NUTRITION RESEARCH 34 (2014) 559–568

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Certain dietary patterns are beneficial for the metabolic syndrome: reviewing the evidence

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ARTICLE INFO

Article history:
Received 13 September 2013
Revised 2 June 2014
Accepted 19 June 2014

Keywords:
Metabolic syndrome
Diet
Mediterranean diet
Dietary patterns
Asia
Human

ABSTRACT

The metabolic syndrome (MetS) is a global public health issue of increasing magnitude. The Asia-Pacific region is expected to be hardest hit due to large population numbers, rising obesity, and insulin resistance (IR). This review assessed the protective effects of dietary patterns and their components on MetS. A literature search was conducted using prominent electronic databases and search terms that included in combination: diet, dietary components, dietary patterns, and metabolic syndrome. Articles were restricted to prospective studies and high quality randomized controlled trials that were conducted on humans, reported in the English language, and within the time period of 2000 to 2012. Traditional factors such as age, gender, physical activity, and obesity were associated with risk of MetS; however, these potential confounders were not always accounted for in study outcomes. Three dietary patterns emerged from the review; a Mediterranean dietary pattern, dietary approaches to stop hypertension diet, and the Nordic Diet. Potential contributors to their beneficial effects on prevalence of MetS or reduction in MetS components included increases in fruits, vegetables, whole grains, dairy and dairy components, calcium, vitamin D, and whey protein, as well as monounsaturated fatty acids, and omega-3 fatty acids. Additional prospective and high quality randomized controlled trial studies that investigate Mediterranean dietary pattern, the dietary approaches to stop hypertension diet, and the Nordic Diet would cement the protective benefits of these diets against the MetS.

1. Introduction

The metabolic syndrome (MetS) is a clustering of risk factors for cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) which include: high blood pressure (BP), low fasting high-density lipoprotein cholesterol (HDL), high fasting triglycerides (TG), high fasting blood glucose, and abdominal obesity [1]. In Caucasian populations, the presence of the MetS is associated with at least a 2-fold increased risk of CVD [2] and at least a five-fold increased risk for T2DM [3]. In Asian

Abbreviations: ALA, alpha-linoleic acid; BP, blood pressure; CHO, carbohydrate; CVD, cardiovascular disease; DASH, dietary approaches to stop hypertension diet; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; GI, glycemic index; GL, glycemic load; HDL, high-density lipoprotein cholesterol; HF, high fiber; HP, high protein; IR, insulin resistance; IS, insulin sensitivity; IL, interleukin; LDL, low-density lipoprotein cholesterol; LFHCn-3, low fat high carbohydrate diet with omega-3; MDP, Mediterranean dietary pattern; MDS, Mediterranean dietary score; Mets, metabolic syndrome; MSDPS, Mediterranean style-dietary pattern score; MUFA, monounsaturated fatty acids; ND, Nordic diet; PA, physical activity; PUFA, polyunsaturated fatty acids; RCT, randomized controlled trial; T2DM, type two diabetes mellitus; TG, triglycerides; UMDS, updated Mediterranean dietary score; VOO, virgin olive oil; WC, waist circumference; WDP, Westernized dietary pattern.

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http://dx.doi.org/10.1016/j.nutres.2014.06.012
0271-5317/

populations, the MetS is associated with even greater risks of CVD and T2DM [4], thus highlighting the importance and relevance of MetS worldwide. As with other chronic diseases, the prevalence of MetS is increasing [4,5], with current prevalence estimates in the Asia-Pacific region between ~10% and 30% [2,4,6].

Preventing and treating this syndrome is an area of public health urgency from the viewpoint of improving the morbidity and mortality statistics as well as in reducing its economic burden. The precise pathogenesis of the syndrome is still unknown with central adiposity [7], insulin resistance (IR) [8–10], and inflammation [11], all being individually implicated, despite the considerable inter-relationships between them [11,12]. Environmental factors that modulate MetS risk include exercise, climate, socioeconomic status, and diet. In a recent review [12], we highlighted the association between MetS and several metabolic factors. We postulated that the adipocytokine, adiponectin, may have a key role in MetS as many diets and nutrients benefit MetS through increases in adiponectin. The focus of this review was to examine the evidence on dietary patterns and their components that were protective for the syndrome. In doing so, we also aimed to identify priority areas for research.

2. Literature search procedure for diet and MetS

Studies were identified by conducting an electronic search of the following databases: Proquest Central, PubMed Central, Science Direct, and Wiley Online Library. Individual Journals were also searched for relevant studies, these included: *American Journal of Clinical Nutrition*, *Cardiovascular and Metabolic Risk*, *Circulation Journal*, *Diabetologia*, *European Journal of Clinical Nutrition*, and *Obesity Journal*. Studies known to the authors that satisfied the inclusion criteria outlined below were also included. The following key words, in various combinations, were used: diet, dietary patterns, dietary components, and metabolic syndrome. Articles were restricted to human studies in the English language that reported individual MetS components as primary endpoints and were published within the time period of 2000 to 2012. Prospective epidemiological studies which fulfilled the above criteria and high quality randomized controlled trial (RCTs), as determined by a Jadad score ≥3 [13] were then identified and included in this analysis, as their design provides high level evidence for causative links between diet and disease. Two reviewers (EKC and PKP) independently assessed the eligibility of all studies for inclusion. Any discrepancy was resolved through discussion.

3. Dietary patterns and MetS

We separated the evidence with prospective cohort studies (n = 5) that described diet and MetS relationships in Table 1 and high quality RCTs (n = 7), as determined by a Jadad score ≥3 [13], that examined the causal relationship between diet and MetS featured in Table 2. Three dietary patterns emerged from our analysis: a Mediterranean dietary pattern (MDP), a dietary approaches to stop hypertension (DASH) diet, and the Nordic Diet (ND). All dietary patterns showed benefits in at least two of the MetS components, with two studies showing benefits in all five MetS components (Tables 1 and 2).

3.1. *MetS and a Westernized dietary pattern*

Although some studies have focused on the importance of individual foods for MetS [14], focusing on dietary patterns rather than single nutrients or food groups is preferred due to the expected synergistic effect on disease risk. The Dietary Guidelines for Australian Adults [15] advocates the following dietary pattern to reduce the risk of CVD and T2DM: plant foods including fruits, vegetables, legumes, and whole grain cereals; animal foods including meat, fish, and poultry; low fat dairy; limiting total fat intake to a moderate amount; limiting saturated fat; choosing foods low in salt; consuming only moderate amounts of sugar; and limiting alcohol intake. However, Australians typically consume low amounts of fruits and vegetables and high intakes of meat and processed convenience foods that are high in salt, sugar, and saturated fat [16]. This pattern, otherwise known as a Westernized dietary pattern (WDP), is very similar to current eating patterns in North America [17] and increasingly similar to patterns emerging in Asian-Pacific countries [18]. This may reflect commonality of influence between population groups due to globalization of the food supply [19]. Prospective studies have identified a WDP to be positively associated with MetS incidence, even after adjusting for adiposity among other confounders such as smoking status and PA [20]. Hence, the detrimental effect of the WDP goes beyond its effect on weight status.

3.2. *MetS and the MDP*

The MDP, as traditionally consumed in Southern Europe, has received significant attention regarding its apparent protective effect against MetS. This pattern is characterized by a diet rich in monounsaturated fatty acids (MUFA) from olives and olive oil; daily intake of whole grain cereals, fruits, vegetables, and dairy; and weekly intakes of fish, poultry, nuts, and legumes. Several studies have found the MDP to be associated with a lower MetS prevalence [21,22]. Moreover, a systematic review and meta-analysis of epidemiological studies and RCTs confirmed that adherence to a MDP was associated with reduced risk of MetS compared to control diets [23], as noted through beneficial effects on all individual criteria for the syndrome. Another meta-analysis also concluded that a MDP reduced hemoglobin A_{1c}, a long term indicator of high blood glucose levels [24].

It is possible that the MDP may exert its benefits on MetS through improvements in insulin sensitivity (IS) and/or inflammation. A well-designed prospective study found improvements in all components of MetS, except for BP, and improvements in IR as well [25]. Evidence that the MDP may act to reduce MetS via decreased inflammation [26] comes from an RCT of good quality [27] which found that, independent of weight loss, the MDP lowered C-reactive protein and interleukins 6, 7, and 8 (IL-6, IL-7, and IL-8) compared to a general healthy diet (50%-60% carbohydrate, 15-20% protein, <30% total fat). The authors indicated that fiber, omega-3 fatty acids, and antioxidants were potential mediators of the