We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,000
Open access books available

148,000
International authors and editors

185M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Chapter

Dietary Patterns for the Treatment of Arterial Hypertension in Patients with Metabolic Syndrome

António Gerson Bastos Francisco,
Isaura da Conceição Almeida Lopes,
Amílcar Bernardo Tomé da Silva
and Henrique Cotchi Simbo Muela

Abstract

Metabolic syndrome (MetS) refers to the commonly occurring disorder comprising central obesity, systemic hypertension (HTN), insulin resistance, atherogenic dyslipidemia specifically hypertriglyceridemia, and reduced levels of high-density lipoprotein cholesterol (HDL). The prevalence of MetS worldwide ranges from 20% to 25% in the adult population and 0% to 19.2% in children, but it can reach almost 80% in type 2 diabetes patients. Increased blood pressure (BP) is considered an important component of MetS. More than 85% of those with MetS, even in the absence of diabetes mellitus (DM), have elevated BP or HTN. Dietary patterns, such as Mediterranean-style, dietary approaches to stop hypertension (DASH), low-carbohydrate, and low-fat diets, can improve insulin resistance and MetS. Dietary patterns high in fruit and vegetable content were generally found to be associated with a lower prevalence of MetS. Evidence reinforces that DASH, Nordic diet, and Mediterranean diet (MD) significantly lowered systolic BP and diastolic BP by 4.26 and 2.38 mm Hg, respectively. Therefore, we aim to review the available evidence on the effect of dietary patterns on the treatment of HTN in patients with MetS.

Keywords: dietary pattern, diet, hypertension, treatment, control, MetS

1. Introduction

Metabolic syndrome (MetS) is a growing public health problem worldwide, which is associated with an increased risk of cardiovascular morbidity and mortality [1–4]. Although many classifications have been proposed for the diagnosis of MetS, the one proposed by the International Diabetes Federation (IDF), which defines MetS as the combination of clinical and metabolic factors, including insulin resistance, hyperglycemia, hypertension (HTN), dyslipidemia, and abdominal obesity, is the most used.

Many researchers consider MetS as a transitional stage prior to organ dysfunction and death from many associated diseases, such as diabetes mellitus (DM) and cardiovascular disease (CVD) [1]. Dietary pattern is an essential element associated with MetS components, such as HTN, dyslipidemia, obesity, diabetes, and consequently CVD [3, 4]. Several studies have reported that an unhealthy diet is associated with higher CVD risk factors, and a healthy dietary pattern is associated with lower risk [2, 4]. Dietary patterns with processed food and red meat have been linked to metabolic factors and CVD, whereas a Mediterranean diet (MD) is beneficial to metabolic risk factors [3, 4].

HTN is the main MetS risk factor that leads to increased cardiovascular morbidity and mortality and is additionally an important risk factor for the development of chronic kidney disease in the presence of obesity, MetS, and microalbuminuria [1]. The association between high BP and MetS is strongly linked to the causative pathway of obesity. Blood pressure (BP) control in persons with MetS may prevent a significant number of coronary heart disease events. The primary step of treatment is lifestyle intervention with reduced caloric intake and increased physical activity. In hypertensive patients, the presence of MetS is associated with higher noncontrolled HTN levels [1], while the optimal antihypertensive treatment has been debated for years.

The relationship between dietary patterns and MetS risk factors is well-established, as indicated by recent meta-analyses [5, 6], and evidence considerably varied across populations. While a "healthy" dietary pattern (a diet rich in high vegetables, fruits, and fish consumption) was inversely associated with MetS [7], a "western" dietary pattern—high consumption of processed food and red meat, refined grains, alcohol and fried foods, increased the risk of MetS [8].

Globally, it was estimated that a quarter of the world's adult population had high BP in 2002, and the prevalence is estimated to increase to 29% by 2025 [9]. The prevalence of obesity and other MetS components in many low and middle-income countries has dramatically increased in the past decade [10]. These include the rising prevalence of HTN and obesity which are the main risk factors for cardiovascular diseases such as heart diseases and stroke worldwide [11].

Several studies have tried to bring more insight into the dietary determinants of MetS [12, 13]. Some of their limitations include a relatively small sample size of the studies, [13, 14] lack of diversity of the populations [15], limitations in the generalizability of the findings [15], and a single-nutrient approach [12, 13], whereas diet by definition is complex. Dietary pattern analysis has emerged as an attractive alternative approach for examining the effect of overall diet reflecting the eating behaviors of the population in the real world, as a result of more recognition of limitations inherent to the single nutrient approach [16]. In the assessment of dietary patterns, using instruments such as principal component analysis (PCA) allows to identify groups of nutrients through the creation of secondary variables representative of nutrients that are often consumed together. These quantitative secondary variables representative of different dietary patterns can be used in subsequent analysis to explore the relationship between specific dietary patterns and MetS. However, the latter approach is also limited by its inability to detect the predictive power of significant single nutrients, which may not be grouped with the other more complex dietary patterns. With this study, we aim to review the effect of dietary patterns on HTN treatment in patients with MetS.

2. Prevalence of metabolic syndrome in the general population and hypertensive patients

MetS is a booming global problem, with an increasing prevalence in many developing countries mainly in the urban populations [17, 18]. It is estimated that approximately one-fourth of the adult European population has MetS, with a similar prevalence in Latin America [19]. Likewise, MetS is considered an emerging epidemic in developing East Asian countries, including Korea, Japan, and China. In this region, the prevalence of MetS is estimated to range from 8% to 13% in men and from 2% to 18% in women, according to the definitions used.

The prevalence of the MetS is increasing in parallel with the growing epidemic of obesity. Almost two-thirds of the population in 2008 were overweight or obese in the United States with more than 25% of the population meeting the diagnostic criteria for MetS [19]. Comparative survey data from the late 1990s and early 2000s (1999–2000 data) showed that the age-adjusted prevalence of MetS among US adults aged 20 years and older increased from 27% (1988–1994 data) to 32% [20]. The 2011–2014 National Health and Nutrition Examination Survey (NHANES) data showed a crude estimated prevalence of 36.5% for adult obesity (32.3% in adults aged 20–39 years, 40.2% in those aged 40–59 years, and 37.0% in those aged ≥60 years) [21]. These data also showed that the overall prevalence of obesity in women was 38.3% and 34.3% in men. Among children and adolescents aged 2–19 years old, there was a prevalence of obesity of around 17% in the same period (8.9% from 2 to 5 years old, 17.5% from 6 to 11 years old, and 20.5% from 12 to 19 years old) [21].

Luckily, since this peaked in the early 2000s (2001–2002 data), the overall prevalence of MetS in the United States has dropped, mainly because of a decrease in the prevalence of hypertriglyceridemia and HTN—and despite the increase in the prevalence of hyperglycemia and obesity/waist circumference prevalence [22]. Data from the 2009–2010 NHANES reported that the age-adjusted prevalence of MetS had decreased to approximately 24% in men and 22% in women [23].

MetS is becoming more common even in African populations where the burden of disease was mainly from infectious diseases [24, 25]. Among a group of hypertensive Nigerians, the prevalence of MetS, according to three different definitions, was reported to be 34.3% according to the ATP III definition for MetS, 35% according to the WHO definition, and 42.9% according to the IDF definition [24, 26]. These rates were generally similar to those reported in the Turkish study that included nondiabetic adults, where the prevalence rates were as follows: 38% according to the NCEP-ATP III definition, 42% according to the American College of Endocrinology (ACE) and IDF definition, 20% according to the EGIR definition, and 19% according to the WHO definition [26] These values are comparable with those reported in Canada, where one-third of adult patients between 40 and 60 years old met the criteria for the MetS [27].

In the United States, African Americans have a higher prevalence of MetS, particularly African American women, and this has been attributed to the higher prevalence of obesity, HTN, and diabetes in this subgroup [28]. However, it was in Mexican Americans that the highest prevalence of age-adjusted MetS was found, where approximately one-third (31.9%) of them met the diagnostic criteria for MetS, compared with 27% of the general population, according to data from a study in 1988–1994 [20].

The prevalence of the MetS is similar in both men (24%) and women (22%), after adjusting for age [23]. However, several considerations have to be taken into account

in women with MetS, including pregnancy, use of oral contraceptives, and polycystic ovarian syndrome [29].

The prevalence of MetS increases as the population ages, with about 40% of elderly people over 60 years old meeting the criteria for MetS [20]. However, MetS can no longer be considered a disease for adult populations only. Evidence published in the last decades indicates that both MetS and DM are increasingly prevalent in the pediatric population, and this growth has been recorded in parallel with the increase in the prevalence of obesity [30].

The presence of high BP is one of the required criteria for the diagnosis of MetS, while evidence also suggests that people with MetS are more likely to have HTN [31]. Results from the Pressioni Arteriose Monitorate E Loro Associazioni (PAMELA) study showed that high BP was the most frequent component of MetS in the patients who participated in the study, and it was found in more than 80%. Furthermore, participants with MetS were more prone to have higher home, office, and ambulatory BP values compared to those without MetS. All-cause mortality was also more prevalent in the population with MetS [32].

Conversely, a significant number of patients with HTN simultaneously fulfill the criteria for the diagnosis of MetS. Results from the Progetto Ipertensione Umbria Monitoraggio Ambulatoriale (PIUMA) study reported that about 34% of the hypertensive patients included also had MetS, and these patients were reported to have more cardiovascular events than those without MetS [33]. In a population-based study with more than 60,000 participants (39,998 men and 20,756 women) with no personal history of cardiovascular disease, who had a health check-up at the IPC Center (Paris, France) between 1999 and 2002, the prevalence of MetS increased proportionally with the increase in BP values [34]. After a 10-year follow-up of participants in the PAMELA study without MetS, the masked and sustained HTN based on ambulatory measurements were all associated with a higher incidence of new-onset MetS [35].

Studies conducted in the African region have consistently reported an increased prevalence of MetS in hypertensive patients despite the still high burden of infectious diseases. Tadewos et al. [36], in their study carried out in Southern Ethiopia reported that the prevalence of MetS was 48.7% and the rate was comparable with the study report from Nigeria, which was 45.6% [20]. This prevalence was even higher among hypertensive women, 54.1% which was similar to the prevalence reported in Nigeria, 54% [37].

3. Vascular pathophysiology of hypertension in metabolic syndrome

The pathogenic mechanisms linked to MetS are complex and remain to be fully explained. It is still debated whether the individual components of MetS represent different pathologies or expressions of the same pathogenic mechanism. Abdominal obesity is the main trigger for most of the mechanisms involved in MetS, thus highlighting the importance of a high caloric intake as the main causative factor [38]. Of all the proposed mechanisms, insulin resistance, neurohormonal activation, and chronic inflammation seem to be the leading players in the initiation, progression, and transition from MetS to cardiovascular disease.

The excitatory effects of insulin on the sympathetic nervous system seem to be centrally mediated, as they are observed only during systemic insulin infusion, but not during local infusion [39]. In addition, high insulin levels increase sodium

reabsorption [40] favoring the extracellular fluid volume expansion, which may increase the risk of arterial HTN [41]. Furthermore, obesity leads to impaired renal-pressure natriuresis and causes sodium retention. Obese individuals require higher BP to preserve sodium balance, indicating impaired renal-pressure natriuresis [42].

The increase of epidemiological studies linking insulin resistance and hyperinsulinemia has sustained the idea of the so-called insulin hypothesis of HTN. There is no doubt that epidemiological studies have linked insulin resistance to HTN [38, 43]. The insulin hypothesis of HTN states that the compensatory hyperinsulinemia that happens with insulin resistance increases sodium reabsorption and sympathetic activity, which combine to raise the BP. Much evidence supporting this hypothesis comes from different studies. First, the correlation between insulin resistance and high blood pressure [44], is emphasized by the fact that even lean persons with essential HTN may have insulin resistance and hyperinsulinemia. Some authors go a step further by claiming that essential HTN is by itself a state of insulin resistance [45]. Second, insulin has multiple actions on the sympathetic nervous system, kidneys, and vasculature bed that may lead to HTN. Third, many drugs that improve insulin resistance and decrease hyperinsulinemia are reported to have antihypertensive effects. For instance, Landin et al. reported in their study that hypertensive men increased insulin sensitivity and significantly decreased arterial pressure after oral administration of metformin to insulin resistant [46]. Another notable example is the known BP lowering effects of the insulin sensitizers glitazones [47]. Finally, it is known that insulin sensitivity is increased by some antihypertensives drugs, such as angiotensin II-converting enzyme inhibitors [48] or angiotensin II receptor antagonists [49]. Despite the large body of evidence supporting the insulin hypothesis of HTN, there is also important evidence against it. For example, the study by Hall and collaborators failed to find a correlation between insulin and HTN in a well-controlled model in dogs [50].

In addition to insulin, leptin is also associated with the relationship between obesity and increased sympathetic activity. Apart from its effect on appetite and metabolism, leptin has actions on the hypothalamus to increase BP through the sympathetic nervous system activation mechanism [51]. Higher circulating levels of leptin are reported to explain the increase in the renal sympathetic tone seen in obese patients [52]. Evidence indicates that the leptin-induced increases in renal sympathetic activity and BP are mediated by the ventromedial and dorsomedial hypothalamus [53].

The finding that leptin or obesity receptor is expressed by the endothelium [54], transformed endothelial cells, just like those of the hypothalamus, into a target for this hormone. The presence of leptin receptors in the vascular endothelium and not only in the central nervous system is important because it allows finding a link between leptin and impaired vascular function in obese individuals [55]. Leptin is a nitric oxide-dependent vasodilator but also increases peripheral vascular resistance and sympathetic nerve activity [56]. The concentration of leptin in plasma is correlated with adiposity, and hyperleptinemia is indeed considered an independent risk factor for cardiovascular disease [57].

Finally, in visceral obese patients, high circulating levels of free fatty acids may induce the activation of the sympathetic nervous system. The increases in the release of free fatty acids into the portal vein from lipolysis in visceral fat depots may explain the association between visceral obesity and increased sympathetic nerve outflow in these patients [58].

The discovery of the role of adipose tissue as an endocrine organ has gained important implications in the understanding of the pathophysiological relationship

between excess body fat and HTN [58]. Nearly all systemic arteries are surrounded by a layer of perivascular adipose tissue (PVAT). In myographic studies, PVAT is routinely removed, and this custom is based on the assumption that PVAT can prevent the diffusion of vasoactive substances. This is perhaps the reason that despite the great presence of PVAT, very little is known about its function in vascular physiology.

4. Dietary pattern, nutrients intake, and metabolic syndrome

Diet, as an important part of lifestyle, has been shown to be significantly associated with different components of MetS [59]. Dietary patterns high in fruit and vegetable content are generally associated with a lower prevalence of MetS. Otherwise, dietary patterns with high meat intake are frequently associated with increased components of MetS, particularly impaired glucose tolerance [5, 59].

The extent to which the consumption of an individual component in the diet is associated with MetS is an issue that still needs to be clarified; however, some studies suggest that dietary quality appears to play a more important role.

The Isle of Ely study [60] was a population-based study of type 2 diabetes and metabolic disorders in men and women from the Isle of Ely in the United Kingdom. Researchers used this cohort to investigate the relationship between dietary patterns and components of MetS in 802 adults aged 40–65 years [60]. The study used PCA to isolate four dietary patterns from food frequency questionnaire data, and related these patterns to components of the MetS. Four diet patterns were derived through the calculation of factor loadings for the variance of frequency for each food most commonly consumed: (a) Diet 1 (fruit, salad, fish (not fried), other vegetables, poultry, green vegetables, pasta/rice, and ice cream), (b) Diet 2 (cakes, sweets, root, vegetables, biscuits, puddings/pies, pulses, green vegetables, chocolate, and cheese), (c) Diet 3 (chocolate, sweets, crisps, cheese, soda, and fruit), and (d) Diet 4 (eggs, fried food, sausages, cheese, fried fish, nuts, and other vegetables).

According to the results from this study, both diets 1 and 2 were inversely associated with each component of the MetS. After adjustment for age, those with a higher score for diet 1 had a lower risk for increased waist–hip ratio (WHR), impaired glucose tolerance, increased plasma triglycerides and type 2 diabetes, and lower risk for decreased high-density lipoprotein cholesterol (HDL)–cholesterol. Otherwise, diets 3 and 4 had no significant associations with different components of MetS. In general, the Isle of Ely Study suggests that eating patterns characterized by high intake of fruit, vegetables, and whole cereals, and low intake of fried foods seemed to be linked to a lower risk of MetS components. Bread and milk were not specifically mentioned as part of a dietary pattern [60].

The Malmö Diet and Cancer Study [61] examined data from a sample (N = 1122) of men and women aged between 45 and 68 years that were analyzed for associations between dietary patterns and MetS components [61]. The dietary patterns that were used in this study differed significantly from that of the Isle of Ely study, possibly due to cultural habits and differences in diet, but also due to study design. Six dietary patterns were identified based on the highest proportion of energy intake from food groups, unlike the previous Isle of Ely study, which was based on the frequency of consumption. Differences in dietary patterns are to be expected, as food groups that contribute a high proportion of energy to the diet would not need to be consumed frequently to be rated high in this analysis (e.g., a high-energy chocolate bar compared to a low-energy piece of broccoli).

The relationship between dietary patterns and components of MetS differed significantly between men and women. Many foods and drinks patterns, with moderate energy intake from cheese and fat meat, were associated with an increased risk of hyperglycemia and central obesity in men. Men who scored highly for this dietary pattern had an odds ratio (OR) of 1.64 (95% CI 1.24–2.17) for hyperglycemia, while women showed no significant association. The "Fiber bread" dietary pattern with high energy intake from fiber-rich bread and fat meat was associated with a decreased risk of central obesity in men (OR 0.61, 95% CI 0.42–0.89). For women, the "White bread" dietary pattern was associated with an increased risk of hyperinsulinemia (OR 1.39, 95% CI 1.02–1.89), while the "Milk fat" dietary pattern was associated with a reduced risk of hyperinsulinemia (OR 0.58, 95% CI 0.40–0.84).

In the CARDIA study, Pereira et al. [62] investigated associations between food groups and MetS as part of the multicenter CARDIA project in the United States. The researchers of the CARDIA study did not identify dietary patterns instead, they evaluated food groups and nutrients and their influence on the onset of new cases of MetS and its components. A strong inverse association was found between consumption of dairy foods and the risk of MetS, particularly in overweight subjects. After controlling for demographic features, non-dietary lifestyle factors and common dairy components such as saturated fat, magnesium, calcium, and vitamin D, the OR for MetS in overweight individuals decreased by 69% for those in the highest quintile for dairy intake compared to those in the lowest quintile. Among those who were not overweight, the OR for MetS decreased by 28% for those in the highest quintile compared to the lowest. Similar relationships were found for both low-fat and high-fat dairy products. A significant relationship was also found between dietary patterns with a high intake of dietary fiber and protein. Fiber intake significantly reduced the risk of MetS; for each 3 g/1000 kcal increase in fiber intake, the OR decreased by 34%. Dietary protein, however, appeared to increase the risk of MetS with a 12% increase in OR for each 1% caloric increase in protein. This relationship was only significant for protein from animal sources, no association was found for plant proteins.

The extent to which the consumption of an individual dietary component is associated with MetS is a question that still needs to be clarified. However, some studies suggest that diet quality seems to play a more important role. Baxter et al. [5] in their study concluded that no individual dietary component could be considered wholly responsible for the association of diet with MetS. Rather it is the overall quality of the diet that appears to offer protection against lifestyle disease, such as MetS [5].

5. Metabolic syndrome and hypertension: therapeutic implications

The reduction of the high cardiometabolic risk in patients with MetS is one of the main goals of interventions performed in these patients. Simple actions such as lifestyle modification measures may oppose the effect of many risk factors (lack of physical activity, overweight/obesity, and atherogenic diet). In addition, hypertensive patients usually need stricter BP control, use of antihypertensive drugs that have little impact on the metabolic profile, and quite often while taking drugs for the treatment of many other metabolic risk factors (dyslipidemia, insulin resistance, pro-thrombotic and pro-inflammatory states).

Lifestyle modifications are certainly the first measure in reaching cardiometabolic risk reduction. The main lifestyle interventions are the promotion of physical activity and weight loss with a calorie-restricted diet [63]. Calorie restriction in the range of

500–1000 kcal/day with 7–10% weight loss in 12 months and regular aerobic exercise of 30–45 minutes daily are the minimal requirements for long-term effectiveness.

Although high caloric restriction diets have not shown long-term benefits in patients with MetS, more intense regular physical activity programs have proven to offer additional cardiovascular benefits and help maintain weight loss. Lifestyle modifications have also favorable effects on BP and lipid profile and decrease the incidence of new-onset diabetes [64]. Furthermore, more recent evidence also suggests a long-term effect on reduction in both cardiovascular morbidity and mortality [65].

Additional lifestyle modifications also have been pointed out to have a positive effect on specific cardiovascular risk factors and should be encouraged in specific patients. Reduction of salt intake and alcohol consumption has a moderate effect on BP lowering, which is improved in combination with weight loss and physical activity increase [66]. Moreover, a dietary pattern rich in vegetables, fruits, and low-fat dairy products (e.g., the dietary approaches to stop hypertension [DASH] diet) substantially lowers BP in comparison with the standard American diet [67]. The MD, which is equally rich in fruits, vegetables, fish, and olive oil, also has a favorable impact on dyslipidemia in patients with MetS [68].

Maintenance of lifestyle modifications needs counseling and, for many individuals, may find it difficult in the long term. For this reason, the gradual introduction of drugs for the treatment of BP, dyslipidemia, insulin resistance, and obesity may be required to lower their cardiometabolic risk [69].

The appropriate antihypertensive treatment in MetS has not yet been established [70]. However, the choice of an antihypertensive class should be made after taking into account possible effects on glucose and lipid metabolism, as well as specific adverse events or contraindications.

No comparative studies are available on the different antihypertensive drug classes in people with HTN and MetS. Taking into account the high risk of developing new-onset diabetes in these patients as a component of cardiometabolic risk, the choice of antihypertensive treatment should not ignore this additional risk. Some international guidelines recommend diuretics as the first-choice therapy for hypertensive patients, without a compelling indication for other antihypertensive classes. However, it has been reported that diuretics increase the risk of new-onset diabetes by 23% [71]. Conversely, calcium-channel blockers (CCBs) and, especially, renin-angiotensin system blockers (ARBs and ACE inhibitors) lower this risk (33% with ACE inhibitors and 43% with ARBs). These differences are probably even more accentuated in the specific subgroup of patients with MetS. Therefore, it looks like plausible that primary antihypertensive treatment in patients with HTN, MetS, and high cardiometabolic risk should focus on inhibition of the renin-angiotensin system with either ACE inhibitors or ARBs.

More evidence comes from comparative studies of antihypertensive drugs that included an important proportion of diabetic individuals, most of them with MetS. In this regard, the Appropriate Blood pressure Control in Diabetes (ABCD) study [72] compared antihypertensive treatment based on the ACE inhibitor enalapril or CCB nisoldipine in the subgroup of hypertensive patients with diabetes. The study was prematurely stopped due to the statistical differences in the number of myocardial infarctions that favored the enalapril group in comparison with nisoldipine.

Patients with HTN and MetS, especially those with type 2 diabetes, are often less responsive to the effects of antihypertensive drugs and may require drug combinations to achieve BP control. Although some studies have demonstrated the benefits of using diuretics in combination with ACE inhibitors [73] or ARBs [74] in patients

with diabetes, two comparative studies (Avoiding Cardiovascular Events through Combination Therapy in Patients Living with Systolic Hypertension [ACCOMPLISH] and Anglo Scandinavian Cardiac Outcome Trial [ASCOT]) suggest that combination of ARB with CCB could be a better option for HTN treatment in these patients.

The ASCOT study [75] compared antihypertensive treatment based on the CCB amlodipine with the addition of the ACE inhibitor perindopril in most patients against the beta-blocker atenolol with the addition of a thiazide diuretic, also in most patients. The study was prematurely stopped due to a consistent benefit of the ACE inhibitor plus CCB. More than 5,000 patients with diabetes were enrolled in ASCOT, and particular analysis of this cohort showed that the benefits of the combination of amlodipine and perindopril were also maintained in those patients with diabetes [76].

The ACCOMPLISH study [77] also compared two combinations of antihypertensive drugs in high-risk patients with HTN. Patients were treated with either the combination of the ACE inhibitor (benazepril) and CCB (amlodipine) or with benazepril plus hydrochlorothiazide. The percentage of diabetic patients in this study was around 60%. The main results showed a 20% reduction in the primary end-point (composite of death from cardiovascular causes, nonfatal stroke, nonfatal myocardial infarction, resuscitation after sudden cardiac arrest, hospitalization for angina, and coronary revascularization) in the group of patients treated with benazepril plus amlodipine. The subgroup analyses did not find differences in the results in patients with or without diabetes.

Evidence to support the preference for ACE inhibitors or ARBs in the treatment of patients with MetS is lacking. The ONgoing Telmisartan alone and in combination with Ramipril Global Endpoint Trial (ONTARGET) [78] compared the ARBs (telmisartan) with ACE inhibitors (ramipril) in patients at high risk of cardiovascular events and around 30% of them were diabetic. The study found no difference in rates of cardiovascular events between the groups.

Normotensive patients with MetS often have BP levels in the prehypertension range (systolic 130–139 mm Hg and/or diastolic 85–89 mm Hg). Particular dietary interventions, such as sodium restriction or intake reduction or the adoption of the DASH diet, in addition to calorie restriction and increase in physical activity, could be useful. For diabetic patients also receiving antihypertensive treatment, ARBs are able to prevent the development of microalbuminuria in normoalbuminuric patients [79] or overt proteinuria in those with microalbuminuria [80]. For the other patients, there is no evidence for antihypertensive treatment, except that the development of HTN is prevented [81].

6. The effect of dietary patterns on blood pressure control in hypertensive patients

The benefits of different dietary patterns in reducing BP were best evaluated with the DASH diet [82] and the Nordic diet [83]. Both of these dietary patterns highlight the importance of ingestion of different combinations of healthy foods for lowering BP. Otherwise, there are little data on which types of dietary patterns are effective in lowering BP in both normotensive and hypertensive adults.

The current evidence on the beneficial effect of dietary patterns on BP in adults has been evaluated in a recent meta-analysis study that included 17 randomized controlled trials. A statistically significant reduction in BP (4.26 mm Hg in SBP and 2.38 mm Hg in DBP, respectively) was observed in this meta-analysis. For the studies

that had no weight loss, sodium restrictions, or increased exercise, SBP and DBP were reduced by 4.25 and 2.27 mm Hg, respectively. A previous meta-analysis found a reduction in SBP and DBP by 6.74 and 3.59 mm Hg, respectively, from the DASH diet only [84]. The study also reported the many differences that existed between the populations that were included in the randomized controlled trials related to sex, age, intervention duration, study methodology, sample size, and difference in the combination of foods included within the different dietary patterns.

The current evidence supports that healthy dietary patterns are beneficial for BP and these include the DASH diet, MD, and Nordic diet [85]. The DASH diet mainly includes fruits, vegetables, low-fat dairy, legumes, whole grains, seeds, and low consumption of meat and saturated fat [86]. The DASH diet has been adopted in many places according to the cultural aspects such as in Australia [87], Brazil [88], and Iran [89]. Analysis of nutrient intakes and BP from the United States showed that reduced consumption of dairy products and fruit and vegetable juices was a major predictor of HTN [90]. Although the DASH diet shows positive effects from the randomized controlled trials, the studies are short-term in nature, and this may limit their generalizability as a long-term intervention.

The Nordic diet consists of foods of Nordic origin such as berries, fruits, whole grains, rapeseed oil, nuts, vegetables, fish, and low-fat dairy products. This diet when compared to a diet comprising the average nutrient intake in Nordic countries, significantly reduced 24-hour ambulatory DBP [83]. The effects of the diet, however, may not be attributed to increases in potassium or reductions in sodium because neither of these electrolytes differed between the control and intervention groups. One of the characteristics of the Nordic diet is its richness in berries.

Experimental studies models have demonstrated that the Nordic diet pattern has a beneficial effect on BP reduction [91], and in the same way, randomized controlled trials have shown that berries intake decreases BP levels [92]. Flavonoids, a type of polyphenols abundant in berries, can be the main contributing factor in the BP reduction seen with Nordic diets [93].

Further research, however, is needed on the effect of the Nordic diet on BP because studies addressing this issue are still scarce. Another dietary pattern, the MD, is usually rich in plant-based foods such as whole grains, vegetables, fruits, nuts, beans, and seeds [94]. This dietary pattern may include moderate amounts of dairy products, poultry, fish, and low amounts of red meat, although food composition may vary between different regions. In the Prevention con Dieta Mediterranean (PREDIMED) study that was carried out in Spain, the supplementation of the MD with extra virgin olive oil and with nuts lowered significantly the DBP in the MD group compared with a low-fat diet group [95]. Equally, analysis of ambulatory BP in 235 individuals of the PREDIMED study after 1 year showed significant reductions in ambulatory SBP by 4.0 and 4.3 mm Hg in the MD supplemented with extra virgin olive oil and nuts, respectively, and 1.9 mm Hg in DBP for both diets [96]. Similar effects were observed in studies of the MD carried out in Italy, where BP was also significantly lowered with this dietary pattern [97]. However, in studies from France [98] and the United States [99], no effect was found. In addition to possible differences in food and recipe composition, the study duration for these trials was less than 6 months. Because the effects of diet tend to occur over longer periods of time, a long-term follow-up may be needed to detect BP-lowering effects.

Research on the Tibetan diet that was carried out in Germany emphasized the consumption of cereals from barley, rice, corn, wheat, rye, oat, and buckwheat, and meat

such as beef, mutton, chicken, roast hare, and venison [100]. Compared with the regular Western diet, there was no significant difference in BP between the Tibetan and Western diets during 12 months follow-up trial. In this regard, studies lying on the Tibetan diet are scarce and additional research is needed before conclusions on its efficacy could be done.

7. Dietary strategies for metabolic syndrome

Although the most effective dietary pattern for the management of MetS has not been established, lifestyle interventions, especially dietary habits, remain the main therapeutic strategy for its management [101]. The improvement in the quality of the foods or switching macronutrient distribution, as one of the specific dietary intervention strategies, has shown beneficial effects on MetS and individual components. Compared to the low-fat and more restricted diets, the current evidence suggests the use of the DASH diet as a strategic intervention in MetS has raised the new paradigm for MetS prevention and treatment.

An isolated nutrient dietary intervention has several limitations, and dietary counseling must be focused on the overall dietary pattern as part of MetS treatment. Recent evidence suggests the implementation of a healthy food-based dietary strategy instead of calorie or single nutrient restriction diets [102, 103]. The dietary strategies and potential health benefits for MetS and different dietary approaches are summarized in **Table 1**.

Dietary pattern	Nutritional Distribution	Improvement in MetS criteria
DASH diet	• Total fats 27% kcal/d • Saturated fats 6% kcal/d • Dietary cholesterol • CH 55% kcal/d • Proteins 18% kcal/d	• Reduction of BP (systolic and diastolic) • Reduction in BMI and waist circumference • Improvement in cardiometabolic profile • Reduction in T2DM incidence
Mediterranean diet	• 35–45% kcal/d from total fat (mainly MUFA[1], EVOO and nuts being the principal source) • 35–45% kcal/d from CH • 15–18% kcal/d from protein	• Reduction of CVD incidence and outcomes • Decreased BP (systolic and diastolic) • Inverse association with mortality • Improvements in dyslipidemia • Decreased incidence of T2DM
Nordic diet	• High content of whole-grain high-fiber products • Low in meat and processed foods	• Reduction of BP (systolic and diastolic) • Increase in HDL-c levels
Plant-based diets	• Reduction or restriction of animal-derived foods • High intake of plant-source foods • Fat profile rich in UFAs	• Reduction of BP (systolic and diastolic) • Decreased body weight and risk of obesity • Reduction of the risk of CVD • Decreased all-cause mortality • Decreased risk of T2DM

Dietary pattern	Nutritional Distribution	Improvement in MetS criteria
Low CH diets and very low CH diets (ketogenic diets)	• <50% kcal/d from carbohydrates and <10% kcal/d from CH in ketogenic diets • High protein (20–30% kcal/d) • High fat intake (30–70% kcal/d)	• Weight-loss and weight-loss maintenance • Reduction of DBP • Reduction of LDL-c and triglycerides levels • Increase in HDL-c levels • Improvements in insulin resistance • Reduction of HbA1c levels
Low-fat diet	• <30% kcal/d from total fat (<10% of saturated fat) • 15–17% kcal/d from protein • 50–60% kcal/d from CH	• Reduction of BP (systolic and diastolic) • Short-term improvement of cholesterol profile • Short-term weight loss • Reduced risk of all-cause mortality
High protein diet	• High protein (20–30% kcal/d) or 1.34–1.50 g/Kg body weight/d from protein • Low CH (40–50% kcal/d)	• Reduction of triglycerides levels
Intermittent fasting	• Fasting for a long period of time	• Weight loss • Improvements in insulin resistance • Improvements in dyslipidemia • Reduction of BP (systolic and diastolic) • Decreased risk of T2DM • Decreased risk of CVD

EVOO, extra virgin olive oil; CH, carbohydrates; CVD, cardiovascular disease; BP, blood pressure; T2DM, type 2 diabetes mellitus; DASH, Dietary Approaches to Stop Hypertension; UFAs, unsaturated fatty acids; BMI, body mass index; DBP, diastolic blood pressure; LDL-c, low-density lipoprotein cholesterol; , HDL-c, high-density lipoprotein cholesterol; HbA1c, glycated hemoglobin; MUFA, monounsaturated fatty acids.
[1]*Adapted from [101]; doi: 10.3390/nu12102983.*

Table 1.
Dietary strategies and potential health benefits for MetS[1].

8. Conclusions

The protective effects of healthy dietary patterns on MetS seem to be due to the sum of small dietary changes rather than the restriction of any single nutrient. The consumption of dietary patterns characterized by high consumption of fruit, vegetables, whole grains, legumes, seeds, nuts, fish, and dairy and low consumption of meat, sweets, and alcohol resulted in significant reductions in blood pressure.

IntechOpen

IntechOpen

Author details

António Gerson Bastos Francisco, Isaura da Conceição Almeida Lopes,
Amílcar Bernardo Tomé da Silva and Henrique Cotchi Simbo Muela*
Department of Physiology of Faculty of Medicine, Agostinho Neto University,
Luanda, Angola

*Address all correspondence to: henrimuela@hotmail.com

IntechOpen

© 2022 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. (cc) BY

References

[1] Agodi A, Maugeri A, Kunzova S, Sochor O, Bauerova H, Kiacova N, et al. Association of dietary patterns with metabolic syndrome: results from the kardiovize brno 2030 study. Nutrients. 2018;**10**(7):898

[2] Farhangi MA, Jahangiry L, Asghari-Jafarabadi M, Najafi M. Association between dietary patterns and metabolic syndrome in a sample of Tehranian adults. Obesity Research and Clinical Practice. 2016;**10**(Suppl 1): S64-S73

[3] Aggarwal A, Aggarwal S, Sharma V. Cardiovascular risk factors in young patients of coronary artery disease: differences over a decade. Journal of Cardiovascular and Thoracic Research. 2014;**6**(3):169-173

[4] Wang J, Ruotsalainen S, Moilanen L, LepistöP,LaaksoM,KuusistoJ.Themetabolic syndrome predicts cardiovascular mortality: a 13-year follow-up study in elderly non-diabetic Finns. European Heart Journal. 2007;**28**(7):857-864

[5] Baxter AJ, Coyne T, McClintock C. Dietary patterns and metabolic syndrome - a review of epidemiologic evidence. Asia Pacific Journal of Clinical Nutrition. 2006;**15**(2):134-142

[6] Shab-Bidar S, Golzarand M, Hajimohammadi M, Mansouri S. A posteriori dietary patterns and metabolic syndrome in adults: a systematic review and meta-analysis of observational studies. Public Health Nutrition. 2018; **21**(9):1681-1692

[7] Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. American Journal of Clinical Nutrition. 2007;**85**(3):910-918

[8] Heidemann C, Scheidt-Nave C, Richter A, Mensink GBM. Dietary patterns are associated with cardiometabolic risk factors in a representative study population of German adults. British Journal of Nutrition. 2011;**106**(8):1253-1262

[9] Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet. 2005;**365**(9455):217-223

[10] Mayige M, Kagaruki G, Ramaiya K, Swai A. Non communicable diseases in Tanzania: a call for urgent action. Tanzania Journal of Health Research. 2011;**13**(5 Suppl 1):378-386

[11] Naghavi M, Forouzanfar MH. Burden of non-communicable diseases in sub-Saharan Africa in 1990 and 2010: Global Burden of Diseases, Injuries, and Risk Factors Study 2010. Lancet. 2013;**381**:95

[12] Bain LKM, Myint PK, Jennings A, Lentjes MAH, Luben RN, Khaw KT, et al. The relationship between dietary magnesium intake, stroke and its major risk factors, blood pressure and cholesterol, in the EPIC-Norfolk cohort. International Journal of Cardiology. 2015;**196**:108-114

[13] Dam V, Dalmeijer GW, Vermeer C, Drummen NE, Knapen MH, van der Schouw YT, et al. Association between vitamin K and the metabolic syndrome: a 10-year follow-up study in adults. Journal of Clinical Endocrinology and Metabolism. 2015;**100**(6):2472-2479

[14] Baudrand R, Campino C, Carvajal CA, Olivieri O, Guidi G,

Faccini G, et al. High sodium intake is associated with increased glucocorticoid production, insulin resistance and metabolic syndrome. Clinical Endocrinology. 2014;**80**(5):677-684

[15] McKeown NM, Meigs JB, Liu S, Saltzman E, Wilson PWF, Jacques PF. Carbohydrate nutrition, insulin resistance, and the prevalence of the metabolic syndrome in the Framingham offspring cohort. Diabetes Care. 2004;**27**(2):538-546

[16] Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Current Opinion in Lipidology. 2002;**13**(1):3-9

[17] Xu H, Li X, Adams H, Kubena K, Guo S. Etiology of metabolic syndrome and dietary intervention. International Journal of Molecular Sciences. 2019;**20**(1):128

[18] Saklayen MG. The global epidemic of the metabolic syndrome. Current Hypertension Reports. 2018;**20**(2):12

[19] Grundy SM. Metabolic syndrome pandemic. Arteriosclerosis, Thrombosis, and Vascular Biology. 2008;**28**(4):629-636

[20] Ford ES, Giles WH, Mokdad AH. Increasing prevalence of the metabolic syndrome among U.S. adults. Diabetes Care. 2004;**27**(10):2444-2449

[21] Ogden CL, Carroll MD, Fryar CD, Flegal KM. Prevalence of obesity among adults and youth. United States, 2011-2014. NCHS Data Brief. 2015;**219**:1-8

[22] Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, et al. Executive summary: Heart disease and stroke statistics-2016 update: A report from the American Heart Association. Circulation. 2016;**133**(4):447-454

[23] Lovre D, Mauvais-Jarvis F. Trends in prevalence of the metabolic syndrome. JAMA - Journal of the American Medical Association. 2015;**314**(9):950

[24] Akintunde AA, Ayodele OE, Akinwusi PO, Opadijo GO. Metabolic syndrome: comparison of occurrence using three definitions in hypertensive patients. Clinical Medicine and Research. 2011;**9**(1):26-31

[25] Fezeu L, Balkau B, Kengne AP, Sobngwi E, Mbanya JC. Metabolic syndrome in a sub-Saharan African setting: central obesity may be the key determinant. Atherosclerosis. 2007;**193**(1):70-76

[26] Can AS, Bersot TP. Analysis of agreement among definitions of metabolic syndrome in nondiabetic Turkish adults: a methodological study. BMC Public Health. 2007;**7**:353

[27] van den Hooven C, Ploemacher J, Godwin M. Metabolic syndrome in a family practice population: prevalence and clinical characteristics. Canadian Family Physician. 2006;**52**(8):982-983

[28] Clark LT, El-Atat F. Metabolic syndrome in African Americans: implications for preventing coronary heart disease. Clinical Cardiology. 2007;**30**(4):161-164

[29] Ramos RG, Olden K. The prevalence of metabolic syndrome among US women of childbearing age. American Journal of Public Health. 2008;**98**(6):1122-1127

[30] de Ferranti SD, Osganian SK. Epidemiology of paediatric metabolic syndrome and type 2 diabetes mellitus. Diabetes and Vascular Disease Research. 2007;**4**(4):285-296

[31] Chimonas T, Karagiannis A, Athyros VG, Achimastos A, Elisaf M,

Panagiotakos DB. Blood pressure levels constitute the most important determinant of the metabolic syndrome in a mediterranean population: a discrimination analysis. Metabolic Syndrome and Related Disorders. 2010;**8**(6):523-529

[32] Mancia G, Bombelli M, Corrao G, Facchetti R, Madotto F, Giannattasio C, et al. Metabolic syndrome in the Pressioni Arteriose Monitorate E Loro Associazioni (PAMELA) Study: Daily life blood pressure, cardiac damage, and prognosis. Hypertension. 2007;**49**(1):40-47

[33] Schillaci G, Pirro M, Vaudo G, Gemelli F, Marchesi S, Porcellati C, et al. Prognostic value of the metabolic syndrome in essential hypertension. Journal of the American College of Cardiology. 2004;**43**(10):1817-1822

[34] Pannier B, Thomas F, Bean K, Jégo B, Benetos A, Guize L. The metabolic syndrome: Similar deleterious impact on all-cause mortality in hypertensive and normotensive subjects. Journal of Hypertension. 2008;**26**(6):1223-1228

[35] Cuspidi C, Facchetti R, Bombelli M, Sala C, Tadic M, Grassi G, et al. Risk of new-onsetmetabolic syndrome associated with white-coat and masked hypertension: data froma general population. Journal of Hypertension. 2018;**36**(9):1833-1839

[36] Tadewos A, Egeno T, Amsalu A. Risk factors of metabolic syndrome among hypertensive patients at Hawassa University comprehensive specialized hospital, Southern Ethiopia. BMC Cardiovascular Disorders. 2017;**17**(1):218

[37] Katsiki N, Athyros V, Karagiannis A, Mikhailidis D. Metabolic syndrome and non-cardiac vascular diseases: an update from human studies. Current Pharmaceutical Design. 2014;**20**(31):4944-4952

[38] Rochlani Y, Pothineni NV, Kovelamudi S, Mehta JL. Metabolic syndrome: pathophysiology, management, and modulation by natural compounds. Therapeutic Advances in Cardiovascular Disease. 2017;**11**(8):215-225

[39] Lembo G, Napoli R, Capaldo B, Rendina V, Iaccarino G, Volpe M, et al. Abnormal sympathetic overactivity evoked by insulin in the skeletal muscle of patients with essential hypertension. Journal of Clinical Investigation. 1992;**90**(1):24-29

[40] ter Maaten JC, Voorburg A, Heine RJ, ter Wee PM, Donker AJM, Gans ROB. Renal handling of urate and sodium during acute physiological hyperinsulinaemia in healthy subjects. Clinical Science. 1997;**92**(1):51-58

[41] Vierhapper H. Effect of exogenous insulin on blood pressure regulation in healthy and diabetic subjects. Hypertension. 1985;**7**(6 Pt 2):II49-II53

[42] Hall JE. Mechanisms of abnormal renal sodium handling in obesity hypertension. American Journal of Hypertension. 1997;**10**(5 Pt 2):49S-55S

[43] Reaven GM. Role of insulin resistance in human disease. Diabetes. 1988;**37**(12):1595-1607

[44] Modan M, Halkin H, Almog S, Lusky A, Eshkol A, Shefi M, et al. Hyperinsulinemia. A link between hypertension obesity and glucose intolerance. Journal of Clinical Investigation. 1985;**75**(3):809-817

[45] Muscelli EO, Saad MJ, Gontijo JA. Insulin resistance in essential hypertension. Brazilian journal of medical and biological research. 1990;**23**(12):1253-1257

[46] McGill JB, Haffner S, Rees TJ, Sowers JR, Tershakovec AM, Weber M. Progress and controversies: treating obesity and insulin resistance in the context of hypertension. Journal of Clinical Hypertension. 2009;**11**(1):36-41

[47] Ogihara T, Rakugi H, Ikegami H, Mikami H, Masuo K. Enhancement of insulin sensitivity by troglitazone lowers blood pressure in diabetic hypertensives. American Journal of Hypertension. 1995;**8**(3):316-320

[48] Sanchez RA, Masnatta LD, Pesiney C, Fischer P, Ramirez AJ. Telmisartan improves insulin resistance in high renin nonmodulating salt-sensitive hypertensives. Journal of Hypertension. 2008;**26**(12):2393-2398

[49] Umeda M, Kanda T, Murakami M. Effects of angiotensin II receptor antagonists on insulin resistance syndrome and leptin in sucrose-fed spontaneously hypertensive rats. Hypertension Research. 2003;**26**(6):485-492

[50] Hall JE, Summers RL, Brands MW, Keen H, Alonso-Galicia M. Resistance to metabolic actions of insulin and its role in hypertension. American Journal of Hypertension. 1994;**7**(8):772-788

[51] Carlyle M, Jones OB, Kuo JJ, Hall JE. Chronic cardiovascular and renal actions of leptin. Hypertension. 2002;**39**(2 Pt 2):496-501

[52] Eikelis N, Schlaich M, Aggarwal A, Kaye D, Esler M. Interactions between leptin and the human sympathetic nervous system. Hypertension. 2003;**41**(5):1072-1079

[53] Marsh AJ, Fontes MAP, Killinger S, Pawlak DB, Polson JW, Dampney RAL. Cardiovascular responses evoked by leptin acting on neurons in the ventromedial and dorsomedial hypothalamus. Hypertension. 2003;**42**(4):488-493

[54] Sierra-Honigmann MR, Nath AK,Murakami C, García-Cardeña G, Papapetropoulos A, Sessa WC, et al. Biological action of leptin as an angiogenic factor. Science. 1998;**281**(5383):1683-1646

[55] Winters B, Mo Z, Brooks-Asplund E, Kim S, Shoukas A, Li D, et al. Reduction of obesity, as induced by leptin, reverses endothelial dysfunction in obese (Lep(ob)) mice. Journal of Applied Physiology. 2000;**89**(6):2382-2390

[56] Shirasaka T, Takasaki M, Kannan H. Cardiovascular effects of leptin and orexins. American Journal of Physiology - Regulatory Integrative and Comparative Physiology. 2003;**284**(3):R639-R651

[57] Considine RV, Sinha MK, Heiman ML, Kriauciunas A, Stephens TW, Nyce MR, et al. Serum immunoreactive-leptin concentrations in normal-weight and obese humans. New England Journal of Medicine. 1996;**334**(5):292-295

[58] Alvarez GE, Beske SD, Ballard TP, Davy KP. Sympathetic neural activation in visceral obesity. Circulation. 2002;**106**(20):2533-2536

[59] Khamis AG, Mwanri AW, Senkoro M, Kreppel K, Bonfoh B, Mfinanga SG, et al. Dietary patterns, nutrient intakes and metabolic conditions among agro-pastoralists in Monduli District, Tanzania. Nutrition and Dietary Supplements. 2022;**14**:11-20

[60] Williams DEM, Prevost AT, Whichelow MJ, Cox BD, Day NE, Wareham NJ. A cross-sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. British Journal of Nutrition. 2000;**83**(3):257-266

[61] Wirfält E, Hedblad B, Gullberg B, Mattisson I, Andrén C, Rosander U, et al. Food patterns and components of the metabolic syndrome in men and women: a cross-sectional study within the Malmö diet and cancer cohort. American Journal of Epidemiology. 2001;**154**(12):1150-1159

[62] Pereira MA, Jacobs DR, van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults: the CARDIA study. Journal of the American Medical Association. 2002;**287**(16):2081-2089

[63] Klein S, Burke LE, Bray GA, Blair S, Allison DB, Pi-Sunyer X, et al. Clinical implications of obesity with specific focus on cardiovascular disease: a statement for professionals from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2004;**110**(18):2952-2967

[64] Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction of the incidence of type 2 diabetes with lifestyle intervention or metformin. New England Journal of Medicine. 2022;**346**(6):393-403

[65] Cook NR, Cutler JA, Obarzanek E, Buring JE, Rexrode KM, Kumanyika SK, et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). British Medical Journal. 2007;**334**(7599):885-888

[66] Nan X, Lu H, Wu J, Xue M, Qian Y, Wang W, et al. The interactive association between sodium intake, alcohol consumption and hypertension among elderly in northern China: A cross-sectional study. BMC Geriatrics. 2021;**21**(1):135

[67] Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) Diet. New England Journal of Medicine. 2001;**344**(1):3-10

[68] Knoops KTB, de Groot LCPGM, Kromhout D, Perrin AE, Moreiras-Varela O, Menotti A, et al. Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: the HALE project. Journal of the American Medical Association. 2004;**292**(12):1433-1439

[69] de la Sierra A, Ruilope LM. Management of cardiovascular risk factors in patients with metabolic syndrome. Cardiovascular & Hematological Agents in Medicinal Chemistry. 2007;**5**(3):209-214

[70] Katsimardou A, Imprialos K, Stavropoulos K, Sachinidis A, Doumas M, Athyros V. Hypertension in metabolic syndrome: novel insights. Current Hypertension Reviews. 2019;**16**(1):12-18

[71] Elliott WJ, Meyer PM. Incident diabetes in clinical trials of antihypertensive drugs: a network meta-analysis. Lancet. 2007;**369**(9557):201-207

[72] Estacio RO, Jeffers BW, Hiatt WR, Biggerstaff SL, Gifford N, Schrier RW. The Effect of Nisoldipine as compared with Enalapril on cardiovascular outcomes in patients with non-insulin-dependent diabetes and hypertension. New England Journal of Medicine. 1998;**338**(10):645-652

[73] Patel A, ADVANCE Collaborative Group, MacMahon S, Chajmers J,

Neal B, Woodwars M, et al. Effects of a fixed combination of perindopril and indapamide on macrovascular and microvascular outcomes in patients with type 2 diabetes mellitus (the ADVANCE trial): A randomised controlled trial. Lancet. 2007;**370**(9590):829-840

[74] Lindholm LH, Ibsen H, Dahlöf B, Devereux RB, Beevers G, de Faire U, et al. Cardiovascular morbidity and mortality in patients with diabetes in the Losartan Intervention For Endpoint reduction in hypertension study (LIFE): a randomised trial against atenolol. Lancet. 2002;**359**(9311):1004-1010

[75] Dahlöf B, Sever PS, Poulter NR, Wedel H, Beevers DG, Caulfield M, et al. Prevention of cardiovascular events with an antihypertensive regimen of amlodipine adding perindopril as required versus atenolol adding bendroflumethiazide as required, in the Anglo-Scandinavian Cardiac Outcomes Trial-Blood Pressure Lowering Arm (ASCOT-BPLA): a multicentre randomised controlled trial. Lancet. 2005;**366**(9489):895-906

[76] Östergren J, Poulter NR, Sever PS, Dahlöf B, Wedel H, Beevers G, et al. The Anglo-Scandinavian Cardiac Outcomes Trial: blood pressure-lowering limb: effects in patients with type II diabetes. Journal of Hypertension. 2008;**26**(11):2103-2111

[77] Jamerson K, Weber MA, Bakris GL, Dahlöf B, Pitt B, Shi V, et al. Benazepril plus amlodipine or hydrochlorothiazide for hypertension in high-risk patients. New England Journal of Medicine. 2008;**359**(23):2417-2428

[78] Baptiste PJ, Wong AYS, Schultze A, Cunnington M, Mann JFE, Clase C, et al. Effects of ACE inhibitors and angiotensin receptor blockers: protocol for a UK cohort study using routinely collected electronic health records with validation against the ONTARGET trial. BMJ Open. 2022;**12**(3):e051907

[79] Remuzzi G, Macia M, Ruggenenti P. Prevention and treatment of diabetic renal disease in type 2 diabetes: the BENEDICT study. Journal of the American Society of Nephrology. 2006;**17**(4 Suppl 2):S90-S97

[80] Parving HH, Lehnert H, Bröchner-Mortensen J, Gomis R, Andersen S, Arner P. The effect of Irbesartan on the development of diabetic nephropathy in patients with type 2 diabetes. New England Journal of Medicine. 2001;**345**(12):870-880

[81] Julius S, Nesbitt SD, Egan BM, Weber MA, Michelson EL, Kaciroti N, et al. Feasibility of treating prehypertension with an angiotensin-receptor blocker. New England Journal of Medicine. 2006;**354**(16):1685-1697

[82] Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. New England Journal of Medicine. 1997;**336**(16):1117-1124

[83] Uusitupa M, Hermansen K, Savolainen MJ, Schwab U, Kolehmainen M, Brader L, et al. Effects of an isocaloric healthy Nordic diet on insulin sensitivity, lipid profile and inflammation markers in metabolic syndrome - a randomized study (SYSDIET). Journal of Internal Medicine. 2013;**274**(1):52-66

[84] Saneei P, Salehi-Abargouei A, Esmaillzadeh A, Azadbakht L. Influence of Dietary Approaches to Stop Hypertension (DASH) diet on blood pressure: a systematic review and meta-analysis on randomized controlled trials.

Nutrition, Metabolism and Cardiovascular Diseases. 2014;**24**(12):1253-1261

[85] Ndanuko RN, Tapsell LC, Charlton KE, Neale EP, Batterham MJ. Dietary patterns and blood pressure in adults: a systematic review and meta-analysis of randomized controlled trials. Advances. Nutrition. 2016;**7**(1):76-89

[86] Moore TJ, Vollmer WM, Appel LJ, Sacks FM, Svetkey LP, Vogt TM, et al. Effect of dietary patterns on ambulatory blood pressure: results from the dietary approaches to Stop Hypertension (DASH) Trial. Hypertension. 1999;**34**(3):472-477

[87] Nowson CA, Wattanapenpaiboon N, Pachett A. Low-sodium dietary approaches to stop hypertension-type diet including lean red meat lowers blood pressure in postmenopausal women. Nutrition Research. 2009;**29**(1):8-18

[88] Lima STRM, de Souza BDSN, França AKT, Salgado Filho N, Sichieri R. Dietary approach to hypertension based on low glycaemic index and principles of DASH (Dietary Approaches to Stop Hypertension): a randomised trial in a primary care service. British Journal of Nutrition. 2013;**110**(8):1472-1279

[89] Azadbakht L, Fard NRP, Karimi M, Baghaei MH, Surkan PJ, Rahimi M, et al. Effects of the Dietary Approaches to Stop Hypertension (DASH) eating plan on cardiovascular risks among type 2 diabetic patients: a randomized crossover clinical trial. Diabetes Care. 2011;**34**(1):55-57

[90] McCarron DA, Morris CD, Henry HJ, Stanton JL. Blood pressure and nutrient intake in the United States. Science. 1984;**224**(4656):1392-1398

[91] Mykkänen OT, Huotari A, Herzig KH, Dunlop TW, Mykkänen H, Kirjavainen PV. Wild blueberries (vaccinium myrtillus) alleviate inflammation and hypertension associated with developing obesity in mice fed with a high-fat diet. PLoS ONE. 2014;**9**(12):e114790

[92] Basu A, Du M, Leyva MJ, Sanchez K, Betts NM, Wu M, et al. Blueberries decrease cardiovascular risk factors in obese men and women with metabolic syndrome. Journal of Nutrition. 2010;**140**(9):1582-1587

[93] Wightman JD, Heuberger RA. Effect of grape and other berries on cardiovascular health. Journal of the Science of Food and Agriculture. 2015;**95**(8):1584-1597

[94] Serra-Majem L, Roman B, Estruch R. Scientific evidence of interventions using the Mediterranean diet: a systematic review. Nutrition Reviews. 2006;**64** (2 Pt 2):S27-S47

[95] Toledo E, Hu FB, Estruch R, Buil-Cosiales P, Corella D, Salas-Salvadó J, et al. Effect of the Mediterranean diet on blood pressure in the PREDIMED trial: results from a randomized controlled trial. BMC Medicine. 2013;**11**(1):207

[96] Doménech M, Roman P, Lapetra J, García De La Corte FJ, Sala-Vila A, de La Torre R, et al. Mediterranean diet reduces 24-hour ambulatory blood pressure, blood glucose, and lipids: one-year randomized, clinical trial. Hypertension. 2014;**64**(1):69-76

[97] Esposito K, Marfella R, Ciotola M, di Palo C, Giugliano F, Giugliano G, et al. Effect of a Mediterranean-style diet on endothelial dysfunction and markers of vascular inflammation in the metabolic syndrome: a randomized trial. Journal of the American Medical Association. 2004;**292**(12):1440-1446

[98] Vincent-Baudry S, Defoort C, Gerber M, Bernard MC, Verger P, Helal O, et al. The Medi-RIVAGE study: reduction of cardiovascular disease risk factors after a 3-mo intervention with a Mediterranean-type diet or a low-fat diet. American Journal of Clinical Nutrition. 2005;**82**(5):964-971

[99] Toobert DJ, Glasgow RE, Strycker LA, Barrera M, Radcliffe JL, Wander RC, et al. Biologic and quality-of-life outcomes from the Mediterranean Lifestyle Program: a randomized clinical trial. Diabetes Care. 2003;**26**(8):2288-2293

[100] von Haehling S, Stellos K, Qusar N, Gawaz M, Bigalke B. Weight reduction in patients with coronary artery disease: comparison of traditional Tibetan medicine and Western diet. International Journal of Cardiology. 2013;**168**(2):1509-1515

[101] Castro-Barquero S, Ruiz-León AM, Sierra-Pérez M, Estruch R, Casas R. Dietary strategies for metabolic syndrome: a comprehensive review. Nutrients. 2020;**12**(10):2983

[102] Mozaffarian D. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity. Circulation. 2016;**133**(2):187-225

[103] Tresserra-Rimbau A, Castro-Barquero S, Vitelli-Storelli F, Becerra-Tomas N, Vázquez-Ruiz Z, Díaz-López A, et al. Associations between dietary polyphenols and type 2 diabetes in a cross-sectional analysis of the PREDIMED-Plus trial: role of body mass index and sex. Antioxidants (Basel). 2019;**8**(11):537