Journal of Nutrition and Metabolism

Change in Nutrition and Lifestyle in the Eastern Mediterranean Region: Health Impact

Guest Editors: Abdulrahman O. Musaiger, Hazzaa M. Al-Hazzaa, Hamed R. Takruri, and Najat Mokhtar

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Editorial Board

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 436762, 2 pages
doi:10.1155/2012/436762

Editorial

Change in Nutrition and Lifestyle in the Eastern Mediterranean Region: Health Impact

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Received 10 April 2012; Accepted 10 April 2012

According to World Health Organization, the Eastern Mediterranean Region (EMR) refers to all Arab countries, excluding Algeria, in addition to Iran, Pakistan, and Afghanistan. These countries have faced marked changes in their demographic, socioeconomic, and health status during the last thirty years. These changes have been reflected in changes in the lifestyle of the population including access to modern amenities. The lifestyle changes have affected levels of physical activity and have also included introduction of a range of processed foods. New foods and food ingredients have been introduced to the diet in this region to varying extents. Similar to populations in many developing countries, the populations of EMR countries are experiencing a nutrition transition characterized by replacement of traditional diets with diets higher in fat, refined sugar, and processed foods. These changes in dietary patterns and lifestyles have been associated with high prevalence of diet-related chronic diseases such as obesity, cardiovascular diseases, type 2 diabetes mellitus, cancer, and osteoporosis in the EMR countries.

The paper by A. C. Fahed et al. presents the relationship between diet, genetics, and diseases in the Middle East and North Africa (MENA). There are different mechanisms in this region through which diet-genetics interaction affects non communicable diseases metabolism and micronutrient pathways and contributes to diseases, including deficiencies in.calcium, iron, folate, and vitamins D, C, and E. The paper by E. S. Al-Eisa and H. I. Al-Sobayel is on physical activity and health beliefs among Saudi women. The findings revealed a high level of inactivity among Saudi women in reference to the international recommendation for minimum activity, and there was significant association between physical activity and health beliefs. The paper by E. Bakhshi et al. addresses the association between age and weight gain in Iranian women. Age was directly associated with overweight and obesity among these group. Women aged 20–40 years have highest weight compared to other age groups.

The paper by D. El Khoury and S. Antoine-Jonville assesses the prevalence of nutritional supplements intake and potential influencing factors among people excercising in gyms in Beirut, Lebanon. The intake of nutritional supplements was found to be 36.3%, with weak presence of medical supervision. Age and sex were associated with patterns of nutritional supplements. The paper by A. A. Al-Nuaim et al. studies the prevalence of physical activity and sedentary behaviours relative to obesity in Saudi adolescents. It was found that adolescents living in rural desert were less physically active than those living in urban or rural farm environment. The results also revealed that male adolescents were more active than females and physical activity levels declined with age.

The paper by A. O. Musaiger et al. focuses on establishing food based dietary guidelines (FBDG) for Arab countries in

the Gulf. This is the first attempt to establishing such guidelines in the region. The paper summarizes the steps taken to develop these guidelines. The FBDG consist of 14 simple and practical advices to prevent and control nutrition-related diseases in these countries. The paper by S. Mehdad et al. assesses obesity indicators and fasting blood glucose among adolescents in Morocco. Body mass index (BMI) and waist circumference (WC) were closely associated with fat mass and body fat. However, these associations depended on geneder and weight status, and Body mass index (BMI) may provide a bett proxy estimate of overall obesity than waist circumference (WC). However, both of them are useful tools to identify adolescents at increased risk of developing excess body fat and high level of fasting blood glucose.

The papers in this special issue provide useful information on change in lifestyle and nutrition status in the Eastern Mediterranean countries. Information provided support actions needed to promote healthy lifestyle and healthy eating among children, adolescents, and adults to prevent and control of nutrition-related diseases. We hope that this special issue will stimulate other investigators to carry out further studies on changes in lifestyle and patterns of diseases in this Region.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 109037, 19 pages
doi:10.1155/2012/109037

Review Article

Diet, Genetics, and Disease: A Focus on the Middle East and North Africa Region

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Received 31 August 2011; Accepted 27 November 2011

Academic Editor: Hamed R. Takruri

The Middle East and North Africa (MENA) region suffers a drastic change from a traditional diet to an industrialized diet. This has led to an unparalleled increase in the prevalence of chronic diseases. This review discusses the role of nutritional genomics, or the dietary signature, in these dietary and disease changes in the MENA. The diet-genetics-disease relation is discussed in detail. Selected disease categories in the MENA are discussed starting with a review of their epidemiology in the different MENA countries, followed by an examination of the known genetic factors that have been reported in the disease discussed, whether inside or outside the MENA. Several diet-genetics-disease relationships in the MENA may be contributing to the increased prevalence of civilization disorders of metabolism and micronutrient deficiencies. Future research in the field of nutritional genomics in the MENA is needed to better define these relationships.

1. Introduction

Over the past few decades, the MENA has been witnessing significant changes in food habits paralleled by an important preponderance of metabolite-related diseases. In a region whose traditional diet is known to be healthy due to high vegetable proteins, fibers, minerals, and vitamins with low content of unfavorable food products, the "industrialization/westernization of the diet" is a well-studied and documented phenomenon [1–3]. The MENA has been losing its traditional diet which was distinguished by its diversity and richness in raw foods, proteins, and multivitamins, in the favor of a more industrial diet which consists of increased preprocessed foods, sugars, fats, alcohol, animal products, saturated- and trans-fatty acids, and relatively less vitamins and minerals with decreased consumption of milk, fruits, and vegetables [4]. A big part of this change is attributed to the lifestyle changes and globalization with the invasion of western fast food to the MENA countries. Dietary choices, minimum physical activity, religious habits, consumer ignorance, high population growth rates, economic factors, and lack of both protection laws and food fortification programs are other critical factors that influence the nutritional status in the region [5]. These changes in dietary and lifestyle patterns contribute to an increase in the rates of micronutrients deficiencies, diet-related chronic diseases, and obesity in all groups of the population in the region [5]. Due to this grave impact on chronic diseases, diet became a target of public health initiatives that aim at restoring the traditional diet of MENA countries in order to improve health conditions in their populations [6–8]. The epidemiology of diet-related diseases in the MENA region and background information on the diet-genetics-disease interaction, followed by nutrigenomic examples on diet-related diseases in the MENA region, will be discussed for the first time in this paper.

2. Epidemiology of Diet-Related Diseases in the MENA

We review the numbers and trends for selected chronic metabolic diseases and micronutrient deficiencies in the different countries of the MENA where data are available

(Figure 1). Given the lack of nationwide data, prevalence rates are commonly reported as estimations [9, 10]. Since 1982, the need for "direct evidence of a secular [increase]" in diseases has been established, prospecting an association with "acculturation" of traditional or rural populations [11]. Still, the numbers show alarming trends for cardiovascular diseases and metabolic disorders, namely, insulin resistance, adiposity, dyslipidemias, and atherosclerosis. Likewise, micronutrient deficiencies (MNDs) have been heavily studied recently due to their crucial contribution to the global burden of many chronic diseases.

The region is witnessing an "explosion" of Type 2 Diabetes Mellitus (T2DM) according to the International Diabetes Foundation (IDF) (Figure 2(a)) with five countries of the MENA ranking among the top ten diabetic worldwide [15]. Similarly, the IDF reports an increase in the incidence of Type 1 DM in children of the MENA over the past decade (Figure 2(b)). The World Health Statistics of the WHO show a sharp rise in the prevalence of obesity (Figure 3), which is the most powerful and easily reported risk marker and hence the sole epidemiological WHO indicator for cardiovascular and metabolic comorbidities. In one epidemiological study, cardiovascular mortality in the MENA has been estimated to triple from 1990 to 2020 (Figure 4). Table 1 summarizes rates of cardiovascular diseases and two major comorbid risk factors, hypertension and the metabolic syndrome, with wide variations across countries of the MENA.

In the other category of diseases, deficiencies in vitamins and minerals affect particularly children and women of childbearing age. MNDs impair physical and mental development of children, exacerbate infections and chronic diseases, and impact morbidity and mortality. Most countries of the MENA have widespread MNDs, yet countries of the Gulf Cooperation Council, Iran, and Tunisia have moderate levels of MNDs [20]. Among MNDs, iron deficiency is the most prevalent nutritional problem in the MENA [21]. Its prevalence in the region varies from 17 to 70% among preschoolers, 14 to 42% among adolescents, and 11 to more than 40% among women of childbearing age. Severe iron deficiency is a direct cause of anemia. Nonnutritional genetic anemias are known to be relatively common in the region but will not be tackled because they are not affected by dietary factors. Nutritional deficiencies other than iron, such as folic acid, vitamin B12, and vitamin C, are also prevalent in some countries of the region but data are scarce [20]. The Middle Eastern and South Asian regions have the highest rates of Vitamin D Deficiency (VDD) worldwide [22]. The prevalence ranges of VDD in the MENA are 46–83% for adolescents and adults, and 50–62% among veiled women [5]. It reaches up to 70% in Iran [23] and 80% in Saudi Arabia [24]. Table 2 shows prevalence of VDD and iron deficiency in countries of the MENA where data are available.

3. The Dietary Signature on the Genome

The effect of food on gene function is the focus of nutritional genomics, an emerging field of study that focuses on the molecular, cellular, and systemic levels of this effect [25, 26]. The abundance of calories, macro- and micronutrients, and bioactive food elements constitutes the nutritional environment that alters the genome, the epigenome, the posttranscriptional regulation, and the posttranslational modifications, leading to a variety of metabolic functional gene-products, as shown in Figure 5. The nutritional environment channels the function of gene-products into certain pathways, preferring certain biological activities over others and resulting in the final phenotypic outcome and health-disease status. Correspondingly, two disciplines of nutritional genomics are entertained: nutrigenomics and nutrigenetics. The former started as a focus on the effect of nutrients on gene expression, while the latter, yet a different field of study, emerged in search of approaches to alter the clinical manifestations of certain rare diseases, such as certain inborn errors of metabolism, via personalized diet. The link between them is the functional gene product. It is the end-point in nutrigenomics and the starting point in nutrigenetics. Other conventional terminologies relevant to the diet-genetics-disease relation will also be treated in the following section, prior to discussion of the dietary signature on the genome in the MENA.

(1) The *genome sequence* of DNA base pairs dictates the primary genetic profile and hence gene function. DNA sequence variants—gene variants and single nucleotide polymorphisms (SNPs)—designate an alteration of gene structure with or without functional changes that might or might not lead to a complex gene-function relationship depicted in different diseases [27]. The epigenome, an emerging concept in genetic research, is a set of nongenetic factors, such as diet, that change the expressed gene outcome without affecting the structure of the DNA *per se*.

(2) *Nutrigenomics* considers environmental factors of alimentary source that may disrupt the DNA sequence in peptide-coding and in promoter regions, affecting the gene product. Other environmental nutrigenomic factors include abundance of macro and micronutrient components of the diet, presence of other bioactive food elements, and caloric content. Under- or overnutrition in the maternal environment sets epigenetic programming mechanisms via energetic control of function and oxidation. Through regulation of many biological functions including mitochondrial activity, cellular stress, inflammation, and telomere shortening, the dietary signature starts when epigenetic mechanisms induce or limit the risk to disease [28]. Possible levels of expression of a certain gene lie in a range of disease susceptibility that is determined by epigenetic mechanisms. These mechanisms are dictated by the functional profile of the cell, which obeys its nutritional state and reflects the nutritional environment.

(3) Although sustainability of *epigenetic programming* along life span is not well understood [28], two temporally distinct profiles may be distinguished. First, the basal epigenome is determined early on in life. Depending on the basal expressivity of DNA, it behaves like a permanently edited version of the genome. Accordingly, increasing evidence of trans-generational inheritance of epigenetics was found in mice [29] through the effect of grandmaternal nutrition on grandchildren during gamete stage, throughout the mother's fetal stage [30]. Second,

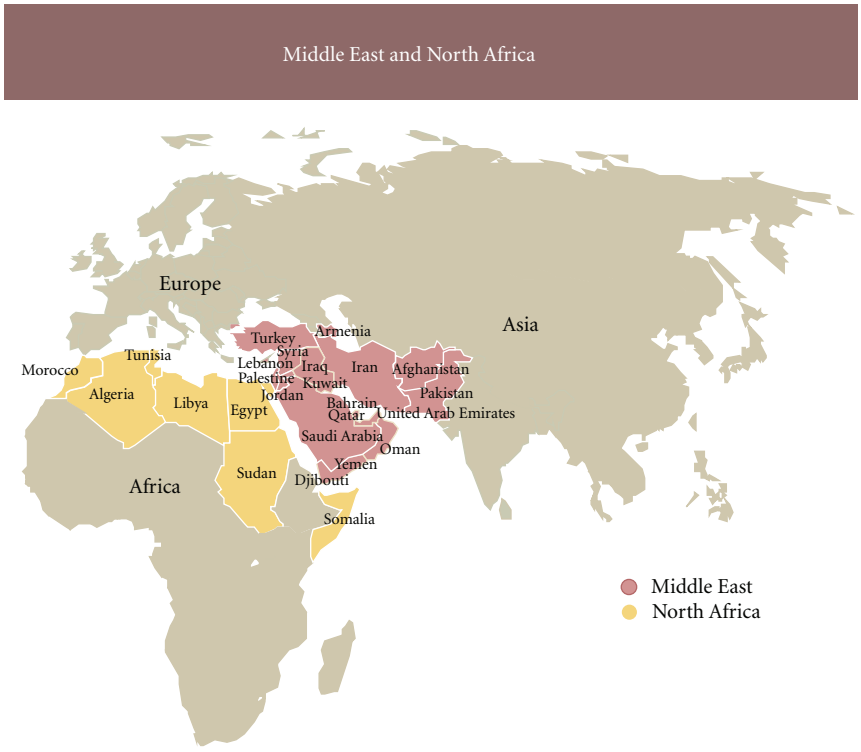

Figure 1: Map of the Middle East and North Africa (MENA) region. The MENA region includes countries such as Algeria, Armenia, and Turkey, that are not members of the WHO Eastern Mediterranean Region (EMR) that is referred to in the literature.

later in life, similar mechanisms affect gene expressivity in response to temporary environmental factors, resulting in a short-lived epigenetic profile. These changes are mainly due to interference of nutrients and bioactive food components with transcription factor conformations [26]. This signature serves as a means for the organism to receive information about its nutritional environment in order for the cells to execute appropriate modifications on the profile of expressed genes [31]. The nutrigenomic signature is not well studied in humans yet; however obvious importance is due to its impact on gene expression, chronic diseases susceptibility, and health status of future generations [31–33].

(4) Regulators of *posttranscriptional modifications* affect alternative RNA splicing which gives rise to different mature mRNA isoforms. Alternative splicing is as highly prevalent as in 35 to 59% of human genes [34]. Post-trancriptional regulators, such as microRNAs and their coacting and counteracting proteins, are part of the RNA and protein pools [35]. They are hence influenced by epigenetic and metabolic factors as well [26, 36].

(5) *Proteomics* is the study of the protein pool in the organism, as an integral part of the cellular function. On the other hand, the metabolome designates the structure, the localization, the post-translational modifications, and the functions of proteins and metabolites along with their interactions in the organism [37]. It defines the current metabolic state and active intracellular pathways in the organism (Figure 5). The functional gene products comprise all the potentially functional molecules and pathways, whether currently active or not, that result from a certain genome-epigenome combination, leading to a certain range of possible phenotypic outcomes, rather than a clearly defined health status.

(6) *Nutrigenetics* is a quite different approach that emerged when dietary interventions were able to successfully alter the course of certain diseases. The basic principle considers how the same dietary environment can result in different phenotypic outcomes of health or disease in metabolizers with different functional gene-products or programmed phenotypes [38]. The concept is similar to how individuals possess different phenotypes as drug-metabolizers. The study of genetic variations affecting nutrient metabolism, from digestion to detoxification, can decipher ambiguities in the diet-disease relationship [38]. However, the challenge lies in the ability of researchers to describe the processes through which the dietary environment imposes itself to precipitate metabolic disorders.

(7) Finally, hypotheses of *Thrifty Profile*, namely thrifty genes and thrifty phenotypes, offer explanations for etiology, predisposition, and rising prevalence of DM and obesity. Early life dietary habits foretell the basal appetite control and cellular nutritional needs through psychological and molecular habituations [28]. Thrifty genes that enable survival during periods of food shortages may have been conserved over generations under the selection pressure of under-nutrition [39]. Thrifty phenotypes may be due to early nutritional challenges that enhance nutrients-saving mechanisms in the growing individual, leading to excessive

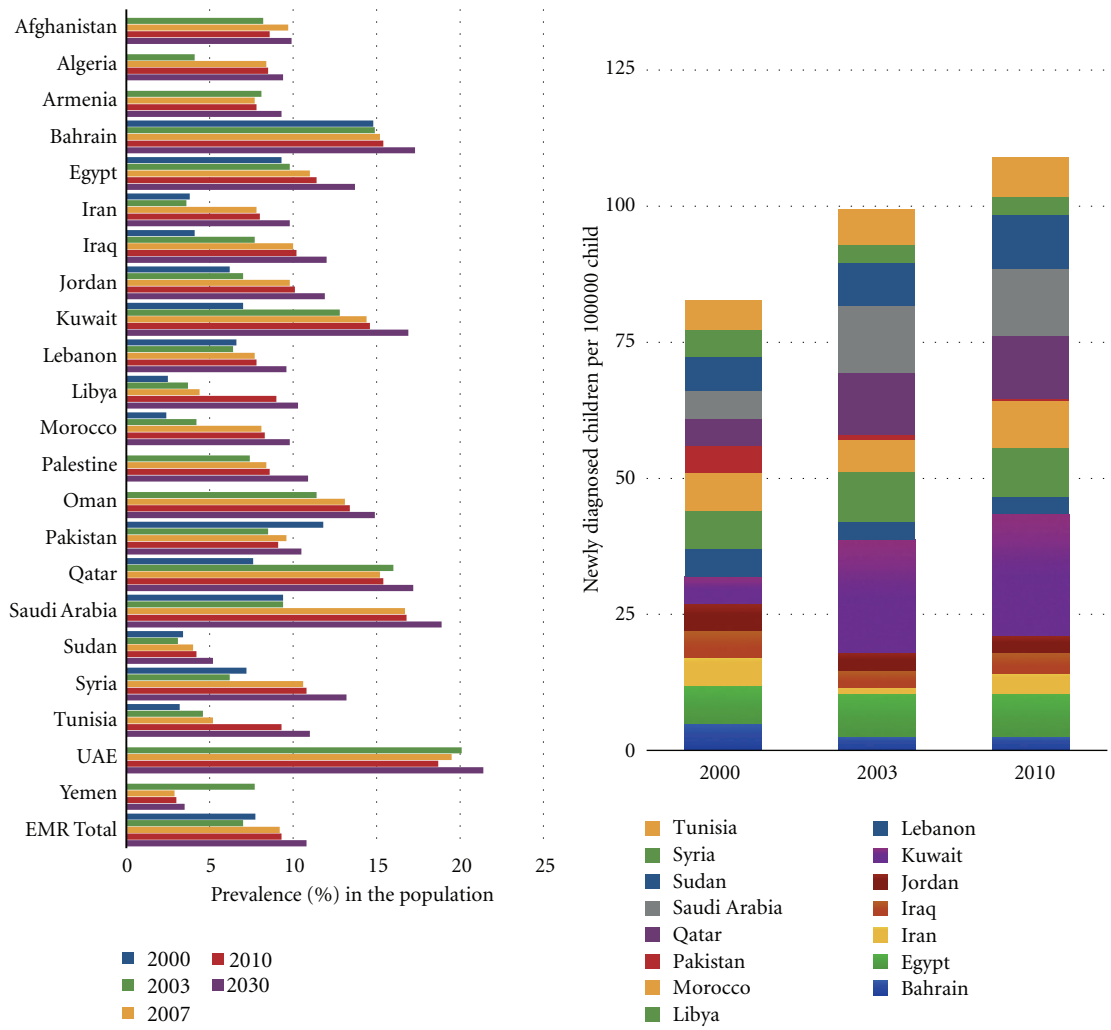

Figure 2: Increasing prevalence of diabetes mellitus in the MENA. (a) General increase in reported prevalence (%) of Type 2 Diabetes Mellitus in the MENA between the years 2000 and 2010. Numbers are reported as approximated by the International Diabetes Federation [12–15]. The expected 2-fold increase for the year 2030 is approximated based on demographic parameters, without accounting for changes in age strata or other risk factors [16]. (b) Overall growth in annual incidence (per 100,000) of Type 1 diabetes mellitus in children younger than 14 years old in the MENA. Numbers are estimations by the International Diabetes Federation based on various years between 1986 and 2000 [12–15].

storage later on and increased risk of metabolic disorders [40]. Both models have not gathered enough evidence apiece; however combined they provide a fertile base for further nutritional genomic research.

An example of a phenotype that has evolved accordingly is taste preferences and ability to digest, absorb, and appropriately respond to nutrients [41]. Genes for taste receptors, among other proteins that handle the metabolism of different nutrients, have been extensively studied. In an extensive review by Garcia-Bailo et al., an important aspect of the dietary signature is addressed: the genetic variations that affect dietary habits and food choices, with an emphasis on their effects on the nutritional environment and the health outcome [41].

Given the rise in multifactorial diseases, nutrigenetics started to involve public health research, hinting at personalized dietary recommendations for prevention of civilization diseases many years before clinical manifestations arise [31]. Adequacy of the general dietary recommendations to the ancient nature of our genes is becoming increasingly dubious. The human genome, as we know it, was sculpted throughout 2 million years of evolution under the diets of our hunters-gatherers ancestors [42]. Later on, the available food choices changed since the introduction of agriculture, but too rapidly for the ancestral stone-age genome to keep up with. This fast nutritional transition revealed evolutionary origins of obesity and diabetes among other civilization epidemics [43]. The experiment-based advancement of dietary recommendations during the past 25 years showed a convergence towards what looks more like a Paleolithic hunter-gatherer diet [44]. Despite low compliance to recommended diets and increasing industrialization of

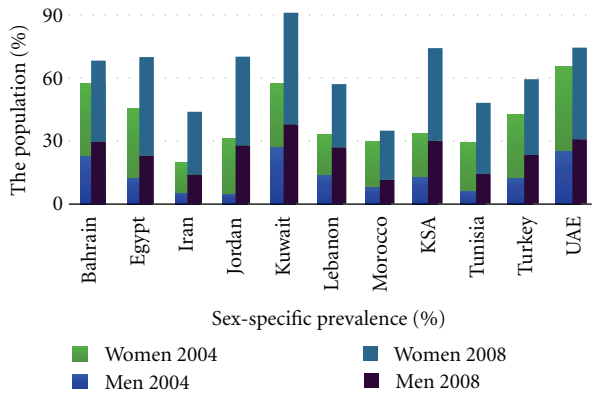

Figure 3: Increasing prevalence of obesity in the MENA. Prevalence (%) of obesity increased in both men and women in countries of the MENA between 2004 and 2008. Numbers are WHO estimates in World Health Statistics of 2005 and 2011. Totals of men and women are integrated for purposes of comparative illustration and do not represent adjusted arithmetic total prevalences. Obesity was defined as body mass index (BMI) $\geq 30\,\mathrm{Kg/m^2}$. Obesity data about Jordanian men in 2004 are not available, but prevalence was estimated to be less than that of women [17, 18]. KSA: Kingdom of Saudi Arabia; UAE: United Arab Emirates.

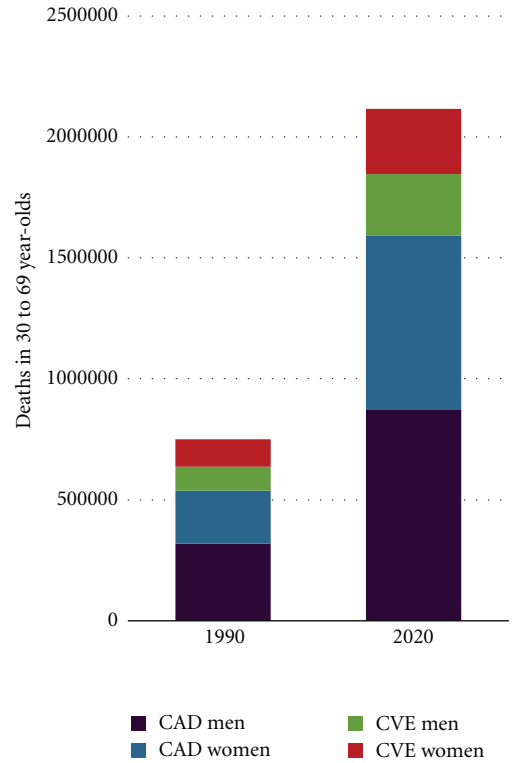

Figure 4: Expected overall increase in mortality due to cardiovascular diseases in the MENA [19]. CAD: Coronary Artery Disease; CVE: Cerebrovascular Event.

actual dietary habits, personalized and ancestral dietary recommendations still seem promising.

4. Nutritional Genomics in the MENA

Diet, genetics, and disease are linked in many ways as could be shown in Figure 5. The MENA is a region that has been witnessing simultaneously a dietary change and a worsening prevalence of chronic diseases. Because of this, nutritional genomics research in such a region can improve our understanding of this rapid change in disease prevalence and shed light on the genomic effects of this dietary transition in the region. Nutritional genomics research in the MENA is minimal. To our knowledge, this is the first review on the topic in the region. We aim to collate studies in MENA countries that discuss any aspect of the dietary signature that we discussed in Figure 5. We approach that using examples of common diseases with rising prevalence in the MENA. The paper discusses two categories of diseases: (1) civilization disorders of metabolism (cardiovascular diseases and metabolic risk factors), and (2) micronutrient deficiencies (MNDs).

We also look at other populations where nutritional genomics research in these disease categories was done and discuss how it applies to our region with recommendations for future research on MENA populations.

5. Diet-Related Civilization Disorders of Metabolism in the MENA Region

Populations of the MENA belong to a unique genetic pool because of the mixture of ethnicities with horizontal mixing of populations throughout history, the high rate of consanguineous marriages within subpopulations, and the geography of the states making up the region (Figure 1). Nevertheless, wide prospective population studies on the effects of polymorphisms on such disorders of metabolism in the MENA are still lacking [25]. Based on literature reports on other populations, a large set of genes and DNA sequence variants are potentially culpable of the rise of metabolic disorders under the effect of industrialized diets. In this part of the paper, we present numerous polymorphisms that predispose to metabolic disorders including T2DM, obesity, dyslipidemias, atherosclerosis, cardiovascular events, and hypertension. The civilization disorders have common pathophysiologies and risk factors of metabolism and, since interrelated and comorbid, will accordingly be treated as one major health outcome in the following discussion about genetic entities common to the different disorders, under the effect of diet.

The *Brain-Derived Neurotrophic Factor* (*BDNF*) is important for energy balance in mice and for regulation of stress response in humans (OMIM 113505). Polymorphisms in this gene are associated with obesity and all subtypes of psychological eating disorders in Europeans (NCBI 627). Recently, three-way association was identified between hoarding behavior of obsessive-compulsive disorder, obesity, and the Val/Val genotype of *BDNF* in the Valine (Val) to Methionine (Met) amino acid change at position 66 (Val66Met) in Caucasians [45]. The suggested evolutionary mechanism for this complex relationship between gene,

Table 1: Rates of cardiovascular disease, hypertension, and the metabolic syndrome in MENA countries from different studies.

Coronary artery disease (CAD)			
Iran	Age-adjusted prevalence (%)	12.7	Nabipour et al. [73]
Jordan	Prevalence (%)	5.9	Nsour et al. [74]
Saudi Arabia,			
(rural)	Prevalence (%)	4.0	Al-Nozha et al. [75]
(urban)	Prevalence (%)	6.2	
(overall)	Prevalence (%)	5.5	
Tunisia	Prevalence (%), [men]	12.5	Ben Romdhane et al. [76]
	Prevalence (%), [women]	20.6	
Cerebrovascular Accidents			
Bahrain	Age-adjusted incidence (per 100,000)	96.2	Al-Jishi and Mohan [77]
Iran	Age-adjusted incidence (per 100,000)	61.5	Ahangar et al. [78]
Kuwait	Age-adjusted incidence (per 100,000)	92.2	Abdul-Ghaffar et al. [79]
Libya	Age-adjusted incidence (per 100,000)	114.2	Radhakrishnan et al. [80]
Palestine	Age-adjusted incidence (per 100,000)	62.7	Sweileh et al. [81]
Qatar	Age-adjusted incidence (per 100,000)	123.7	Hamad et al. [82]
Saudi Arabia	Age-adjusted incidence (per 100,000)	38.5	Al-Rajeh et al. [83]
Hypertension (HTN)			
Algeria	Prevalence (%), [Age > 25]	36.2	Yahia-Berrouiguet et al. [84]
Bahrain	Prevalence (%), [Age > 20]	42.1	Al-Zurba [85]
Egypt	Age-adjusted prevalence (%)	27.4	Ibrahim et al. [86]
	Prevalence (%), [Age > 25]	26.3	Galal [87]
Iran	Prevalence (%), [Age > 19]	25.6	Sarraf-Zadegan et al. [88]
	Prevalence (%), [Age: 30–55]	23.0	Haghdoost et al. [89]
	Prevalence (%), [Age > 55]	49.5	
Iraq	Prevalence (%), [Age > 20]	19.3	WHO: STEPwise, [90]
Jordan	Prevalence (%), [Age > 18]	30.2	Zindah et al. [91]
Lebanon	Prevalence (%), [Age: 18–65]	31.2	Sibai et al. [92]
Morocco	Prevalence (%), [Age > 20]	33.6	Tazi et al. [93]
Oman	Prevalence (%), [Age > 20]	21.5	Hasab et al. [94]
Palestine (WB),			
(rural)	Prevalence (%), [Age: 30–65]	25.4	Abdul-Rahim et al. [95]
(urban)	Prevalence (%), [Age: 30–65]	21.5	
Qatar	Prevalence (%), [Age: 25–65]	32.1	Bener et al. [96]
Saudi Arabia	Prevalence (%), [Age: 30–70]	26.1	Al-Nozha et al. [97]
Sudan	Prevalence (%), [Age: 25–64]	23.6	WHO: STEPwise, [90]
Syria	Prevalence (%), [Age: 18–65]	40.6	Maziak et al. [98]
Turkey	Age-adjusted prevalence (%)	25.7	Sonmez et al. [99]
UAE	Prevalence (%), [Age > 20]	20.8	Baynouna et al. [100]
Yemen	Prevalence (%), [Age > 35]	26.0	Gunaid and Assabri [101]
Middle East	Prevalence (%), (overall)	21.7	Motlagh et al. [102]
Metabolic Syndrome			
Algeria	Prevalence (%), [Age > 20]	17.4	Mehio Sibai et al. [103]
Iran	Prevalence (%), [Age > 19]	23.3	Mehio Sibai et al. [103]
Jordan	Prevalence (%), [Age > 18]	36.3	Khader et al. [104]

Table 1: Continued.

Kuwait	Prevalence (%), [Age > 20]	24.8	Al Rashdan and Al Nesef [105]
Lebanon	Prevalence (%), [Age: 18–65]	25.4	Mehio Sibai et al. [103]
Morocco, (rural)	Prevalence (%), [women]	16.3	Rguibi and Belahsen [106]
Oman,			
(overall)	Prevalence (%), [Age > 20]	21.0	Al-Lawati et al. [107]
(Nizwa)	Age adjusted prevalence (%)	8.0	Al-Lawati et al. [107]
Palestine (WB)	Prevalence (%), [Age: 30–65]	17.0	Abdul-Rahim et al. [95]
Qatar	Prevalence (%), [Age > 20]	27.7	Musallam et al. [108]
	Age adjusted prevalence (%)	26.5	Bener et al. [109]
Saudi Arabia	Age adjusted prevalence (%)	39.3	Al-Nozha et al. [110]
Tunisia	Prevalence (%), [Age > 20]	16.3	Bouguerra et al. [111]
UAE	Prevalence (%)	39.6	Malik and Razig [112]

Nonadjusted rates from different studies are not valid for comparison but displayed to present the burden of the morbidities. HTN is defined as BP > 140/90 or use of antihypertensive medications. Metabolic Syndrome definition is based on Adult Treatment Panel III, except for Palestine and Tunisia where, respectively, WHO criteria and hypercholesterolemia (Total Cholesterol ≥5.2 mmol/l) instead of low HDL cholesterol were used. UAE: United Arab Emirates; WB: West Bank [103, 113–116].

psychopathology, and body weight is the conservation of a thrifty gene, once an old survival strategy.

Control of fetal appetite was recently shown to be a function of the *Fat Mass- and Obesity-Associated* (*FTO*) gene expression [28] which codes a nuclear oxygenase that affects tissue lipid metabolism [46] (NCBI 79068) and depends on energy balance during development [28]. A strong relation links *FTO* SNPs to higher risk of obesity and T2DM in many international studies (OMIM 610966) [47, 48].

Transcription Factor 7-Like 2 (*TCF7L2*) gene codes a transcription factor involved in blood glucose homeostasis. The rs7903146 variant association to T2DM varies greatly over ethnicities (OMIM 602228). However in Palestinians, this SNP (114758349C > T) increases the risk for T2DM, and homozygotes are affected at younger age [49].

Calpain 10 (*CAPN10*), which codes a calcium-dependent cysteine protease, is being increasingly studied for its role in T2DM (NCBI 11132). SNP-44 of *CAPN10* has significant association with T2DM and total cholesterol in Gaza [50], while only UCSNP-19 SNP and haplotype-111 are proven to be high risks for T2DM in Tunisia [51].

The association of T2DM with polymorphisms of the *Angiotensin Converting Enzy*me (*ACE*) and the *Methylene Tetrahydrofolate Reductase* (*MTHFR*) is not well proven [52]. However data in Tunisians suggest synergistic action of the *ACE* Insertion/Deletion (I/D) dimorphism with the *MTHFR* C677T SNP on risk of T2DM [52]. Fairly common, *ACE* D and *MTHFR* 677T alleles are, respectively, present in around 77 and 27% of Moroccans [53]. Nevertheless, *ACE* DD genotype in Tunisians is associated with higher ACE activity and might become a useful clinical marker for CAD risk assessment of acute myocardial infarction [52, 54]. In Lebanon, *ACE* D allele and age, combined, are associated with higher risk for hypertension [54]. Also, Lebanese with *MTHFR* C677T turned out to be more susceptible to diabetic nephropathy than Bahrainis with the same SNP [55]. The SNP cannot constitute an independent risk factor in Arabs [56]. Its effect is presumably due to high homocysteine levels and hence must be evaluated depending on dietary and ethnic backgrounds [55].

In genes encoding the G protein-coupled Beta-2- and 3-Adrenergic Receptors (*ADRB2, ADRB3)*, evolutionary selection of specific alleles exists in Africans, Asians, and Europeans. *ADRB2* Glu27 and Gln27 are, respectively, factors of exercise-dependent obesity risk and metabolic syndrome susceptibility (OMIM 109690). Glu/Glu and Glu/Gln can independently predict severe Coronary Artery Disease (CAD) in Saudi Arabs [57]. However *ADRB3* Trp64Arg SNP is a CAD predictor only in presence of other risk factors in Arabs, but not an independent one [57]. ADRB3 is mainly located in adipose tissues causing easier weight gain and earlier T2DM onset in Trp64Arg individuals in several populations [58] (NCBI 155) (OMIM 109691).

Peroxisome Proliferator-Activated Receptor Gamma (*PPARG*) genes encode nuclear receptors and regulators of adipocyte differentiation and possibly lipid metabolism and insulin sensitivity (OMIM 601487). Pro12Ala isoform of *PPARG2* seems to activate transcription less effectively and carry less morbidity. Carriers of a Pro12Ala polymorphism may have a weaker BMI correlation to *amount* of dietary fat when compared to Pro homozygotes [59], while response to *quality* of dietary fat is greater in terms of BMI, lipid profile, and fasting insulin levels [60, 61]. However these associations were not found for many of the studied populations (OMIM 601487).

Apolipoproteins (APOs) are involved in lipid metabolism. *APOE* polymorphisms have been heavily studied. In the *APOE* G219T SNP, TT individuals have prolonged postprandial lipemia [62]. *Apo E* has three major isoforms, E2, E3, or E4. *APOE* E4 individuals may be protected effectively by lower dietary fat intake [63] while non-E4 individuals have minimal to no benefit from dietary intervention on lipid profile [64]. In Iranians, E2 allele was associated with lower total cholesterol levels [65]. However, despite correlation

Table 2: Rates of Vitamin D deficiency and iron deficiency in MENA countries from different studies.

Vitamin D deficiency (VDD)			
Iran	Prevalence (%), [girls], [adolescent]	Up to 70	Moussavi et al. [143]
Jordan	Prevalence (%),		
	[adult females]	37.3	Batieha et al. [144]
	[adult males]	5.1	
Lebanon	Prevalence (%),		
	[girls]	32	El-Hajj Fuleihan et al. [145, 146]
	[boys]	9–12	
Morocco (Rabat)	Prevalence (%), [women]	91	Arabi et al. [147]
Saudi Arabia	Prevalence (%), [girls], [adolescent]	Up to 80	Siddiqui and Kamfar [148]
Tunisia (Ariana)	Prevalence (%), [women], [Age: 20–60]	47.6	Arabi et al. [147]
Turkey (Ankara)	Prevalence (%),		
	[mothers]	46	Arabi et al. [147]
	[newborns]	80	
Iron deficiency			
Arab Gulf countries	Prevalence (%),		
	[children], [preschool age]	20–67	Musaiger [149]
	[children], [school age]	12.6–50	
	[pregnant women]	22.7–54	
Bahrain	Prevalence (%),		
	[children], [Age: 6–59 months]	48	Bagchi [150]
	[women], [Age: 15–49]	37.3	
Egypt	Prevalence (%),		
	[children], [Age: 6–59 months]	25	Bagchi [150]
	[women], [Age: 15–49]	11	
Iran	Prevalence (%),		
	[children], [Age: 6–59 months]	15–30	Bagchi [150]
	[women], [Age: 15–49]	33.4	
Jordan	Prevalence (%),[children], [school age]	20	Bagchi [150]
	Prevalence (%), [women], [Age: 15–49]	28	
Lebanon	Prevalence (%), [children], [Age: 6–59 months]	23	Bagchi [150]
Morocco	Prevalence (%),		
	[children], [Age: 6–59 months]	35	Bagchi [150]
	[women], [Age: 15–49]	30.1	
Oman	Prevalence (%),		
	[children], [Age: 5–14]	41	Bagchi [150]
	[women], [Age: 15–49]	40	
Pakistan	Prevalence (%),		
	[children], [Age: 6–59 months]	60	Bagchi [150]
	[women], [Age: 15–49]	30	
Palestine	Prevalence (%),		
	[children], [Age: 6–59 months]	53	Bagchi [150]
	[women], [Age: 15–49]	36.2	
Saudi Arabia	Prevalence (%), [children], [preschool age]	17	Bagchi [150]
Syria	Prevalence (%),		
	[children], [Age: 6–59 months]	23	Bagchi [150]
	[women], [Age: 15–49]	40.8	

Table 2: Continued.

UAE	Prevalence (%),		
	[children], [Age: 6–59 months]	34	Bagchi [150]
	[pregnant women]	14	
Yemen	Prevalence (%), [children], [preschool age]	70	Bagchi [150]

Different limits of blood levels define VDD, ranging from insufficiency to severe deficiency, similar for Iron deficiency. UAE: United Arab Emirates [147, 150].

between APOE2 and LDL subfraction profiles in healthy Arabs, no similar association was found in Arabs with CAD [66]. *APOE* E2, E3, and E4 carriers constitute approximately 11, 79, and 10% of Moroccans, respectively [53].

Moreover, mutations in *Lipoprotein Lipase* (*LPL*), which is crucial for receptor-mediated lipoprotein uptake, drastically affect lipoprotein metabolism disorders (NCBI 4023). In Saudi Arab population however, lack of association between *LPL* polymorphisms and CAD was noticed [56]. Strong evidence exists for Hepatic Lipase (*LIPC*) C514T homozygotes. They have more atherogenic lipid profile in response to dietary fat in addition to impaired adaptation to higher animal fat with higher cardiovascular diseases risk [67, 68].

Finally, the Paraoxonase (*PON1*) gene encodes for an anti-atherosclerotic esterase which capacitates high-density lipoproteins to prevent lipoprotein oxidation. Gln192Arg and Leu55Met are two common polymorphisms of *PON1* that modulate PON1 activity in the serum, which predicts the architecture of apolipoprotein, lipoprotein, and lipid levels [69]. In the late 1990s, PON1 status, including genotype and serum activity levels, has been proven to predict cardiovascular risk much better than genotype alone [70]. However, in Turkish subjects, there was no consistent association between the polymorphisms and the lipid levels [71]. An individual's polymorphism might be suggestive of a high risk while his dietary signature is making the actual PON1 activity favorable, that is, low risk. This interaction between diet and genes can hinder the significance of genetic screening, and enhance the relevance of proteomics and metabolomics. The lesson learned from the *PON1* role in cardiovascular disease is of utmost relevance. Functional genomic analysis is required for adequate risk assessment; an individual may be screened for all known polymorphisms of *PON1*, but still not be assigned a risk category for cardiovascular disease [72].

Discrepancies between genotype and function impose limitations on genetic screening. Similarly for most of the polymorphisms presented previously, the degree to which genetic screening can be helpful in decision-making is controversial. More activity correlation studies are needed to examine the "penetrance" of polymorphisms. Also, insufficient nutrigenomic and proteomic evidence may be misleading [117]. Hence, further multidisciplinary studies, with coordination between laboratories, will be needed to decide which gene/polymorphism would be worth screening in a particular population.

Further multidisciplinary nutritional genomics research is needed for more specific targeted individualized advising and therapy. However, given the current lack of adequate understanding of the genetic etiologies of civilization diseases and wide-scale regional genetic screening studies, reversal of dietary changes is rendered the simplest available measure to control the metabolic epidemic of civilization diseases in the MENA.

6. Micronutrient Deficiencies (MNDs) in the MENA Region

Micronutrients (vitamins and minerals) are required throughout life, in minute amounts in the human body, to function as cofactors of enzymes or as structural components of proteins, or to maintain genome stability, among other physiological roles [118]. Both their excess and deficiency may cause DNA damage, alter growth and development, contribute to a wide array of chronic diseases, and jeopardize health [118]. MNDs are highly prevalent in MENA countries as was established earlier. Deficiencies in iodine, iron, and vitamin A are very important MNDs in terms of prevalence and potential threat to public health worldwide; however relevant gene-diet interaction has not been sufficiently studied in the MENA. This section will thus be restricted to the following MNDs of particular interest in diet-genetics-disease interaction: vitamin D, calcium, iron, folate, and vitamins C, E, B6, and B12.

6.1. Vitamin D Deficiency (VDD). Vitamin D is a fat-soluble vitamin, with two forms, one present in a narrow range of foods (D2) and another formed under the skin when exposed to the ultraviolet B (UVB) light fraction of sunlight (D3); both are activated by the liver and kidneys [119] (Figure 6). Prolonged VDD can result in rickets in young children and osteoporosis and fractures in adults [120]. Recently, low vitamin D levels have been associated with increased risk of hypertension, cardiovascular diseases [121], cancer [122], diabetes [123], musculoskeletal and immunity disorders, and infectious diseases [124].

Despite the sunny climate, the MENA has a highly prevalent VDD across all age groups, with the highest rate of rickets worldwide [22]. The main reasons are limited sun exposure and low dietary vitamin D intake, along with frequent pregnancies, short breastfeeding periods [125], skin pigmentation [126], body mass index [127], religious practices [128], and educational levels [129].

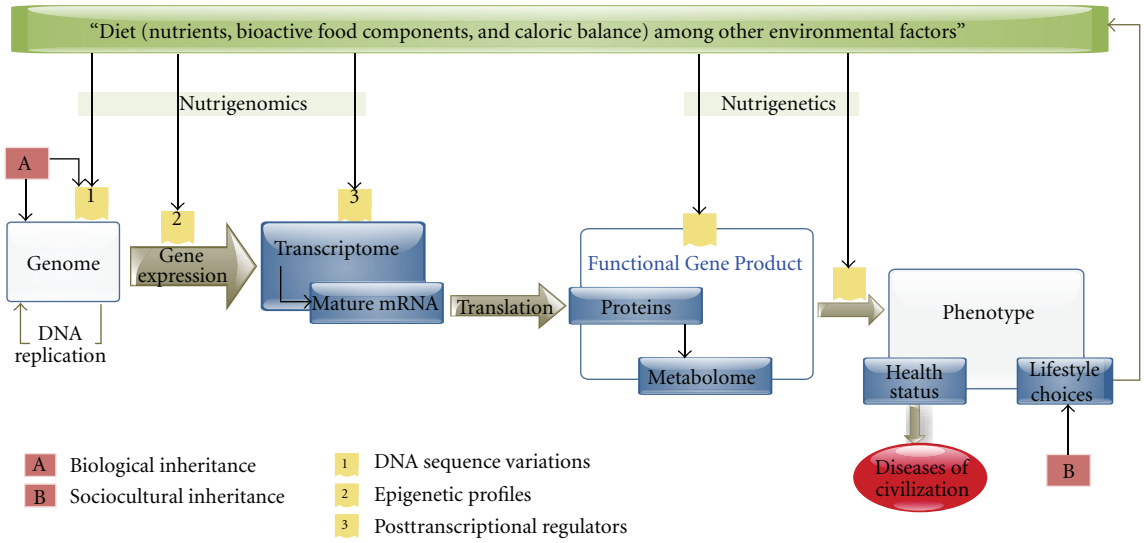

Figure 5: The dietary signature. The biologically inherited DNA genome accumulates DNA sequence variations over generations. Epigenetic profiles determine which parts of it are to be transcribed. Once transcribed to RNA, it matures into different mature RNA outcomes depending on the post-transcriptional regulators. Among the effects of the environment on DNA sequence variations, epigenetic profiles, and post-transcriptional regulators, the effect of diet is studied in nutrigenomics. After translation, and under the impact of dietary status surrounding the primarily translated proteome, the final set of functional proteins, activated pathways, and subsequent metabolites constitutes the functional Gene Product. The gene product is only potentially functional towards a certain phenotypic outcome. The downstream end result of health status depends greatly on what nutrients are fed into the systemic machine of gene products. The functional gene product is the end-point in nutrigenomics and the starting point in nutrigenetics. It is a marker of the phenotypic outcome: expression of disease and prognosis. Phenotype may dictate the lifestyle choices available to a certain individual, including taste preferences, which are also delineated by culturally inherited customs and habits. In their turn, lifestyle choices including dietary habits determine environmental exposures. Furthermore, civilization diseases have been hidden for a long period of time due to the sociocultural inheritance of adequately evolved matching lifestyle preferences and diet choices that have been masking a biologically inherited limited gene pool. The genes being in *status quo*, in presence of a nutritional transition, the rates of civilization diseases are on the rise because of the loss of the protective adequacy of the diet. This highlights the presence of hidden genes, the phenotypic expression of which can be masked by a specific nutritional state, such as that corresponding to the Mediterranean diet, as more increasingly being recommended recently in the literature. However this cannot be answered if sequence variations and specific SNPs affecting nutritional needs are not tested for in the specific populations.

In addition to nutritional and social factors of VDD, genetic factors also play an important role and are depicted on the metabolic pathway of vitamin D shown in Figure 6. Genetic variations predisposing to VDD are related to Vitamin D Receptor (*VDR*) polymorphisms at intron 8 (BsmI) and exon 2 (FokI) [130]. The Fok1 polymorphism (C>T) in the translation initiation site creates an upstream initiation codon and a three amino acids longer molecule in the f allele compared to the F allele [131] which gives a more transcriptionally active VDR [132] leading to the tolerance to low vitamin D levels observed in Egyptian FF homozygotes [130]. This suggests possible evolutionary adaption to dietary intake or lifestyle changes. Only FF homozygote children have increased calcium absorption and bone mineral density [131]. Conversely, the decreased calcium absorption linked to the f allele was correlated with an increase in colon cancer risk only when calcium dietary intake is low [133]. FF genotype seems hence more advantageous than ff genotype. Paradoxically, FF (shorter VDR) was correlated with rickets unlike ff (longer VDR) in Turks and Egyptians. Thus, further studies are needed to understand the complex genetics and risks of rickets. *VDR* B allele also predisposes to VDD since Egyptian B homozygotes had severe rickets [130]. In other studies in the Middle East, high vitamin D doses were needed to treat patients with rickets [134]. Thus, the unexpected high prevalence of VDD in the MENA could be linked to VDR polymorphisms.

Moreover, a G>A polymorphism at position −3731 of the cdx-2 (Caudal-Type Homeobox Transcription Factor) binding element on the *VDR* gene promoter is another genetic variant of *VDR* that affects calcium absorption. The Cdx2 promoter A allele (cdx-A) binds cdx2 more strongly and has a greater transcriptional activity compared to the cdx-G allele. Thus, the A allele may increase intestinal *VDR* expression, subsequently enhancing calcium intestinal absorption and increasing bone mineral density. The differential expression of *VDR* shows how genetic differences influence the body response to nutrients [135].

Bioactive food components may exert an effect on gene expression and enzyme activity, subsequently decreasing disease risk. For example, 4′,5,7-Trihydroxyisoflavone (genistein), a soy component, is a genome-protective nutrient. It inhibits the activity of CYP24A1 (Figure 6) and thus $1,25(OH)_2D$ degradation, increasing VDR stability and the half-life and biological effects of vitamin D [136]. Folate can also inhibit this activity by increasing methylation of

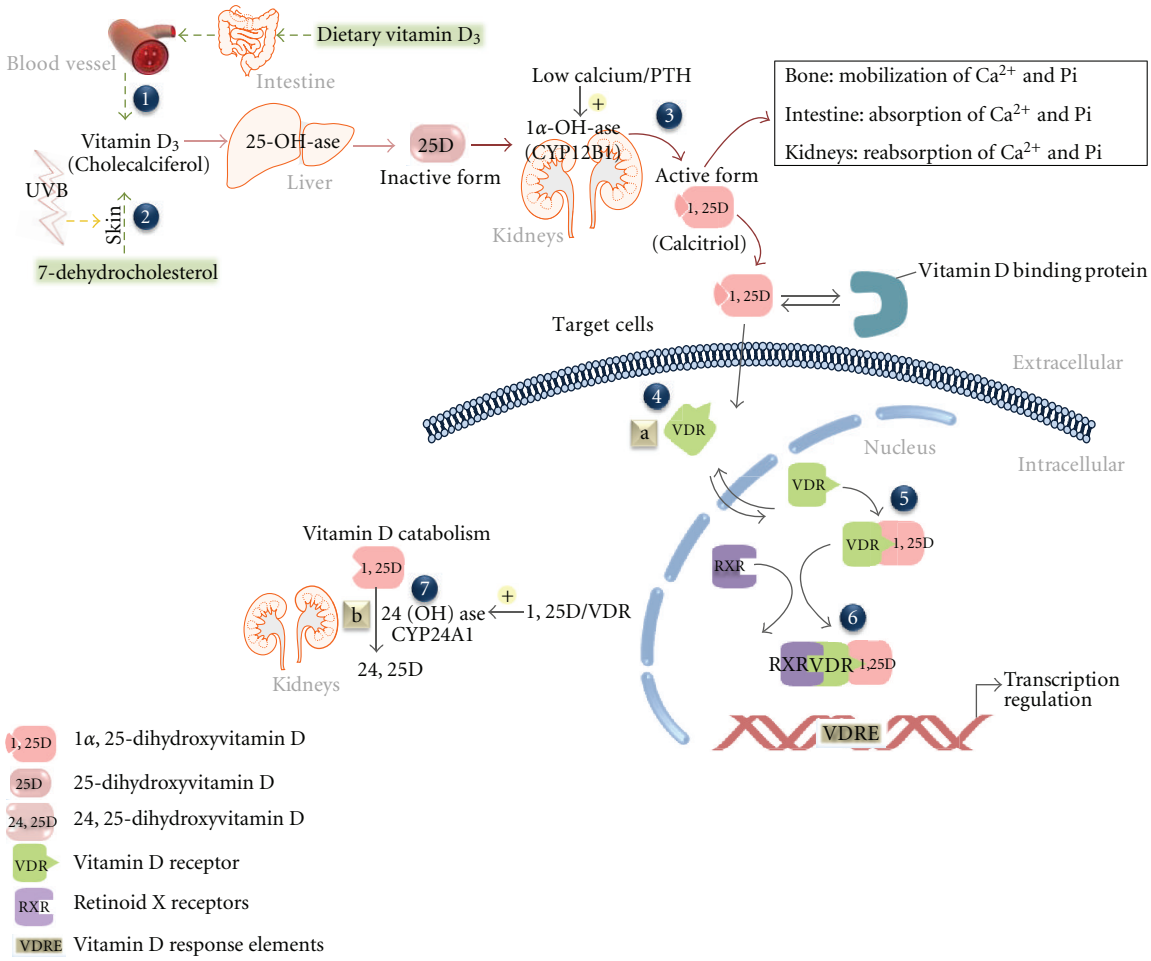

Figure 6: Vitamin D pathway and sites of interaction with dietary factors. Cutaneous or dietary vitamin D is hydroxylated in the liver to form 25-hydroxyvitamin D (1,2) and in the kidney to form 1α,25-dihydroxyvitamin D (3). 1α,25-dihydroxyvitamin D binds to VDR (4), the 1α,25-dihydroxyvitamin D ligand promotes VDR-RXR heterodimerization (5), and the complex binds to VDRE to mediate transcriptional regulation of target genes (6). The concept of gene-diet interaction is described in the vitamin D pathway by the different polymorphisms in the VDR gene (a) and the dietary regulation of CYP24A1 enzyme (b).

the promoter of *CYP24A1*. Also, addition of vitamin D and calcium to the western diet significantly decreases the incidence of colon cancer [133].

6.2. Iron Deficiency. Iron (Fe) is an essential mineral needed in small amounts mainly for the production of hemoglobin and utilization of oxygen among other vital functions. Iron deficiency is a common MND mostly caused by low intake of iron, blood loss, and parasitic infections [137]. Iron absorption is enhanced by vitamin C, low pH, and heme iron and hindered by bioactive vegetables components (polyphones, tannins, phytates) and calcium [138].

Genetic factors that contribute to iron deficiency, in addition to the dietary intake, are underscored by the ability of many individuals to maintain normal iron levels despite low iron dietary intake. Nutritional iron deficiency and genetic iron deficiency have been experimentally distinguished in mice. Hephaestin (Heph) is a multicopper oxidase that allows iron basolateral surface export. Sex-linked anemia (*Sla*) mice bearing a deletion in *Heph* gene compared to control mice showed different responses to diet; *Sla* mice had duodenal iron accumulation and low plasma iron [139]. Additionally, mutations in the genes of human hemochromatosis protein (*HFE*) and its interacting protein beta-2 microglobulin (*B2M*), which play an important role in iron metabolism, cause murine iron deficiency [140].

6.3. Folate Deficiency. Folic acid is a water soluble B vitamin of exclusive dietary origin. It provides the one-carbon metabolism with its main coenzyme form, tetrahydrofolate (THF). A key enzyme herein, methylenetetrahydrofolate reductase (MTHFR), catalyzes vitamin B12-dependent conversion of homocysteine to methionine, a precursor of S-adenosylmethionine (SAM), a methyl donor to DNA [141]. Thus, folate deficiency results in hyperhomocysteinemia (HHC), a risk factor for CAD [142].

MTHFR C677T is prevalent in 4% of Pakistanis [32], 2% of Yemenite Jews, 10% of Muslim Arab Israelis, and 11% of Lebanese [151]. It leads to a thermolabile MTHFR, which precipitates HHC in low folate states. This gene-environment combination is a risk factor for cardiovascular diseases [152], neural tube defects, and other chronic diseases [153].

C677T is a genetic variation that affects individual dietary requirements because it makes prevention of folate-related diseases that require higher folate intake. Korean C homozygotes develop HHC only with low folate levels, while T homozygotes have HHC even with normal folate levels [154]. Surprisingly however, the hyperhomocysteinemia, low folate levels, and increased cardiovascular risk observed in Indian Asians compared to European whites were not attributed to the *MTHFR* 677T variant [155]. Studies specific to the MENA are therefore needed because of possible variations from other regions.

The example of MTHFR and folate also underscores the genome-epigenome interplay. The TT genotype alters DNA methylation and gene expression in peripheral blood mononuclear cells only in folate deficient patients [156]. Paradoxically, the same polymorphism is inversely associated with and hence has a protective role against colorectal cancer (CRC). CRC risk decreases with adequate methionine intake, which leads to an increased formation of SAM and a negative feedback inhibition of MTHFR activity. However, the protective roles of MTHFR mutation and methionine dietary intake require an adequate dietary folate intake [157]. These findings suggest that inadequate folate intake puts carriers of particular genetic variants at higher risk of cancer. Thus personalized dietary interventions might be beneficial in reducing cancer risks.

Serum vitamin B12 deficiency is highly prevalent in Iran [158]. Thus, low folate and vitamin B12 levels can be inversely linked to the hyperhomocysteinemia observed in this population. Importantly, high prevalence of CAD was observed in a Turkish population with low plasma folate despite low plasma cholesterol concentrations [159]. It remains to determine the link between hyperhomocysteinemia, low folate intake, CAD risk, and MTHFR variants, to explain this prevalence in Turkey and possibly in other countries of the MENA region. This would add folate supplementation as a possible treatment for hyperhomocysteinemia. Other studies have also reported the possible contribution of the level of pyridoxal phosphate (PLP or vitamin B6) to hyperhomocysteinemia and vascular disease; low PLP levels were observed in individuals with the homozygote TT genotype compared to healthy individuals from some countries of the MENA [160, 161]. These data corroborate the various dietary signatures on the specific genetic profile and show that other mechanisms, enzymes, and vitamins should be examined as well.

6.4. Vitamin B12 Deficiency. Like folate deficiency, vitamin B12 (cobalamin) deficiency can affect establishment of the disease depending on the genetic background. A common genetic variant is detected in Methionine Synthase Reductase (MTRR), an important enzyme for maintaining Methionine Synthase in its active state. The polymorphism is an A66G substitution resulting in an Ile22Met residue. The homozygous genotype was associated with an increased risk of neural tube defects (NTDs) when combined with low vitamin B12 levels. Vitamin B12 deficiency is highly prevalent among Iranian women of childbearing age [158]. However polymorphisms in both *MTHFR* and *MTRR* increase NTDs risk [162].

6.5. Vitamins C and E Deficiencies. As antioxidants, vitamins C and E have an important function in the diet-gene interaction. Glutathione S-transferases (GSTs) transfer glutathione to different substrates. A common deletion of *GSTM1* gene, a deletion polymorphism in *GSTT1*, and an A313G polymorphism of *GSTP1* result, respectively, in a nonfunctional genotype, loss of enzyme activity, and altered activity of the *GST* isoforms. The GST enzymes were found protective against serum ascorbic acid deficiency when vitamin C consumption is low, since GST null genotypes with low vitamin C intake had an increased serum ascorbic acid deficiency risk [163]. The Hp1 and Hp2 polymorphisms in the hemoglobin-binding protein haptoglobin (Hp) were also studied in vitamin C deficiency. Unlike Hp1 carriers, Hp2 homozygotes had lowest serum vitamin C concentrations when dietary vitamin C intake is insufficient. Thus, Hp1 has a greater antioxidant capacity preventing hemoglobin-iron-related vitamin C oxidation and depletion [164].

A protective role for vitamin E against atherosclerosis, cancer, and neurodegenerative diseases has also been reported. Polymorphisms in the proteins involved in vitamin E metabolism lead to differential vitamin E uptake and response among individuals, and subsequently different disease risk [165]. Dietary vitamin E intake also influences the body mass index (BMI) and risk of obesity via modifying genetic variants of SIRT1 (sirtuin protein family of nicotinamide-adenine-dinucleotide- (NAD+)-dependent histone deacetylases) [166].

Well-studied gene-diet interactions are also critical in the pathophysiology of cancer. Given the evidence that VDR polymorphisms, MTHFR genotype, and DNA methylation in a low calcium or folate intake are associated with an increased cancer risk, the dietary signature greatly influences carcinogenesis. Significant dietary factors include antioxidants such as vitamin C, carotenoids, lycopene, tocopherols (vitamin E), and many other micronutrients present in fruits and vegetables.

Being one of the leading causes of death worldwide as well as in the MENA, cancer has been extensively studied, and the diet-genetics-cancer interaction is currently being thoroughly investigated for each and every one of the involved micronutrients. So, the effect of the diet-genetics interaction on carcinogenesis will not be dwelled upon in this paper.

The aforementioned studies collectively depict the interaction between diet, genetic variability, and disease. Genetic variants might affect gene expression patterns and epigenetic events resulting in differential body responses to diet. However, a small individualized nutritional intervention that is well studied to provide the needed concentrations of micronutrients can influence genetic variants to decrease disease

risk. Thus, nutrigenetics is a tool for choosing the appropriate diet according to the individual's genetic makeup.

7. A Call for Nutritional Genomics Research in the MENA

All previous data support the crosstalk between diet and genome. Differential responses to dietary components among individuals are determined by genetic factors. The deleterious effects of some genotypes can be circumvented by an increased intake of particular nutrients to overcome the genetic susceptibility, which opens the horizon for personalized diet. In turn, nutrients might affect genome, gene expression, and phenotype. Although hard and complex, it is worthwhile to identify the genes that predispose individuals to chronic diseases and the nutrients that regulate their expressions to modify personal risks and to prevent, mitigate, or treat diseases. Studying on an individual basis the interactions between diet and genetics could help select appropriate diet to optimize health status. Indeed, the picture becomes more complicated when lifestyle, behavioral, and other environmental factors interfere with the diet-genetics interaction.

Of note is the unique ethnic combination of the region's native populations that make studies from other regions inapplicable to the MENA. In spite of the multiethnic origins, high rates of consanguinity in the subpopulations render the genetic pool paradoxically limited and significantly increase not only the risk of congenital abnormalities but also the susceptibility of the population to chronic diseases and genetic disorders [167]. Screening for the common polymorphisms in the MENA can give insights on their prevalence in the region or can help discover polymorphisms indigenous for the region. Such action could help alleviate the burden of chronic diseases in the MENA simply by suggesting adequate adjustments of dietary factors to hide a genetic polymorphism or to prevent DNA damage.

In some of the examples provided previously, success can be achieved, but in others, researchers ought to be more cautious. Selecting which polymorphisms are to be screened for, at the population level in the MENA, should be made after careful understanding of the effects of these variants on diet and disease. This is crucial to avoid misleading results and unnecessary costs. Unfortunately, functional studies are limited, but wide-scale screening and associations from other regions in the world could guide the decision-making process regarding screening in the MENA. At the same time, more effort and money should be invested in molecular and cellular research in nutritional genomics in order to better understand the function of the dietary signature and to more confidently guide population screening and personalized diet.

8. Conclusions

(i) MENA countries are witnessing a radical change in dietary patterns from a traditional diet to a less healthy industrialized diet.

(ii) Rising prevalence for civilization diseases of metabolism and micronutrient deficiencies in the MENA parallels the change in dietary habits and is mostly caused by it.

(iii) Nutrigenomic factors and the dietary signature on the genome play a role in the diet-disease interactions.

(iv) Genetic sequence variations, epigenetic profiles, and posttranscriptional and posttranslational modifications are some of the mechanisms that define the diet-genetics-disease relationship.

(v) A large set of gene polymorphisms have been correlated with civilization diseases of metabolism, only a little of which have been studied in MENA countries.

(vi) There are different mechanisms through which diet-genetics interaction affects micronutrient pathways and contributes to disease, including vitamin D and calcium, iron, folate, and vitamins C and E.

(vii) Given the drastic dietary changes in the region over a short period of time, diet is the most obvious public health intervention, yet system biology and genomics research should not be underestimated.

(viii) Wide-scale screening for certain gene polymorphisms in the MENA might allow for efficient intervention with personalized diet.

(ix) More nutrigenomics research is needed to look at function and mechanisms of the diet-genetics-disease interaction.

Abbreviations

MENA: Middle East and North Africa
WHO: World Health Organization
OMIM: Online Mendelian Inheritance in Man
NCBI: National Center for Biotechnology Information
SNP: Single Nucleotide Polymorphism
MNDs: Micronutrient Deficiencies.

Conflict of Interests

The authors declare that they have no conflict of interests.

Authors' Contribution

A. C. Fahed and G. M. Nemer designed the narrative review and the different sections of the manuscript, supervised the work, and compiled the final draft. A. M. El-Hage-Sleiman and T. I. Farhat performed the literature search, designed the figures, and wrote equally different sections of the manuscript. A. K. M. El-Hage-Sleiman and T. I. Farhat contributed equally to this paper. All authors read and approved the final manuscript.

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Acknowledgments

The authors would like to thank all the Nemer Lab team members for their support during the preparation of this work. They would also like to thank Dr. Amy Zenger from the Writing Center at the American University of Beirut for editing the manuscript.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 642187, 6 pages
doi:10.1155/2012/642187

Research Article

Physical Activity and Health Beliefs among Saudi Women

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Received 12 May 2011; Revised 30 October 2011; Accepted 14 December 2011

Academic Editor: Hazzaa M. Al-Hazzaa

Background. Physical activity (PA) is associated with health benefits and disease prevention and is often prescribed in managing many health conditions. Understanding the cultural influences is relevant in order to effectively promote PA. The objective of this study was to assess the level of PA among Saudi women, measured by daily step count, and the association between PA and health beliefs. *Methods*. A total of 161 eligible participants were asked to complete two questionnaires to assess health beliefs: Health Locus of Control (HLC) and Self-Efficacy Assessment Scale. Each participant was given a pedometer and a diary to record their daily PA for two weeks. *Results*. One hundred and five participants completed the two weeks pedometer data (mean age 26.3 ± 7.1 years, BMI $25 \pm 4.2\,\text{kg/m}^2$). The average pedometer score over two weeks was 5114 ± 2213 steps. Step count had strong correlation with self-efficacy ($r_s = 0.75$), mild correlation with internal HLC ($r_s = 0.42$), and mild negative correlation with external HLC ($r_s = -0.35$). *Conclusion*. The study demonstrates high level of inactivity among Saudi females in reference to the international recommendation for minimum activity. The data also reveal an association between PA and health beliefs. Ultimately, such information can be used to design gender- and culture-sensitive interventions that could enhance adherence to PA.

1. Introduction

It is widely reported that regular physical activity reduces the risk of a number of medical conditions, and contributes to personal wellbeing [1]. The World Health Organization (WHO) regards physical inactivity as one of the leading causes of death and disability [2], and a leading cause of non-communicable chronic conditions, such as hypertension, diabetes, and obesity [3].

As a result of this, clinical practitioners often prescribe physical activity as an essential component for the management of many health conditions [4]. However, medical advice alone has not been effective in promoting physical activity [5], resulting in extensive research on the means to promote physical activity. Despite this, there is no universally accepted method due to the multiple factors that influence physical activity.

In order to facilitate the promotion of physical activity, an understanding of social and cultural influences is of paramount importance. It is well known and generally accepted that different cultures have different health outcomes influenced by different beliefs [6]. Sociodemographic factors have also been examined in relation to health promoting behaviors, but inconsistent results were reported [7–9]. Overall, there is sufficient evidence in the literature to show that the level of physical activity among societies is influenced by health beliefs, psychosocial status, and self-efficacy [9].

Significant increase in the level of physical inactivity among the Saudi population has been recently reported, predisposing them to health problems [10, 11]. So far, the majority of studies conducted on the Saudi society have focused on either the male population, or children and adolescents [12, 13], however, the prevalence of sedentary lifestyle-related obesity has been escalating among Saudi females [14]. This demonstrates a growing need to understand how social restraints imposed upon Saudi women affect women's health and their response to current treatment methods.

The literature suggests a specific gender-based consideration when making recommendations to promote physical activity [15]. This means that intervention and motivation

programs should be customized to suit the needs of the individual, with gender as a primary consideration.

In Saudi Arabia, women are prohibited from driving and require a guardian for commuting. Such cultural factors faced by Saudi females could prohibit or limit exercise activities, thereby increasing the prevalence of physical inactivity among such population [10]. For this reason, it is deemed necessary to study factors affecting physical activity in the Saudi culture in order to design appropriate interventions to improve it. To our knowledge, the identification of a baseline activity level of Saudi females has not been previously established.

There are number of methods reported in the literature to measure physical activity [16]. The most frequent of these is the use of self-report diaries or retrospective recall questionnaires, yet the subjective nature of such tools reduces their validity [17]. Recently, the use of pedometers has been considered an objective measure of physical activity [18]. Validity of the pedometers in measuring step count has been widely established [19, 20].

The use of pedometers to assess physical activity has been justified by the fact that walking is the most widely advocated form of physical activity. Walking is suggested as the mode of activity most likely to increase physical activity at a population level [21], particularly for sedentary adults [22]. Walking behavior has received recent attention based on its physical and psychological health benefits [23, 24], and its ease to physically perform and low cost in comparison to other forms of physical activity [25, 26].

This paper seeks to quantify the level of physical activity among Saudi females. The secondary objective of the study is to investigate the psychosocial factors associated with level of physical activity among Saudi females. Given the apparent interaction between culture, beliefs, and health in the literature, emphasis will be placed on investigation of the relationship between the level of physical activity and health beliefs.

2. Methods

2.1. Participants. Participants were recruited through advertisement using posters and flyers, university and hospital newsletters, through primary health care centers, and announcements in female health clubs and community centers in Riyadh city. Literate Saudi females between the ages of 18 and 45 years old were targeted. Pregnant volunteers were excluded, as well as those with history of fracture or surgery to the back, pelvis, or lower limb. Participation in the study was also prohibited by eating disorders, conditions affecting cognitive function, or conditions affecting the ability to walk.

2.2. Instrumentation

2.2.1. Measurement of Physical Activity. To assess the level of physical activity, step counts were measured by the *Omron HJ-152K-E pedometer*, which has been reported to have acceptable validity and reliability [27].

2.2.2. Measurement of Health Beliefs. To assess health beliefs, the Arabic versions of two well-established and validated questionnaires were used.

Multidimensional Health Locus of Control (HLC). It contains three 6-item subscales: internality; powerful others externality; chance externality. Each item scored from 1 (strongly disagree) to 6 (strongly agree) for the externally worded items and reverse scored for the internally worded items [28]. Those who have confidence that whatever happens to them is substantially within their domain of influence are said to have a predominantly internal locus of control, while those who believe that they are influenced by external forces are considered to have an external locus of control [29]. The Arabic version of the HLC was constructed and validated by Badr and Moody [6].

Self-Efficacy Assessment Scale. It comprises of 10 items scored on a 4-point Likert scale, to examine beliefs about ability to cope with a large variety of stressors [30]. This scale measures the belief people have in their own abilities to perform the desired behaviors in various situations [31] and was validated in different languages including Arabic [30].

2.3. Procedure. Phone interviews were conducted to screen all interested volunteers to ensure eligibility to the study. Consent was sought and obtained from each eligible participant. Ethical approval for the study was granted by the University Institutional Review Board.

On the first visit, baseline assessment was conducted and participants demographics (age, occupation, education, marital status, residential area) and anthropometric measures (weight, height, BMI) were taken. At this baseline assessment, participants were asked to complete the HLC Questionnaire and the Self-Efficacy Assessment Scale.

Each participant was given a pedometer to wear daily for 2 weeks. A two-week data collection period was selected to attain accurate information regarding the usual physical activity pattern. Also, the motivational effect of the pedometer use, and the associated bias were eliminated by the prolonged period. Participants were asked to record the pedometer reading (number of steps) in a diary at the end of each day. The diaries provide a log of daily step count. All participants were encouraged to maintain their typical level of walking to obtain a baseline indicator of their activity.

2.4. Data Analysis. A cross-sectional research design was used. Descriptive statistics were computed to describe the participants' demographics and anthropometric data.

The analysis strategy was based on themes that emerged from the literature. Since beliefs are considered mult dimensional with a poorly understood causal structure, a univariate analysis approach is often desirable over a multivariate analysis [26]. Hence, a univariate correlational analysis was conducted to examine the relationship between the level of physical activity and measures of health beliefs. Walking behavior was considered the critical dependent variable. Specifically, nonparametric correlations were made between

Table 1: Participants' demographics and step count ($n = 105$).

Continuous variables	Minimum	Maximum	Mean ± SD
Age (years)	19	44	26.3 (±7.1)
Weight (Kg)	37.4	131.2	73.2 (±16.4)
BMI (kg/m^2)	15.4	45	25 (±6.2)
Step count (steps)	575	12630	5114 (±2213)

Table 2: Social status, education level, and residential area ($n = 105$).

Categorical variables	Frequency n (%)
Social status	
Single	69 (65.7%)
Married	21 (20.0%)
Other	15 (14.3%)
Education level	
High school	72 (68.6%)
Bachelor	28 (26.6%)
Diploma	5 (4.8%)
Residential area	
North	21 (20.0%)
South	19 (18.1%)
East	37 (35.2%)
West	17 (16.2%)
Center	11 (10.5%)

the step count obtained by the pedometers with the participants' self-reports in the two questionnaires. Strength of association was assessed using Glantz classification [32].

3. Results

A total of 320 volunteers were initially screened, of which 161 volunteers were recruited based on the inclusion criteria. Demographic data are presented in Table 1. One hundred and five subjects completed the two weeks step-count data (mean age = 26.3 ± 7.1 years; mean BMI: 25 ± 4.2 kg/m^2). All participants had a minimum education of high school degree, and 31.4% had a college degree (Table 2). The majority of the sample was university students at the time of the study (71%), and the remaining were workers (29%). The average number of steps taken daily by our sample was 5114 (±2213). Step count did not correlate with the participants' demographics, social status, or residential location.

The outcome measures scores are presented in Table 3. Overall, participants had higher internal HLC than external HLC, with particularly lower chance HLC. Participants were found to have moderate to high self-efficacy. Step count had strong correlation with self-efficacy ($r_s = 0.75$, $P = 0.03$), mild correlation with internal HLC ($r_s = 0.42$, $P = 0.02$), and mild negative correlation with external HLC ($r_s = -0.35$, $P = 0.03$).

Table 3: Outcome measures scores ($n = 105$).

	Mean (SD)	Range	Maximum score
Self-efficacy	27.3 (4.9)	15–39	40
Internal HLC	26.8 (4.1)	17–36	36
Chance HLC	18.5 (4.7)	6–29	36
Powerful other HLC	22.3 (4.9)	9–34	36

HLC: Health Locus of Control.

4. Discussion

This study was derived on the premise that factors such as gender, age, occupational stressors, socioeconomic status are likely to influence the outcome of health [9]. The results support the view that health behaviors are associated with health beliefs, particularly HLC (beliefs about what controls one's health) [33], and self-efficacy (beliefs about one's ability to cope with stressors) [30].

The notion of perceived locus of control is the most widely known of the psychological constructs associated with health beliefs [34]. Health locus of control has been extensively studied in relation to health behaviors [35]. These results support previous work suggesting that higher internal HLC is positively associated with higher performance of regular physical activity, while external HLC is negatively associated with it [36]. Internal scoring people have a greater tendency to attribute life outcomes to personal characteristics relating to ability, effort, and personal power of control [37]. On the other hand, people who score higher in external locus of control are more likely to attribute successes and failures in life to factors such as fate, luck, and chance [37, 38]. It seems natural that those with high internal locus of control assume control over their health and thereby tend to have a high level of physical activity, and that the opposite is true for people with high external locus of control.

Self-efficacy is another concept that is also widely researched in health promotion [39, 40]. The current data confirmed the positive role of efficacy beliefs in initiating and maintaining a regular program of physical exercise [41]. The novelty in this study lies in challenging the empirical assumption that Arabs have higher external and lower internal HLC, and thus fewer health-promoting behaviors [37]. This sample of Saudi young educated females had higher internal HLC suggesting that they assume more responsibility for their actions. Previous evidence suggests that Arabs tend to perceive forces outside the individual as causing illness, thus expressing higher external HLC [42]. According to Cohen and Azaiza [37], these perceptions are incorporated in the cultural belief system and are thus not always related to level of education. In contrast to this view, other scholars note that the Islamic religion stresses that individuals take personal responsibility for their health and that it encourages active health-promoting behaviors [43].

One of the key findings of this study is the low number of steps taken by Saudi females, which is substantially lower than the widely promoted target of 10,000 steps per day required to attain health-related benefits [20]. The mean number of steps of this sample would place them in the

"low active" category (5000–7499 steps/day) of Tudor-Locke and Bassett [20]. This low level of physical activity has never been reported in similar age groups, and, instead, mimics the level of activity in adults 65 years of age or older [44–47]. Other reports of physical inactivity among men and women in the Gulf Cooperation Council, including Saudi Arabia, also showed low levels of sufficient physical activity, more prominent in women compared to men [48]. Estimates were 39.0–42.1% for men and 26.3–28.4% for women, based on only two nationally representative samples from Saudi Arabia and Kuwait. However, those reports were based on data collected using self-report questionnaires on physical activity only, and as such cannot be conclusively verified.

These findings could be analyzed in the context of the Saudi social system and the role of women in this system. Conservative social norms defining the roles for males and females in Muslim countries influence the context in which they can be physically active and reduce potential weight gain [48]. In Saudi Arabia, women have restrictions to movement outside their homes and limited opportunities to attend health centers [49]. In addition, the hot climate, high dependency on automobiles, as well as the employment of domestic helpers, seem to contribute to low levels of activity in daily life [48].

Data from the WHO (2009) also showed that physical inactivity is globally more prevalent among girls and women than their male counterparts [50]. Many factors hinder the participation of women in physical activity and their access to health care, including lower income for women, required agreement from a senior member of the household to engage in physical activity, having a greater workload in the home and care-giving roles, limited mobility, and cultural restrictions [50].

The social structure in Saudi Arabia tends to remain male-dominated, collectivistic, and patriarchal, with great emphasis on family values and group cohesiveness. Consequently, women who grow up in this kind of society may develop a lower internal sense of control and lower confidence level. This may carry even broader implications, since women will not play their important role in encouraging health behaviors in the family setting and on the community level [51]. This pattern seems to be beginning to reverse itself, since the Saudi society is undergoing a major modernization process in health and other services, resulting from higher urbanization, more education, and more women working outside the home. This was accompanied by a government reform in favor of women and recent legislation to empower women to play their role in the development of the country.

In light of the above discussion, this study demonstrates that there is an association between internality and the likelihood of making healthy choices. Success in adopting and maintaining regular exercise depends largely on the individual's self-regulatory efficacy [52, 53]. Clinicians may need to operationalize these findings by designing strategies and messages to directly promote these specific significant constructs in enhancing physical activity.

Clinicians are also advised to remember that behavior change is a slow process which requires constant attention [54]. However, it is possible to predict health-related behaviors: people with a more internal HLC generally adhere more closely to health regimens, while more externally oriented individuals are less likely to engage in health-protective behaviors [38].

This study needs to be interpreted within the context of its limitations. First, the sampling frame of Riyadh limits the generalizability of the findings to other regions. Other limitations of the study include the high attrition, the homogeneous self-selected sample, and the fact that the study was run in an academic setting.

5. Conclusion

It is important to understand the factors and personal characteristics that affect the perseverance of health-promoting behaviors, in order to construct effective interventions. This study provides a baseline assessment of physical activity among Saudi women. The data showed a correlation between physical activity and health beliefs. Practitioners should devote attention and resources to empowering women to take responsibility for promoting personal and family health. This work can contribute to the development of physical activity interventions that are relevant to the Saudi society.

Conflict of Interests

The authors have no conflicts of interest to report.

Acknowledgments

The authors acknowledge the support of the King Saud University Research Center at the Female Center for Scientific and Medical Colleges, Riyadh, Saudi Arabia. Further support was also provided by King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia. The authors also would like to acknowledge Mrs. Jawaher Alaqeel, the demonstrator at College of Applied Medical Sciences in King Saud University, for her valuable contribution in coordinating data collection in this study.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 848403, 9 pages
doi:10.1155/2012/848403

Research Article

Changes in Body Mass Index across Age Groups in Iranian Women: Results from the National Health Survey

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Received 19 July 2011; Revised 12 October 2011; Accepted 16 October 2011

Academic Editor: Abdulrahman O. Musaiger

Background. To investigate the associations between some factors with weight gain across age groups in Iranian women. *Methods*. Proportional odds model was used to estimate the probability of BMI categorized as a function of education, economic index, workforce, smoking, marital status, and place of residence adjusted for age, using data from the "National Health Survey in Iran" database. It included 14176 women aged 20–69 years. *Results*. For all covariates, age was directly associated with overweight and obesity before 60 years of age. Among women aged 20–40 years, the rates of change in probabilities of overweight and obesity were highest. Among women, being inactive, with high economic index, married, being nonsmoker, in an urban residence, with lower educational attainment, all increased the probabilities of overweight and obesity. *Conclusions*. Women aged 20–40 years gained weight faster than other groups. They may need additional information and more support on how to reduce their risk for weight gain through positive health behaviors.

1. Introduction

Overweight and obesity are as public health problems, due to both their rapid growth in recent decades and to their related health disorders, such as cardiovascular diseases, diabetes, some cancers, and other diseases [1–8]. Studies have also showed relationships between obesity and chronic pain [9] and Alzheimer's disease [10].

In 2002, nearly half a billion of the world population considered to be overweight or obese [11]. Obesity is assuming epidemic proportions in both developed and developing countries [12–15]. In 2003-04, 17.1% of US children and adolescents were overweight and 32.2% of adults were obese [16]. Almost one third of adult Canadians are at increased risk of disability, disease, and premature death due to obesity [17]. Obesity is relatively common in Europe, especially in southern and eastern countries, and studies from repeated surveys suggest that the prevalence of obesity has been increasing last years [18]. Up to 2000, the prevalence of obesity in Western countries was suggested to vary between 15 percent and 20 percent [19].

In recent years, the statistics were appalling. The prevalence of obesity in USA, Canada, Australia, United Kingdom, Iran, and Egypt was 31.8, 24.3, 25.1, 24.9, 21.6, and 34.6, respectively [20]. Overall, more than one out of ten of the world adult population was obese. Nearly 1.5 billion adults, 20 and older, are now considered to be overweight or obese. Of these, nearly 300 million women and more than 200 million men were obese [21]. In 2010, almost 43 million children (35 million in developing countries and 8 million in developed countries) were estimated to be overweight or obese [22].

Most studies have investigated the relationship between sociodemographic factors and obesity. It has found a significant association between weight gain and aging [23–26].

Sobal and Stunkard [27] found a strong inverse relationship between socioeconomic status and obesity in women in affluent societies, with a higher proportion of obese women

in lower socioeconomic groups. In low-income countries, obesity is more common among middle-age women, people of higher socioeconomic status, and people living in urban communities [28, 29].

Although the association of overweight with smoking, alcohol consumption, dietary habits, and physical activity has been analyzed in many studies, the findings are not consistent. Wilsgaard et al. [30] showed that being a smoker is associated with lower BMI values.

We aimed to assess the associations between some factors with weight gain across age groups among women by using cross-sectional data from the National Health Survey in Iran (NHSI).

2. Material and Methods

2.1. Study Population. The National Health Survey in Iran (NHSI) is a survey designed to gain comprehensive knowledge and information about health care problems and difficulties throughout the country, 1999-2000. The survey was conducted under the supervision and with the financial support of the Iranian Ministry of Health and Medical Education. The population sample of the survey consisted of one thousandth of the total Iranian population; non-Iranian were excluded. They were randomly chosen by cluster sampling. Each cluster comprises of 8 households. The choice of 8 households for the cluster size was based on one-day performance capacity of the data collection group: four persons (2 physicians, 1 interviewer, and 1 lab technician). The statistical framework was based on the household lists available with every Health Department in the provinces, usually updated annually. Data from the National Health Survey were considered in this investigation. In this study, 14176 women, 8957 urban, and 5219 rural aged 20–69 years were investigated. These data were collected by the National Research Center of Medical Sciences and are presented partially at the Department of Biostatistics and Epidemiology/Tehran University of Medical Sciences for research [31]. We excluded pregnant women from the analyses. This study was approved by the Ethic Committee of the University of Social Welfare and Rehabilitation Sciences.

2.2. Measurements

2.2.1. Response Variable. Height and weight were measured rather than self-reported. Height was measured without shoes to the nearest 5 mm. Weight was measured to the nearest 0.1 kg with the subject in light indoor clothes, with emptied pockets and without shoes. BMI (body mass index) was calculated as weight in kilograms divided by square of height in meters, squared, and subjects were classified into underweight defined as BMI < 18.5, normal weight as BMI 18.5–24.9, overweight as BMI 25.0–29.9, and obese as BMI ≥ 30.

2.2.2. Independent Variables

Age. Information about the respondent age was based on their self-reported birth year, and subjects were stratified into five 10-year age groups (20–29, 30–39, 40–49, 50–59, and 60–69 years).

Education. Educational level was measured in years of school. Years of schooling were divided into three groups: person with basic (0–8 years), moderate (9–12 years), or high (more than 12 years) education.

Economic Index. Due to ethical considerations, we did not ask respondents about their income. Because they were afraid of paying their taxes. We surrogated economic index for their household income. Economic index was defined as square meter of living place divided by number of household. Participants were classified by their economy index status into four classes: (1) low (economic index ≤ Quartile 1), (2) lower-middle (Quartile 1 < economic index ≤ Quartile 2), (3) upper-middle (Quartile 2 < economic index ≤ Quartile 3), and (4) high (economic index > Quartile 3).

Place of Residence. The subjects were grouped according to their place of residence as living in cities (urban) or villages (rural).

Workforce. Active workforce was defined as the part of the female population that belongs to the currently employed (as employees) or self-employed category as opposed to inactive workforce (being a housewife/houseworker, pensioner, student, or unemployed).

Smoking. Smoking status was dichotomized into smoker (those who smoke every day and have smoked at least 100 cigarettes in their lives) versus nonsmoker (others).

Marital Status. To make the marital status variable, it was dichotomized into legally married and nonmarried groups.

Note that we have no information on household income and physical activity, but economic index is surrogate for household income and we used workforce factor. Due to ethical considerations, we did not ask respondents about their income, because they were afraid of paying their taxes. The consumption of alcohol is prohibited in Iran. Therefore, there were no information on alcohol consumption.

2.3. Statistical Analysis. We used proportional odds model to assess the influence of the independent variables listed previously on the probability of obesity and overweight. We carried out score tests for the proportional odds assumption, which was found to hold. In addition, we tested the interaction terms using reduced models excluding nonsignificant terms. For obesity and overweight, odds ratios and 95% confidence intervals were calculated. For all covariates, we calculated the probability of obesity and overweight across age groups. All analyses were performed using SAS software, version 9.1 for windows.

3. Results

The mean BMI of women was 25.33 kg m^{-2} (95% CI: 25.25–25.41). Prevalence (%) of the body mass index levels according to independent variables was assessed (Table 1). Table 1 shows that obesity is much more prevalent among women

Table 1: Prevalence (%) of underweight, normal weight, overweight, and obesity according to sociodemographic and smoking in a random sample of 14176 women in Iran, 1999-2000.

Variable	Underweight	Normal weight	overweight	obese
Age group (years)				
20–30	10.5	57.8	22.6	9.1
30–40	4.0	42.4	33.5	20.1
40–50	3.2	35.8	35.2	25.8
50–60	2.6	35.0	37.1	25.3
60–69	4.4	41.4	36.2	18.0
Education level				
Basic	5.8	44.6	30.8	18.8
Moderate	6.5	47.9	30.9	14.6
High	11.0	63.4	19.9	5.7
Economic index				
Low	8.0	50.6	27.2	14.2
Lower-middle	5.5	44.2	30.9	19.4
Upper-middle	5.4	45.0	31.5	18.1
High	5.2	42.9	32.9	19.0
Workforce				
Inactive	5.2	44.0	31.8	18.9
Active	13.1	61.0	20.0	6.0
Smoking status				
Nonsmoker	6.1	45.9	30.5	17.5
Smoker	6.6	46.5	31.1	15.8
Marital status				
Non-married	8.1	49.4	29.9	12.6
Married	5.6	45.0	30.6	18.8
Place of residence				
Rural	8.3	54.4	25.8	11.5
Urban	4.8	41.0	33.2	21.0

aged 40–60 years, less educated, high economic index, inactive workforce, nonsmoker, married, and resident in city.

We started by fitting a preliminary proportional odds model including only age to observe the influence of the potential confounders on overweight and obesity. Unadjusted odds ratios were 2.50, 3.41, 3.52, and 2.45 for age groups 30–40, 40–50, 50–60, and 60–69 years, respectively.

To assess effects of factors in obesity and overweight across age groups, adjustment for age was performed by using proportional odds model. With four response categories, the model had three intercepts. They are of interest for computing response probabilities. For all covariates, the probability of overweight and obesity was calculated. The results are presented in Figures 1–6.

Figures 1–6 show that age was directly associated with overweight and obesity before 60 years of age. In other words, the probabilities of overweight and obesity increase from 20 to about 50 years of age and decrease after age 60 years. The curves are either flat or in increase in the 50–60 age group. We observe rise in a very high rate among women aged 20–40 years.

We used proportional odds model including age, economic index, workforce status, education level, place of residence, smoking status, and marital status. All were significantly associated with underweight, normal weight, overweight, and obesity. Odds ratios and 95% confidence intervals were calculated (Table 2).

Table 2 shows that among women, being inactive, with high economic index, married, being nonsmoker, in an urban residence, with lower educational attainment, all increased the probability of overweight and obesity. Younger age decreased the probability of overweight and obesity. The odds ratios were 2.16 (95% CI: 1.96–2.35), 2.93 (95% CI: 2.67–3.23), 2.96 (95% CI: 2.63–3.32), and 1.99 (95% CI: 1.76–2.25) for age groups 30–40, 40–50, 50–60, and 60–69 years, respectively.

For overweight and obese participants with moderate and high education, odds ratios were 0.90 (95% CI: 0.83–0.98) and 0.57 (95% CI: 0.47–0.69), respectively.

Women with high economic index were more likely to be overweight and obese. The odds ratios for overweight and obese participants with lower-middle, upper-middle, and

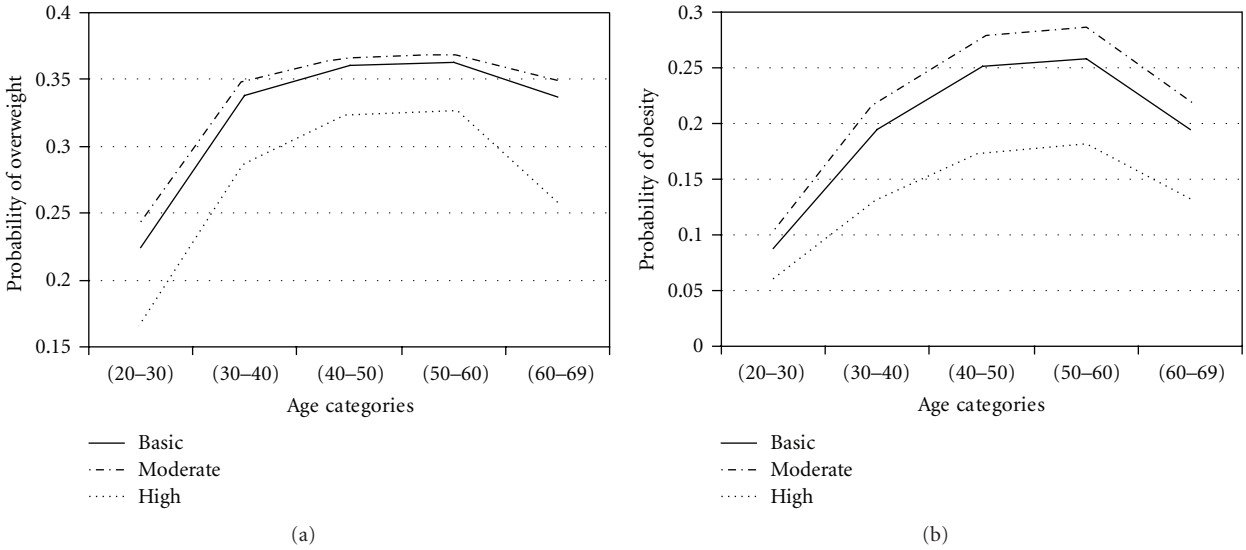

Figure 1: Probabilities of overweight and obesity across age groups for education level.

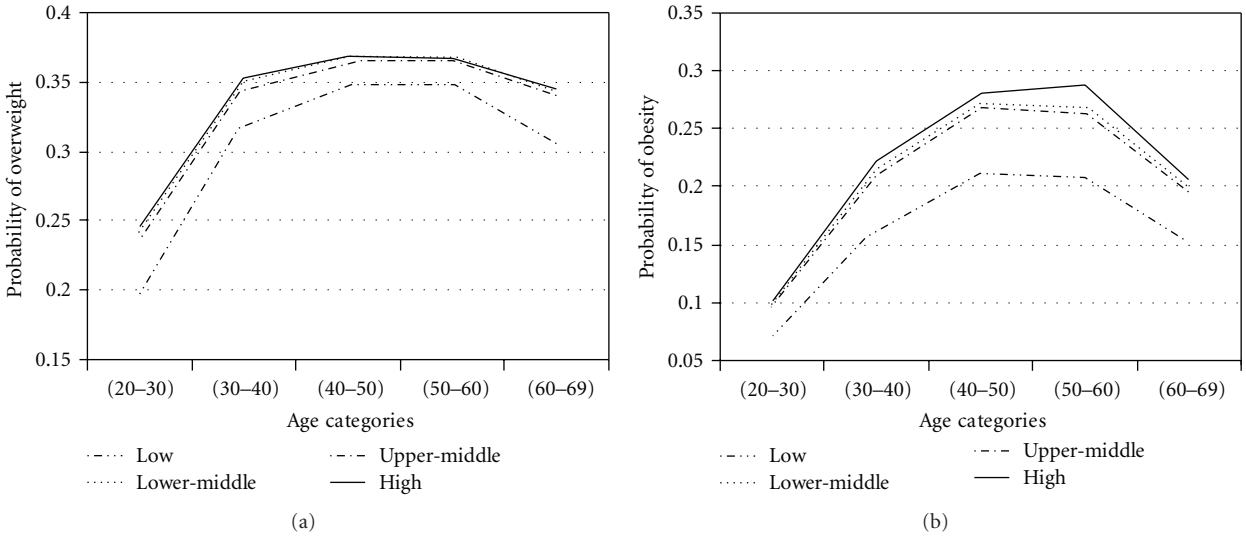

Figure 2: Probabilities of overweight and obesity across age groups for economic index.

high levels were 1.37 (95% CI: 1.26–1.50), 1.38 (95% CI: 1.27–1.51), and 1.49 (95% CI: 1.36–1.63), respectively.

We observed an association between workforce level and BMI groups. For active participants odds ratio was 0.57 (95% CI: 051–0.64).

Overall, nonsmokers were more obese. For smokers, odds ratio was 0.68 (95% CI: 0.54–0.85).

Among women, the odds for urban was 1.97 times that for rural (95% CI: 1.84–2.11).

Married women were more obese. Odds ratio was 1.19 (95% CI: 1.10–1.29).

4. Discussion

Concern about the increased prevalence of overweight and obesity has heightened interest in the association between some factors with weight gain across age groups. In this cross-sectional study we found probabilities of overweight and obesity by identifying a variety of factors that are associated with weight gain. Overall, probability of overweight is higher than probability of obesity. Age was directly associated with overweight and obesity before 60 years of age. The probabilities of overweight and obesity initially increased, and these probabilities decreased for women aged more than 60 years. It is possible that weight loss among older women is result of medical advice to control or prevent obesity-related chronic diseases. For all covariates, the highest probabilities of overweight and obesity were among women aged 50–60 years. Among women aged 20–40 years, the rates of change in probabilities of overweight and obesity were highest. The mechanism of weight gain in women aged 20–40 years is likely multifactorial; that is, younger people

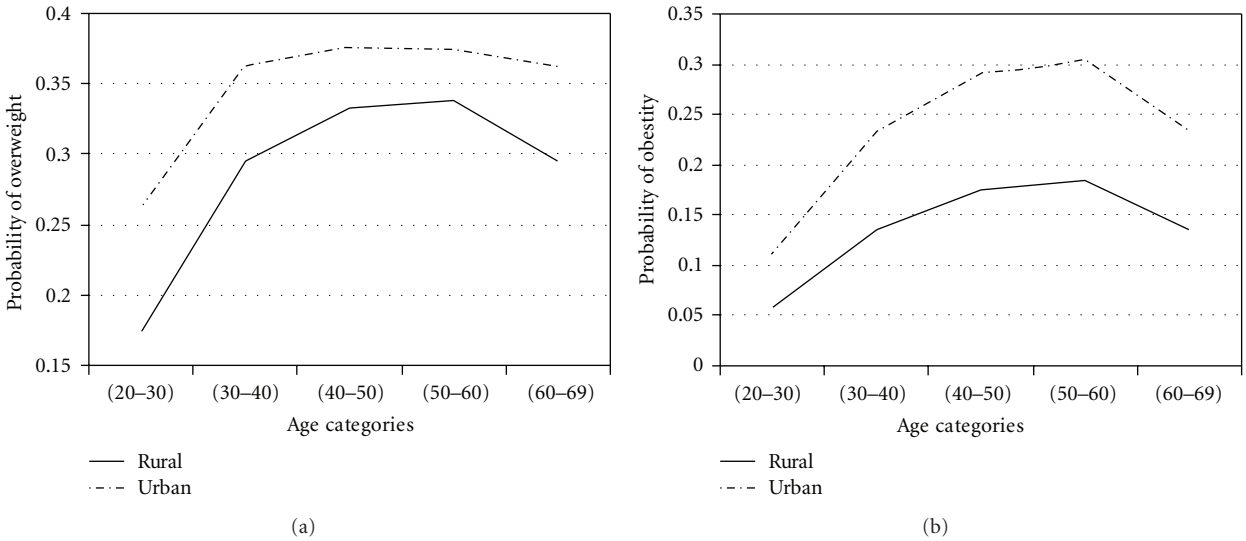

Figure 3: Probabilities of overweight and obesity across age groups for place of residence.

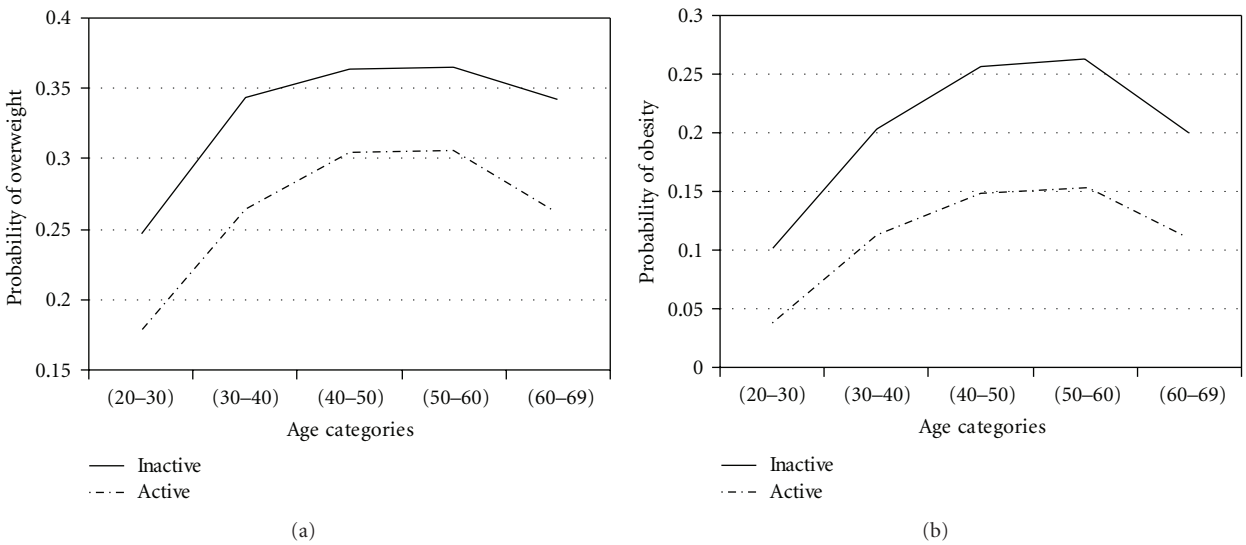

Figure 4: Probabilities of overweight and obesity across age groups for workforce level.

love fast food and their spouses have to follow them. An increased consumption of fast foods by young adults has been repeatedly shown to be associated with obesity and excess weight gain [32]. Although some studies showed that any association between number of children and weight gain is a result of lifestyle and behaviors associated with family life rather than being as result of the biological impact of pregnancy in women [31, 33], it may include physiological mechanisms in the women, especially after their pregnancy. Prevention of weight gain among women aged 20–40 years may have a significant public health impact [34] and further work is needed to understand these relationships.

Education. Women with moderate education had higher probabilities of overweight and obesity than high educated women. Our results are consistent with some studies [26, 35–38]. Note that the women with moderate education had higher probabilities of overweight and obesity than basic educated women. The differences in probabilities of overweight and obesity between high educated and two other levels were noticeable. Higher education may provide knowledge or resource influences on weight loss.

Economic Index. Many studies have found an inverse relation between socioeconomic level and weight [39–45]. It is not straightforward matter to compare those results with ours, because of the different study designs, time span, different region, and method of analysis. In our study, subjects with high level had higher probabilities of overweight and obesity than the other level. These results are consistent with the findings of some study in developing country [46]. In Iran, economy, business, social affair, and so forth are controlled

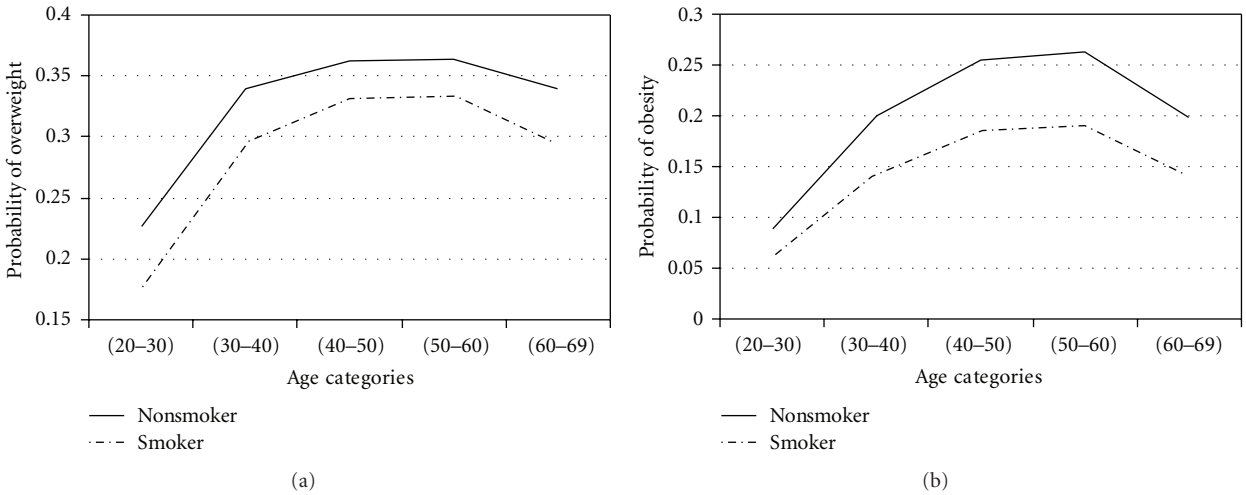

Figure 5: Probabilities of overweight and obesity across age groups for smoking status.

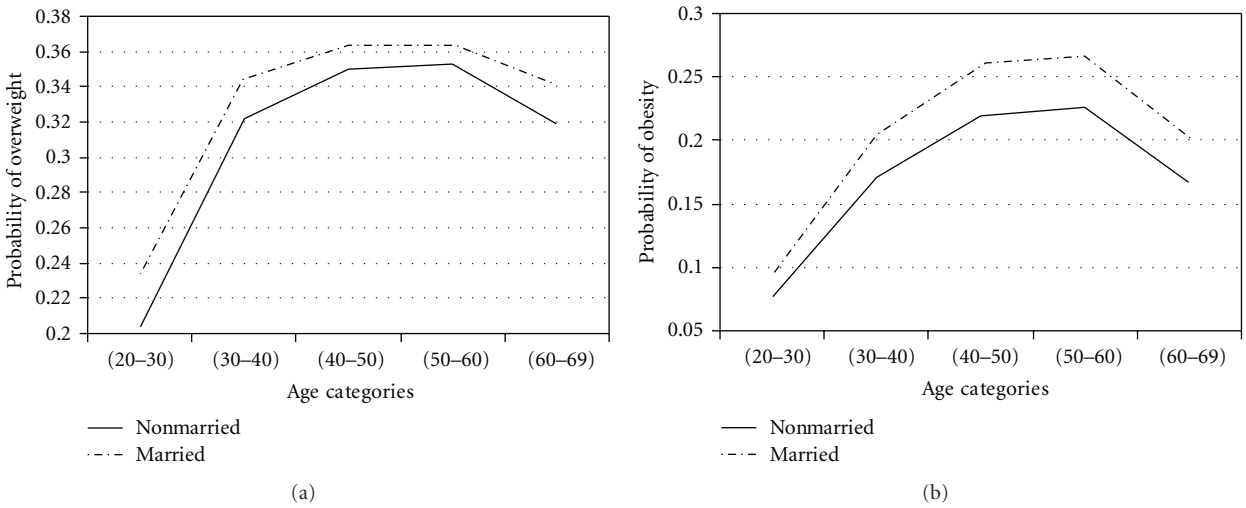

Figure 6: Probabilities of overweight and obesity across age groups for marital status.

by some people named Bazarry. These people have usually low education. Higher economy may not provide knowledge or resource influences on weight loss.

Residence. Urban women had higher probabilities of overweight and obesity than rural women. Among urban women, the probability of overweight initially increased and then changes were fairly slow but this decreasing was sharply in rural women aged >60 years. Among women aged 50–60 years, the probability of obesity for urban was approximately 2 times that for rural.

Workforce. Inactive women had higher probabilities of overweight and obesity than active women. Our results are consistent with some studies. For example, Swedish women who returned to work soon after pregnancy also retained less weight than women who stayed at home [47, 48]. Obesity may be more acceptable among unemployed persons. It is also possible that there is more discrimination against the obese, or obese women may end up in lower status jobs through stronger selective processes in Iran. Another explanation for the effect of the workforce may involve energy expenditure at work or the structured lifestyle that active woman imposes.

Smoking. The increase in body weight by age was found to be lower among smokers than among nonsmokers. Biological mechanisms as well as psychological factors may be involved. An increase of energy expenditure while smoking, both in resting and in light physical activity conditions, may relate to weight loss in smokers. Our results are consistent with the findings of most studies [49–53].

Marital Status. Most studies showed that marriage is associated with weight gain [54, 55]. The finding in this study showed that women who were married tended to gain more weight across the age than those who were not married. The rate of change in probability of overweight in aged <40 years

Table 2: Adjusted* odds ratios for the likelihood of being overweight and obese§‡, by sociodemographic and smoking among random sample of 14176 Iranian women in the proportional odds model, 1999-2000.

Variable	OR#	95% CI†
Age group (years)		
20–30	1.00	
30–40	2.16	1.96–2.35
40–50	2.93	2.67–3.23
50–60	2.96	2.63–3.32
60–69	1.99	1.76–2.25
Education level		
Basic	1.00	
Moderate	0.90	0.83–0.98
High	0.57	0.47–0.69
Economy index		
Low	1.00	
Lower-middle	1.37	1.26–1.50
Upper-middle	1.38	1.27–1.51
High	1.49	1.36–1.63
Place of residence		
rural	1.00	
urban	1.97	1.84–2.11
Workforce		
Inactive	1.00	
Active	0.57	0.51–0.64
Smoking status		
Nonsmoker	1.00	
Smoker	0.68	0.54–0.85
Marital status		
Non-married	1.00	
Married	1.19	1.10–1.29

*Adjusted for all other variables.
§Obese, BMI ≥ 30; overweight BMI 25.0–29.9.
‡BMI: body mass index (weight (kg)/height $(m)^2$) .
#OR: odds ratio.
†CI: confidence interval.

was noticeable. It is possible that the presence of a spouse may operate as a social factor on weight gain.

In Iran, it is commonly believed that overweight and obese people are lazy and gluttonous and they lack self-control. Many obese people do not go out in public because the devices are too uncomfortable. For example, they cannot go to the movies because the seats are too small. Obese people are also more likely to lose the benefits of exercise and it may cause further weight gain. They often feel inferior to others because many people would not to be friends with an obese person. They often get disapproving stares from others. Some people believe that an obese person is taking up more space than he or she should and a job is often denied because of their weights.

Limitations and Strength. Some limitations of this study should be noted. Cause-and-effect cannot be inferred from our cross-sectional data. However, this should be confirmed by further longitudinal studies. It is a limitation that in this study marital status could be categorized into legally married and nonmarried only. Nonmarried people are also a very heterogeneous group and should be more closely examined in further studies. Unfortunately, income and physical activity were not used in our investigation.

Strengths of this study include the national random sample with a considerable age range and a BMI measurement that has been shown to be more valid than self-report measures on body weight and height. Obese people tend to underreport their BMI whereas thin people do the reverse [56, 57].

5. Conclusions

Increases in response were observed through the 20–60 years; however, all age beyond 60 years result in a decrease in probabilities of overweight and obesity. Women aged 20–40

years gained weight faster than other groups. They may need additional information and more support on how to reduce their risk for weight gain through positive health behaviors.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 703490, 12 pages
doi:10.1155/2012/703490

Research Article

Intake of Nutritional Supplements among People Exercising in Gyms in Beirut City

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Received 31 July 2011; Accepted 5 October 2011

Academic Editor: Abdulrahman O. Musaiger

The use of nutritional supplements among exercisers in gyms has been never investigated in the Middle East. The aim of the current study was to assess the prevalence intake of nutritional supplements and the potential influencing factors among people exercising in gyms in Beirut city. In this cross-sectional study, 512 exercisers, aged between 20 and 50 years, were randomly selected from gyms. The intake of nutritional supplements was reported among 36.3% (95% confidence interval 32.2–40.5) of participants, with a weak presence of medical supervision. Patterns of supplement use differed by gender and age. Men and younger exercisers were found to focus on supplements associated with performance enhancement and muscle building, while women and older exercisers were more concerned with health-promoting products such as vitamins, minerals, and herbal supplements. An appropriate dissemination of accurate and scientifically sound information regarding the benefits and side effects of nutritional supplements is highly recommended in the sports environment in Beirut city.

1. Introduction

Lebanon is a Mediterranean country with an estimated population of about 4 million, of which 40% lives in the capital Beirut. Lebanon has been regarded as a country in transition, experiencing a shift in disease type and prevalence as well as in lifestyle and dietary habits [1]. The consumption of nutritional supplements is a major dietary component that might have affected the Lebanese culture through westernization and urbanization.

Nutritional supplements are food components, for example protein, and not foods, or pharmaceutical preparations, for example vitamins and minerals capsule or tablet, supplying one or more nutrients in a concentrated form including proteins, minerals, vitamins, trace elements, and other components that are theoretically present in a normal and balanced diet [2]. Nutritional supplements are usually offered in an untypical form of food, including tablets, capsules, powders, or pills. Although many individuals use supplements, those engaged in sport and physical activities were found to represent an important portion of people purchasing supplements [3].

There is enough evidence that physically active people do not require additional nutrients apart from those obtained from a balanced diet [4]. The American Dietetic Association, the Dietitians of Canada, and the American College of Sports Medicine stated that only those persons who restrict their energy intake, use severe weight-loss practices, eliminate one or more food groups from their diets or consume high-carbohydrate diets with low micronutrient density may require dietary supplementation [5].

Despite these recommendations, the use of supplements has greatly increased in the past years [6]. In fact, nutritional supplements' industry is currently an international market worth billions of dollars [7]. In the United States, more than 3 million people were reported to be using or to have used ergogenic supplements [8]. There has been an increasing use of nutritional supplements by people engaged in physical or

athletic activities [9]. Supplement use among athletes is well documented. It was estimated to range from 40 to as high as 88% [10, 11] and was found to vary according to types of sports, cultural aspects, age groups, and gender [3].

Apart from elite sports club, the highest density of supplement users may reside in the gyms. People exercising in gyms may represent a major target for the supplement market due to their increased widespread existence and to the ease of their access to a variety of sports foods and nutritional supplements. However, limited number of studies described the prevalence of supplement use among people exercising in gyms [12–14].

The increase in demand for nutritional supplements was attributed to various reasons, including enhancing performance, improving health, preventing nutritional deficiencies and illness, increasing muscle mass, decreasing body fat, boosting immunity, increasing alertness and mental activity, improving recovery, and reducing stress [15–18]. However, the exact benefits of nutritional supplements are still not well established [5, 19, 20]. Moreover, various potential risks were described when using nutritional supplements in high doses or without medical supervision [21].

The practices of athletes and exercising individuals in the Middle East region, and more specifically in Lebanon, remain undocumented. Thus, this study aimed to assess the prevalence of nutritional supplements' intake among people who exercise in gyms in the city of Beirut, and to discuss the potential influencing factors as well as the major sources of information and motives associated with their use in an effort to tailor the adequate nutritional awareness campaigns targeted towards exercisers themselves as well as people influencing their decisions.

2. Materials and Methods

This was a cross-sectional study carried out in the city of Beirut, Lebanon, from June 2010 to August 2010.

2.1. Selection of Population. The sample size calculation ($n = 504$) was based on the equation $n = z^2 * p * (1 - p)/W^2$, where n was the estimated sample size, z the normal distribution (defined as 1.96 for research with 95% confidence), p the estimated proportion of individuals who use supplements (30%), and W the study margin of error (4%). A total of 512 participants were included in the study.

A two-stage sampling was performed. In the first stage, all commercial gyms were identified based on the address listings provided by various public and information agencies in the city of Beirut. Gyms that reported offering only one type of physical activity were excluded from the study. Telephone contacts were carried out in order to assess their current existence and activities. In the second phase, a systematic random scheme was used in order to select adults from the eligible gyms ($n = 50$) in proportion to the population size of each district of Beirut city, including Achrafieyh, Ain el Maryseh, Bashoura, Mazraa, Minet el Hosn, Mousaytbeh, Ras Beirut, Rmeil, Saife, Zkak el Blat, Port, and Dahieh. Such selection allowed for a more regular distribution of participants from various socioeconomic groups. To be included in the study, individuals had to be exercisers aged between 20 and 50 years with no regard to gender or socioeconomic status. All participants signed a formal consent after being informed about the objectives of the study.

The study was conducted according to the principles expressed in the Helsinki Declaration and was approved by the Institutional Review Board of the American University of Beirut, Lebanon.

2.2. Questionnaire. The administered questionnaire consisted of 17 questions, divided into three main parts. The first part included questions concerning demographic characteristics such as age, gender, educational background, disease history, alcohol consumption, and smoking status. The second part tackled sports-related features, such as type, frequency, and total duration of physical activities. The third part of the questionnaire consisted of questions related to supplement use. In this section of the questionnaire, participants had to mention about the sources of sports nutrition information, the motivations for the use of nutritional supplements, as well as the types of supplements being used and the duration and timing of their consumption. This questionnaire was previously tested in a pilot study conducted in gyms from two different regions of the city of Beirut, and a final version was developed. All surveys were filled by the researchers themselves, after reading the questions to the participants.

2.3. Statistical Analysis. Statistical analyses were conducted using SPSS software (version 17.0; SPSS, Chicago, Ill).

All variables were categorical. Descriptive analyses were based on frequencies and percentages. Pearson chi-square tests were used to identify associations of supplement intake status (user/nonuser) with factors potentially related to its use.

Independent two-step cluster analyses were used to motivate modality grouping within each question (types of nutritional supplements, reasons for supplement use, and sources of supplement information). This method creates groups of subjects as homogeneous as possible inside each group, and as contrasted as possible between groups. It combines sequential and hierarchical agglomerative methods preclustering and then subclustering data. The determination of the number of clusters was based on the largest relative increase in distance between the two closest clusters defined by the Schwarz Bayesian Criterion as well as on potentially meaningful explanations. The type of nutritional supplements in use was best described by the following modalities: performance supplements (aggregating creatine, amino acid pills, arginine, glutamine, and branched-chain amino acids), vitamins/minerals (including multivitamins, multiminerals, vitamin and mineral supplements, as well as vitamin C and vitamin E), weight/fat loss supplements (including carnitine, protein bars, and protein shakes), alertness/energy supplements (comprising caffeine and sports energy drinks), natural supplements (with herbal supplements, iron, calcium tablets, and fish oil pills), and the last cluster included soy and sports bar. Finally, protein powder,

casein protein, whey protein, and antioxidants remained independent as they were not found to fit into any of the six clusters. Four clusters have been identified covering all reasons for supplement use among those proposed: disease prevention (prevention of nutritional deficiencies, treatment of medical problems, and prevention of diseases in the future), immunity/energy boosting (immunity boosting, increased alertness and mental activity, and decreased stress), muscle building (muscle gain or weight gain, muscle repair or recovery, strength enhancement, and performance improvement), and weight/fat loss (meal replacement, weight loss, and decreased body fat). The sources of supplement information were described by three clusters: medical/paramedical (dietitians and physicians), media (magazines, internet, media, books, and friends), and coaches (coaches and companies). These clusters have been used for subsequent analyses except otherwise stated.

Types of nutritional supplements, reasons for supplement use, and sources of supplement information were analyzed by gender and age group. Several variables were found to influence these nutritional supplements-associated parameters. Age appeared as a common variable in few studies [22, 23]. On the other hand, the role of gender is still not clear [10, 24]. The odd ratio measured the associations of types of nutritional supplements, reasons for supplement use, and sources of supplement information with male and female gender from one side and various age groups from another side.

Differences were considered statistically significant at $P < 0.05$.

3. Results

3.1. Demographic Characteristics. Table 1 summarizes the basic characteristics of participants. Out of the 512 participants, 60.9% were men. The population was young, with 63.7% being in the 20–30 year age group. More than half of exercisers (69.1%) reported having a university degree, including bachelor degree, masters degree, and above.

3.2. Alcohol Consumption, Smoking and Disease History. As shown in Table 1, 65.6% were nonconsumers of alcoholic beverages. In addition, 61.7% were nonsmokers, and 92.8% described no disease history at the time of the survey.

3.3. Physical Activity. Most of those interviewed exercised for more than a year (75.4%) (Table 1). The majority of participants exercised regularly for 3 to 5 times a week (64.1%) and 68.6% spent 1 to 2 hours per day exercising. The highest percentage of exercisers mainly performed strength training (65.4%) and treadmill (63.5%) in gyms (data not shown).

3.4. Use of Nutritional Supplements. The intake of nutritional supplements was reported by 36.3% (95% confidence interval 32.2–40.5) of participants.

Supplement use status was significantly associated with gender and total time of exercise (Table 1). Among users, a large proportion were men (72.0%, $P < 0.001$) and were participants who have been exercising for a duration longer than a year (83.3%, $P < 0.01$). Other factors, including age group, education, alcohol intake, smoking status, disease history, frequency of exercise, and total time of daily exercise, had no significant associations with supplement use.

When analyzing supplement use by types of physical activities in Table 2, only strength training ($P < 0.001$), treadmill ($P < 0.05$), and fights and martial arts ($P < 0.05$) had significant associations with the use of nutritional supplements. While exercisers performing strength training (80.6%) and treadmill (57.0%) reported significantly higher percentages of supplement use as compared with exercisers involved in other activities, those performing fights and martial arts had significantly lower levels of intake of nutritional supplements (14.5%).

3.5. Types of Supplements. The types of nutritional supplements consumed by participants are shown in Figure 1. The five most commonly consumed supplements were protein powder (39.8%), amino acid pills (34.9%), whey protein (32.3%), creatine (19.4%), and multivitamins (17.7%). The intake of two or more products simultaneously was reported by 25.6% of participants (data not shown).

Almost half of the participants (44.1%) reported using supplements for more than 2 years, while 22% described taking them for 1 to 2 years (data not shown).

3.5.1. Types of Supplements according to Gender. As shown in Table 3, men consumed performance supplements ($P < 0.001$), weight/fat loss supplements ($P < 0.05$), alertness/energy supplements ($P < 0.05$), protein powder ($P < 0.001$), and whey protein ($P < 0.001$) to a greater extent than women. On the other hand, women focused more on products associated with health benefits, including vitamins/minerals ($P < 0.01$) and natural supplements ($P < 0.001$) in comparison to men.

3.5.2. Types of Supplements according to Age Group. Types of used supplements differed as well by age groups as shown in Table 3. Participants aged above 40 years consumed less of the performance supplements ($P < 0.01$) and protein powder ($P < 0.05$) in comparison to those aged below 30 years. Moreover, exercisers aged between 30 and 40 years were found to take weight/fat loss supplements to a lesser extent than those younger than 30 years ($P < 0.05$). On the other hand, older exercisers consumed more of the natural supplements in comparison to younger ones ($P < 0.001$).

3.6. Reasons for Supplement Use. The major reported reasons for supplement use were to promote muscle gain (47.3%) and to enhance strength (34.4%, Figure 2). Other reasons included to replace meal (33.9%), increase muscle repair or recovery (25.3%), and enhance performance (22.0%).

3.6.1. Reasons for Supplement Use according to Gender. As shown in Table 4, men focused on the muscle building ($P < 0.001$) and fat reduction ($P = 0.001$) aspects of nutritional

Table 1: Sociodemographic and lifestyle characteristics of all participants and of users of nutritional supplements. No missing data.

	Percentage of total population (n = 512)	Percentage of supplement users (n = 186)	P
Gender			
Male	60.9	72.0	<0.001
Female	39.1	28.0	
Age group (years)			
20–30	63.7	64.0	
30–40	26.6	26.9	0.936
40–50	9.8	9.1	
Education			
Brevet	10.2	9.1	
Lebanese Bachelor	13.7	10.8	
Technical degree	5.5	6.5	0.615
Bachelor	56.8	59.1	
Masters or above	12.3	12.4	
Others	1.6	2.2	
Alcohol intake			
No	65.6	60.8	0.080
Yes	34.4	39.2	
Smoking status			
No	61.7	59.1	
Current	31.3	34.4	0.500
Former	7.0	6.5	
Disease history			
No	92.8	90.3	0.106
Yes	7.2	9.7	
Total time of exercise			
<1 month	3.9	1.6	
1–6 months	11.5	10.2	0.005
7 months–1 year	9.2	4.8	
>1 year	75.4	83.3	
Frequency of exercise			
<3 times/week	16.8	14.0	
3–5 times/week	64.1	62.4	0.099
>5 times/week	19.1	23.7	
Total time of daily exercise			
<1 hour/day	18.0	16.7	
1-2 hours/day	68.6	71.0	0.673
>2 hours/day	13.5	12.4	

supplements to a greater extent than women. On the other hand, women were more interested than men in the health-related aspects of supplements, such as disease prevention ($P < 0.001$).

3.6.2. Reasons for Supplement Use according to Age Group. When analyzing the reasons for using nutritional supplements by age group, significant differences were also noted (Table 4). Exercisers aged between 30 and 40 years were less concerned about the muscle-building functions of supplements in comparison to younger ones ($P = 0.050$). Participants older than 40 years were even less concerned ($P < 0.01$). On the other hand, exercisers above the age of 40 years had an increased interest in the disease prevention characteristics of nutritional supplements in comparison to those younger than 30 years ($P < 0.001$).

3.7. Sources of Supplement Information. A big proportion of participants consumed supplements without seeking any professional guidance (Figure 3). The highest percentage of supplement users was found to seek information from "uncertain" sources, including coaches (44.6%) and internet (36.6%). Media, including magazines, internet, media, and books, constituted an important source of supplement information for exercisers. In fact, 60.8% of supplement users were found to rely on media-related sources. On

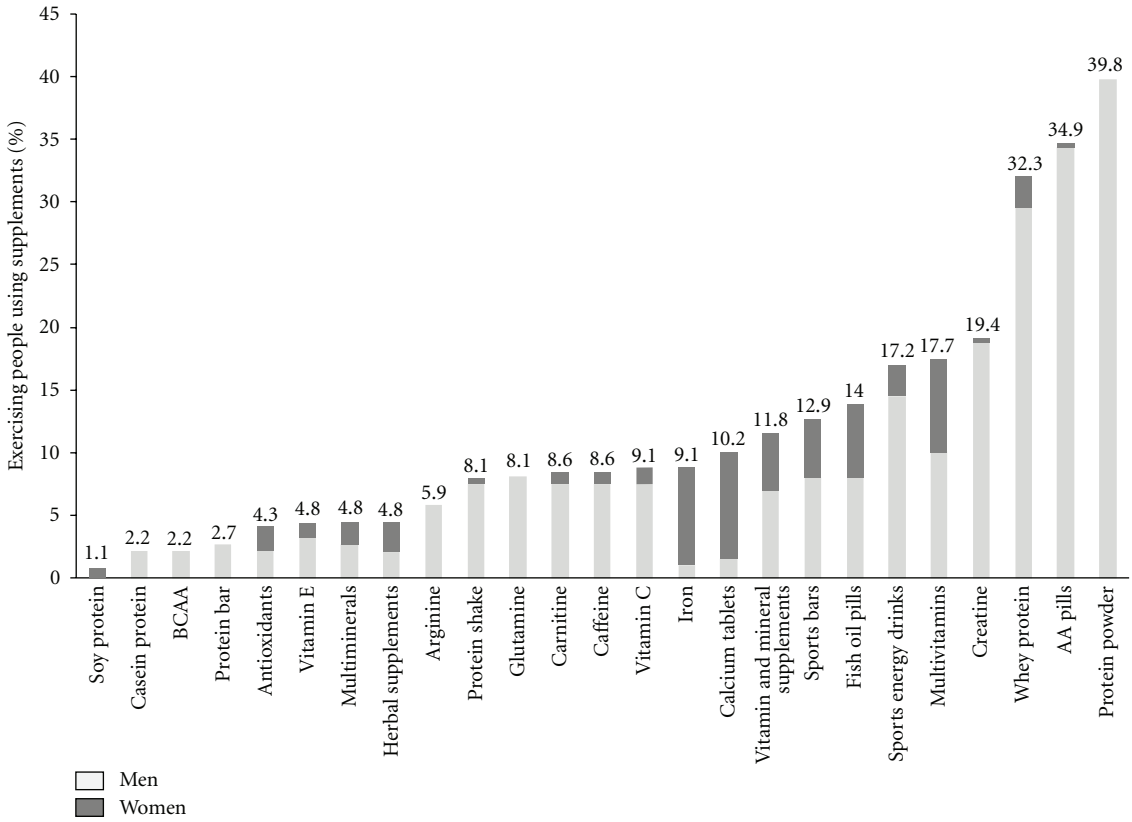

Figure 1: Types of nutritional supplements used among supplement users ($n = 186$); BCAA: branched-chain amino acids; AA pills: amino acid pills. There are no missing data.

the other hand, only 34.4% and 26.9% of exercisers got information from medical sources including physicians and dietitians, respectively.

3.7.1. Source of Supplement Information according to Gender. Sources of information regarding nutritional supplements were found to differ among males and females (Table 5). Men relied mainly on nonmedical sources, including media ($P < 0.001$) and coaches ($P < 0.001$). On the other hand, women cared more to seek information from medical professional sources including dietitians and physicians ($P < 0.001$).

3.7.2. Sources of Supplement Information according to Age Group. When analyzing data according to age group, a trend was also observed (Table 5). Younger exercisers, aged below 30 years, got their information regarding nutritional supplements from coaches to a significantly greater extent than those aged above 40 years ($P < 0.01$). On the other hand, older exercisers, aged above 40 years, consulted with medical/paramedical professionals to a greater extent than younger age groups ($P < 0.01$).

3.8. Supplement Labels. A rate of 87.6% of supplement users reported checking labels on nutritional supplements (data not shown). Amongst those who indicated not reading labels, almost half of them (52.2%) were found to trust enough their trainers.

4. Discussion

Our study is the first to illustrate the prevalence use of nutritional supplements among exercisers, not athletes, in gyms in the Middle Eastern region. In the current study, 36.3% of participants reported using nutritional supplements among a representative sample of people exercising at gyms in Beirut city. Such prevalence rate is almost the same as that described in the study of Goston and Correia [13] (36.8%) among exercisers in gyms in the city of Belo Horizonte, Brazil. Even if significant, supplement use in Beirut city was found to be way lower than rates observed in New York City (84.7%) and in Spain (56.1%) among exercisers [12, 14]. Exercisers in gyms constitute an important target for nutritional supplement market. However, most studies investigating about supplement use worldwide focused on athletes [10, 15, 18, 25–27], among which the highest percent of consumers is found [28]. Discrepancies in reported prevalence rates could be explained by the different types of gyms included in the studies, the varied characteristics of participants, the various modes of data collection, as well as the potential under- or overreporting of supplement use and the lack of knowledge about the exact definition of supplement among exercisers [16, 24, 29, 30]. In the current study, only gyms offering different sports activities were selected in order to avoid the inclusion of people focusing on body-building activities. It is well established that

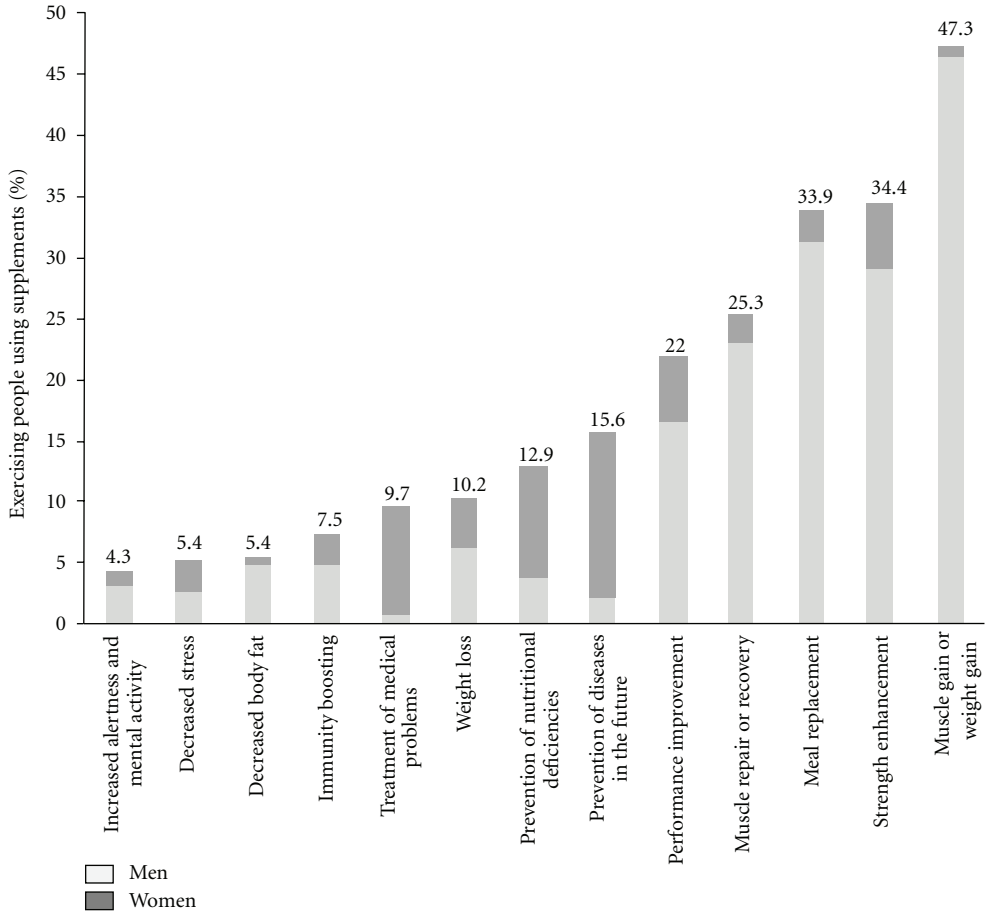

Figure 2: Reasons for supplement use among supplement users ($n = 186$). There are no missing data.

body-builders consume more nutritional supplements than other sport participants [10, 27].

Supplement use patterns were found to differ by gender and total time of exercise. The role of gender as a determinant of supplement use is still not clearly established. In the current study, male exercisers constituted a bigger proportion of supplement users taking into account that more males participated in the study. Similarly, supplement use was reported to be higher among male exercisers [13] and adolescent athletes [31]. In contrary, Sobal and Marquart [10] found a significantly higher prevalence of supplement use among female athletes. On the other hand, Sundgot-Borgen et al. [24] did not find any significant difference between sexes. The association of exercising duration with the status of supplement use has been rarely investigated. In the current study, participants who have been exercising for a long duration were the ones to consume nutritional supplements the most. A greater exercising period is most likely associated with increased interest in sports-related information, increased exposure to sports-related media, and increased interaction with trainers, coaches, and sports fellows. All these factors were described with major impacts on the decision-making process regarding the use of nutritional supplements [32]. At last, differences in supplement use patterns can be also observed between various sports activities. Supplement use is most frequent in sports that emphasize performance and muscle size. In fact, consumption of nutritional supplements in strength sports such as weight lifting, power lifting, and bodybuilding was found to be higher than that in other sports [10, 33]. In the current study, strength training, and to a lesser extent treadmill, was associated with a greater utilization of nutritional supplements, unlike fights and martial arts that do not usually emphasize on muscle building and strength.

Similarly to the current study, protein supplements were among the most widely used nutritional ergogenic supplements in other studies, ranging from 28% in Sevilla, Spain [14], and 42.3% in New York City [12], up to 58% in Belo Horizonte, Brazil [13]. These observations originate primarily from misconceptions regarding protein supplement effectiveness [34]. However, the association between protein intake and muscle mass has not been yet scientifically proven [34, 35]. Even in athletes involved in intense training and with elevated dietary protein needs, a well-balanced diet that maintains energy balance can achieve these recommendations [36–38]. On the other hand, as observed in the current study, vitamin and mineral supplements were found to be frequently consumed in exercise [12–14]. Although physical activity may slightly increase the requirements for certain vitamins and minerals [39, 40], many of which are

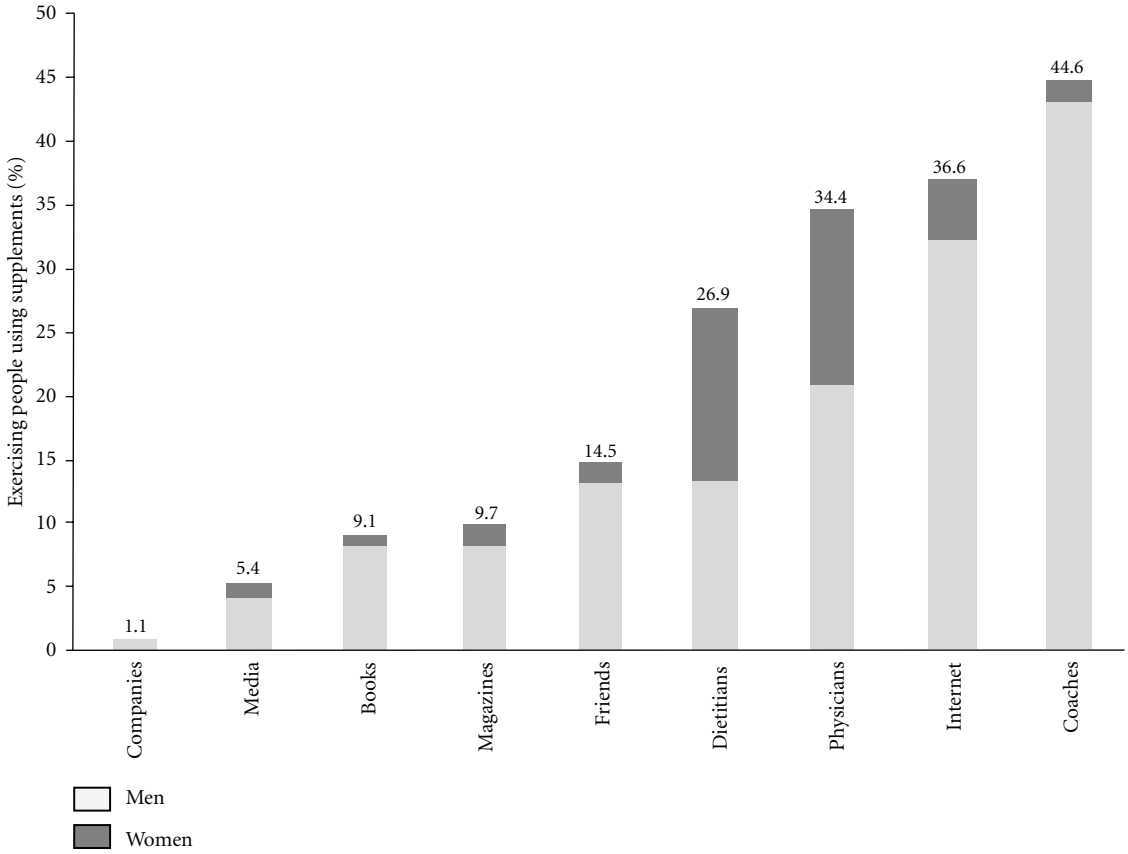

Figure 3: Sources of information among supplement users ($n = 186$). There are no missing data.

involved in muscle contraction as well as in energy store replenishment and muscle repair, this is generally met by the high energy intake of exercisers and athletes [39].

In the current study, men and younger exercisers focused on supplements generally associated with performance enhancement, body building, and fat reduction including those rich in proteins and amino acids, while women and older exercisers were more concerned with supplements with general health benefits such as those rich in vitamins, minerals, and herbal products. Such pattern has been similarly observed in various studies [12, 15, 16, 41, 42]. In the study of Goston and Correia [13], men and young exercisers were more likely to use supplements rich in proteins and branched-chain amino acids while women and persons older than 40 years took supplements rich in vitamins/minerals and natural/phytotherapeutic agents. Similarly, female varsity college athletes were more likely to take calcium and multivitamins, while males had a significantly important intake of amino acids, glutamine, weight gainers, and whey protein [16].

Reasons for selecting nutritional supplements were various, differing as well according to gender and age group. In general, females were more likely to take supplements for health or because of inadequacy in dietary habits, while males reported taking supplements to improve speed, strength, power, and weight/muscle gain [10, 15, 16, 25, 30, 43, 44]. In the present study, supplement use was essentially revolving around muscle gain, muscle repair, and performance enhancement in men and young exercisers. On the other hand, women and old exercisers used nutritional supplements for health-oriented purposes, including prevention of nutritional deficiencies, treatment of medical problems, and prevention of future diseases. Similarly, in the study of Goston and Correia [13], people younger than 30 years took supplements with the purpose of increasing muscle mass, while those older than 45 years consumed supplements to prevent future illness. Moreover, the use of multivitamins, vitamin C, and herbal products was higher among female university athletes in Singapore for general health benefits, while athletes who wanted to gain muscle mass used protein and amino acids [45]. Among exercisers in New York City, more of the oldest participants consumed multivitamins, minerals, and vitamin E to prevent future illness, while those aged 45 years or younger chose protein shakes and bars to build muscle [12].

The increased supplement utilization rates among exercisers could be partially attributed to a positive attitude towards supplements as a part of an appropriate dietary pattern [32, 46]. However, there is still no conclusive evidence that supplementation enhances health or sports performance. Supplementation may benefit athletes with preexisting deficiencies or who are on caloric restrictions or traveling for prolonged periods to regions with inadequate or limited food supply [39]. Most of supplement users are not familiar with

Table 2: Types of physical activities performed in the gyms by supplement users ($n = 186$). No missing data.

Types of physical activities	Percentage supplement use (n)	P
Strength training		
No	19.4 (36)	<0.001
Yes	80.6 (150)	
Treadmill		
No	43.0 (80)	0.021
Yes	57.0 (106)	
Team sport		
No	72.6 (135)	0.265
Yes	27.4 (51)	
Water sport		
No	80.6 (150)	0.808
Yes	19.4 (36)	
Fights and Martial Arts		
No	85.5 (159)	0.019
Yes	14.5 (27)	
Yoga		
No	94.1 (175)	0.515
Yes	5.9 (11)	
Others		
No	89.8 (167)	0.389
Yes	10.2 (19)	

the negative impacts of nutritional supplements on health if inappropriately used. In the study of Tian et al. [45] on university athletes in Singapore, 86.4% were unaware that supplements can adversely affect health. The potential risks of several nonanabolic nutritional supplements when used in high doses or without the counseling of a physician have been described [21]. In the current study, even if the consumption amounts of nutritional supplements were not assessed, such a high consumption rate may reflect inappropriate and dangerous consumption patterns.

This lack of awareness is majorly attributed to the inadequate sources of information of exercisers and athletes regarding nutritional supplements. Nearly 80% of athletes obtain information from "questionable" sources including media, internet, peers, coaches, and trainers [15, 17, 44, 47]. In the current study, coaches were the primary source of supplement information, mainly for younger male exercisers. Athletic trainers and coaches were also described as the most trusted professionals for supplement information by male athletes in other studies [11, 26, 48]. Advices provided by coaches and athletic trainers are usually inaccurate, inappropriate, or even potentially damaging. A big number of athletic trainers and coaches have a minimal specialized knowledge in sports nutrition. Moreover, they have ready access to and financial interest in an ever-increasing range of supplements and sports foods, which might greatly influence the type and direction of their consultations.

Media, including books, magazines, television, and internet, was also perceived as a powerful influence on a person's decision to use nutritional supplements [32]. Media, including internet, media, magazines, and books, influenced the decisionmaking of 60.8% of participants in the current study. Magazines, newspapers, and internet were also the major sources of information about supplements of 39.7% of university athletes in Singapore [45]. Similarly, internet (79%), magazines (68%), and television (52%) were the most popular media sources for supplement information of college athletes [48]. Exercisers are constantly exposed to advertisements in magazines and internet, which distort clinical studies and formulate misleading claims [31, 32, 49, 50]. Although media information may not be clinically validated [51], 52% of consumers were found to believe that "almost all" or "most" health information on the internet is credible according to the Pew Internet and American Life Project Report [52].

Consultation with medical professionals, including physicians and dietitians, is practiced to a lower extent in the sports environment. In the current study, 73.1% of exercisers had never received any guidance from a nutritionist. Similarly, Rocha and Pereira [53] showed that most athletes (78%) do not obtain their supplement information from nutritionists. In other studies, only 10 to 14% of participants considered dietitians as their primary source of supplement information [26, 44]. This observation could be majorly attributed to the limited access to health professionals, including dietitians, in gyms and sports centers.

Due to the limited knowledge about supplement safety and toxicity, polypharmacy, or the concurrent use of more than one product, is another major issue among athletes and exercisers [17, 43]. The highest rates were described among athletes. Baylis et al. [54] reported that 77% of elite Australian swimmers concurrently used more than one vitamin/mineral product. In a study on intercollegiate student athletes, 88% used one or more nutritional supplements [26]. Multivitamins were often combined with vitamin C, calcium, vitamin E, and iron by Singaporean university athletes [45]. Among exercisers, it was also commonly practiced though at lower rates. In the study of Goston and Correia [13], 43.5% of exercisers reported the simultaneous use of two or more products. In the current study, the rate of utilization of two or more products was almost half (25.6%). However, it remains significant and worth followup and intervention.

Product labeling was enacted in the United States by the Dietary Supplement Health and Education Act of 1994 in order to protect consumer access to nutritional supplements while providing guidelines for their consumption [51]. In the current study, 87.6% of supplement users did check supplement labels before consumption. This value is much higher and promising than those previously reported, where 33.3% [17] and 57% [15] of athletes attempted to seek information and read labels before using any supplement. However, if not properly supervised, reading labels might be erroneous and misleading. Both U.S. Food and Drug Administration

Table 3: Types of nutritional supplements by gender and age group ($n = 186$). CI: confidence interval. No missing data.

Types of nutritional supplements	Gender		Age group (years)		
	Men	Women	20–30	30–40	40–50
Performance supplements cluster					
Percentage (n)	54.5 (73)	1.9 (1)	42.0 (50)	46.0 (23)	5.9 (1)
Odd ratio (95% CI)	1.000	0.016 (0.002–0.122)	1.000	1.176 (0.605–2.285)	0.086 (0.011–0.672)
P		<0.001		0.010	
Vitamins/minerals cluster					
Percentage (n)	23.9 (32)	46.2 (24)	28.6 (34)	28.0 (14)	47.1 (8)
Odd ratio (95% CI)	1.000	2.732 (1.392–5.363)	1.000	0.972 (0.466–2.026)	2.222 (0.792–6.238)
P		0.003		0.278	
Weight/fat loss supplements cluster					
Percentage (n)	20.9 (28)	5.8 (3)	21.8 (26)	6.0 (3)	11.8 (2)
Odd ratio (95% CI)	1.000	0.232 (0.067–0.799)	1.000	0.228 (0.066–0.793)	0.477 (0.102–2.221)
P		0.013		0.035	
Alertness/energy supplements cluster					
Percentage (n)	25.4 (34)	9.6 (5)	25.2 (30)	14.0 (7)	11.8 (2)
Odd ratio (95% CI)	1.000	0.313 (0.115–0.851)	1.000	0.483 (0.196–1.187)	0.396 (0.085–1.831)
P		0.018		0.163	
Soy and sports bar cluster					
Percentage (n)	11.2 (15)	17.3 (9)	15.1 (18)	8.0 (4)	11.8 (2)
Odd ratio (95% CI)	1.000	1.660 (0.677–4.072)	1.000	0.488 (0.156–1.523)	0.748 (0.157–3.554)
P		0.264		0.447	
Natural supplements cluster					
Percentage (n)	13.4 (18)	63.5 (33)	18.5 (22)	34.0 (17)	70.6 (12)
Odd ratio (95% CI)	1.000	11.193 (5.278–23.737)	1.000	2.271 (1.077–4.789)	10.582 (3.380–33.131)
P		<0.001		<0.001	
Protein powder					
Percentage (n)	55.2 (74)	0 (0)	43.7 (52)	40.0 (20)	11.8 (2)
Odd ratio (95% CI)	1.000	0.000	1.000	0.859 (0.439–1.682)	0.172 (0.038–0.785)
P		<0.001		0.042	
Casein protein					
Percentage (n)	3.0 (4)	0 (0)	2.5 (3)	0.0	5.9 (1)
Odd ratio (95% CI)	1.000	0.000	1.000	0.000	2.417 (0.237–24.659)
P		0.208		0.316	
Whey protein					
Percentage (n)	41.0 (55)	9.6 (5)	31.9 (38)	38.0 (19)	17.6 (3)
Odd ratio (95% CI)	1.000	0.153 (0.057–0.409)	1.000	1.306 (0.656–2.602)	0.457 (0.124–1.685)
P		<0.001		0.298	
Antioxidants					
Percentage (n)	3.0 (4)	7.7 (4)	1.7 (2)	8.0 (4)	11.8 (2)
Odd ratio (95% CI)	1.000	2.708 (0.651–11.260)	1.000	5.087 (0.901–28.731)	7.800 (1.022–59.529)
P		0.156		0.051	

and the American College of Sports Medicine encourage individuals to examine supplement safety, efficacy, potency, and legality prior to use under the supervision of healthcare professionals [40].

5. Conclusion

In conclusion, we identify a potential overintake of nutritional supplements among exercisers in the gyms of Beirut city. This pattern reflects a serious public health concern

Table 4: Reasons for supplement use by gender and age group ($n = 186$).

Reasons for supplement use	Gender		Age group (years)		
	Men	Woman	20–30	30–40	40–50
Disease prevention cluster					
Percentage (n)	7.5 (10)	69.2 (36)	17.6 (21)	22.0 (11)	82.4 (14)
Odd ratio (95% CI)	1.000	27.900 (11.655–66.787)	1.000	1.316 (0.581–2.984)	21.778 (5.742–82.594)
P		<0.001		<0.001	
Immunity/energy boosting cluster					
Percentage (n)	9.7 (13)	17.3 (9)	12.6 (15)	8.0 (4)	17.6 (3)
Odd ratio (95% CI)	1.000	1.948 (0.7778–4.880)	1.000	0.603 (0.190–1.916)	1.486 (0.382–5.785)
P		0.149		0.516	
Muscle building cluster					
Percentage (n)	85.1 (114)	40.4 (21)	81.5 (97)	62.0 (31)	41.2 (7)
Odd ratio (95% CI)	1.000	0.119 (0.057–0.247)	1.000	0.370 (0.177–0.772)	0.159 (0.054–0.463)
P		<0.001		<0.001	
Weight/fat loss cluster					
Percentage (n)	50.7 (68)	23.1 (12)	42.0 (50)	52.0 (26)	23.5 (4)
Odd ratio (95% CI)	1.000	0.291 (0.141–0.603)	1.000	1.495 (0.770–2.903)	0.425 (0.131–1.379)
P		0.001		0.115	

There are no missing data.
CI: confidence interval.

Table 5: Source of supplement information by gender and age group ($n = 186$).

Source of information	Gender		Age group (years)		
	Men	Woman	20–30	30–40	40–50
Medical/paramedical cluster					
Percentage (n)	42.5 (57)	88.5 (46)	46.2 (55)	66.0 (33)	88.2 (15)
Odd ratio (95% CI)	1.000	10.357 (4.139–25.912)	1.000	2.259 (1.136–4.491)	8.727 (1.911–39.854)
P		<0.001		0.001	
Media cluster					
Percantage (n)	55.2 (74)	21.2 (11)	50.4 (60)	38.0 (19)	35.3 (6)
Odd ratio (95% CI)	1.000	0.218 (0.013–0.459)	1.000	0.603 (0.307–1.183)	0.536 (0.186–1.544)
P		<0.001		0.223	
Coaches cluster					
Percantage (n)	61.2 (82)	5.8 (3)	52.1 (62)	42.0 (21)	11.8 (2)
Odd ratio (95% CI)	1.000	0.039 (0.012–0.131)	1.000	0.666 (0.342–1.297)	0.123 (0.027–0.560)
P		<0.001		0.006	

There are no missing data.
CI: confidence interval.

since practiced with minimal professional guidance. As nutritional supplements do not compensate for poor food choices and inadequate dietary habits and as they are not risk-free, it is extremely essential to disseminate accurate and scientifically sound information regarding appropriate use, potential benefits, and possible side effects of these products in the sports environment. Health professionals, including physicians, dietitians, and pharmacists, should combine their expertise with that of coaches and athletic trainers in order to provide more comprehensive nutrition services to exercisers.

Conflict of Interests

The authors have no conflict of interests.

Acknowledgments

The authors thank the gyms and study participants for their cooperation. They also thank Amanda Yacoub, Darine Shatila, and Lina Akkad who assisted in the collection of data for this study.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 417589, 9 pages
doi:10.1155/2012/417589

Research Article

The Prevalence of Physical Activity and Sedentary Behaviours Relative to Obesity among Adolescents from Al-Ahsa, Saudi Arabia: Rural versus Urban Variations

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Received 24 August 2011; Revised 10 October 2011; Accepted 11 October 2011

Academic Editor: Abdulrahman O. Musaiger

Purpose. The aims of this study were to explore the lifestyle of young people living in Al-Ahsa Governorate; to investigate differences due to gender, age, school type, and geographical location. *Methods*. 1270 volunteered youth (15–19 years) completed a self-report questionnaire that contained 47 items relating to patterns of physical activity (PA), sedentary activity, and eating habits. The questionnaire allows the calculation of total energy expenditure in metabolic equivalent (MET-min) values per week. *Results*. Significant differences in the PA levels of youth were evident with regard to gender, geographical areas, and type of school. Also, normal weight males reported the highest levels of PA compared to overweight and obese. *Conclusions*. Youth living in rural desert were less physically active than those living in urban or rural farm environments. Youth of "normal" weight were more active than obese. Males were more active than females and PA levels appeared to decline with age.

1. Introduction

A strong body of evidence, comprising both observational and experimental research, indicates that regular participation in physical activity (PA) among young people provides immediate and long-term benefits for physical and psychological well-being. The evidence base is growing rapidly; recent large-scale epidemiological studies utilising valid measures of PA have demonstrated stronger associations than have been observed previously and helped to clarify dose-response relationships between activity and specific health outcomes [1–3]. Physical inactivity, on the contrary, is the fourth leading risk factor for global mortality, accounting for 6% of deaths globally and ranking before overweight and obesity (5%) and after high blood pressure (13%), tobacco use (9%), and high blood glucose (6%) [4]. The benefits of regular PA have been clearly set out across the lifespan. For adults, engaging in 30 minutes of moderate intensity PA on at least 5 days a week helps to prevent and manage over 20 chronic conditions, including coronary heart disease, stroke, type 2 diabetes, cancer, obesity, mental health problems, and musculoskeletal conditions [4]. The strength of the relationship between PA and health outcomes persists throughout people's lives, highlighting the potential health gains that could be achieved if people become more active during childhood and throughout their lifespan. There is a clear relationship between the amount of PA people and all-cause mortality. While increasing the activity levels of all people who are not meeting the recommendations is important, targeting those people who are significantly inactive (i.e., engaging in less than 30 minutes of activity per week) will produce the greatest reduction in chronic disease [4].

The most recent guidelines on recommended levels of PA for children and young people (5–18 years) indicate that

they should engage in moderate-to-vigorous intensity PA for at least 60 minutes and up to several hours every day, and they should minimise the amount of time being sedentary [5]. PA provides important health benefits for young people. This conclusion is based upon evidence from observational studies in which higher levels of activity were associated with more favourable health outcomes and experimental studies in which exercise treatments resulted in improvements in health-related measures [6, 7]. In addition, there is increasing evidence that the environment plays a role in influencing PA of young people and adults [8]. The physical or built environment has come to the forefront of public health research in the past 10 years, leading to a surge of research on environmental attributes and their associations with PA behaviours [9].

The Gulf Cooperation Council Countries including the Kingdom of Saudi Arabia have witnessed significant lifestyle changes due to rapid urbanisation, dominance of the automobile for personal travel, introduction of labour-saving devices in the home and the workplace, availability of high-fat and dense-caloric foods, satellite TV, increased reliance on computer, and telecommunication technology as well as decreased occupational-work demands [10]. These lifestyle changes have had a considerable impact on reducing the physical requirements of daily life and have encouraged sedentary lifestyles amongst both young people and adults. Consequently, such remarkable lifestyle transformation is thought to be greatly responsible for the epidemic of non-communicable diseases in the whole region [11, 12]. Physical inactivity and unhealthy diets are considered among the leading causes of major noncommunicable diseases, including cardiovascular disease, type 2 diabetes, and certain types of cancer, thus contributing substantially to the global burden of disease, death, and disability in the Arab countries [13, 14]. In addition, recent research findings have shown that TV viewing (a sedentary activity) and PA appear to be separate entities and are independently associated with metabolic risk [15].

An alarming high rate of physical inactivity among the Saudi populations has been reported, predisposing them to health problems [16, 17]. Additionally, Saudi youth are not immune from the global epidemic of obesity. Although childhood obesity has been observed and widely reported in developed countries, in recent years, there is an ever-increasing prevalence in developing countries. This prevalence of childhood obesity is high in the Middle East, Central and Eastern Europe [18]. Recent national estimates of combined overweight and obesity prevalence among Saudi adolescents aged 13–18 years were 36.6% for males and 38.4% for females [19].

Studies on the physical activity patterns and sedentary behaviours as related to obesity among Saudi adolescents are scarce. Therefore, the major aims of this study were (1) to explore lifestyle and health habits of young people living in Al-Ahsa city and its surrounding area; (2) to investigate possible differences due to gender, age, school type, and geographical location. Special attention will be given to the prevalence of PA and sedentary behaviours of youth from both sexes living in rural and urban environments, and how that relates to their obesity level as assessed by Body Mass Index (BMI) and Waist Circumference (WC). It is expected that the findings from this regional study will provide substantive information on PA/inactivity patterns and health habits of young males and females in this region. Moreover, due to the limited available research data on PA and obesity measures of youth in Al-Ahsa, particularly with regard to different geographical locations, the study will afford a baseline indication of the prevalence of obesity and inactivity of youth in this region of the Kingdom of Saudi Arabia (KSA).

1.1. Participants. The study was carried out in Al-Ahsa Governorate located at the Eastern Province of Saudi Arabia. Since the primary objective of the study was to provide reliable population estimates of PA patterns and health habits, the sample design called for a wide geographical coverage of the Al-Ahsa schools communities (i.e., urban, rural farm, and rural desert "Bedouin"), with careful representation of the population in urban, rural, public, and private secondary schools. The sample size was determined so that it would be within ± 0.05 of the population proportion with a 95% confidence level. A total of 1270 secondary-school boys and girls (15–19 years) living in Al-Ahsa Governorate volunteered to take part in this study following informed consent (participant and parental) along with institutional ethical approval. The stratified sample, representing different geographical areas of the Governorate, included 607 females ($M = 17.07 \pm 1.27$ yrs) and 663 males ($M = 17.08 \pm 1.10$ yrs).

1.2. Geographical Locations. A cross-sectional study was conducted in Al-Ahsa Governorate which is divided into five districts, namely, "Al-Hofuf, Al-Mubaraz, East villages, North villages and Al-Hejar." A secondary school (one all boys and one all girls) from each district was randomly selected to take part in the study. Also, two private schools for each sex were randomly selected from Al-Hofuf and Al-Mubaraz districts. A total of seven schools were selected to be involved in the study representing urban, rural, and rural farm geographical locations.

1.3. Lifestyle Questionnaire. A validated self-report questionnaire was used to assess the PA patterns, sedentary activity, and health habits of the selected sample. This research tool was also used in the Arab Teens Lifestyle Study (ATLS) [10] and contained 47 items relating to patterns of PA, sedentary behaviours (television viewing time and video and computer use), and eating habits. The physical activity questionnaire was previously shown to have a high reliability (ICC = 0.85; 95% CL = 0.70–0.93) and an acceptable validity ($r = 0.30$; $P < 0.05$) against pedometer on a sample of males 15–25 years old [20]. In another validity study involving both males and females aged 14–19 years against pedometer, it was found to have a validity coefficient of 0.37 ($P < 0.05$) [21]. The physical activity questionnaire covers all domains of physical activity including transport, household, fitness, and sports activities. Moderate-intensity physical activity includes activities such as normal pace walking,

brisk walking, recreational swimming, household activities, and moderate-intensity recreational sports such as volleyball, badminton, and table tennis. Vigorous-intensity physical activity and sports included activities such as stair climbing, jogging, running, cycling, self-defense, weight training, and vigorous-intensity sports such as soccer, basketball, handball, and singles tennis. Physical activities were assigned MET values based on the compendium of physical activity [22] and the compendium of physical activity for youth [23]. Moderate-intensity recreational sports were assigned an average MET value equivalent to 4 METs. Vigorous-intensity sports were assigned an average MET value equivalent to 8 METs. Slow walking, normal pace walking, and brisk walking were assigned MET values of 2.8, 3.5, and 4.5 METs, respectively, based on modified METs values from the compendium of physical activity for youth [24]. The questionnaire allows the calculation of total energy expenditure per week based on metabolic equivalent (MET-min) values of all types of physical activities reported by the participant. To measure the participants' levels of physical activity, the total METs min per week and the METs min per week spent in vigorous physical activity were used. The classifications adopted for activity levels in this paper were based on 2 cut-off points of 30 minutes and 60 minutes per day of at least a moderate level of physical activity. This was then converted into 3 activity categories based on total METs minute per week as follows: Active: > 1680 METs min per week (60 minutes $\times$ 7 days $\times$ 4 METs). The daily 60 minutes of at least a moderate level of physical activity is based on recent physical activity recommendations [5]. Minimally active: $\geq 840 <$ 1680 (30 minutes $\times$ 7 days $\times$ 4 METs). Inactive: < 840 METs min per week [6].

1.4. BMI Measurement. Body weight was measured to the nearest 100 grams using Seca weight scales (Seca Ltd., Hamburg, Germany). Participants were weighed barefooted and without excess outer clothing. To ensure measurement accuracy, the scale was checked for a zero reading before each weighing. Height was measured to the nearest 0.5 centimetre using a Seca portable height measure (Seca Ltd., Hamburg, Germany). BMI was calculated using the formulae: weight (kg)/height (m^2). BMI was classified according to the International Obesity Task Force (IOTF) criteria [25].

1.5. Waist Circumference Measurement. Direct measurements of waist circumference were obtained to the nearest 0.5 centimetre according to Pollock and Wilmore [26]. Participants were asked to remove any outer or winter clothing (excess clothing). Waist circumference was measured horizontally to the nearest 0.5 cm using a nonstretchable measuring tape (Richter measuring tape, Seca Ltd., Hamburg, Germany) at the level of umbilical and at the end of normal expiration. The cut-off point for waist circumference classification was a waist-to-height ratio of 0.5. [27]. Those who exceed 0.5 are considered "at risk" of cardiovascular diseases. Waist circumference is considered a simple measure of fat distribution in children and adolescents and is least affected by gender, race, and overall adiposity [27, 28].

1.6. Statistical Analysis. A range of statistical procedures were performed on the data to establish associations and differences in the health and lifestyle habits of young people from different locations and genders. Comparisons between genders, geographical locations, and age groups were conducted using 2-way and 3-way analyses of variance (ANOVA) on the young people's PA levels, BMI, and waist circumferences. Descriptive statistics were utilised to highlight the prevalence of overweight and obesity as well as classifications according to activity index. Furthermore, Pearson's correlations were performed to establish relationships between health status variables (e.g., BMI, waist circumference, and PA levels) and sedentary lifestyle habits such as TV viewing time and computer usage. SPSS version 18 (SPSS Inc. Chicago, IL, USA) was used for all analyses.

2. Results

The descriptive characteristics of the main dependent variables for the total sample and subsamples are presented in Table 1. These include anthropometric, activity, and obesity measures for the participants from different geographical locations. A wide range of differences in physical activity, sedentary time, and obesity measures are evident between the two sexes and three geographical locations.

2.1. Differences in Physical Activity Levels. Univariate ANOVA revealed a highly significant difference in the PA levels of young males and females in Al-Ahsa Governorate ($F_{1,1218} = 305.61$, $P < 0.001$). The differences in PA remained after controlling for adiposity (BMI and WC). The mean total METs per week for males and females was 2240.08 and 558.72 METs, respectively. Using Chi-square analysis, frequency data (i.e., Chi-square test of independence) re-vealed a significant difference in the PA levels between young males and females in Al-Ahsa ($\chi^2{}_2 = 319.17$, $P < 0.001$). With regard to females, there were 81.5% inactive, 14.5% minimally active, and only 4% active. Conversely, 35.7% of males were inactive, 19.8% minimally active, and 44.5% active.

Univariate analyses on total PA of the whole sample revealed significant differences ($P < 0.05$) between age groups. However, this seemed to be due largely to the significant differences ($P = 0.015$) in the PA levels of males across the different age groups (Figure 1). The significant ($P < 0.05$) gender by age interaction indicates that boys' PA declined at a far greater rate than girls across the age groups. While the decline was clearly evident in males, females reported low physical activity levels across all age groups.

With respect to the number of minutes walking per week, the univariate analyses revealed a significant difference ($P < 0.001$) between males and females ($M = 49.4$ minutes and 19.4 minutes, resp.). However, there were no significant differences ($P > 0.05$) across the age groups (i.e., 15 to 19 years). This is illustrated in Figure 2.

There was also a significant main effect due to weight status in both males ($F_{2,615} = 22.98$, $P < 0.001$) and females ($F_{2,586} = 5.03$, $P = 0.007$). In both cases, young males and females of "normal" weight were the most active, while obese

Table 1: Mean ± SD of the main dependent variables for the total sample and sub-samples.

Variable	Urban		Rural farm		Rural desert		Whole group	
	Male $n = 371$	Female $n = 333$	Male $n = 207$	Female $n = 189$	Male $n = 85$	Female $n = 85$	Male $n = 663$	Female $n = 607$
Age	17.03 ± 1.02	16.78 ± 1.21	17.13 ± 1.25	17.50 ± 1.21	17.15 ± 1.04	17.24 ± 1.35	17.08 ± 1.10	17.07 ± 1.27
Weight	70.08 ± 21.62	60.47 ± 20.03	63.31 ± 18.37	54.12 ± 15.51	69.10 ± 20.05	62.23 ± 18.83	67.76 ± 20.62	58.74 ± 18.80
Height	168.6 ± 7.41	154.91 ± 9.00	166.86 ± 6.61	153.75 ± 8.02	167.29 ± 6.07	154.16 ± 5.74	167.86 ± 7.02	154.44 ± 8.32
BMI	24.58 ± 7.18	26.35 ± 21.84	22.67 ± 6.16	23.89 ± 20	24.59 ± 6.66	26.00 ± 6.84	23.97 ± 5.764	25.54 ± 19.83
Abdominal Circumference	78.73 ± 16.87	82.47 ± 15.02	73.90 ± 14.15	78.58 ± 12.65	76.36 ± 13.91	81.89 ± 15.24	76.85 ± 15.79	81.17 ± 14.44
Time spent on TV	2.60 ± 1.81	2.28 ± 1.67	2.29 ± 1.62	2.71 ± 1.97	2.48 ± 2.13	3.63 ± 2.20	2.49 ± 1.80	2.60 ± 1.90
Time spent on computer	2.58 ± 2.02	3.57 ± 2.45	2.34 ± 2.05	2.98 ± 2.29	1.96 ± 2.26	2.12 ± 2.09	2.43 ± 2.07	3.19 ± 2.40
Total METs min/week (vigorous)	1780 ± 2037	112 ± 76	1653 ± 2066	176 ± 410	1286 ± 1448	64 ± 41	1678 ± 1987	125 ± 232
Total METs min/week (moderate)	702 ± 772	475 ± 409	740 ± 841	696 ± 584	368 ± 358	540 ± 394	676 ± 769	564 ± 490

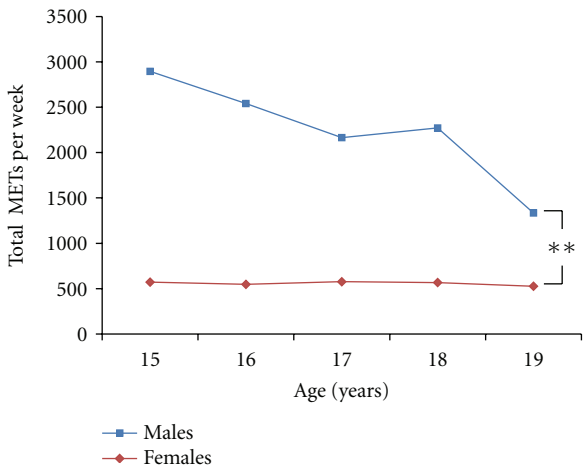

Figure 1: Total METs per week in males and females across different age groups. $^{**}P < 0.001$ for differences in METs per week between males and females across each age group.

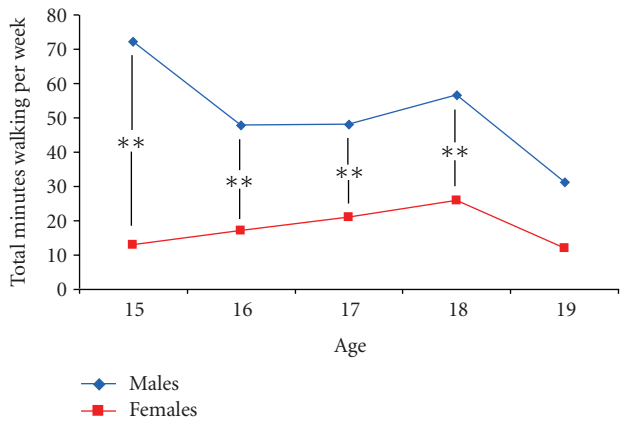

Figure 2: Number of minutes walking per week in males and females. $^{**}P < 0.01$ for differences in the total number of minutes walking per week between males and females across each age group.

youth were the least active. This is highlighted by the mean values in Figure 3.

Bonferroni posthoc pairwise comparisons revealed that there were significant differences between the PA levels of normal weight, overweight, and obese males, with normal weight males reporting the highest levels of PA. However, with respect to the females, the only significant difference was between normal weight and obese youth (604 and 392 METs, resp.).

When geographical areas of schools were considered, a highly significant difference in PA was also evident ($F_{2,1221} = 5.95$, $P = 0.003$). There was also a highly significant difference between males and females across the three geographical areas ($F_{1,1221} = 174.21$, $P < 0.001$) (see Table 1). Bonferroni posthoc analysis revealed that rural desert youth were significantly less active than those living in rural farm environments ($P = 0.001$) or urban areas ($P = 0.023$). However, there was no significant difference between males from urban and rural farm areas and between females from urban and rural desert areas. Mean (±SD) of total METs per week across gender and geographical groups is presented in Table 1.

Univariate ANOVA revealed significant ($F_{1,1220} = 10.422$, $P = 0.003$) differences in PA levels between youth from private and public schools. However, while females in public schools were significantly more active than those in private schools ($F_{1,586} = 7.71$, $P = 0.006$), no such differences were apparent amongst males ($P > 0.05$).

2.2. Differences in Body Weight Classifications. Descriptive statistics indicated that both males and females exhibited

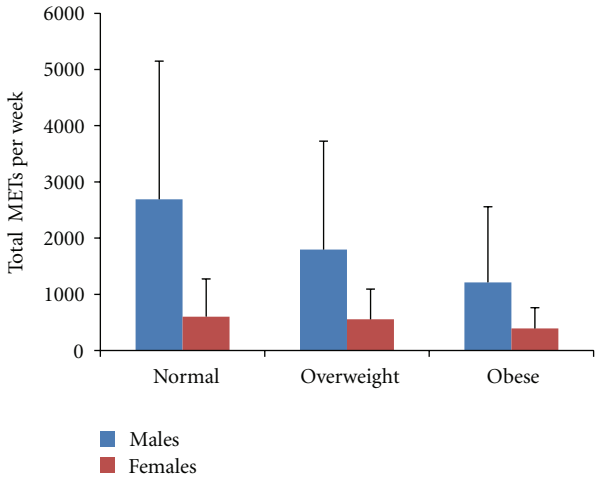

Figure 3: Total METs per week for males and females across obesity index.

Table 2: BMI classifications according to IOTF.

Geographical location		BMI classification Normal $n = 770$	Overweight $n = 211$	Obese $n = 220$
Urban	Males	60.5%	17.6%	21.9%
	Females	62.8%	16.8%	20.4%
	Both sexes	61.6%	17.2%	21.2%
Rural farm	Males	73.3%	12.6%	14.1%
	Females	71.4%	17.5%	11.1%
	Both sexes	72.4%	14.9%	12.7%
Rural desert	Males	56.5%	23.5%	20%
	Females	48.8%	29.8%	21.4%
	Both sexes	52.7%	26.6%	20.7%
All	Males	64.1%	16.8%	19.1%
	Females	63.5%	18.8%	17.7%

a similar prevalence of overweight (16.8% and 18.8% for males and females, resp.) and obesity (19.1% and 17.7% for males and females, resp.). This equates to a total of 35.9% of males and 36.5% of females being overweight or obese. The weight status classification of youth from different geographical locations indicates that there is a high percentage of overweight and obese amongst youth of urban and rural desert. This appears to be particularly high amongst rural desert, with 51.2% of females and 43.5% of males being classified as overweight or obese (see Table 2).

In comparing various age groups, univariate analyses revealed no significant differences in BMI ($P > 0.05$). Also, no significant differences in BMI between the schools from different geographical locations were evident. However, when examining each gender group separately, Bonferroni posthoc analysis revealed that BMI of males from rural desert was significantly ($P = 0.004$) higher than males from rural farm schools. Mean (± SD) of BMI across gender groups from different geographical environments is presented in Table 3.

Table 3: BMI according to geographical location of schools.

	Urban $n = 684$	Rural farm $n = 385$	Rural desert $n = 152$
Males	24.58 ± 7.18	22.67 ± 6.16	24.59 ± 6.66
Females	26.35 ± 21.84	23.89 ± 19.20	26.00 ± 6.84

As for private and public schools, univariate ANOVA revealed no significant difference in BMI, nor was there a difference in BMI across the various age groups (both, $P > 0.05$). With respect to waist circumference, the mean values for males and females were 81.17 cm and 76.85 cm, respectively. However, with reference to the gender-specific classifications, the percentages of "at-risk" males and females were 26.5% and 54.2%, respectively (see Table 4).

The descriptive statistics of the waist circumference for the different geographical locations indicated that the rural farm males and females had the lowest "at-risk" percentage, compared to urban and rural desert, with 34.6%, 41.5%, and 44.2%, respectively. Additionally, results indicated that 38.6% of public school males and females were "at risk" compared to 45.5% of private school (see Table 5). Also, a greater percentage of males (34.1%) in private schools were "at risk" compared to public schools (24.7%).

Pearson's correlation revealed a highly significant negative relationship between PA and BMI ($r = -0.103$, $P < 0.001$). However, when the data for males and females were analysed separately, it was evident that the relationship was only significant in the male participants. Also, there was a highly significant negative relationship between PA and waist circumference ($r = -0.237$, $P < 0.001$) even when data for each sex were analysed independently. This indicates that the more active the individual, the lower the BMI and waist circumference.

The results revealed that there was a relationship between weight status and sedentary behaviours as represented by TV viewing, video, and computer time. For instance, in females, BMI and waist circumference were significantly related to computer time ($r = 0.083$, $P = 0.042$ and $r = 0.121$, $P = 0.003$, resp.). Moreover, in males, both BMI and waist circumference were significantly related to sedentary time ($r = 0.110$, $P = 0.006$ and $r = 0.137$, $P = 0.001$, resp.). Also, a highly significant positive relationship was evident between waist circumference and BMI ($r = 0.766$, $P < 0.001$). This supports the concurrent validity of the two measures used for weight status.

3. Discussion

The Kingdom of Saudi Arabia has witnessed significant lifestyle changes during the last three decades. Subsequently, physical inactivity, sedentary lifestyle, and an ever-increasing rate of obesity has become prevalent in Saudi society [29, 30]. The present study is the first of its kind to be conducted in this region to provide comparative data on the levels of

Table 4: Waist circumference classification according to gender and geographical location.

Subgroups	Waist circumference classification							
	Urban		Rural farm		Rural desert		Total sample	
	Normal $n = 383$	"At risk" $n = 272$	Normal $n = 248$	"At risk" $n = 131$	"Normal" $n = 92$	"At risk" $n = 73$	Normal $n = 723$	"At risk" $n = 476$
Males	75.3%	24.7%	79.7%	20.3%	70.2%	29.8%	73.5%	26.5%
Females	49.5%	50.5%	49.2%	50.8%	40.7%	59.3%	45.8%	54.2%
Whole group	58.5%	41.5%	65.4%	34.6%	55.8%	44.2%	60.3%	39.7%

Table 5: Waist circumference classification according to school type and gender.

Subgroups	Waist circumference classification			
	Public		Private	
	Normal $n = 231$	"At risk" $n = 145$	Normal $n = 152$	"At risk" $n = 127$
Males	75.3%	24.7%	65.9%	34.1%
Females	49.5%	50.5%	37.5%	62.5%
Whole group	61.4%	38.6%	54.5%	45.5%

physical activity of adolescents from urban and rural areas. The findings of this study show that whilst males reported more physical activity than females across the different ages (METs min per week), the significant gender by age interaction indicates that males' PA has been declining at a far greater rate than females across the age groups. This points out that the older the males were, the less active they were. The decline in PA was only clearly evident in males, with females reporting low PA levels across all age groups. This trend of declined PA with age in males and the consistently low levels of PA in females is a worrying one from a public health perspective.

The same trend of declining PA with age was reported in other studies involving non-Saudi populations [31, 32]. Additionally, when the geographical area of the school was considered in this study, significant differences in PA between males and females were clearly evident (see Table 1). Rural desert youth were significantly less active than those living in rural farm or urban environments, possibly due to a number of environmental factors that will be explained later in this paper. As for obesity, the findings from this study indicated that both males and females exhibited a high prevalence of overweight/obesity (36.6% and 39.0%, resp.). These findings concur with a number of previous studies on Saudi youth and young adults [33–35]. The weight status classification of youth from different geographical locations indicates that there is a high percentage of overweight/obesity amongst youth from urban and rural desert areas. This appears to be particularly high amongst rural desert youth, with 51.2% of females and 43.5% of males being classified as overweight or obese (see Table 2). With respect to waist circumference, the mean values for males and females were 81.17 cm and 76.85 cm, correspondingly. As for the gender-specific classifications, the percentage of "at-risk" males and females were 26.5% and 54.2% (see Table 4), signifying that there was a seriously high percentage of "at-risk" youth, particularly amongst females.

There are a number of plausible explanations for the findings of this study with regard to rural desert youth's PA and obesity. The low levels of PA and higher percentage of obesity amongst rural desert youth compared to those living in rural farm or urban environments might be due to a number of environmental factors. Firstly, with regard to PA, the harsh desert climate, which is extremely hot in summer and very cold and windy in winter, is normally not conducive to engagement in PA for a substantial part of the year, a problem further compounded by the absence of appropriate facilities for exercise in these locations. This might be part of the reason why youth in rural desert areas are less active than youth in rural farm areas. On the other hand, youth in rural farm lands are expected to take part in some of the farming activities that are physically demanding, like ploughing, planting, and harvesting. In general, engagement in PA by young people, particularly in rural environments of Saudi Arabia, is not regarded as a desired pursuit (leisure time activity) due to cultural attitudes and beliefs. It is usually perceived that the pursuit of academic excellence has greater status than PA. Normally, parents encourage their children to engage in educational and spiritual activities rather than leisure time physical activities. Additionally, there is a general lack of availability of parks, sports grounds, and facilities that are suitable for youth to get involved in PA or sports. Moreover, attitudes, societal norms, and expectations of rural desert communities are less encouraging towards engagement in sporting activities that require adherence to particular outfits/clothing than other communities. Moreover, youth living in rural farm or urban environments, normally, have better access to sports facilities compared to rural desert youth. The noticeable and consistent difference in PA of males and females across the age groups in this region could be due to a number of cultural and environmental factors; these may include social norms, expectations, and perceptions as well as the opportunities for PA afforded by both the home and the wider community for males and females.

Secondly, with regard to weight classification, the current study revealed that the combined prevalence of overweight and obesity was 37.78% with 19.63% overweight and 18.15% obese amongst the 1270 participants. A previous study on

adolescents from Al-Ahsa region by Amin et al. [33] revealed a combined prevalence of obesity and overweight of 23.9% (9.7% obese and 14.2% overweight) among males aged 10–14 years. Hence, the findings of the current study draw attention to the fact that the prevalence of obesity amongst youth in this region seems to be on the increase in recent years. Also, an earlier cross-sectional household survey that involved 13,177 youth and adult Saudis aged 15 years and over, indicated that the prevalence of overweight (BMI 25–30) was higher among males than females (29% versus 27%), while the prevalence of obesity (BMI > 30) was higher among females than males (24% versus 16%) [34, 35]. This equates to 45% of males and 51% of females being classified as overweight or obese. Furthermore, an earlier study by El Mouzan et al. [19] reported that the overall prevalence of overweight was 11.7% and obesity 15.8% amongst males aged 6 to 18 years. The highest prevalence of obesity was recorded in the capital city of Riyadh (18%). A more recent study on the dietary behaviour and lifestyle of Saudi female university students reported an overweight of 31.4% and obesity of 16.5%. This represents a total of 47.9% of young female adults who were either overweight or obese [36]. Additionally, a recent systematic review paper on obesity in Gulf Co-operation Council States [37] that reviewed 45 studies, reported prevalence of overweight and obesity in adults of 25–50% and 13–50%, respectively, with a higher prevalence of obesity amongst women. The findings of these studies point to the increasing prevalence of obesity in recent years.

Moreover, the findings of the current study revealed that the prevalence of obesity amongst Saudi youth has matched or exceeded that of other regions of the world. For example, Wang and Lobstein [38] reported a combined prevalence of overweight and obesity of 46.4% in the Americas, 41.7% in Eastern Med, 38.2% in Europe, and 22.9% in South East Asia. This signifies the urgency of formulating policies and designing intervention strategies to reverse and reduce the epidemic of obesity and safeguard the future health of young people and adults in Saudi Arabia. The findings have also indicated that the young males of "normal" weight were the most active, while the obese were the least active; this is illustrated by the mean values in Figure 3. Whilst "normal" weight males were significantly more active than both overweight and obese males, in females, those with "normal" weight were only significantly more active than the obese females. The descriptive statistics with respect to waist circumference revealed that the youth from rural farm locations had the lowest percentage of "at risk" compared to youth from urban and rural desert locations, with 34.6%, 41.5%, and 44.2%, respectively. It is noteworthy to point out that these results seem to reflect the level of PA across the geographical locations, with males and females from rural farm locations being the most physically active and the least "at-risk" group. Additionally, the rural desert youth appeared to be the least active and had the highest prevalence of overweight/obesity (47.3%) compared to both the urban (38.3%) and rural farm (27.6%) youth. Recent studies on populations from other countries have pointed out differences between urban and rural youth. A large national cross-sectional population survey of 5–15 year old New Zealanders [39] found that rural children had a significantly lower BMI, smaller waist circumferences, and thinner skinfold measurements than urban children. There was no significant difference in the energy intake per day of rural and urban children. Similarly, there was no significant difference in the frequency of bouts of physical activity undertaken by rural and urban children. Also, in another study involving 362 Portuguese youth (165 males, 197 females) 13–16 years of age representing urban or rural residence, youth of both sexes from rural settings were 76% more likely to be classified as aerobically fit compared to those from urban areas [40]. This study suggested that the interaction of several environmental factors such as age, gender, weight status, parental education, and screen time may explain why rural Portuguese youth were more likely to be classified as physically fit compared to urban youth.

The low levels of PA and high percentage of overweight/obese amongst males and females in the current study might be related to certain aspects of their lifestyle, dietary habits, and environmental factors. For example, using saturated fat in traditional cooking is commonplace in this region. A recent study by Washi and Ageib [41] on poor diet quality and food habits of Saudi youth found an increase in dietary intake or energy from fats as well as the fact that rice, bread, and meat are regarded as the staple diet, which are used in almost every meal. This seems to concur with other studies (dealing with this age group) which found that obese children and adolescents consume significantly more servings of meat, grain products, fast foods, sugar, sweetened drinks, and potato chips. These contribute to a higher caloric intake compared to nonobese children and adolescents [42].

Research findings have pointed out that the prevalence of obesity amongst youth over the past three decades seems to be increasing in almost all industrialized countries and in several lower-income countries [38]. In societies that have been undergoing rapid socioeconomic transitions (e.g., Saudi Arabia), obesity has increased at an accelerated rate with the prevalence of overweight or obesity in school-age children doubled or tripled in several industrialized countries, such as Canada, the United States, Brazil, Greece, and the UK [37]. A strong inverse relationship between socioeconomic status and obesity appears to exist among women in developed countries, but this relationship is inconsistent for men and children. In contrast, in developing countries a strong relationship exists between socioeconomic status and obesity among men, women, and children [43]. In the current study, overweight and obesity were associated with different geographical locations and socioeconomic backgrounds as represented by type of school attended: private or public. A higher percentage of overweight and obese youth was found amongst those who live in urban and rural desert areas. This appears to be particularly high amongst the rural desert youth, with females and males having 51.2% and 43.5% in the overweight/obese category respectively. Additionally, this study found that there was a relationship between levels of PA and obesity, with those reporting higher levels of PA tending to possess lower BMI. However, this relationship was only significant amongst male participants. A similar relationship was evident between PA and waist circumference. This indicates that the more active the

individual, the lower the BMI and waist circumference. Furthermore, a relationship was evident between weight status and sedentary lifestyle, with a higher BMI recorded by youth reporting greater time use of computer. Moreover, a larger waist circumference was recorded by youth who reported more sedentary time (TV viewing and computer time).

The current study indicated that females in public schools were significantly more active than those in private schools. This might be due to socioeconomic differences such as the excessive use of automobile transportation, availability of satellite TV, computers, and other electronic devices that encourage inactivity. The combined impact of high-fat diets, reduced PA, and the traditional societal perception of fatness as a sign of affluence and beauty could be significant contributors to the prevalence of obesity amongst more affluent females. Socioeconomic differentials may be associated with the problem of overweight and obesity amongst youth in Al-Ahsa. This is reflected by the high number of "at-risk" youth amongst both males and females in private schools. Moreover, since the prevalence of sedentary lifestyle and obesity seems to increase with age, one would expect this problem to get even more serious in the future, as the participants get older.

There are a number of limitations to this study. In addition to the inherent limitations of self-report approaches to the assessment of PA and sedentary behaviour, the instrument used here may have been less sensitive to the normal daily PA of youth in rural desert. Additionally, the differences in maturation status between youth from the three geographical groups may have affected obesity classification. Further studies on lifestyle and health habits of youth in the Al-Ahsa Governorate are needed. These may involve the use of objective methods of assessing PA and investigate other risk factors of the metabolic syndrome.

4. Conclusions

This study has a number of strengths, including being the first study in the region to provide comparative data on PA and obesity of youth from urban and rural areas. The study used an appropriate tool for data collection and recruited a representative sample of the geographical areas of the region under study to explore environmental differences. The findings demonstrated that factors such as gender, age, and geographical location seem to influence youth PA levels and obesity. Youth living in rural desert were less physically active than their counterparts living in urban or rural farm environments. Young males of "normal" weight were more active than their overweight and obese counterparts. Also, PA levels of young males, as measured by METs min per week, appear to decline gradually with age, indicating that the older the males, the less active they were. Moreover, males were generally more active than females, with females exhibiting higher rates of obesity and acutely lower levels of PA across all ages.

Acknowledgment

This research was supported by the Research Committee of Newman University College.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 905303, 10 pages
doi:10.1155/2012/905303

Review Article

Food-Based Dietary Guidelines for the Arab Gulf Countries

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Received 29 August 2011; Accepted 27 October 2011

Academic Editor: Najat Mokhtar

The concept of food-based dietary guidelines (FBDG) has been promoted by several international organizations. However, there are no FBDG for the countries in the Arab region. As the Arab Gulf countries share similar a socioeconomic and nutrition situation, an attempt was made to develop FBDG for these countries. This paper summarizes the steps taken to develope such guidelines by the Arab Center for Nutrition. The FBDG were developed through 6 steps: (1) determination of the purpose and goals for establishing FBDG, (2) characteristics of FBDG, (3) determination of the food consumption patterns, (4) review the current nutrition situation, (5) determination of the lifestyle patterns that are associated with diet-related diseases and (6) formulating the FBDG. The FBDG consist of 14 simple and practical pieces of advice taking into consideration the sociocultural status and nutritional problems in the Arab Gulf countries. The FBDG can be a useful tool in educating the public in healthy eating and prevention of diet-related chronic diseases.

1. Introduction

The Arab Gulf countries, namely, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates have undergone a rapid change in their socio-economic situation, food consumption patterns, and lifestyle and health status during the past four decades. This was mainly caused by the sharp increase in income due to accumulated oil revenues. Communicable diseases have almost diminished and diet-related chronic diseases have become the main health problems. However, undernutrition and micronutrient deficiencies still exist, especially among vulnerable groups [1].

The concept of food-based dietary guidelines (FBDG) has been promoted by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) of the United Nations since the 1992 International Conference on Nutrition in Rome, Italy. One of the recommendations of this conference was that individual countries should develop simple dietary guidelines that are based on their specific public health concerns and relevant to people of different ages, lifestyles, and cultures [2].

The action needed to promote healthy nutrition and a healthy lifestyle has been emphasized at several meetings in Arab Gulf counties [2, 3]. In 1997, the first Workshop on Diet, Nutrition and a Healthy Lifestyle in the Arab Gulf countries was held in Manama, Bahrain. Two main recommendations were proposed: establishing food-based dietary guidelines (FBDG) for the Arab Gulf countries, and promoting a healthy lifestyle in these countries [3].

A simplified Arabic version of the FBDG for the Arab Gulf countries was published in a booklet to be used by the public. It was distributed to many health authorities in the region, and it is also available in the website of the Arab Center of Nutrition for more dissemination. Several comments regarding rephrasing and clarifying some statements in this version were received. Therefore an attempt was done to release the second version, including all the comments received from the public, nutritionists, and professionals.

The main objectives of this paper, therefore, are to summarize the steps taken to develope the food-based dietary guidelines for the Arab Gulf countries, and to explore the scientific bases of these guidelines.

2. Methods

Developing Food-Based Dietary Guidelines (FBDG) for the Arab Gulf Countries

Step 1 (Determine the Purpose and Goals for Establishing FBDG). The Arab Gulf countries are facing great challenges to prevent and control several nutritional problems and diet-related chronic diseases. Two types of nutritional and health problems occur: those associated with change in lifestyle, such as obesity, cardiovascular disease, diabetes, hypertension, cancer, dental caries, and osteoporosis and those associated with nutrient deficiencies, such as iron deficiency anemia, undernutrition among preschool children, and deficiencies of vitamin D and calcium. In addition, food-borne diseases are a problem of concern in these countries [1]. Therefore, the need for simple dietary guidelines to address the burden of these diseases is urgent, especially as some of these diseases contribute to more than 50% of total mortality in this region [4].

There are no specific food-based dietary guidelines used by Arab countries in general. Nutritionists, dietitians and other health workers in the Arabian Gulf region have been relying on FBDG developed for other countries, such as USA, Canada, and UK, to convey nutrition messages to the public.

In Oman, an attempt was made to establish guidelines to healthy eating. However, these guidelines lack some issues related to the prevention and control of diet-related chronic disease such as reduced intake of salt and added sugar in foods, weight maintenance, and avoiding alcoholic drinks and smoking. Encouraging drinking of water and other liquids were given very little attention; it was mentioned in conjunction with physical activity, without any further advices. In general, these guidelines were prepared for the people who are responsible to educate the public, but not directed to the public [5]. In general our work is different than Omani guidelines in two main issues: (1) the Omani guidelines were prepared for the health workers and not for the public, and (2) the Omani guidelines were focused in portion size of the food groups while the current guidelines focused on food-based advices.

An attempt, therefore, has been made to develop FBDG specifically for Arab Gulf countries to provide simple and practical dietary guidelines to help prevent and control the main nutrition-related disorders and that take into account the socio-cultural, lifestyle, and dietary habits of the people in these countries.

Step 2 (Characteristics of FBDG). To successfully promote healthy eating habits, a number of specific characteristics of FBDG were identified based on current knowledge and available information on food, nutrition, and health status in the countries of the region. These characteristics can be summarized as follows [2, 6].

(1) The guidelines should address the prevention and control of the main nutritional problems and diet-related diseases in the Arab Gulf countries.

(2) They should be based on affordable and available foods, which are commonly consumed by the public, including traditional foods.

(3) They should consider the local dietary habits and food consumption patterns in the Arab Gulf countries.

(4) They should take into account food safety situation.

(5) They should consider the cultural and religious background of the population in Arab Gulf countries.

(6) They should consist of short, clear, and simple messages.

(7) They should promote a healthy lifestyle, especially the promotion of physical activity.

(8) They should be based on current scientific and health information.

Step 3 (Determine the Food Consumption Patterns). A systematic literature review of the studies published in English between 1990 and 2010 was carried out, using PubMed and Google Scholar search to find out the food consumption patterns and nutrition situation in the Arab Gulf Countries. The key words used were food consumption, nutrition, diet, anaemia, iodine deficiency disorders, cardiovascular disease, diabetes, vitamin D deficiency and undernutrition for each country. Over 800 papers and reports were identified primarily. About 120 papers that possibly addressed food and nutrition in the Arab Gulf states were then identified to be included in the main review. However, for the purpose of this report, 40 papers were selected from these 120 papers to give general background on the food and nutrition status in these states.

There has been a drastic change in food consumption patterns in the Arab Gulf countries. This change includes both quantitative and qualitative change in diet. The structure of diet has shifted towards a high-energy-density diet with more fat and added sugar in foods, more saturated fat (mostly from animal origin) and lower intake of complex carbohydrates, dietary fiber, fruit, and vegetables [1]. For example, the total per capita energy intake exceeds 3000 kcal in all Arab Gulf countries, and the fat represents 25–35% of total energy. However, animal fat represents 40–52% of total per capita fat intake in the region [7].

The intake of animal source foods is growing steady and it replaced many typical diets in the region [8]. In general, poultry and eggs were more consumed compare to red meat, and fish less than that of poultry and eggs. Data from FAO Food Balance Sheets indicated that the daily per capita availability of poultry meat during 2003–2005 ranged from 106–163 grams in the Arab Gulf countries, compared to 2–73 grams in other countries in the Middle East. There was a slight increase in fish intake during 1990–2005; however, the average daily per capita availability of fish was still low compared to red meat and poultry (ranged from 24 to 52 grams) [7]. Although the total production of milk and dairy

products is increasing in the Gulf Region during the past decade, the per capita intake of these foods is still below the daily requirements. The daily per capita availability of milk and dairy products has decreased by 20% and 33% in Kuwait and UAE, respectively, and increased by 15% in Saudi Arabia, during 1990–2005 [9].

The intake of fiber-rich foods is particularly important, as the relationship between dietary fiber and prevention of some chronic diseases is well established [10]. Since fiber is only available in foods of plant origin, the intake of fruit, vegetables, and complex carbohydrates is a good indicator for fiber intake. The consumption of fruit and vegetables by people in this region is below the recommended allowances. The WHO/EMRO reported that more than 85% of adults in the Arab Gulf countries consumed fruit and vegetables below 5 servings per day [11]. Additionally, the consumption of whole grain in this region is decreasing markedly, with more dependence on refined cereals [12]. In Saudi Arabia, for example, it was found that the main contribution to fiber intake came from vegetable-based foods (31%), followed by cereal and their products (26%), and fruit and their products [13].

Food rich in salt is highly consumed in the region. Data available from food composition of dishes commonly consumed in the Arab Gulf countries showed a high content of sodium in these dishes [14]. The high use of table salt, spices, and pickles, in addition to the salinity of water are contributing factors for the high intake of sodium in these countries [15]. Among children and adolescents, the high consumption of fast foods and French fries is playing a great role in the increasing intake of sodium among these age groups [16].

High intake of foods rich in added sugar, particularly among children and adolescents, has been reported by many studies in the region [17–19]. Potential health problems associated with overconsumption of food rich in free sugar such as overweight, dental caries, and potential enamel erosion are well documented [20]. In Saudi Arabia, for example, carbonated beverages and canned fruit drinks represented 26% and 25% of daily fluid consumption by adolescents, respectively [21].

Step 4 (Determine the Food and Nutritional Status). Undernutrition, manifested by stunting, wasting, and underweight, is still a problem of concern among preschool children (1–5 years) in the region. The prevalence of stunting in these children ranged from 18% to 22% whereas wasting ranged from 6% to 13%, and underweight ranged from 7% to 23% [8, 22].

Despite the high per capita income in the Arab Gulf countries, anemia especially iron deficiency anemia, remains an important nutrition problem. According to WHO criteria for hemoglobin, the prevalence of anemia was 20%–60% among preschool children, 13–50% among school children and adolescents, and 23%–54% in women of childbearing age [23]. Low intake of dietary iron as well as foods enhancing iron absorption is the most possible factor that contributes to iron deficiency anemia [24].

Vitamin A deficiency is less common compared to other micronutrient deficiencies. It was estimated that the prevalence of vitamin A deficiency among 0–72-month-old children ranged from 16% to 20% [22, 25]. Iodine deficiency disorders are not a problem of concern in most Arab Gulf countries. They are mostly prevalent in the mountain area. The prevalence of goiter in these countries ranged from 2% to 10% [25].

Although these countries have a sunny environment, vitamin D deficiency is one of the main public health problem. In Qatar, for example, it was reported that 69% of children below 16 years had vitamin D deficiency [26]. Studies in Saudi Arabia revealed that 28% to 80% of adults had vitamin D deficiency [27]. Low sunlight exposure, low intake of dietary vitamin D and calcium, and short duration of breastfeeding during the first six months are the main risk factors for occurrence of this problem [26].

The change in dietary habits, lifestyle, and life expectancy in the Arab Gulf countries has led to a remarkable change in disease trends. Diet-related chronic diseases such as cardiovascular disease (CVD), diabetes mellitus, hypertension, obesity, cancer, dental caries, and osteoporosis have become the main health problems [13]. Overweight and obesity have become epidemic among all age groups in the Arab Gulf countries, responsible for increased morbidity [1]. It was estimated that 12%–25% of school children aged 6–11 years were overweight and obese in this region. The proportion increased to 15%–45% among adolescents (11–18 years), and to 30% to 60% among adult men, and to 35% to 75% among adult women [12]. Inactivity, high consumption of high-energy-density foods, multipregnancy, and long duration of watching television or using the internet were reported as contributing factors for high prevalence of obesity [1, 13, 28].

Cardiovascular diseases (CVD) are the main cause of death in the region. Health statistics revealed that 28–30% of total deaths in the Arab Gulf countries were due to CVD [4]. With changes in lifestyle, exposure to risk factors for CVD has become more prominent, such as diets high in saturated fat and low in dietary fiber, hypertension, diabetes, hyperlipidemia, smoking, and inactivity [13].

The prevalence of diabetes among adults in the Arab Gulf countries is higher than that reported in Western Region. The rate of type 2 diabetes among adults ranged from 12% to 23%. Prediabetes and undiagnosed diabetes are particularly important since they can lead to chronic disease complication, if left untreated [29]. In Saudi Arabia, for example, it was found that 28% of diabetes were unaware of their condition [30]. Age is one of the main factors associated with increasing prevalence of type 2 diabetes and impaired glucose tolerance among the Gulf population [31]. Obesity, especially abdominal obesity, is the potent risk factors for the high proportion of type 2 diabetes [32]. In general, diabetes is getting more attention by health authorities in the region, due to health and economic burden on government services [33].

The high risk of diabetes and CVD associated with obesity in the Arab Gulf countries may lead to the metabolic syndrome [34–36]. The prevalence of the metabolic syndrome

Table 1: Food groups and suggested daily servings.

Food Group	Servings	Serving sizes
Cereals and their products	6–11	1 slice, 1/4 Arabic flat bread, 30 g cornflakes, 1/2 cup cooked cereals (rice, wheat oat, macaroni), 6 small crackers (use whole meal cereals).
Vegetables	3–5	1 cup raw leafy vegetables or cooked vegetables, 3/4 cup vegetable juice.
Fruit	2–4	1 medium piece of fruit (banana, apple, mango, pear), 1/2 cup fresh, frozen or canned fruit, 3/4 cup fruit juice.
Milk and dairy products	2-3	1 cup of milk, laban or yoghurt, 43 g of cheese, 1 tablespoon cream cheese (use low fat dairy product).
Meat, chicken, fish, eggs, legumes and nuts	2–4	50–80 g of meat, chicken or fish, one egg, 2 tablespoons of peanut butter, 1/2 cup legumes, 1/3 cup nuts, 2 tablespoons of seeds.

Source: Arab Center for Nutrition [56].

ranged from 29.6% to 36.2% in men and 36% to 46% in women using International Diabetes Federation definition. Overall, the prevalence of the metabolic syndrome in the Arab Gulf countries is 10–15% higher than in most developed countries [30].

Data on the prevalence of diet-related cancer in the Arab Gulf are mostly hospital based. It was estimated that about 10–12% of total deaths were due to cancer. Breast, bronchial, lung, stomach, colon, and liver cancers are the most common types of cancer which may be related to diet [4].

Osteoporosis is a growing public health problem in the Arab Gulf. Studies in the region showed that a lower bone density was common, especially among women [37–39]. The main risk factors are female sex, age, menopause, smoking and vitamin D and calcium deficiencies [40].

Food-borne diseases are now considered a major public health problem worldwide. The diseases may be toxic or infectious in nature and are caused by the ingestion of contaminated foods. These diseases can be grouped on the basis of causative agents: bacteria, fungi, viruses, parasites, and chemicals. The health consequence due to these diseases can be very severe and may lead to death, especially in individuals with low disease resistance, such as infants, young children, pregnant women, and the elderly. Food-borne diseases in Arab Gulf countries are mainly caused by bacteria, specifically salmonellosis, hepatitis A, shigellosis, and poisoning with staphylococcus are the main constitutes of these diseases [41, 42].

Step 5 (Determine the Lifestyle Patterns That Are Associated with Diet-Related Diseases). In addition to the changes in food consumption patterns, other changes in lifestyle, are also apparent and include smoking, a decrease in physical activity, an increase in alcohol consumption, and drug abuse. The increase in sedentary lifestyles is mainly due to the abundant use of cars, dependency on housemaids for home management, as well as due to spending a long time watching television and using the Internet, particularly by children, teenagers, and young people [13, 43]. The prevalence of adult physically activity for at least 150 min/week (based on the international standard definition) ranged from 30% to 42% for men and 26% to 29% for women. Participation in physical activity in the GCC states was estimated to be considerably lower than those for many developed countries [30].

An increase in smoking amongst both males and females was reported, with the prevalence of cigarette smoking ranging from 20–50% among men, and 5% to 12% among women [44]. The smoking of *shisha* (water pipe) has also increased sharply in the region and become more acceptable in the community [45]. This has increased the rate of smoking among the Arab Gulf population. In addition, passive smoking complicated the problem, as many family members, especially women and children are regularly exposed to a smoking environment at home. It was estimated that 30–40% of women in Bahrain were exposed to a smoking environment in the home [46].

Step 6 (Formulating and Testing the First Draft of the FBDG). After collecting information on nutritional status and lifestyle, the first draft of the FBDG was formulated and reviewed by five nutrition experts in the region. The draft was also pretested on a small number of people in the Arab Gulf countries. The draft was distributed to the nutritionists and dietitians in the region. No major comments were obtained from this limited number of the public. However, several comments and suggestions were provided by the experts. The first draft of the Arabic version was then modified and revised based on the comments received by both the experts and nutritionists.

3. Findings and Discussion

The Food-Based Dietary Guidelines (FBDG) for Arab Gulf Countries

3.1. Eat a Variety of Different Foods Every Day. The human body needs more than 40 nutrients to maintain good health and prevent disease. However, there is no single food which contains all these nutrients in their required entirety and in the right quantity to maintain a healthy body. Therefore, increasing the variety of foods consumed is important to ensure an adequacy to intake of these nutrients in our meals, breakfast, lunch, supper, and snacks [47].

As each type of food can be rich in certain nutrients but poor in others, it is important to eat food from all five food groups, as listed in these guidelines, to ensure a varied diet (Table 1). Select one or more type of food and try to combine them in your favorite way in every meal. For example, for

lunch, you could select rice from the cereal group to eat with fish (meat group) in addition to vegetables and salad (vegetable group), along with a glass of fruit juice (fruit group).

3.2. Eat an Adequate Amount of Fruit and Vegetables Daily. Fruit and vegetables must comprise a basic part of your daily diet to maintain a healthy body. Their consumption can contribute to the prevention of several diet-related chronic diseases [48–50]. Studies indicate that the majority of the population of Arab Gulf countries does not consume sufficient quantities of fruit and vegetables, particularly children and teenagers, and this deprives them of essential nutrients [14]. It is crucial to vary your daily intake of fruit and vegetables to obtain the maximum nutritional and health benefits of such foods. It is recommended to eat at least three servings of vegetables and two of fruit daily, as shown in (Table 1).

3.3. Eat Meat, Fish, Chicken, Legumes, and Nuts Regularly. Meat, fish, and poultry are the main source of dietary balanced protein and are rich in essential nutrients, especially iron, zinc, and other vitamins [51]. Communities in the Arab Gulf region frequently suffer from anemia, mainly iron deficiency anemia [23]. Meat, fish, and chicken are good sources of good absorbable iron. Take one to two servings of fish, skinless poultry, or lean meat daily (as prescribed in the food groups). Increased fish intake is especially important as scientific information showed that the consumption of fish or fish oil containing omega-3 polyunsaturated fatty acids reduces the risk of coronary heart disease [52]. At the same time, red meat consumption should be restricted to not more than 0.5 kg per week, as high consumption of red meat may increase the risk of stomach and colon cancer [53]. Limit your intake of processed meat products that are rich in fat and salt such as sausages and mortadella, and eat low-fat processed meat. Reduce the intake of liver, cerebrums, and kidneys due to their high cholesterol content. Also, reduce the intake of salted fish and fish sauces such as *Mihiyawa (Mishawa)* and *Tareeh* as they contain a great amount of salt [14].

Legumes are a rich source of protein, some vitamins, and minerals, and dietary fiber. Legumes include, among others, beans, lentils, cowpeas, kidney beans, lupine, green peas, and soybeans. On the other hand, nuts such as walnuts, hazelnuts, almonds, and pine nuts, as well as seeds such as watermelon seeds, muskmelon, and sunflower are very rich sources of energy for their high fat content, which ranges between 30% to 60% [54]. Nuts and seeds are also important sources of certain vitamins, minerals, phytochemicals, and unsaturated fatty acids that are recommended for their protective role against heart disease [55]. The intake of nuts and seeds is recommended, at least, once to twice a week, using the serving size prescribed in the food groups. Reduce the intake of salty nuts and seeds for their high content of sodium and instead choose unsalted roasted nuts. Nevertheless, it should be noted that overconsumption of nuts can contribute to an increase in calories.

3.4. Make Sure That Your Daily Diet Contains an Adequate Amount of Cereals and Their Products. Arab Gulf communities rely on grain-based foods, mainly rice, as the main food in addition to wheat (which is processed to produce bread, macaroni, pastries, cakes, and other products) [1]. It is important to consume adequate amounts of these foods particularly those made from whole grains—one of the most important sources of fiber and other nutrients. Unfortunately, many people do not consume an adequate amount of food that consists of complex carbohydrates such as whole-wheat products, although it is recommended that at least 55% of calories should come from carbohydrates [8].

Try to concentrate on foods based on whole grains especially bread, biscuits, and other bakery products. Cereal-based foods such as cakes, biscuits, and pastries which can have high levels of added fats and sugars are not included in this recommendation and should be regarded as occasional treats only. Active adolescents and youths need more carbohydrates to compensate for daily exerted energy than nonactive adolescents. Foods from grains such as rice, oats and wheat, in addition to carbohydrates supply the body with some vitamins, minerals, and dietary fiber. Additionally, these foods are low in fat except when fat is added during processing or cooking. Whole-grains are different from peeled grains in that the latter lose some of their nutrients and fiber, a fact that reduces their nutritional value. For those who find the taste of whole grains unpleasant or where they are not available, this can be compensated for by eating other types of food like fruit and cooked or fresh vegetables to ensure an adequate intake of dietary fiber. It is recommended that brown or whole grain bread be an essential part of your daily intake, as it is available and affordable. Also, at least half of your daily intake of grains must be whole grains as much as possible [56].

Eat fortified grains when possible. This term refers to grains to which vitamins and minerals are added to flour to increase their nutritional value. Hence eat grains fortified with iron, folic acid, calcium, and vitamin D whenever possible. There is considerable interest in the production of grains fortified with vitamins and minerals that compensate for any deficiency resulting from the elimination of these nutrients during processing. The most common nutrients used in fortification are folic acid, iron, and some of the B vitamins. The main fortified grain-based foods available in the region are cornflakes, bread, and some types of biscuit. Read the label on the product to ensure that the foods have been fortified with these nutrients [57].

3.5. Consume an Adequate Amount of Milk and Dairy Products Every Day. Milk and dairy products, which contain many essential nutrients, are important for the body and for its development. Dairy products are the best source of calcium, which is vital to strengthen bones and for a healthy nervous system [58]. In general, young female adolescents and elderly people are more susceptible to a "deficiency in calcium" and this is one of the leading causes of osteoporosis—a disease that is currently widely prevalent among Arab Gulf communities [38, 59, 60].

The consumption of milk and dairy products is important for building a healthy body, particularly during childhood and adolescence. Studies of dairy products, particularly yogurt and cheese along with milk, have revealed a positive link between the consumption of dairy products and bone density and the existence of high mineral content [61]. Dairy products should not be avoided on the grounds that they lead to becoming overweight. Children between 2 to 8 years old should consume about 2 cups of low-fat milk or the equivalent each day while nine year olds and above are advised to consume 3 cups of low-fat milk or the equivalent each day. For those who are allergic to milk or who are intolerant to lactose, yogurt or cheese (low fat) are suitable substitute, for milk [51].

3.6. Reduce the Intake of Food Rich in Fat. Many foods and traditional dishes consumed in the Arab Gulf region are known for their considerable high fat content (5%–20%) [14], and this does not mean to exclude these dishes, but to reduce the amount consumed. Fat provides energy, essential fatty acids necessary for development and fat helps in the absorption of certain vitamins. Nevertheless, moderate intakes of fat should always be maintained. Dietary fats can be classified into two types, based on their relation to heart disease and their effect on raising cholesterol levels in the blood. Animal fat, which may raise blood cholesterol, is mainly found in meat, chicken skin, cheese, whole-milk butter, and liver. Most of vegetable fats do not increase blood cholesterol [62]. However, remember that fats contain plenty of energy, so excessive intake of food rich in fat may play an important factor for prevalence of obesity in this region [1]. Try to get energy requirements from foods of plant origins such as grains, legumes, seeds, and nuts. If you eat foods which contain a high amount of animal fat at one meal, try to eat foods low in this type of fat in the second meal. Also try to replace meat with fish whenever possible and affordable.

3.7. Reduce the Intake of Food and Drink High in Sugar. Sugar is considered a carbohydrate and a source of energy. In general, all carbohydrates (except dietary fiber) are converted to sugars. Natural sugars are found in many foods such as milk, fruit, certain vegetables, bread, grains, and potatoes. Frequent intake of foods rich in added sugar, especially sweets, chocolates, and sugary drinks (such as soft drinks and canned juices) can contribute to tooth decay, unless the teeth are cleaned immediately after eating such foods. Evidence from many research studies suggests that the proportion of tooth decay increases with an increase in the intake of sugar per day [8, 63]. In order to combat teeth decay, you must reduce the intake of food rich in sugar, regularly clean your teeth, and use toothpaste containing fluoride. Overconsumption of food rich in sugar leads to an increase in energy intake, which contributes to an increase in your weight.

3.8. Reduce the Use of Salt and Intake of Salty Foods. Dietary salt is an inorganic compound consisting of sodium and chloride ions. It is found naturally in many foods and it is also added to many foods for flavoring and preservation. It has been found that Arab Gulf people consume more sodium than they need [13]. Many Gulf traditional dishes, canned, and fast foods contain high amounts of salt. Studies show that an overintake of sodium is associated with high blood pressure, strokes, and contributes to heart attacks, heart failure, and kidney failure [64, 65]. It is recommended not to exceed 5 g sodium per day [8]. To achieve low intake of salt, people should consume fresh foods, foods normally processed without salt, and add low salt or avoid addition of salt to food. In case of using salt, use iodized salt. Among the substitutes for salt are acidic ingredients such as vinegar, lemon, line, spices, and herbs [51].

3.9. Drink Adequate Amounts of Water and Other Liquids Daily. Water is an essential nutrient for life. It accounts for more than 60% of our bodies and plays important roles in digestion, absorption, and transportation of nutrients in the body, as well as for elimination of waste products and thermoregulation [66].

The quantity of water consumed may differ from one person to another and there are no fixed recommendations in this regard. Factors like body size, weather, physical activity, and individual differences have an effect on the body's need for fluids [67]. Usually, thirst is the common indicator of this need, but this mechanism does not always work fully and in many times you may need the water before you get the sign of thirst. Therefore, a general sound recommendation is drinking water and other fluids daily in appropriate amount, especially in the Gulf region, which is known for hot weather and high humidity. However, intake of fluids containing added sugar should be avoided as much as possible.

Drinking water and other fluids is not the only way to get the required intake of fluids; many of the food consumed contains a good amount of water. For instance, about 85% to 95% of most fruit and vegetable weight is water and meat contains 45% to 65% of water while cheese contains 25–35% water [14].

3.10. Maintain an Appropriate Weight for Your Height. Obesity has become an epidemic in the Arab Gulf countries during the last two decades. Studies indicate that more than half of adults in these countries are overweight or obese. Meanwhile, the rate of overweight and obesity has risen threefold among children and adolescents during the same period [12]. The more weight a person has the more the chances of developing hypertension, cardiovascular disease, hypercholesterolemia, and certain kinds of cancers, osteoarthritis and other respiratory problems [68]. Appropriate weight for height is the key to a long healthy life.

Body mass index (BMI) is often used to measure your healthy weight. BMI is calculated as body weight in kilograms divided by height in meters, squared. People with BMI ranging between 18.5 and 24.9 are considered to be at healthy weight, a BMI between 25.0 and 29.9 to be overweight, and a BMI of 30.0 and over to be obese [69].

The major health objective of adults therefore should be to maintain a weight that sustains a healthy life and prevent extra weight gain. The way to achieve a healthy body weight is to balance energy intake (food and drinks) with energy expenditure (physical activity). Excess body fat can be

reduced by reducing calorie intake and increasing physical activity [70]. As for children and adolescents, priority should be given to halt the overweight rate along with maintaining natural development. Studies indicate that maintaining a healthy weight for children and adolescents helps to minimize the risk of obesity and its complications in adulthood [8, 68]. Consult your doctor or the dietitian for the appropriate weight of your child.

3.11. Make Physical Activity a Part of Your Daily Routine. Studies in the Arab Gulf countries indicate a serious decline in physical activity especially among women and adults and that these communities tend to be sedentary. It was shown that inactivity is one of the main factors contributing to high prevalence of obesity in the region and that children and adolescents have become less active [13, 43].

Physical activity and maintenance of optimum weight are two important issues for good health and both can benefit your health in different ways. Children, adolescents, adults, and elderly people can enjoy wellbeing and improve their health status if they start daily physical activity. Light physical activity includes moving the body about while moderate-intense physical activity is any bodily movement that requires the exertion of much more energy like walking for at least 30 minutes. A target of 30 minutes for adults and 60 minutes for children of moderate physical activity most days of the week, preferably daily, is recommended [70].

If you have been practicing physical activity for 30 minutes a day, you can further improve your health by increasing the time of practice. You can practice physical activity at any suitable time, no matter the type or speed of activity of your choice. It is possible to divide time into two periods of 15 minutes each, or to three periods of 10 minutes each. Choose an activity of your choice that you feel you would like to continue. You might see people who prefer to engage in activity relevant to their daily routine, like mowing the lawn or using the stairs, while others prefer to engage in specific activity such as playing football, jogging, or walking. Anyway, engaging in any daily physical activity counts [71].

Adults (over 19 years) who suffer from one of the following diseases or have special conditions related to these diseases are advised to seek a medical consultation to check their fitness before they engage in any vigorous activity [72]:

(i) Existence of chronic disease, for example, heart disease, hypertension, diabetes, osteoarthritis, and obesity.

(ii) Existence of risks leading to heart disease such as smoking, and a rise in blood cholesterol.

(iii) Over 40 years old men and 50 years old women.

3.12. Do Not Smoke and Reduce the Risk of Exposure to Smoking Environments. Indicators have revealed an increase in the proportion of smokers in the Arab Gulf countries particularly among adolescents [73]. Moreover, smoking *Shisha* (water pipe) is widely practiced by a considerable proportion of the population at different ages and among different classes [45, 74]. The Arab Gulf communities have begun to accept the smoking of *shisha* among women and adolescents believing wrongly that it is not as harmful as smoking cigarettes. This led to an increase in the use of *shisha* by these groups [45].

It is well known that smoking is linked to many heart and respiratory system diseases, as well as to lung cancer, therefore not smoking is highly recommended. Many Muslim scholars have issued claims *(Fatwa)* prohibiting smoking [75]. Smoking *Shisha* is actually worse than smoking cigarettes because the *Shisha's* tobacco contains greater quantities of nicotine and evidence shows that many of its toxicants are insoluble in the *Shisha's* bottled water. Unfortunately, people who are exposed to a smoking environment are also exposed to the same health implications as the smokers themselves. Studies have revealed that a passive smoker is not different from a smoker with regard to the risk of smoking-related diseases [76–78]. Valid advice is not only the cessation of smoking, but also to stay away from smoking environments where there are cigarettes and *Shisha* or any other type of smoking.

3.13. Avoid Drinking Alcoholic Beverages. Alcoholic beverage consumption varies in Arab Gulf countries. In some countries, which allow importation of alcoholic beverages the percentage of those who drink alcohol is on the rise, especially among teenagers and young people. In other countries, alcoholic beverages are forbidden, hence these countries witness less alcoholism, nevertheless, economic open-market policies and globalization have contributed to the rise in the number of alcohol drinkers in both environments. Alcohol intake is associated with many diseases, mainly the risks of cirrhosis (hepatitis), hypertension, and esophagus cancer and pancreas infection. In addition, alcoholism damages the heart and cerebrum, increases traffic accident rates, and negatively affects attentiveness at work [79–82]. Alcohol intake during pregnancy has an adverse impact on children's development and behavior and can result in deformity and mental retardation [83]. Alcoholic beverages may contribute to family disagreements and problems such as divorce, violence, and children's misbehavior [79].

Although some dietary institutions advice moderate intakes of alcohol and point out some of alcohol's healthy pros, it is worth mentioning that the great majority of local Gulf communities are Muslim (more than 98%) and therefore drinking all types of alcohol is prohibited.

3.14. Ensure Safety of Food Eaten. Recently, emerging food-borne illnesses have begun to constitute a serious concern for medical authorities in all the Arab Gulf countries. The symptoms of such illnesses range from mild to serious and include abdominal cramps, diarrhea, nausea, vomiting and dehydration, and other severe systems of dysfunction such as paralysis and meningitis. Microbial food poisoning is one of the most common types of food-borne diseases that affect many people as a result of eating contaminated foods or foods containing poisons. Symptoms include stomach ache, flatulence, and diarrhea which affect the health of susceptible groups, namely, children and elderly people [41].

To avoid microbial illnesses, wash your hands before and after cooking or eating especially when dealing with raw meat. Also, clean surfaces that are directly in contact with food, vegetables, and fruit and do not use these surfaces for chopping up, cutting, or slicing raw meat, chicken, and poultry. It is also important to separate fresh foods from cooked or ready-to-serve foods while shopping, preparing, or freezing. Food should be cooked at a safe temperature, particularly fish, poultry, eggs, meat and its products. Furthermore, it is highly recommended that perishable foods are instantly stored in the refrigerator or freezer and that people follow the proper method of thawing out frozen items before they are cooked. Other important advice is to avoid nonpasteurized milk and raw eggs or dishes which contain these ingredients.

4. Conclusion

The current FBDG are useful guides for the communities in the Arab Gulf countries to promote their healthy eating and lifestyle to reduce the incidence of nutrition-related diseases among them. However, such guidelines need to be revised periodically (every 3 to 5 years) with the change of scientific evidence and research regarding the risk factors for nutrition-related diseases. We hope that these guidelines will stimulate other investigators in other Arab countries to establish their own ones.

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Hindawi Publishing Corporation
Journal of Nutrition and Metabolism
Volume 2012, Article ID 510458, 7 pages
doi:10.1155/2012/510458

Research Article

Body Mass Index, Waist Circumference, Body Fat, Fasting Blood Glucose in a Sample of Moroccan Adolescents Aged 11–17 Years

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Received 10 May 2011; Revised 4 August 2011; Accepted 15 September 2011

Academic Editor: Hazzaa M. Al-Hazzaa

Objectives. The study aimed to assess the relationship between body fat and each of body mass index (BMI) and waist circumference (WC), and to test the effectiveness of fat mass (FM), percent of body fat (PBF), BMI, and WC in predicting high levels of fasting blood glucose (FBG). *Methods*. A total of 167 adolescents aged 11–17 years were recruited from Rabat region. BMI and WC were determined using standard equipments. FM and PBF were derived from isotope dilution technique. FBG was determined by the hexokinase method. *Results*. Regardless of the weight status, BMI showed a strong positive correlation with FM and PBF in both genders. WC was significantly correlated with FM in boys and girls, and with PBF in different groups of girls and boys of the study sample. However, there was no significant relationship between WC and PBF in normal weight and overweight-obese groups of boys. FBG was highly correlated with FM and PBF in girls of the study sample and in overweight-obese girls. Similar significant relationship between FBG and both BMI and WC was observed in overweight-obese girls, while there was no significant association between FBG and other variables in boys and normal-weight girls. *Conclusion*. BMI and WC were closely associated with FM and PBF, respectively. However, the degree of these associations depends on gender and weight status. BMI may provide a better proxy estimate of overall adiposity than WC; nevertheless, both of them would appear to be a reasonable surrogate for FM and PBF as screening tools to identify adolescents at risk of developing excess body fat and high level of FBG.

1. Introduction

Over the last decades, there has been a worldwide growing prevalence of overweight and obesity among people of all ages [1, 2]. Obesity and its incidence reached epidemic levels and have become major public health concerns [3]. The real risk factor of obesity is an excess in adiposity which is strongly associated with adverse health outcomes, including diabetes mellitus, dyslipidemia [4], blood pressure [5] coronary disease, kidney disease, cancer, musculosketal consequences, asthma, and decreased fertility [6].

Given the major short- and long-term consequences of childhood obesity on health, well-being, and costs to health care and social security systems, as well as the better chances for intervention at young ages, public and private funding agencies should give a high priority to research on obesity in children and adolescents [7]. Early identification of adolescents at risk for excess adiposity and its related metabolic complications requires reliable, simple, and specific measures of excess body fat for this age group [8].

To this end, a set of techniques are used to assess obesity such as isotope dilution and dual energy X-ray absorptiometry (DEXA). These techniques offer accurate measurement of adiposity but they are expensive and cannot be used everywhere [9]. Thus, measuring body fat in most clinical and epidemiological settings is relatively difficult, and surrogate anthropometric measures, such as body mass index (BMI; kg/m^2) and waist circumference (WC) are used for assessment of obesity in children and adolescents.

A number of studies have explored the relationship between BMI and adiposity measures and showed high degree

of correlation between them in children and adolescents [9–12]. However, BMI provides misleading information about body fat [13, 14] and its clinical interpretation remains controversial [15]. Other studies have reported strong positive correlation between WC and body fat [16, 17], and WC has been advocated as an indicator of central obesity [18, 19]. However, it was indicated that WC may overestimate total and trunk fat [20] and it is not clear which of the central adiposity measures best predict the overall adiposity [21].

The goals of this study were to assess, for the first time in Morocco and North Africa: (a) the relationship between body fat, assessed by isotope dilution technique, and each of BMI and WC in adolescents, and (b) the effectiveness of fat mass (FM), percent body fat (PBF), BMI, and WC to predict adolescents with high-blood glucose level as health risk related to excess body fat.

2. Materials and Methods

2.1. Study Design and Data Collection. The study was carried out in Rabat region (Morocco) after receiving the institutional approval from the Ministry of National Education. A total of 167 adolescents (123 girls and 44 boys) aged 11–17 years were recruited from seven randomly selected secondary schools. The adolescents who participated in the study were selected by their teacher based on their weight status (overweight/obese and normal weight). A written consent was obtained from the parents or tutors, and verbal consent was provided by each subject. Anthropometric measures, saliva, and blood samples were taken at schools. Fat mass, percent body fat and fasting blood glucose level were determined at the laboratory of "Unité Mixte de Recherche en Nutrition et Alimentation, URAC39 (Université Ibn Tofaïl-Centre National de l'Energie, des Sciences et Techniques Nucléaires-CNESTEN-Rabat)."

2.2. Anthropometry. Anthropometric measurements were taken by trained operators using standard equipments. Body weight was measured to the nearest 0.1 Kg using portable scale (Seca, Germany) with minimal clothing and no shoes. Height was measured to the nearest 0.1 cm using a height bar (2 meters, dismantling) without shoes. BMI was calculated as weight in kilogram divided by the square of height in meter (Kg/m^2). WC was measured to the nearest 0.1 cm in standing position at the midpoint between the lowest rib and the iliac crest and at the end of normal expiration, using a measuring tape.

Using these measurements and the new WHO growth reference 5–19 years [22], the weight status of each subject was categorized: obese (z-score > +2SD, equivalent to BMI > 30 kg/m^2 at 19 years), overweight (z-scores > +1SD, equivalent to BMI > 25 kg/m^2 at 19 years), and normal weight ($-2SD \leq$ z-scores $\leq +1SD$, equivalent to $18 \leq 25\,kg/m^2 <$ BMI $\leq 25\,kg/m^2$ at 19 years).

2.3. Body Composition Determined by Isotope Dilution Technique (Deuterium Oxide). In our study, FM and PBF were estimated from total body water (TBW). TBW was determined by isotope dilution technique using the deuterium oxide (^2H_2O). Naturally, the body water pool contains a small amount of deuterium (^2H). This represents the natural abundance of ^2H in body water. When ^2H is ingested, it mixes with body water within a few hours. The amount of deuterium in body water above that naturally present is known as the enrichment of body water that reaches a "plateau" after 3–5 hours [23]. Each adolescent received orally a dose of ^2H_2O (0.5 g/kg body weight). The saliva samples were taken at baseline, after an overnight fast, and at 3 h after ingesting the ^2H (endpoint). The level of ^2H in saliva samples was measured by Fourier transform infrared spectroscopy (FTIR) [24]. TBW was calculated from the saliva sample by the plateau method, assuming that this plateau was reached at 3 hours [25]. The following equations were used [23]:

$$\text{Deuterium space(L)} = \frac{\text{Dose amount (mg)}}{\left(\text{Enrichment } ^2\text{H in saliva (mg/kg)}\right)}. \quad (1)$$

In order to correct the in vivo isotope exchange in calculating TBW, it is necessary to divide by 1.041 [26]

$$\text{TBW (L)} = \frac{\text{Deuterium space (L)}}{1.041}. \quad (2)$$

FM and PBF were calculated from TBW using the following equations:

$$\text{Fat free mass (FFM) (kg)} = \frac{\text{TBW (L)}}{\text{Hydration factor}},$$
$$\text{FM (kg)} = \text{Weight (kg)} - \text{FFM (kg)}, \quad (3)$$
$$\text{PBF (\%)} = \frac{\text{FM (kg)}}{\text{Weight (kg)}} \times 100.$$

In this study, we used the hydration factors (see Table 1) for children and adolescents [27].

2.4. Fasting Blood Glucose. All subjects had fasted for 12 hours prior to blood draw. Blood samples were stored in ice till the delivery to the laboratory (within 4 hours), and subsequently stored at −80°C until analysis. Fasting blood glucose (FBG) concentration was measured using the glucose hexokinase methodology [28].

2.5. Statistical Analysis. Means and standard deviations were calculated for each variable using descriptive statistics. Two-way ANOVA was used to examine the effect of gender, weight status, and their interaction. Pearson's correlation was used to assess the relationship between body fat (FM and PBF) and each of BMI and WC, and their association with FBG. All statistical analyses were performed using SPSS (statistical package for social sciences, version 17.0). The Kolmogorov-Smirnov normality test was used to determine whether data set was well modeled by a normal distribution or not. P values < 0.05 were considered significant.

Table 1: Hydration factor of fat-free mass in children and adolescents.

Age (years)	Boys	Girls
11-12	75.4	76.6
13-14	74.7	75.5
15-16	74.2	75.0
17–20	73.8	74.5

3. Results

A total of 167 adolescents participated in the study. 42% were overweight or obese and 58% had normal weight. Since the number of obese and overweight subjects was low, boys and girls of the study sample were divided into two groups (normal weight and overweight-obese). The mean and standard deviations (SD) of age, weight, height, BMI, WC, FM, PBF, and FBG are presented in Table 2. Statistical analyses showed that PBF was significantly higher in girls than boys ($P = 0.001$), while there was no gender effect on the other variables. Weight, BMI, WC, FM, and PBF were significantly higher in overweight-obese groups compared to normal weight groups ($P < 0.0001$); however weight status had no effect on FBG. Regarding the interaction between gender and weight status, it had a significant effect on BMI ($P = 0.025$), while it had no effect on WC, FM, PBF, and FBG.

Table 3 shows the correlations between body fat and each of BMI and WC. BMI was positively correlated to FM, with Pearson's correlation coefficients (r) above 0.57, in both genders of the study sample (boys, $r = 0.850$; girls, $r = 0.896$: all $P < 0.0001$) and in different weight status groups (boys: normal weight, $r = 0.770$; overweight-obese, $r = 0.739$; girls: normal weight, $r = 0.690$; overweight-obese, $r = 0.799$: all $P < 0.0001$). BMI was also significantly correlated with PBF in both genders of the study sample (boys, $r = 0.711$; girls, $r = 0.724$: all $P < 0.0001$) and in normal weight boys ($r = 0.648$, $P = 0.005$), overweight-obese boys ($r = 0.413$, $P = 0.032$), normal weight girls ($r = 0.505$, $P < 0.0001$), and overweight-obese girls ($r = 0.488$, $P = 0.001$).

On the other hand, WC showed significant positive correlation with FM in both genders of the study sample (boys, $r = 0.717$; girls, $r = 0.824$: all $P < 0.0001$) and in different weight status groups (boys: normal weight, $r = 0.513$, $P = 0.035$; overweight-obese, $r = 0.571$, $P = 0.002$; girls: normal weight, $r = 0.626$, $P < 0.0001$; overweight-obese, $r = 0.628$, $P < 0.0001$). Similarly, significant correlation between WC and PBF was seen in both genders of the study sample (boys, $r = 0.575$; girls, $r = 0.677$: all $P < 0.0001$), in normal weight and overweight-obese girls ($r = 0.434$, $P < 0.0001$; $r = 0.404$, $P = 0.008$, resp.). However, there was no significant correlation between PBF and WC in normal weight and overweight-obese boys.

Overall, the relationships of BMI and WC with each of FM and PBF were found to be dependent on gender and weight status. The relationship between BMI and PBF was stronger in overweight-obese girls than overweight-obese boys. Similarly, the relationship between WC and PBF was stronger in both normal weight and overweight-obese girls than normal weight and overweight-obese boys. On the other hand, the association of BMI and WC with FM was observed to be more significant than with PBF mainly in overweight-obese boys.

Table 4 shows the Pearson's correlation coefficients of FBG with FM, PBF, BMI, and WC. FBG was found to be strongly correlated with FM in girls of the study sample ($r = 0.241$, $P = 0.007$) and in overweight-obese girls ($r = 0.583$, $P < 0.0001$). Similar positive correlation was observed between FBG and PBF in girls of the study sample ($r = 0.246$, $P = 0.006$) and in overweight-obese girls ($r = 0.561$, $P < 0.0001$). In addition, a significant correlation was found between FBG and both BMI and WC in overweight-obese girls ($r = 0.330$, $P = 0.033$ and $r = 0.528$, $P = 0.004$, resp.). However, the relationship of FBG to FM, PBF, BMI and WC was not significant in boys. On the other hand, there was a trend toward a negative correlation between FBG and FM, in overweight-obese group of boys, and both BMI and WC in normal weight girls, but these correlations were not significant.

4. Discussion

4.1. Relationship between BMI and Each of FM and PBF. BMI is commonly used as an indicator of overall obesity in adults due to its simplicity and correlation with percent body fat [29], but its use in children and adolescents is still a controversial issue because it seems to give a limited insight of excess body fat degree [8, 30]. Children with the same BMI may show a noticeable variation in total body fat [13]. Unlike adults, annual increase in BMI during childhood is generally attributed to the lean rather than to the fat component of BMI [31–33]. The association between BMI and PBF in young subjects differs among ethnic groups, and BMI does not fully explain differences in PBF [34].

Our results showed a high significant relationship between BMI and each of FM and PBF in both boys and girls. These results are in agreement with previous studies, suggesting that BMI is highly related to adiposity and may be useful in identifying excess body fat in children and adolescents [35–38] and that correlation of BMI with FM is greater than with PBF [9, 38], we have now confirmed this in a different ethnic sample of adolescents from North Africa. In addition, and most of all, our findings confirm the results of previous studies, indicating the high positive relationship between BMI and PBF among adolescents [11], the role of BMI as a predictor of PBF, and the gender differences in the relationship between PBF and BMI [39].

4.2. Relationship between WC and Each of FM and PBF. A number of studies have reported the strong positive correlation between WC and body fat [16, 17]. WC rather than BMI agrees with perception of body size, possibly due to its relation with abdominal fat at different ages [40], and could serve better than BMI and skin fold thickness for identifying central adiposity [41]. WC has been shown to have a significant role in identifying overweight and obese individuals [42]. However, it was indicated that WC may overestimate total

Table 2: Characteristics of study sample (mean ± SD) and main effect of gender, weight status, and their interaction (two-way ANOVA).

Variables	Gender	Total	Normal weight	Overweight-obese	*P* values		
		Boys: $n = 44$ Girls: $n = 123$	Boys: $n = 17$ Girls: $n = 80$	Boys: $n = 27$ Girls: $n = 43$	Effect of gender	Effect of weight status	Effect of interaction between gender and weight status
Age, years	Boys	14.19 ± 0.93	14.44 ± 0.83	14.03 ± 0.96	0.559	0.997	0.041
	Girls	14.29 ± 1.18	14.15 ± 1.15	14.57 ± 1.21			
Weight, kg	Boys	61.64 ± 13.23	55.0 ± 10.0	65.80 ± 13.49	0.185	<0.0001	0.005
	Girls	54.45 ± 13.28	47.4 ± 7.3	67.93 ± 11.52			
Height, m	Boys	1.62 ± 0.11	1.65 ± 0.11	1.60 ± 0.11	0.012	0.284	0.019
	Girls	1.58 ± 0.07	1.58 ± 0.08	1.60 ± 0.06			
BMI, kg/m^2	Boys	23.49 ± 3.96	20.12 ± 2.27	25.61 ± 3.27	0.893	<0.0001	0.025
	Girls	21.62 ± 4.47	19.02 ± 2.07	26.58 ± 3.49			
WC, cm	Boys	81.27 ± 11.98	72.4 ± 8.4	86.83 ± 10.52	0.472	<0.0001	0.222
	Girls	75.38 ± 11.76	69.3 ± 7.7	86.98 ± 9.08			
FM, kg	Boys	18.71 ± 10.48	10.64 ± 5.92	23.79 ± 9.53	0.054	<0.0001	0.840
	Girls	17.41 ± 8.90	12.87 ± 4.67	26.07 ± 8.66			
PBF, %	Boys	29.27 ± 12.46	19.08 ± 9.92	35.68 ± 9.26	0.001	<0.0001	0.073
	Girls	30.48 ± 8.92	26.63 ± 6.59	37.83 ± 8.18			
FBG, g/L	Boys	0.92 ± 0.14	0.89 ± 0.11	0.94 ± 0.15	0.306	0.182	0.195
	Girls	0.89 ± 0.11	0.89 ± 0.10	0.89 ± 0.12			

BMI: body mass index (kg/m^2); WC: waist circumference (cm): FM, fat mass (kg): PBF, percent body fat (%): FBG: fasting blood glucose (g/L).

Table 3: Pearson's correlation coefficients (r) of BMI and WC with each of FM and PBF.

	BMI		WC	
	FM	PBF	FM	PBF
Boys				
Total ($n = 44$)	0.850**	0.711**	0.717**	0.575**
Normal weight ($n = 17$)	0.770**	0.648**	0.513*	0.347
Overweight-obese ($n = 27$)	0.739**	0.413*	0.571**	0.289
Girls				
Total ($n = 123$)	0.896**	0.724**	0.824**	0.677**
Normal weight ($n = 80$)	0.690**	0.505**	0.626**	0.434**
Overweight-obese ($n = 43$)	0.799**	0.488**	0.628**	0.404**

*Correlation is significant at $P < 0.05$.
**Correlation is significant at $P < 0.01$.

Table 4: Pearson's correlation coefficients of FBG with FM, PBF, BMI, and WC.

	FBG			
	FM	PBF	BMI	WC
Boys				
Total ($n = 44$)	0.121	0.155	0.193	0.214
Normal weight ($n = 17$)	0.180	0.103	0.273	0.214
Overweight-obese ($n = 27$)	−0.049	0.005	0.026	0.270
Girls				
Total ($n = 123$)	0.241**	0.246**	0.094	0.090
Normal weight ($n = 80$)	0.076	0.105	−0.036	−0.142
Overweight-obese ($n = 43$)	0.583**	0.561**	0.330*	0.528**

*Correlation is significant at $P < 0.05$.
**Correlation is significant at $P < 0.01$.
Dependent variable: FBG.

and trunk fat [5, 20] and that the relationship between WC and body fat could be influenced by weight status and gender in youth [10]. The present study explored the relationship between WC and each of FM and PBF.

WC was found to be closely associated to FM and PBF in both boys and girls of the study sample, and in normal weight and overweight-obese girls. Our results are consistent with those of previous studies which suggest WC as a good diagnostic test for fatness in adolescents [17, 20]. Regarding the effect of weight status on the relationship between WC and adiposity measures, our results differ in some respects from earlier studies, probably relating to the low number of overweight and obese adolescents who participated in the study. However, these results confirm that the relationship between WC and direct measures of overall adiposity may be influenced by gender. This gender difference was apparent in our study as the correlations were stronger in girls compared to those observed in boys. These finding agree with a previous study which showed that girls have a higher FM than boys and WC may not reflect total fat [5].

4.3. Relationship Between FBG and Each of BMI, WC, FM, and PBF. The current study aimed to test the effectiveness of FM, PBF, BMI, and WC in predicting high levels of FBG as health risk related to excess body fat in adolescents. Many studies support the hypothesis that the relationship between adiposity and risk of disease begins early in life [43, 44].

The increased intra-abdominal adipose tissue is the most clinically relevant type of body fat that is associated with metabolic complications and adverse health effects including hyperinsulinemia and type 2 diabetes in childhood [45, 46]. However, it is not yet clear whether this association can be found in youth of all ethnic groups.

Our results showed high positive association of FBG with FM and PBF in girls of the study sample and in overweight-obese girls as well. Similar positive association of FBG with BMI and WC was observed in overweight-obese girls. Our findings are in line with available data from previous studies on the relationship between adiposity and blood glucose level. It has been reported that the level of FBG was found to be higher in overweight and obese children compared to the normal children [47] and that adolescents with high levels of overall and abdominal adiposities had the least favorable glucose levels [48]. Independently of the amount of fat mass, intra-abdominal fat accumulation was found to be strongly related to insulin resistance and hyperglycemia in obese adolescents [49]. Moreover, it was indicated that overweight and obesity were associated with increased risk for developing Type 2 Diabetes [50–52]. The high significant relationship of FBG to BMI, WC, FM and PBF seen in the current study, especially in overweight and obese girls, may be due to the decreased insulin sensitivity which was found to be strongly associated with excess body fat in previous studies [53–56], while weight loss was found to be associated with a decrease in insulin concentration and an increase in insulin sensitivity in adolescents [57, 58]. Also such positive relationship in overweight-obese group of girls may be explained by the clustering of metabolic syndrome factors which place individuals at risk for Type 2 diabetes as it has been reported in another study [59].

On the other hand, there was no significant correlation between FBG and BMI, WC, FM, and PBF in boys, may be due to the small sample size.

Our study had some limitations such as the small size of the whole sample and weight status groups particularly for boys. Our ability to recruit more subjects was hampered by the surge of influenza A/H1N1 during the course of the study. Also the authorization to access to schools has not been renewed by the concerned authorities for 2010-2011 academic year.

Another limitation is that the relationship between adiposity measures and each of BMI and WC, in one hand, and between FBG and other variables, on the other hand, may depend on pubertal stages (PS) that were not addressed in our study. For instance, it was observed in a previous study that the relationship between WC and PBF changes with sexual maturity, and that the normal pattern from PS1 to PS5 is for PBF to decrease and WC to increase [60].

5. Conclusion

BMI and WC were closely associated with FM and PBF, derived from isotope dilution technique, in a sample of Moroccan adolescents from Rabat. It should be noted, however, that these associations depend on gender and weight status, and that BMI may provide a better proxy estimate of overall obesity than WC. Nevertheless, both of them appear to be reasonable surrogate for FM and PBF, particularly in epidemiological studies, as screening tools to identify adolescents at increased risk of developing excess body fat and high levels of fasting blood glucose.

Further research is needed for this group of population and should include (1) studies to confirm our results taking into account the puberty stage, (2) investigation of the association of overall and central obesity with fasting blood glucose level among girls in different age or ethnic groups and the mechanism that produces the gender difference observed in the current study, and (3) relationship of BMI, WC, FM, and PBF with other metabolic abnormalities for early prevention of health risks related to overweight and obesity.

Abbreviations

BMI:	Body mass index
CNESTEN:	Centre National de l'Energie, des Sciences et Techniques Nucléaires
FBG:	Fasting blood glucose
FFM:	Fat-free mass
FM:	Fat mass
FTIR:	Fourier transform infrared spectroscopy
PBF:	Percent body fat
TBW:	Total body water
WC:	Waist circumference
WHO:	World Health Organization.

Conflict of Interests

All authors declare having no conflict of interest.

Acknowledgments

The authors thank the volunteers who participated in the present study and all who contributed in data collection mainly Professors N. El Haloui and A. Derouiche, Ph.D. students (N. Attalhi, G. Choua, H. Labraimi, E. Aglago, K. Janah, ...) and medical staff (Dr. H. Belghiti and Dr M. Azelaf, ...). They also thank the International Atomic Energy Agency for its funding and technical assistance.

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