50	3.5	59	12.3
Metabolic syndrome	3	2.7	737	44.4	89	6.2	159	33.2
Smoking	2	1.8	41	2.5	420	29.1	144	30.0

^aSystolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg.

TC = serum total cholesterol; TG = triglycerides; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; FBS = fasting blood sugar; 2-hpp = 2-hour post-load plasma glucose.

P < 0.0001 in all cases except for: high blood pressure in males, P = 0.0147; smoking in females, P = 0.44; smoking in males, P = 0.40.

Table 5 Age-adjusted odds ratio of cardiovascular disease risk factors for 3 measures of obesity [high body mass index (BMI): > 30 kg/m²; high waist circumference (WC): ≥ 88 cm in women and ≥ 102 cm in men; high waist/hip ratio (WHR): ≥ 0.80 in women and ≥ 0.95 in men]

Risk factor	High BMI		High WC		High WHR	
	OR	95%CI	OR	95%CI	OR	95%CI
TC ≥ 240 mg/dL	1.65	1.50–1.80	1.65	1.50–1.80	1.63	1.40–1.80
TG ≥ 200 mg/dL	1.48	1.37–1.59	1.24	1.13–1.37	1.14	1.08–1.29
LDL-C ≥ 160 mg/dL	1.53	1.38–1.68	1.52	1.33–1.73	1.22	1.19–1.28
HDL-C < 40 mg/dL	0.98	0.63–1.68	0.83	0.76–0.90	1.24	1.19–1.29
High blood pressure	1.78	1.60–1.98	2.01	1.73–2.34	1.00 ^a	0.96–1.03
FBS >126 mg/dL	1.85	1.51–2.26	2.02	1.55–2.63	1.22	1.16–1.30
Impaired 2-hpp	9.98	7.93–12.57	5.18	4.25–6.32	1.20	1.10–1.31
Metabolic syndrome	0.60 ^a	0.57–0.64	0.49	0.45–0.52	1.47	1.39–1.55
Smoking	1.91	1.57–2.32	1.98	1.54–2.54	1.23	1.19–1.35

^aNot statistically significant, $P \geq 0.05$.

BMI = body mass index; TC = serum total cholesterol; TG = triglycerides; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; FBS = fasting blood sugar; 2-hpp = 2-hour post-load plasma glucose.

OR = odds ratio; CI = confidence interval.

several epidemiological and clinical studies confirming impaired glucose tolerance, obesity, dyslipidaemia and hypertension as part of a multiple metabolic syndrome [16–18].

Our results are also in agreement with many other studies showing an association between body composition and BP [19,20]. Since obesity is the strongest determinant of hypertension, weight control could be the most effective way to prevent hypertension in a population and to reduce BP among overweight hypertensive patients.

In the present study, odds ratio for smoking was significantly high in those with generalized and abdominal obesity, but the prevalence of smoking was not significantly higher in obese compared to non-obese persons. Different studies have shown a complicated association between smoking and CVD. Smoking is a major CVD risk factor, but at the same time, seems to protect against obesity [21,22]. Nevertheless

weight control should be an integral part of CVD prevention among both non-smokers and smokers.

Our results indicated a significant association between CVD risk factors (other than smoking) and both generalized and abdominal obesity. In addition, all biochemical CVD risk factors increased with BMI, WC and WHR. However the relationship between BMI and body fat content varies, and simple measures such as WC and WHR can more easily predict the health burden of obesity across populations.

Few studies exist on the prevalence of abdominal obesity. A study in Oman found a prevalence of 24.6%, significantly higher in women (44.3%) than in men (4.7%) [23]. In a previous Iranian study, prevalence of obesity and abdominal obesity was higher in women than in men; 67% vs. 29% and 93% vs. 74%, respectively [24]. A WHO consultation on obesity in 1997 concluded that at the population level, the obesity

epidemic reflects profound changes in different societies. Key changes to societal structures implicated in the rapid global rise of obesity include increasing urbanization, a fall in spontaneous and work-related physical activity and overconsumption of high-fat foods [25].

Limited data exist on the prevalence of metabolic syndrome in the Region, it is reported to be 21% in Oman [23] and 23.1% [26] to 33.7% [27] in different parts of the Islamic Republic of Iran. A review of the 3 surveys conducted at national level in 1999, 1995 and 2002 showed non-communicable diseases and their related morbidity and mortality were becoming a significant serious public health problem in this country [28].

The Middle East area has the highest dietary energy surplus in the developing world, and taking into consideration the rapid changes in the demographic characteristics of the Region, this has led to rapidly rising obesity rates [29].

Such a high prevalence of CVD risk factors in our community can be a reflection of the sedentary lifestyle and the rapid nutrition transition in the country, which may be secondary to the rapid change in fertility and mortality patterns and to urbanization which have led to a considerable imbalance in food consumption, with low nutrient density characterizing diets, and overconsumption evident among more than a third of households [30].

Conclusion

The prevalence of generalized and abdominal obesity as well as related CVD risk factors is quite high in the Islamic Republic of Iran. Measurement of WC should be integrated into routine physical examinations. Public health strategies for obesity prevention from an early age along with community-based interventions for lifestyle change should be integrated into the present health care system.

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A strategy for health promotion in the Eastern Mediterranean Region: 2006–2013

To achieve improved health and quality of life, the concept and principles of health promotion are increasingly being adopted by countries around the world. Thus a strategic framework for health promotion in the Eastern Mediterranean Region was developed by the WHO Regional Office for the Eastern Mediterranean in early 2004 through an internal process of consultation. Through review by a wider range of stakeholders, a regional strategy evolved. Following the Bangkok Conference in 2005, the strategy was further reviewed to reflect the Bangkok Charter. This document, *A strategy for health promotion in the Eastern Mediterranean Region: 2006-2013*, presents the regional strategy for health promotion. The strategy is grounded in a holistic view of health, which considers health to be a fundamental human right. It is intended to provide support to the countries of the Region in developing sound and explicit national policies and strategies for health promotion, keeping in mind the roles and responsibilities of all the stakeholders from different sectors.

The document is available on line at: <http://www.emro.who.int/dsaf/dsa794.pdf>.