A Review on Underlying Differences in the Prevalence of Metabolic Syndrome in the Middle East, Europe and North America

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Abstract

Increasing burden of obesity, the metabolic syndrome (MetS), Type 2 Diabetes Mellitus (T2DM), and CardioVascular Diseases (CVD) in developing countries has created an urgent need for more researches on the various factors responsible for increasing their prevalence. Literature search was carried out using the terms obesity, insulin resistance, diabetes, dyslipidemia, physical inactivity, the metabolic syndrome, and developing countries, in order to review the criteria and risk factors of MetS and its prevalence in Middle East countries from web sites and published documents. The prevalence of the syndrome and its underlying factors was also compared between some of the Middle East and some of European and American countries. The pattern of the components of metabolic syndrome varies in the Middle East region in comparison with Europe and North America. In addition to differences of diet behaviors, the genetic factors and some of geographic dependent elements may influence the variation of metabolic syndrome architecture worldwide particularly in the Middle East region.

Introduction

Increasing burden of obesity, MetS, T2DM, and CVD in developing countries has created an urgent need for more researches on the various factors responsible for increasing their prevalence [1-4]. MetS has generated much concern over the past few years because it clearly represents a high risk for developing diabetes type 2 and cardiovascular diseases. Hypertriglyceridemia, obesity, insulin resistance, glucose intolerance, hypertension, and physical inactivity are the main risk factors of MetS [5-7], but its association with other interrelated factors is still unknown.

Although it's suggested that the improvement of economic situation, nutrition transition, and increased urbanization in developing countries play the important roles in increasing prevalence of obesity and the MetS [1,8-13], more researches is needed to confirm these suggestions. Greater efforts are also needed to properly diagnose other affecting environmental and genetic factors in order to find out the basic mechanisms which lead to the susceptibility of individuals to the MetS [14-17]. It is well documented now that the prevalence of metabolic syndrome is increasing worldwide. However, it seems that not only its prevalence in some geographic regions and ethnic groups is higher than others but also the patterns of its related components are widely different [18].

In this article, we reviewed the criteria and risk factors of MetS and then discussed its prevalence in the Middle East countries. After that we compared the prevalence of the syndrome and its underlying factors between some of the Middle East and some of the European countries and finally discussed in brief about other probably influencing factors on metabolic syndrome or its related components.

Clinical Diagnosis of Metabolic Syndrome

Different organizations have recommended clinical criteria for the diagnosis of the MetS (Table 1). There is general consensus regarding the main components of the syndrome (glucose intolerance, obesity, raised blood pressure and dyslipidaemia [elevated triglycerides, low levels of high density lipoprotein cholesterol]) but different definitions also reveal fundamental differences in positioning of the predominant causes of the syndrome, for example obesity in men using the World Health Organization (WHO) definition requires body mass index (BMI) >30 kg/m² or waist:hip ratio >0.90, whereas the waist circumference is required by the National Cholesterol Education Program (NCEP) (>102 cm), European Group for the study of Insulin Resistance (EGIR) and International Diabetes Federation (IDF) (>94 cm) [19-22].

The World Health Organization (WHO), the National Cholesterol Education Program–Adult Treatment Panel III (NCEP–ATP III) and the International Diabetes Federation (IDF), have recognized the MetS as a major CVD risk factor [7,23].

World health organization (WHO) definition

The first attempt at a global definition of the MetS was by WHO [24] (Table 1). Primary to the WHO definition was the biological and physiological description of insulin resistance (measured by the euglycaemic clamp, a method for the quantification of tissue sensitivity to insulin) [7,19,21,22,25]. Insulin resistance was defined as 1 of the following: type 2 diabetes; impaired fasting glucose (IFG); impaired glucose tolerance (IGT), or for those with normal fasting glucose values (<110 mg/dL), a glucose uptake below the lowest quartile for background population under hyperinsulinemic.
In the context of insulin resistance, two other risk factors are sufficient for the diagnosis of MetS (Table 1) [22]. The most important limitation of WHO criteria was related to the use of the euglycaemic clamp, making the definition practically impossible to use in either clinical practice or epidemiological studies [20,22].

**European group for studying insulin resistance (EGIR) definition**

EGIR relied on fasting insulin instead of the euglycaemic clamp to measure insulin resistance [21,26] (Table 1). The EGIR believed that insulin resistance was the underlying cause of the MetS, but restricted the use of the definition to those in whom insulin resistance could be easily and reliably measured. Hence, people with diabetes were excluded from the definition [20,22]. The EGIR definition also introduced waist circumference EGIR (94 cm for men and 80 cm for women) as the measure of adiposity and included modified cut points for hypertension, triglycerides (TGs), high-density lipoprotein (HDL) cholesterol [21,22].

**American association of clinical endocrinology (AACE) definition**

AACE is a modification of the ATPIII definition, based on the belief that insulin resistance is the core feature [28]. There are four factors as ‘identifying abnormalities’ of the MetS in AACE criteria: elevated triglycerides, reduced HDL-C, elevated blood pressure, and elevated fasting and post load glucose [20,22]. Factors which increase the likelihood of the syndrome rather than as key identifying abnormalities are listed as obesity, diagnosis of hypertension, gestational diabetes or CVD or family history of diabetes, hypertension, non-European ancestry or age greater than 40 years and a sedentary lifestyle [20]. The AACE statement deliberately does not provide a specific definition of the syndrome so the diagnosis was allowed to rely on clinical judgment [22].

**International diabetes federation (IDF) definition**

The IDF is a useful definition for clinicians to identify which persons are at risk of type 2 diabetes and CVD [20]. It also facilitates epidemiological and clinical research into the MetS [22]. Central obesity is an important determinant of the MetS by the IDF group and they recognized that there is a strong association between waist circumference, CVD and other component of the MetS (Table 1). Visceral fat accumulation determined by CT scan has been demonstrated to have close correlation with the development of metabolic and CVD, so it is placed in pivotal position of the new definition and an essential component [20].

The IDF Consensus group have recommended cut points for central obesity based on waist circumference which are applicable to individual ethnic groups (Table 1) [21,22]. It was also decided that the definition should be less ‘glucose-centric’. Moreover insulin resistance was omitted as a component as other components such as waist circumference and triglycerides are so highly correlated with insulin resistance [29], so few of those with insulin resistance would be missed.

The thresholds of other components were similar to those used in the ATPIII except for glucose, where the cutoff of 5.6 mmol/l (100 mg/dl) recommended by the American Diabetes Association was adopted for impaired fasting glucose [20].

<table>
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<tr>
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<tbody>
<tr>
<td>Insulin resistance</td>
<td>None</td>
<td>None, but any 3 of the following 5 features</td>
<td>IGT, IFG, T2DM, or lowered insulin sensitivity* plus any 2 of the following</td>
<td>Plasma insulin &gt;75th percentile plus any 2 of the following</td>
<td>IGT or IFG plus any of the following based on clinical judgment</td>
</tr>
<tr>
<td>Body weight</td>
<td>Increased WC (population specific) plus any 2 of the following</td>
<td>WC ≥ 102 cm in men or ≥ 88 cm in women</td>
<td>Men: waist-to-hip ratio &gt;0.90; women: waist-to-hip ratio &gt;0.85 and/or BMI &gt;30 kg/m²</td>
<td>WC ≥ 94 cm in men or ≥ 80 cm in women</td>
<td>BMI ≥ 25 kg/m²</td>
</tr>
<tr>
<td>Lipid</td>
<td>TG ≥ 150 mg/dL on TG Rx or HDL-C &lt;40 mg/dL in men or &lt;50 mg/dL in women or on HDL-C Rx</td>
<td>TG ≥ 150 mg/dL</td>
<td>TG ≥ 150 mg/dL and/or HDL-C &lt;35 mg/dL in men or &lt;39 mg/dL in women</td>
<td>TG ≥ 150 mg/dL and/or HDL-C &lt;39 mg/dL in men or women</td>
<td>TG ≥ 150 mg/dL and HDL-C &lt;40 mg/dL in men or &lt;50 mg/dL in women</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>≥ 130 mm Hg systolic or ≥ 85 mm Hg diastolic on hypertension Rx</td>
<td>≥ 130/85 mm Hg</td>
<td>≥ 140/90 mm Hg</td>
<td>≥ 140/90 mm Hg or on hypertension Rx</td>
<td>≥ 130/85 mm Hg</td>
</tr>
</tbody>
</table>
and higher CVD risk [32]. Since there is a strong connection between
Risk Factors plays an important role in insulin resistance [39-42].

Diabetes Mellitus defines impaired fasting glucose as >100 mg/dL (5.6
mmol/L) but <126 mg/dL (7.0 mmol/L) and impaired glucose
tolerance as 2-hour oral glucose tolerance test values >140 mg/dL (7.8
mmol/L) [33].

The Expert Committee on the Diagnosis and Classification of
Diabetes Mellitus defines impaired fasting glucose as >100 mg/dL (5.6
mmol/L) but <126 mg/dL (7.0 mmol/L) and impaired glucose
tolerance as 2-hour oral glucose tolerance test values >140 mg/dL (7.8
mmol/L) [33].

**Table 1: Proposed Criteria for Clinical Diagnosis of the MetS**

<table>
<thead>
<tr>
<th>Glucose</th>
<th>IGT, IFG, or T2DM</th>
<th>IGT or IFG (but not diabetes)</th>
<th>Microalbuminuria (urinary average excretion rate ≥ 20µg/min or albumin-creatinine ratio ≥ 20 mg/g)</th>
<th>Other features of insulin resistance²</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 100 mg/dL (includes diabetes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;110 mg/dL (includes diabetes)¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>IDF: International Diabetes Federation; NCEP: National Cholesterol Education Program; WHO: World Health Organization; EGIS: European Group for Studying Insulin Resistance; AACE: American Association of Clinical Endocrinology; IGT: Impaired Glucose Tolerance (2-h glucose ≥ 140 mg/dL); IFG: Impaired Fasting Glucose (110 ≤ fasting glucose ≤ 126 mg/dL); T2DM: Type 2 diabetes Mellitus; WC: Waist Circumference; BMI: Body Mass Index; TG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; Rx: Recommended Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹The 2001 definition identified fasting plasma glucose of ≥ 110 mg/dL (6.1 mmol/L) as elevated. This was modified in 2004 to be ≥ 100 mg/dL (5.6 mmol/L), in accordance with the American Diabetes Association’s updated definition of IFG.

²Includes family history of T2D mellitus, polycystic ovary syndrome, sedentary lifestyle, advancing age, and ethnic groups susceptible to T2D mellitus.

**Risk Factors**

Nutritionally-related pattern have changed considerably in the
Middle East countries during recent years because of social
development in the absence of steady economic growth and changes in
dietary and physical activity pattern [30]. Bear all these facts in mind,
the main risk factors of the MetS are the followings:

**Insulin resistance**

Insulin resistance, implying depressed cellular sensitivity to insulin
[31], is present in the majority of people with the MetS which strongly
associates with other metabolic risk factors and also CVD risk [32].

The obesity epidemic is considered by ATP III as mainly responsible
for the increasing prevalence of MetS [32]. Obesity has been strongly
associated with insulin resistance [34], T2DM [35] and the MetS [36]
and higher CVD risk [32]. Since there is a strong connection between
abdominal obesity and metabolic risk factors , ATP III defined the
MetS as a clustering of metabolic complications of obesity [32].

It is claimed that intra-abdominal fat and visceral adipose tissue are
strongly associated with insulin resistance and therefore the MetS than
other adipose tissue compartments [37,38]. It is noteworthy to
mention that, several studies declared that subcutaneous truncal fat
plays an important role in insulin resistance [39-42].

Researchers suggest that sensitivity of individuals to changes in
body fat is genotype-dependent [43,44]. Some results identified
quantitative trait loci with significant effects on adipocyte-derived
protein and revealed the emergence of a consistent pattern of linkage
results for obesity-related traits across a number of human populations
[45]. Also it is suggested that genetic factors explain 50 to 90% of the
variance in BMI in twins and estimates of parent–offspring and sibling
correlations in agreement with heritabilities of 20 to 80% is generally
reported [46]. Common genetic polymorphisms are important
determinants of obesity [47,48], such as the Trp64Arg variant in the
Beta-3 adrenergic receptor gene and the Val103Ile variant in the
MC4R receptor [49].

Among different countries in the Middle East region there is
significant heterogeneity in obesity prevalence [50]. In Iran the
prevalence of obesity was shown to be 22.3% among adults (30.6% in
females and 14.2% in males) [51]. In 2005, among urban Iranians aged
15-70 years the prevalence rate was between 22% and 40% [52]. As
reported in these studies, Iranian females have a higher prevalence of
obesity compared to men. In other Middle East countries such as
Saudi Arabia (24% in females and 16% in males, age ≥ 15 years) [53],
Oman (23.8% in females and 16.7% in males, age ≥ 20 years) [54],
Lebanon (18.8% in females and 14.3% in males, age ≥ 20 years) [55]
and Turkey (24.6% vs. 14.4% in males, age ≥ 20 years) [56] the
prevalence is higher in women the same as Iran.

**Hypertension**

Hypertension is listed among the MetS components [57]. It is the
most important MetS risk factor that predisposes to increased
cardiovascular morbidity and mortality [58]. Elevated blood pressure
strongly associates with central obesity and insulin resistance [32,59].
In a worldwide survey, 26.4% of the adult population in 2000 had
hypertension (26.6% of men and 26.1% of women), and 29.2% were
projected to have this condition by 2025 (29.0% of men and 29.5% of
women) [60]. The number of adults with hypertension in 2025 was
predicted to increase by about 60% to a total of 1.56 billion [60]. In
a survey done in Iran in 2007, the prevalence rate of hypertension was
26.6% (28.6% in females and 24.7% in males) [51]. In 2003, the
prevalence of hypertension in Turkey is 31.8% (36.1% in females and
27.5% in males, age ≥ 18 years) [61], which is higher than the rate in
Iran. In another study done among a Turkish population, the
prevalence of SBP ≥ 140 mmHg was 12.0% and of DBP ≥ 90 mmHg
was 8.2% [62]. The age-adjusted prevalence of hypertension in Oman
was shown to be 38.3% [63]. Subjects with impaired fasting glucose,
diabetes, or hypercholesteremia and obesity were more likely to have
hypertension [63].

**Physical inactivity**

Changes of occupations, advent of newer technologies, and rapid
pace of urban life have increasingly brought about more sedentary
work and less energy expenditure [1]. Data from the World Health
Survey (2002–2003) conducted in 51 countries, most of which were
developing countries showed that about 15% of men and 20% of
women were at risk for chronic diseases due to physical inactivity [64].
The prevalence of physical inactivity at less than the levels
recommended for enhancing health is high in both developing (from
17 to 91%) and developed countries (from 4 to 84%) [65].
Immigrant women from Iran and Turkey had higher prevalence of abdominal obesity, an unfavorable lipid profile, and a high degree of physical inactivity during leisure time compared with women born in Sweden which may predispose for a higher incidence of diabetes and atherosclerotic cardiovascular disease [66]. The mentioned study indicates important ethnic differences in cardiovascular disease risk factor pattern [66]. In Saudi Arabia, inactivity prevalence was very high (96.1%) and women were more inactive than men (98.1% vs. 93.9%) [67]. It reveals that the majority of men and women in Saudi Arabia did not reach the recommended physical activity levels necessary for promoting health and preventing diseases [67].

In addition to sedentary life which has resulted in an epidemic of metabolic disorders and excessive body fat accumulation, it was demonstrated that the collective genome of the microorganisms inhabiting our body, known as the microbiome- may have a great role in the pathogenesis of obesity given its direct interaction with environmental factors [68]. Individuals with a low bacterial richness were characterized by more marked overall adiposity, insulin resistance and dyslipidaemia and a more pronounced inflammatory phenotype when compared with high bacterial richness individuals [68,69]. Human microbiome varies among individuals depending on age, diet, and geographical distribution and has been linked with important human diseases, including inflammation-linked disorders, such as allergies, obesity, and inflammatory bowel disease [70,71]. The relative proportion of Bacteroidetes is decreased in obese people by comparison with lean people, which increases with weight loss on low-calorie diets [72]. These reports indicated that the low glycemic index and rich fiber diets may influence the gene expression capacity of the gastrointestinal microbiome. It does not need, here to discuss about the probably microbiome gene mutations those could change the functions of the gene even in presence of mentioned healthy diets.

It was indicated that individual differences in habitual physical activity level are characterized by a significant genetic component [43]. Gene expression alterations by exercise deficiency contribute to morbidity and mortality, which highlights the importance of using the evolutionary pressures that have shaped human physiological responses to define better the functions for exercise-induced changes in gene expression in both physiological and pathophysiological conditions [73].

**Dyslipidemia**

Atherogenic dyslipidemia includes elevated serum triglyceride and apolipoprotein B (apoB), increased small LDL particles, and a reduced level of HDL cholesterol [74].

It’s suggested that some genetic and environmental factors affect the prevalence of lipid abnormalities [75-77]. Strong single-gene effects are found for low-density lipoprotein (LDL) cholesterol, lipoprotein (a) (Lp(a)), low-density lipoprotein (HDL) cholesterol, and high apolipoprotein (apo) B [78]. Kathiresan et al. [79] identified 30 distinct loci associated with lipoprotein concentrations (each with P <5 10^-8) and suggested that the cumulative effect of multiple common variants contributes to polygenic dyslipidemia. The Ala54Thr polymorphism in the fatty acid-binding protein 2 (FABP2) gene as well as the T–455C and C–482T polymorphisms in the apolipoprotein C-III (APOC3) gene promoter have been associated with features of the MetS in specific populations [80]. An interaction of the hepatic lipase (HL) promoter polymorphism with lipid-lowering medications in determining the level of HL activity has been also reported [81].

Low HDL-C was shown to be the most common metabolic abnormality in both sexes in studies done in Iran and Oman [5,82]. Among Iranian adolescents, low serum HDL and high serum triglyceride were the most common components of the MetS [83]. The prevalence of total hypercholesterolemia (TC ≥ 200 mg/dl) and hypertriglyceridemia (TG ≥ 150 mg/dl) was estimated to be 42.9% (45.4% in females and 40.4% in males) and 36.4% among Iranian adults (33.2% in females and 39.6% in males) in 2007, respectively [51]. In Saudi Arabia the prevalence of hypertriglyceridemia was 40.3% (47.6% in males, 33.7% in females) [84] and hypercholesterolemia was 54% (54.9% among males and 53.2% for females) [84]. In a Turkish study, low HDL-C and hypertriglyceridemia were present in 31.8% and 30.7% subjects diagnosed with MetS [56].

**Other risk factors**

Some research suggest that various factors such as rapid nutrition transition [1,85], rural-to-urban migration [1,7,86-89], increasingly sedentary occupations and life style such as smoking [6,90-93], and maternal-fetal factors [1] may influence the prevalence rate of the MetS and obesity. In one survey, it was revealed that a Mediterranean-style diet might play a role in reducing the inflammatory state and endothelial dysfunction associated with the MetS [94]. Moreover, the diet reduced the components of the syndrome and the overall prevalence of the MetS was reduced by approximately one half [94]. Additionally, it was found that the prevalence of diabetes, obesity, hypertension and MetS decreased with high educational levels [95-100].

Several studies demonstrated there are some diseases and conditions associated with higher incidence of the MetS. For instance, MetS was 9.1 times more likely to be present in subjects with obstructive sleep apnea, since this disease was independently associated with increased systolic and diastolic blood pressure, higher fasting insulin and triglyceride concentrations, decreased HDL cholesterol and increased cholesterol: HDL ratio which are the MetS risk factors [101]. Factors such as lower adiponectin concentration levels is strongly associated with the clinical phenotype of the MetS which may be useful factor for management of this syndrome [102]. In another survey, MetS was significantly more common in psoriatic patients after the age of 40 years while these patients also had a higher prevalence of hypertriglyceridaemia and abdominal obesity, whereas hyperglycaemia, arterial hypertension and high-density lipoprotein cholesterol plasma levels were similar [103]. The MetS is highly prevalent in US schizophrenia patients with the rate of 40.9% and 42.7%, respectively using the NCEP and AHA derived criteria, higher among women which stand for more cardiovascular risk [104]. In women with PCOS, the prevalence of the MetS and its components are more common leading to higher risk for cardiovascular disease [105].

Although there is evidence available in humans indicating that dietary fat quality influences metabolic abnormalities [106], the relation between nutrition, MetS, and atherosclerosis is complicated and intriguing [107].

Systemic responses to exposure to environmental chemical factors could potentially increase the risk of obesity [108], metabolic syndrome and insulin resistance [109], hypertension and non-alcoholic fatty liver diseases [110]. Harmful air pollutants lead to cardiovascular diseases such as artery blockages leading to heart attack and death of heart tissue due to oxygen deprivation, leading to permanent heart damage [111]. Moreover, impaired synthesis of hemoglobin and anemia, respiratory diseases, malignant disease,
hypertension, kidney damage, miscarriages and premature infants, nervous system disorders, brain damage, male infertility, loss of learning and behavioral disorders in children are from the negative effects of high concentrations of the air pollution in the body [111].

While some researchers suggest that hemodynamic, hepatic, inflammatory and psychological factors, microalbuminuria, prothrombotic and proinflammatory state in combination with the race and ethnicity are associated with the MetS prevalence [6,50,112-118], greater efforts are needed to investigate the score of each one as a risk factor of MetS.

Epidemiology of the Metabolic Syndrome in the Middle East Countries

The MetS is increasing in line with the rising prevalence of obesity in developing countries. High prevalence of the MetS has been reported from the Middle East countries; Iran [119], Turkey [120], Saudi Arabia [121,122], and United Arab Emirate [123] (Table 2). The prevalence rates are also high in Egypt [124], Qatar [125], Jordan [126,127] and Lebanon [128].

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Country/region</th>
<th>Age (yr)</th>
<th>Sample (n)</th>
<th>Criterion for diagnosis</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarrafzadegan et al. 2008 [130]</td>
<td>Iran, urban and rural areas of 3 cities in Iran. Iran, urban and rural areas of all 30 provinces</td>
<td>≥ 19 25-64</td>
<td>12,514 adults 3024</td>
<td>ATP III ATP III IDF ATPIII/AHA/NHLBI</td>
<td>23.3 10.7 35.1</td>
</tr>
<tr>
<td>Delavari et al. 2009 [136]</td>
<td>Iran, urban and rural areas of all 30 provinces</td>
<td></td>
<td></td>
<td></td>
<td>34.7</td>
</tr>
<tr>
<td>Azizi et al. 2003 [5]</td>
<td>Iran, Capital, Tehran</td>
<td>≥ 20</td>
<td>10,368 of the adults 4,397 / 5,971</td>
<td>ATP III</td>
<td>30.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24 42 age-standardized prevalence: 33.7</td>
<td></td>
</tr>
<tr>
<td>Delavar et al. 2009 [134]</td>
<td>Iran, North, Babol</td>
<td>30-50</td>
<td>984 women</td>
<td>ATP III</td>
<td>31.0</td>
</tr>
<tr>
<td>Hashemi et al. 2012 [132]</td>
<td>Iran, South East, Zahedan</td>
<td>≥ 19</td>
<td>1,802 (735 men and 1,067 women)</td>
<td>NCEP ATP III IDF IDF -AHA/NHLBI</td>
<td>15.4 24.9 20.0 28.1</td>
</tr>
<tr>
<td>Azimi-Nezhad et al. 2009 [137]</td>
<td>Iran, East, Khorasan province</td>
<td>15-65</td>
<td>2483 men and 2445 women</td>
<td>ATP III</td>
<td>39.9</td>
</tr>
<tr>
<td>Sharifi et al. 2009 [138]</td>
<td>Iran, West, Zanjan</td>
<td>≥20</td>
<td>2941 (1396 men and 1545 women)</td>
<td>ATP III</td>
<td>23.1 24.4</td>
</tr>
<tr>
<td>Mousavi et al. 2009[133]</td>
<td>Iran, Centre, Isfahan</td>
<td>&gt;20</td>
<td>6,331 women</td>
<td>ATP III</td>
<td>34.2</td>
</tr>
<tr>
<td>Kozan et al. 2006 [120]</td>
<td>Turkey, urban and rural (seven geographical regions)</td>
<td>20–90</td>
<td>2,108 men (1,372 in urban and 736 in rural areas) and 2,151 women (1,423 in urban and 728 in rural areas</td>
<td>ATP III</td>
<td>33.9 28 39.6</td>
</tr>
<tr>
<td>Sanisoglu et al. 2006 [100]</td>
<td>Turkey, in the seven main different regions</td>
<td>&gt;30</td>
<td>15,468</td>
<td>-</td>
<td>17.91 10.09 27.33</td>
</tr>
<tr>
<td>Aboul Ella et al. 2010 [124]</td>
<td>Egypt</td>
<td>10-18</td>
<td>4250</td>
<td>NCEP</td>
<td>7.4</td>
</tr>
<tr>
<td>Al-Daghri et al. 2010 [119]</td>
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<tr>
<td>Al-Nozha et al. 2005 [121]</td>
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<tr>
<td>Al-Lawati et al. 2003 [81]</td>
<td>Oman</td>
<td>≥ 20</td>
<td>1419</td>
<td>ATP-III</td>
<td>21 19.5 23.0</td>
</tr>
<tr>
<td>Malik et al. 2008 [123]</td>
<td>United Arab Emirates</td>
<td>≥ 20</td>
<td>4097</td>
<td>NCEP IDF</td>
<td>39.6 40.5</td>
</tr>
</tbody>
</table>
respectively. On the other hand, Zahedan (a southeastern city of Iran) the MetS in Iran [131]. Furthermore, the prevalence is higher in boys and girls in Tehran [83].

The prevalence of the MetS was 32.1%, 33.2% and 18.4% according to IDF, ATP III and WHO, respectively [129]. The result of another Iranian survey indicated the higher prevalence of the MetS in women, in urban areas, and in the 55- to 64-year age-group compared with the prevalence in men, in rural areas, and in other age-groups, respectively by NCEP/ATP III, IDF and modified ATP III/AHA/NHLBI definitions [119,130]. High socioeconomic status of family, medical history of parents and dietary habits were influencing factors in the prevalence of the MetS in Iran [131]. Furthermore, the prevalence is higher in Iranian women compared with men [5,130,132].

The MetS was estimated to affect >11 million Iranians [119]. Age-standardized prevalence of the MetS in Tehran -the capital of Iran- was reported to be 33.7% (24% in men and 42% in women) [5]. Using ATP III criteria, the prevalence of the syndrome in other cities of Iran was 34.2% and 31% in women of Isfahan [133] and Babol [134], respectively. On the other hand, Zahedan (a southeastern city of Iran) showed lower prevalence of MetS: 21.0% (15.4% in male, 24.9% female) using NCEP, ATP III criteria [132].

Different studies reported a considerably high prevalence of the MetS among Iranian youth [10]. Among 622 high school girls in Mashhad aged 15-17, the prevalence was 6.5% and increased to 45.1% in obese subjects [131]. Also there was 10.1% prevalence among 3,036 boys and girls in Tehran [83].

In a Turkish study, the prevalence of obesity and MetS was shown to be high (35.08% and 17.91% respectively), particularly among women, but the prevalence of hypertension and hypercholesterolemia was relatively low in Turkish people [100]. Although another study reported a higher prevalence of the MetS in Turkish adults (27% in men and 38.6% in women) [135]. The overall prevalence of MetS in a Qatari population was 26.5% and 33.7% according to ATP III and IDF criteria, more common among women [125]. Age and BMI were indicated the higher prevalence of the MetS in women, in urban areas, and in other age-groups, respectively by NCEP ATP III criteria, the prevalence of the syndrome in other cities of Iran revealed that some factors like high maternal BMI, low levels of cardiorespiratory fitness and physical activity independently contribute to the MetS and small increases in physical activity may significantly diminish the risk of MetS in healthy children [142].

In Egypt, the prevalence of the MetS is considerable among adolescents (with overall prevalence of 7.4%), particularly among obese participants [124], which is in line with Iran’s prevalence rate. Family history of obesity and diabetes mellitus significantly increased the prevalence of MetS significantly as well as inactivity [124]. The prevalence of the MetS manifestations among Arab children is extremely high and dyslipidemia is the most common MetS abnormality [119,136-140].

### Table 2: Prevalence of the metabolic syndrome in Iran and Middle East countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Male</th>
<th>Female</th>
<th>Sample (n)</th>
<th>Age (yr)</th>
<th>Country</th>
<th>Author and year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar</td>
<td>1496</td>
<td>NCEP</td>
<td>2109 2184</td>
<td>30-64</td>
<td>France</td>
<td>Balkau et al. 2003 [146]</td>
</tr>
<tr>
<td>Cyprus</td>
<td>20-80</td>
<td>IDF</td>
<td>1200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>1121</td>
<td>NCEP</td>
<td>111 Royal Jordanian Air Force pilots</td>
<td>18 (age adjusted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>18-65</td>
<td>IDF</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is a paucity of data on prevalence of the MetS from other Middle East countries: Kuwait, Omani, Cyprus, Bahrain, Syria, Yemen, Iraq, and Palestine.

In a study done among Iranian adults, the overall prevalence of the MetS was 32.1%, 33.2% and 18.4% according to IDF, ATP III and WHO, respectively [129]. The result of another Iranian survey indicated the higher prevalence of the MetS in women, in urban areas, and in the 55- to 64-year age-group compared with the prevalence in men, in rural areas, and in other age-groups, respectively by NCEP/ATP III, IDF and modified ATP III/AHA/NHLBI definitions [119,130]. High socioeconomic status of family, medical history of parents and dietary habits were influencing factors in the prevalence of the MetS in Iran [131]. Furthermore, the prevalence is higher in Iranian women compared with men [5,130,132].

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In Egypt, the prevalence of the MetS is considerable among adolescents (with overall prevalence of 7.4%), particularly among obese participants [124], which is in line with Iran’s prevalence rate. Family history of obesity and diabetes mellitus significantly increased the prevalence of MetS significantly as well as inactivity [124]. The prevalence of the MetS manifestations among Arab children is extremely high and dyslipidemia is the most common MetS abnormality [119,136-140].

### Prevalence of Metabolic Syndrome in Some of European and American Countries

In most countries, between 20% and 30% of the adult population can be characterized as having the MetS and it is even higher in some populations or segments of the population [39,141]. With increasing affluence and aging of the population, the prevalence rises undoubtedly [141].

In a cohort study done among European youth, the prevalence of MetS was 0.2% and 1.4% in 10- and 15-y-olds, respectively [142]. They declared that some factors like high maternal BMI, low levels of cardiorespiratory fitness and physical activity independently contribute to the MetS and small increases in physical activity may significantly diminish the risk of MetS in healthy children [142].

A study based on 11 prospective European cohort studies, reported that the overall prevalence of the MetS was slightly higher in non-diabetic adult men (15.7%) than in women (14.2%) and these groups have an increased risk of death from all causes as well as cardiovascular disease [143]. The prevalence rates of MetS in different European and American countries have been shown in Table 3 (Figure 1).

<table>
<thead>
<tr>
<th>Prevalence (%)</th>
<th>Criterion for diagnosis</th>
<th>Sample (n)</th>
<th>Age (yr)</th>
<th>Country</th>
<th>Author and year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Female</td>
<td>NCEP</td>
<td>D.E.S.I.R.</td>
<td>30-64</td>
<td>France</td>
<td>Balkau et al. 2003 [146]</td>
</tr>
<tr>
<td>5.9% in men and 2.1% in women at t0</td>
<td>NCEP ATP III</td>
<td>371 apparently healthy families</td>
<td>31.2</td>
<td>France</td>
<td>Maumus et al. 2005 [147]</td>
</tr>
</tbody>
</table>
From 1999 to 2002, the prevalence of MetS increased from 11.0% to 12.8% in men and from 7.2% to 8.8% in women (from the STANISLAS cohort). From 1999 to 2002, the prevalence of MetS increased from 11.0% to 12.8% in men and from 7.2% to 8.8% in women (from the STANISLAS cohort)

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Prevalence (men, women)</th>
<th>Definition</th>
<th>Country</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 [152]</td>
<td>13.7/20.6</td>
<td>ATP III</td>
<td>Northwest Russia, Arkhangelsk</td>
<td>Sidorenkov O et al. 2010</td>
</tr>
<tr>
<td>2009 [113]</td>
<td>13.7/20.6</td>
<td>ATP III</td>
<td>Canada</td>
<td>Riediger et al., 2011</td>
</tr>
</tbody>
</table>

Table 3: Prevalence of the metabolic syndrome in some European and American countries.

Several studies have been performed in US reporting the prevalence of the MetS [6,85,144,145]. In a study done by Park et al. [6], the MetS was present in 22.8% and 22.6% of US men and women, respectively which varies substantially by ethnicity and several potentially modifiable lifestyle factors. For instance, older age, postmenopausal status, Mexican American ethnicity, higher body mass index, current smoking, low household income, high carbohydrate intake, no alcohol consumption, and physical inactivity were associated with increased odds of the MetS [6]. Increases in high blood pressure, waist circumference, and hypertriglyceridemia accounted for an increase in the prevalence of the MetS, particularly among women in another US study [144]. The use of the IDF definition of the MetS leads to a higher prevalence estimate of the MetS than the estimate based on the NCEP definition in the US (39.0 ± 1.1% vs. 34.5 ± 0.9%) [145].

In a French cohort study, the age-specific frequency of the MetS is more than 2.5 times higher than in US and this ratio increased with age [146]. In another French study, Mets was associated with other hemodynamic, hepatic, inflammatory and psychological risk factors, and with a 70% increase in all-cause mortality [112].

Azimi-Nezhad et al. [18] investigated the difference in the prevalence of MetS between an Iranian and a French population. According to ATP III the prevalence of MetS 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%), among 1,386 French and 1,194 Iranian adults. High prevalence of low HDL-C concentrations in the Iranian population, especially in Iranian women, compared with French women was the main finding of the study.
Conclusion and Suggestions

Prevalence of the MetS and its components has shown a rapid rise in developing countries in the past few decades leading to increased risk of CVD and consequent morbidity and mortality. For this reason, there is an urgent need to develop better approaches in order to prevent and manage the syndrome and strike at the underlying causes.

The pattern of the components of metabolic syndrome varies in the Middle East region in comparison with Europe and North America. In addition to differences of diet behaviors, the genetic factors and some of geographic dependent elements may influence the variation of metabolic syndrome architecture worldwide particularly in the Middle East region. Therefore, the study of differences between for example; gastrointestinal microbiomes and obviously the regional prevalent nutro-microorganisms, the European people and Middle Eastern individuals is recommended.

Both genetic and environmental factors seem to contribute to MetS prevalence. Studies have shown that genetic factors play a significant role in the prevalence of MetS risk factors. It is suggested that sensitivity of individuals to changes in body fat are genotype-dependent. Also insulin resistance and type 2 diabetes mellitus (NIDDM) are multi-factorial in origin with both genetic and environmental factors contributing to their development. Moreover, the intersection of both lipid abnormalities and hypertension involving some of genetic and environmental factors is of special interest in some families. Genetic component also affects the individual habitual physical activity level by some indications and the propensity toward being spontaneously active could be partly influenced by the genotype.

As populations differ in prevalence of many complex genetic diseases which are probably influenced by the level of gene expression [154-158], we suggest that more researches should be done on allele frequency differences at regulatory polymorphisms which may account for some differences in prevalence of MetS.

References


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