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High Prevalence of Metabolic Syndrome in Iran in Comparison with France: What Are the Components That Explain This?

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Abstract

Background: The aim of this study was to investigate the difference in the prevalence of metabolic syndrome and its components between an Iranian and a French population.
Methods: The prevalence of metabolic syndrome, defined according to the Adult Treatment Panel III (ATP III), and of related abnormalities, was estimated in 1,386 French and 1,194 Iranian adults.
Results: The prevalence of metabolic syndrome was significantly higher in Iranian women (55.0%), followed by Iranian men (30.1%), than in French men (13.7%) and French women (6.6%). Iranian women were characterized by high rates of abdominal obesity (65.0%), hypertension (52.1%), hypertriglyceridemia (43.1%), and low high-density lipoprotein cholesterol (HDL-C; 92.7%). Iranian men were characterized by high rates of hypertension (48.9%), hypertriglyceridemia (42.8%), and low HDL-C (81.8%). French men had high rates of hypertension (44.7%) and mild rates of hypertriglyceridemia (28.6%) and hyperglycemia (23.9%). There was a relationship between waist circumference and the lipid components of metabolic syndrome in both countries.
Conclusion: The main finding of this study is the high prevalence of low HDL-C concentrations in the Iranian population, especially in Iranian women, compared with French women. Explanation of this observation could help in establishing prevention strategies.

Introduction

Metabolic syndrome is a cluster of four major cardiovascular risk factors: Obesity, insulin resistance (hyperglycemia), dyslipidemia, and arterial hypertension (HT).[1] The prevalence of metabolic syndrome varies greatly among countries and ethnic groups[2]; it fluctuates between 20% and 30% among Europeans and white Americans, with a similar distribution for men and women.[3] However, in Asian countries, particularly in Middle Eastern societies, metabolic syndrome seems to be more prevalent, with a different pattern of related components and a different distribution for the sexes.[4,5] Certain questions arise about the nature of these east–west differences, although population-based studies and comparative scientific reports are scarce. The aim of this study was to compare the prevalence of metabolic syndrome and its components in a French population, the STANISLAS cohort, with an Iranian population, to analyze the eventual differences observed.

Materials and Methods

Study populations

The French population was part of the STANISLAS cohort, a 10-year longitudinal study conducted since 1994 on 1,006 families recruited at the Centre for Preventive Medicine of Vandoeuvre-lès-Nancy, in the east of France.[6] These apparently healthy individuals were identified from the files of the State Health Insurance Fund and invited to this health examination center for routine checkups. In this study, we present data from a random subsample of 678 men and 708 women between 35 and 55 years old who attended the second checkup in 1999–2000. Each subject gave written informed consent for participating in this study, which was

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approved by the Comité Consultatif de Protection des Personnes dans la Recherche Biomédicale de Lorraine (France). In addition, we certify that all applicable governmental regulations concerning the ethical use of human volunteers were followed during this research. The Iranian population had participated in a national survey on noncommunicable disease that started in 2003. Using a multistage sampling method, 5,000 subjects were recruited from the Greater Khorasan province, in northeastern Iran.[7] In this study, we present data from a random subsample of 589 men and 605 women in the same age range as our French subsample, who participated in the first recruitment.

Data collection and definition of metabolic syndrome

Lifestyle information, such as socioeconomic status, tobacco, alcohol and drug consumption, physical activity, and personal medical history, was collected in both countries using appropriate questionnaires. Physical examinations and functional tests were performed and basic blood constituents were measured as described previously.[6,7] Weight and height were measured while the participants were standing in light clothing without shoes. Weight was recorded with digital scales to the nearest 200 grams. Height was measured to the nearest 0.1 cm using wall-mounted stadiometers, with the subjects' shoulders in a normal position. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist circumference was taken at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone), and hip circumference was measured at the maximum level over light clothing, using a standard tape measure, without any pressure on the body surface. Measurements were recorded to the nearest 0.1 cm. All measurements were taken by trained nurses according to standard procedures, and the reliability of the measuring devices was periodically checked during the study period. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were calculated as the mean of three measurements taken under standardized conditions with a sphygmomanometer, with the subject in a supine position. In both centers, blood samples were collected in the early morning after an overnight fast.

In France, concentrations of fasting glucose, total cholesterol and triglycerides (TG) were measured in fresh aliquots within 2 h with commercially available kits on an AU5021 apparatus (all from Merck, Darmstadt, Germany). High-density lipoprotein cholesterol (HDL-C) was measured after precipitation with phosphotungstate on a Cobas-Mira analyzer (Roche). All of the blood measurements were performed in the same laboratory (Centre of Preventive Medicine of Vandoeuvre-lès-Nancy, France) and monitored by the French national quality control scheme for biomedical samples.

In Iran, serum glucose, total cholesterol, HDL-C, and TG were assayed using standard techniques with the Cobas autoanalyzer system (ABX Diagnostics, Montpellier, France). Blood measurements were performed in the laboratories under the scrutiny of the state health center and were monitored by the Iranian national quality reference control scheme. Low-density lipoprotein cholesterol (LDL-C) concentrations were calculated for both populations according to the Friedewald formula [LDL-C = total cholesterol − HDL-C − (TG/2.2) when TG was <4.52 mmol/L, all analytes being expressed in mmol/L].

Metabolic syndrome was confirmed, according to the definition by the National Cholesterol Education Program Adult Treatment Panel (NECP ATP III NC),[3] if a subject met more than three of the following criteria: Waist circumference ≥ 88 cm in women or ≥ 102 cm in men; TG ≥ 1.7 mmol/L or drug treatment for elevated TG; HDL-C ≤ 1.03 mmol/L in men or ≤ 1.3 mmol/L in women or drug treatment for reduced HDL-C; SBP ≥ 130 mmHg or DBP ≥ 85 mmHg or antihypertensive drug treatment; fasting glucose ≥ 5.6 mmol/L or drug treatment for elevated glucose.

Data analysis

Statistical analyses were performed using the SAS software package version 9.2 (SAS Institute Inc., Cary, NC). For continuous variables, differences in characteristics between countries or age were tested using analyses of variance with interaction terms (ANOVA). Student–Newman–Keuls multiple-range tests were performed to compare the four population groups. For categorical variables, differences between countries or ages were analyzed using chi-squared tests. Participants were placed in four age groups. Pearson correlation coefficients were calculated between the components of metabolic syndrome in each population group, and statistical significance for group interaction was estimated. Factor analyses were then undertaken and followed by orthogonal (varimax) rotations to assist interpretation of the factors and to ensure that they were uncorrelated. We determined the number of factors to retain using the Scree test. The Scree plot is a plot of the eigenvalues of derived factors. Only variables with factor loading having absolute values greater than 0.20 were shown (see Table 4, below). For all tests, statistical significance was set at $P \leq 0.05$.

Results

The general characteristics and components of metabolic syndrome according to sex and age are presented in Table 1. In men, weight, height, BMI, waist circumference, and concentrations of total cholesterol, HDL-C, and fasting glucose were significantly lower in the Iranians than in the French, whereas DBP, TG concentration, the level of LDL-C, and the number of ATP III criteria were significantly higher. SBP in men was not significantly different between the countries. In women, differences between Iran and France were significant for all the variables of interest, except for weight and fasting glucose concentration. Height, total cholesterol, and HDL-C were lower in Iran in comparison with France. Conversely, BMI, waist circumference, DBP and SBP, TG, LDL-C, and the number of ATP III criteria were significantly higher in Iranian women.

In both countries, for men and for women, waist circumference, DBP and SBP, the level of LDL-C (except for Iranian men), and the number of ATP III criteria significantly increased with age. All lipid profile components to HDL-C ratios, including LDL-C/HDL-C, TG/HDL-C, and total cholesterol/HDL-C, were higher in Iranian men and women than in their French counterparts. Levels of LDL-C were higher in Iranian people than in French individuals.

Height was significantly and inversely related to age only in men of both countries, whereas weight did not differ, whatever the population group, and BMI slightly increased with age only in French men. In women of both countries and in French

Table 1. General Characteristics and Components of Metabolic Syndrome in Iranian and French Samples Aged 36–55 Years[a]

		Men				P ANOVA[b]			Women				P ANOVA[b]		
		36–40 years	*41–45 years*	*46–50 years*	*51–55 years*	*Age*	*Country*	*Interaction*	*36–40 years*	*41–45 years*	*46–50 years*	*51–55 years*	*Age*	*Country*	*Interaction*
Number	Iran	135	161	148	145				146	157	167	134			
	France	50	240	269	119				108	311	203	86			
Age (years)	Iran	38.1±1.4	43.3±1.4	47.7±1.3	52.9±1.5	—	—	—	38.1±1.5	43.0±1.5	48.0±1.5	53.0±1.5	—	—	—
	France	39.0±0.9	43.2±1.3	47.7±1.4	52.5±1.4				38.4±1.4	43.0±1.4	47.8±1.5	52.4±1.5			
Weight (kg)	Iran	69.1±13.1	70.7±12.1	70.1±12.1	68.7±12.7	0.729	**≤0.001**	0.392	64.1±13.4	65.4±12.8	66.1±13.6	63.6±13.4	0.881	0.365	0.332
	France	79.3±8.9	79.1±11.2	79.6±11.4	80.4±12.2	0.519			63.9±10.1	63.2±11.9	64.3±11.4	64.8±9.9	0.556		
Height (m)	Iran	1.68±0.06	1.69±0.07	1.67±0.06	1.67±0.07	0.006	**≤0.001**	0.612	1.54±0.06	1.55±0.06	1.55±0.06	1.53±0.05	0.079	**≤0.001**	0.282
	France	1.75±0.06	1.74±0.06	1.73±0.07	1.73±0.06	0.006			1.61±0.06	1.61±0.06	1.60±0.06	1.60±0.06	0.158		
Body mass index (kg/m^2)	Iran	24.1±3.9	24.6±3.9	25.1±3.7	24.4±3.8	0.289	**≤0.001**	0.224	26.7±5.3	27.1±4.8	27.5±5.5	26.9±5.2	0.594	**≤0.001**	0.558
	France	25.7±2.9	25.8±3.3	26.4±3.3	26.7±3.6	0.033			24.4±3.8	24.3±4.6	25.0±4.4	25.1±4.3	0.190		
Waist circumference (cm)	Iran	86.8±14.2	87.6±13.4	90.4±12.7	89.8±12.7	0.016	**0.012**	0.602	90.7±13.2	93.5±14.2	93.8±14.6	94.8±13.5	0.015	**≤0.001**	0.457
	France	88.4±7.7	89.3±8.9	91.0±9.3	92.8±9.2	0.002			76.2±9.0	76.1±10.3	77.8±10.0	79.2±10.1	0.027		
Diastolic blood pressure (mmHg)	Iran	80.8±10.1	80.1±10.3	82.7±10.9	82.6±10.6	0.041	**≤0.001**	0.099	75.4±12.9	79.4±12.7	81.7±14.7	84.1±15.3	**≤0.001**	**≤0.001**	0.309
	France	72.8±8.3	76.5±9.3	77.6±10.2	79.5±11.5	**≤0.001**			69.4±9.8	70.1±9.9	73.4±9.5	77.4±8.9	**≤0.001**		
Systolic blood pressure (mmHg)	Iran	122.6±14.3	122.2±13.4	128.6±18.8	130.6±17.4	**≤0.001**	0.089	0.205	119.6±16.1	123.5±17.7	129.8±19.8	137.4±23.7	**≤0.001**	**≤0.001**	0.074
	France	123.1±11.1	126.0±11.5	128.1±12.5	132.7±16.0	**≤0.001**			117.0±11.4	118.1±13.2	121.9±13.6	127.7±15.2	**≤0.001**		
Total cholesterol (mmol/L)	Iran	4.88±0.93	4.88±1.01	4.88±0.81	4.96±1.00	0.513	**≤0.001**	0.104	4.77±0.90	4.87±1.05	5.18±1.21	5.43±0.91	**≤0.001**	**≤0.001**	0.285
	France	5.64±0.84	5.89±1.01	6.09±1.07	6.06±0.98	0.005			5.55±1.12	5.46±0.83	5.68±0.85	6.14±0.93	**≤0.001**		
HDL-C (mmol/L)	Iran	0.80±0.31	0.79±0.36	0.83±0.38	0.80±0.28	0.861	**≤0.001**	0.573	0.89±0.30	0.87±0.27	0.88±0.39	0.87±0.27	0.625	**≤0.001**	0.220
	France	1.35±0.34	1.43±0.43	1.40±0.38	1.40±0.35	0.537			1.69±0.42	1.72±0.44	1.79±0.43	1.79±0.50	0.049		
LDL-C (mmol/L)	Iran	3.40±0.89	3.42±1.00	3.40±0.76	3.47±0.93	0.900	**≤0.001**	0.133	3.24±0.79	3.43±0.98	3.61±1.06	3.81±0.88	≤0.001	**≤0.001**	0.206
	France	3.76±0.77	3.96±0.95	4.14±0.91	4.15±0.88	0.009			3.45±0.84	3.41±0.83	3.53±0.84	3.93±0.94	≤0.001		
LDL-C/HDL-C	Iran	4.65±2.01	5.01±2.55	4.47±1.73	4.67±2.11	0.162	**≤0.001**	0.076	4.01±1.85	4.36±1.97	4.58±2.17	4.80±2.09	0.010	**≤0.001**	0.078
	France	2.96±0.91	3.07±1.36	3.16±1.15	3.16±1.09	0.633			2.18±0.79	2.17±0.94	2.12±0.79	2.43±1.09	0.051		
Cholesterol/HDL-C	Iran	7.19±4.69	7.11±3.15	6.72±2.83	7.61±7.20	0.460	**≤0.001**	0.309	5.98±2.88	6.25±2.79	6.68±3.04	7.05±3.07	0.013	**≤0.001**	0.058
	France	4.39±1.14	4.51±1.62	4.68±1.61	4.58±1.34	0.484			3.49±1.34	3.39±1.05	3.34±0.89	3.71±1.26	0.050		
Triglycerides (TG) (mmol/L)	Iran	1.95±1.24	1.78±0.97	1.85±1.28	1.97±1.23	0.753	**≤0.001**	0.567	1.70±1.13	1.57±0.92	1.89±1.10	2.07±1.25	0.001	**≤0.001**	0.109
	France	1.42±0.83	1.42±1.01	1.47±1.07	1.39±0.98	0.907			1.25±3.58	0.90±0.42	0.98±0.57	1.15±0.56	0.701		
TG/HDL-C	Iran	3.44±5.14	2.89±2.54	3.07±3.83	3.27±4.23	0.659	**≤0.001**	0.663	2.34±2.51	2.31±2.76	2.70±2.73	3.06±3.21	0.084	**≤0.001**	0.828
	France	1.18±0.85	1.19±1.11	1.28±1.67	1.14±1.10	0.752			1.00±4.22	0.59±0.42	0.60±0.43	0.75±0.59	0.167		
Fasting glucose (mmol/L)	Iran	4.76±0.86	4.92±1.57	5.06±1.94	4.96±1.47	0.201	**≤0.001**	0.872	4.61±0.97	4.73±1.04	5.22±1.84	5.25±1.88	**≤0.001**	0.489	**0.046**
	France	5.14±0.43	5.25±0.70	5.40±1.01	5.43±0.56	0.014			4.85±0.42	4.92±0.47	5.06±0.54	5.16±0.56	**≤0.001**		
Number of criteria[c]	Iran	1.8±1.1	1.9±1.1	2.0±1.2	2.2±1.2	0.005	**≤0.001**	0.958	2.3±1.0	2.5±1.1	2.8±1.2	3.0±1.1	**≤0.001**	**≤0.001**	0.248
	France	1.0±1.1	1.1±1.1	1.2±1.1	1.4±1.1	0.019			0.5±0.8	0.6±1.0	0.7±0.9	1.0±1.1	0.003		

[a]Values are expressed as the frequencies for number of individuals and mean±standard deviation for the rest of variables.
[b]*P* ANOVA, age (*P* for trend), country differences, and age·country interaction.
[c]ATP III criteria (AHA/NHLBI statement from 2005) are three out of the five of the following: (1) WC ≥88 cm (women) or ≥102 cm (men); (2) triglycerides ≥1.7 mmol/L or drug treatment for elevated triglycerides; (3) HDL-C ≤1.3 mmol/L (women) or <1.03 mmol/L (men) or drug treatment for reduced HDL-C; (4) systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or antihypertensive drug treatment; and (5) fasting glucose ≥5.6 mmol/L or drug treatment for elevated glucose.
ANOVA, analysis of variance; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; ATP III, Adult Treatment Panel III; AHA/NHLBI, American Heart Association/National Heart, Lung and Blood Institute; WC, waist circumference.

men, cholesterol and fasting glucose significantly increased with increasing age. Age was significantly related to TG in Iranian women and to HDL-C in French women.

Consequently, the prevalence of metabolic syndrome was significantly higher in Iranians than in the French of either sex (Table 2). Student–Newman–Keuls multiple range tests were performed to compare the four population groups, after adjustment for age. Metabolic syndrome prevalence was significantly higher in Iranian women (55.0%), followed by Iranian men (30.1%), French men (13.7%), and French women (6.6%). Iranian women were characterized by high rates of abnormality in abdominal obesity (65.0%), HT (52.1%), hypertriglyceridemia (43.1%), and low HDL-C (92.7%). Iranian men were characterized by high rates of HT (48.9%), hypertriglyceridemia (42.8%), and low HDL-C (81.8%). French men had high rates of HT (44.7%) and mild rates of hypertriglyceridemia (28.6%) and hyperglycemia (23.9%).

Metabolic syndrome component rates increased steadily with age in the four sex/country groups (Table 2). In men, the prevalence of the individual components of metabolic syndrome, hypertriglyceridemia and low HDL-C was significantly higher in Iran than in France, whereas high fasting glucose was more prevalent in French men. In women, high waist circumference, high blood pressure, hypertriglyceridemia, and low HDL-C were significantly more prevalent in Iran than in France. In men only, the prevalence of high waist circumference increased with age, whereas hypertriglyceridemia increased with age in women only.

Correlation coefficients between the components of metabolic syndrome according to sex and country are presented in Table 3. All coefficients were significantly different from 0 ($P \leq 0.001$). Relationships between all of the metabolic syndrome components that correlated significantly were stronger in French individuals than in Iranians.

Factor analysis identified two major factors—"blood pressure" and "lipids" (Table 4). In the two groups of Iranians and in French men, the "blood pressure" factor included DBP, SBP, and waist girth; the "lipids" factor included TG, fasting glucose, waist circumference, and HDL-C. In French women, fasting glucose aggregated with components of "blood pressure" factors.

Discussion

This is the first study conducted in French and Iranian populations to investigate common points as well as differences in metabolic syndrome between the two countries. The main findings of this study are a high prevalence of metabolic syndrome and multiple and questionable prevalence of low HDL-C and high waist circumference in Iranian women compared with French women. Although these wide differences may be derived from different laboratory methods used in the two countries, these findings agree with previous studies that advised screening for the progression of metabolic syndrome in Iran, including the measurement of waist circumference, TG, and HDL-C.[8–10] In addition, HDL-C was associated with waist circumference in our analysis, which suggests a relationship between increased waist circumference and decreased HDL-C concentrations.

Several studies have shown a high prevalence of metabolic syndrome, low HDL-C, and waist circumference in Iranian adults and adolescents[11–26] as well as in other Middle Eastern populations.[27–29] These studies also indicate that there is a higher prevalence of metabolic syndrome among Iranian women than among Iranian men. There is a variation in the prevalence of metabolic syndrome in adults between the different geographical parts of Iran,[4,8,23,25] from 23.7% in the west to 50% in the south.[23,25] Although these studies note small differences in the prevalence of metabolic syndrome and related abnormalities around Iran,[23] low HDL-C is mentioned as the predominant abnormality in several geographic parts of this country,[11–26] consistent with our results. Sharifi et al.[25] found that low HDL-C was the most prevalent abnormality in 2,941 Iranians over 20 years of age (prevalence of low HDL-C was 73%, with 63% for men and 93.3% for women). Azizi et al. also showed that among people affected by metabolic syndrome, low HDL-C was the most common abnormality (91%).[9] Evidence indicates a higher prevalence of low levels of HDL-C in Iranian adults and youths than in American, Swedish, or German populations.[30,31] The high prevalence of low HDL-C, even in nonobese and normo-triglyceridaemic individuals, supports ethnic predisposition. The findings of Koochek et al.[32] illustrated the significant association between migration from Iran to Sweden and the prevalence of HT and smoking, but not dyslipidemia, and consequently provide further confirmatory evidence of such ethnic predisposition to low HDL-C.[30,32]

The prevalence of metabolic syndrome in France is lower than in North America and in other European countries.[33] The Monica study[34] highlighted a French north–south gradient for metabolic syndrome, with higher prevalence in Lille than in Toulouse. The prevalence of metabolic syndrome in France varies from 11.7% in men to 7.5% in women, according to the NCEP ATP III.[33–42] Our results showed that the prevalence of metabolic syndrome in the STANISLAS subsample is in this range. Our study also revealed that high blood pressure was the most prevalent abnormality in French individuals. This finding is consistent with previous studies.[37,38]

Why is metabolic syndrome more prevalent among Iranian people, particularly women, than among the French population? Should we expect a higher cardiovascular mortality rate in Iranian women in the next decades? One reason that might explain these differences could be that the French participants in this study were apparently healthy, but when compared with other published reports,[35,37,38] there are no noteworthy differences between our study population and other populations.

The Iranian dietary pattern is significantly associated with dyslipidemia, particularly with a high prevalence of low HDL-C and high waist circumference.[43] In line with concepts concerning nutritional effects, recent meta-analysis documents have shown the effect of the Mediterranean dietary pattern in increasing levels of HDL-C in developed societies as it does in southern European countries.[44] Richard et al. also recently reported that even without weight loss, the Mediterranean diet leads to significant changes in the blood lipid profile.[45] Consistent with the effect of environmental factors on HDL-C levels, this is more marked in Iranian women because they have a sedentary lifestyle, use labor-saving devices, have physically inactive leisure activities, and consume high-calorie diets rich in fat.[8] Interestingly, Esmaillzadeh et al.[46] found an independent association between major Iranian dietary patterns and plasma concentrations of inflammatory markers such as interleukin 6 and C-reactive protein (CRP). It has also been reported that CRP is strongly associated with stable coronary artery disease and

Table 2. Prevalence of Metabolic Syndrome, Its Components According to ATP III Criteria (AHA/NHLBI Statement)[a]

		Men				P			Women				P		
Metabolic syndrome criteria[b]		*36–40 years*	*41–45 years*	*46–50 years*	*51–55 years*	*Age*[c]	*Country*[d]	*Interaction*[e]	*36–40 years*	*41–45 years*	*46–50 years*	*51–55 years*	*Age*	*Country*	*Interaction*[e]
High waist circumference	Iran	0.103	0.130	0.189	0.172	**0.048**	0.123	0.865	0.609	0.668	0.648	0.671	0.361	≤**0.001**	0.701
	France	0.080	0.088	0.134	0.160	**0.024**			0.150	0.140	0.163	0.186	0.417		
High blood pressure	Iran	0.423	0.428	0.540	0.565	**0.003**	0.104	0.455	0.349	0.445	0.607	0.686	≤**0.001**	≤**0.001**	0.455
	France	0.320	0.408	0.446	0.580	≤**0.001**			0.178	0.198	0.281	0.337	**0.001**		
High triglyceride	Iran	0.422	0.409	0.405	0.475	0.387	≤**0.001**	0.574	0.404	0.343	0.458	0.529	**0.008**	≤**0.001**	0.851
	France	0.280	0.271	0.309	0.269	0.822			0.065	0.068	0.089	0.163	**0.023**		
Low HDL-C	Iran	0.822	0.819	0.777	0.855	0.633	≤**0.001**	0.260	0.911	0.942	0.934	0.917	0.874	≤**0.001**	0.484
	France	0.160	0.142	0.152	0.109	0.458			0.168	0.179	0.113	0.160	0.113		
High glucose	Iran	0.081	0.093	0.114	0.137	**0.049**	≤**0.001**	0.987	0.041	0.076	0.142	0.186	≤**0.001**	0.488	0.725
	France	0.160	0.217	0.249	0.294	**0.033**			0.009	0.084	0.128	0.198	≤**0.001**		
Metabolic syndrome	Iran	0.259	0.254	0.297	0.393	**0.009**	≤**0.001**	0.975	0.431	0.496	0.631	0.641	≤**0.001**	≤**0.001**	0.705
	France	0.100	0.108	0.145	0.193	**0.022**			0.028	0.065	0.069	0.105	0.039		

Values are expressed as the frequency.

[a]Frequency.

[b]ATP III criteria (AHA/NHLBI statement from 2005) are three of the five following: (1) WC ≥88 cm (women) or ≥102 cm (men); (2) triglycerides ≥1.7 mmol/L or drug treatment for elevated triglycerides; (3) HDL-C <1.3 mmol/L (women) or <1.03 mmol/L (men) or drug treatment for reduced HDL-C; (4) SBP ≥130 mmHg or DBP ≥85 mmHg or antihypertensive drug treatment; and (5) fasting glucose ≥5.6 mmol/L or drug treatment for elevated glucose.

[c]Cochran–Armitage trend test.

[d]Chi-squared test.

[e]Test for age·country interaction by using logistic regression model.

HDL-C, high-density lipoprotein cholesterol; ATP III, Adult Treatment Panel III; AHA/NHLBI, American Heart Association/National Heart, Lung and Blood Institute.

Table 3. Pearson Correlation Coefficients Between the Components of the Metabolic Syndrome According to Sex and Countries

	Components	SBP	Interaction P value	DBP	Interaction P value	TG	Interaction P value	Waist girth	Interaction P value	Glucose	Interaction P value
DBP ¥	Iran men	0.711***	≤0.001[a]	—		—		—		—	
	Iran women	0.762***		—		—		—		—	
	France men	0.718***		—		—		—		—	
	France women	0.777***		—		—		—		—	
TG ¥	Iran men	0.124**	0.366	0.039[b]	0.048	—		—		—	
	Iran women	0.155***		0.122**		—		—		—	
	France men	0.158***		0.157***		—		—		—	
	France women	0.141***		0.144***		—		—		—	
Waist circumference	Iran men	0.251***	0.019	0.217***	0.505	0.232***	≤0.001	—		—	
	Iran women	0.241***		0.235***		0.146***		—		—	
	France men	0.326***		0.298***		0.333***		—		—	
	France women	0.385***		0.309***		0.142***		—		—	
Fasting ¥ glucose	Iran men	0.049°	0.057	0.072[b]	0.951	0.124***	≤0.001	0.204***	0.242	—	
	Iran women	0.194***		0.120**		0.143***		0.203***		—	
	France men	0.151***		0.145***		0.253***		0.267***		—	
	France women	0.254***		0.195***		0.002°		0.266***		—	
HDL-C ¥	Iran men	−0.100*	0.609	−0.032[b]	0.328	−0.466***	≤0.001	−0.145***	≤0.001	−0.077[b]	0.194
	Iran women	−0.069°		−0.108**		−0.358***		−0.133***		−0.084*	
	France men	−0.076*		−0.119**		−0.433***		−0.297***		−0.121**	
	France women	−0.082*		−0.081*		−0.184***		−0.369***		−0.040[b]	

[a]Significance for group interactions.
[b]NS, Not significant.
*≤0.05, **≤0.01, ***≤0.001: test to 0 for correlation coefficients.
¥ DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol.

that its measurement may thus improve coronary risk assessment in Iranian patients with coronary artery disease.[47] Interestingly, serum high-sensitivity CRP is an independent predictor of coronary artery disease defined by angiography in the Iranian population.[48]

For both countries, our analysis showed correlation between waist circumference and TG, and an inverse relationship with HDL-C. These findings agree with the study by Chateau-Degat et al.,[49] who reported that the presence of abdominal obesity, increased levels of TG, and low levels of HDL-C are more prevalent in Canadian women than in men of different ethnicities. Interestingly, studies by Nabipour et al.[23] in Iran and Menotti et al.[50] in Italy have shown that, of the components of metabolic syndrome, low HDL-C is significantly and independently associated with nonfatal ischemic heart disease in the Iranian population, and its presence is also a predictor of coronary heart disease and cardiovascular disease.[50] In a meta-analysis, Hagdoost et al.[51] reported greater prevalence and risk of HT, as a component of metabolic syndrome, in Iranian women in comparison with men. Another Iranian study[52] indicated that the hazard ratio of metabolic syndrome components of ischemic heart disease is higher in Iranian women at 1.72 (1.08–2.74) than in men, at 1.58 (1.06–2.35).

In addition to the environmental factors and ethnic differences above, Kathireasan et al.[53] proposed a genetic risk score using 14 genome-wide significant single-nucleotide polymorphisms for HDL-C. In their opinion, genetic risk scores are strongly correlated with HDL-C levels. However, the difference in HDL-C levels between the most 'deleterious' and the most 'favorable' genetic score was 0.306 mmol/L. Previous studies have reported great differences between Middle Eastern countries and other countries regarding the prevalence of low HDL-C and hypertriglyceridemia.[5,9,25,28] For

Table 4. Results of Factor Analysis with Metabolic Syndrome Components and Factor Loadings in the Four Groups[a]

	Iranian men		Iranian women		French men		French women	
Components	Factor 1: BP	Factor 2: Lipids	Factor 1: BP	Factor 2: Lipids	Factor 1: BP	Factor 2: Lipids	Factor 1: BP	Factor 2: Lipids
SBP	0.775	—[b]	0.816	—	0.782	—	0.832	—
DBP	0.780	—	0.806	—	0.769	—	0.810	—
TG	—	0.611	—	0.505	—	0.607	—	0.251
Waist girth	0.259	0.332	0.251	0.279	0.295	0.490	0.310	0.547
Fasting glucose	—	0.201	—	0.252	—	0.304	0.254	—
HDL-C	—	−0.562	—	−0.482	—	−0.549	—	−0.506

[a]Factor loadings represent the correlations between the variables and the factors.
[b]Factor loading <0.20.
BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol.

instance, 37% of U.S. adults[54] and 69% of Middle Eastern populations have low HDL-C levels.[9] These differences are greater than could be explained by genetic factors alone.

As an answer, although the difference in the prevalence of metabolic syndrome in the two countries supports the heterogeneity of metabolic syndrome,[49,54] we might suppose that Iranian women are more at risk of cardiovascular disease than their European counterparts. Although it seems that environmental factors, including diet and drink patterns as well as physical activity, may play a considerable role in explaining the main differences in the prevalence of metabolic syndrome, particularly in women of the two countries, the contribution to these differences made by genetic factors should ultimately be considered.

Study limitations and strengths

Analytical variations in laboratory data and anthropometric measurements may have some impact on the differences that we observed in the two populations. However, our findings are consistent with ethnic differences previously highlighted among children and the adolescent population. The main strength of our study is its novelty in comparing two populations, one from Europe and one from Asia. Our results provide confirmatory evidence that Asians are ethnically predisposed to the HDL-C disorder and metabolic syndrome documented in populations of children and adolescents.

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Author Disclosure Statement

We declare that there are no competing financial interests.

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