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Diet and Hypertension

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For years, a sodium-restricted diet was one of the cornerstones of hypertension therapy and little attention was given to the role other nutrients might play in the management of blood pressure. Today, evidence from laboratory investigations, clinical trials, and epidemiologic studies demonstrates that foods providing nutrients such as polyphenols, vitamins, minerals, and other compounds may be beneficial in the management of hypertension. In addition, there's growing interest in the potential of dietary patterns to promote healthy blood pressure.

This continuing education course explores foods and dietary patterns that may be beneficial for controlling hypertension and discusses the mechanisms by which diet may affect blood pressure.

Historical Dietary Approaches to Managing Hypertension

Interest in the dietary management of hypertension began in the 1920s, when two physicians named Allen and Sherill suggested that a low-salt diet might be beneficial for controlling blood pressure.[1] In 1939, Walter Kempner, a physician at Duke University, introduced the Rice Diet (consisting only of rice, fruit, and juices, with a 150 mg/day sodium restriction), which proved to be highly effective in treating hypertension.[1] Two large prospective cohort studies conducted during the 1970s and 1980s, the Multiple Risk Factor and Intervention Trial and the international INTERSALT Study, demonstrated significant correlations between population sodium intake and the risk of hypertension.[2] In the 1990s, the Dietary Approaches to Stop Hypertension (DASH) study found that a diet high in fruits and vegetables and low in total and saturated fat was beneficial in lowering blood pressure in people with both normal and elevated blood pressure (EBP).[3]

Foods Beneficial for Blood Pressure

Some foods seem to independently lower blood pressure and decrease the risk of hypertension. The following is a summary of some of these foods and their possible mechanisms for affecting blood pressure.

Beets

The association between fruit and vegetable intake and reduced blood pressure has been noted in large observational studies and often has been attributed to the vitamin, mineral, and phytochemical content of these foods.[4] In recent years, however, attention also has turned to other potentially antihypertensive components of fruits and vegetables, particularly nitrate, an inorganic nitrogen compound.[4]

About 80% of dietary nitrate is provided by vegetables, which vary widely in their nitrate content.[5] The highest concentrations (> 250 mg/100 g fresh weight) are found in beets, collard greens, chervil, cress, lettuce, arugula, and spinach. Asparagus, peppers, green beans, peas, and onions are among the vegetables providing the lowest amounts (< 20 mg/100 g fresh weight).[5]

Beetroot juice is a highly concentrated source of nitrate, providing more than 10 times the amount of nitrate found in other vegetable juices (approximately 27 mg/L).[4,5] The effect of beetroot juice on blood pressure has been evaluated in numerous studies. A meta-analysis of 16 randomized clinical trials conducted between 2006 and 2012 among 254 subjects found that daily consumption of beetroot juice containing 5 mmol to 45 mmol (321 mg to 2,790 mg per 140 mL to 500 mL) of nitrate resulted in a significant decrease in systolic blood pressure (-4.4 mm Hg) compared with nitrate-free placebo beverages.6 No significant effect was seen for diastolic blood pressure, which decreased by 1.1 mm Hg.[6]

In addition, a British clinical trial conducted among 23 healthy subjects demonstrated that daily ingestion of 200 g of bread supplemented with 100 g of beetroot resulted in a significant reduction in mean diastolic blood pressure, but had no significant effect on systolic blood pressure.[7]

The favorable effect of dietary nitrate on blood pressure is believed to be due to its role in the formation of nitric oxide, a powerful vasodilator that helps to regulate endothelial function.[4] Reduced levels of nitric oxide in the body have been linked with impaired vascular health and the development of hypertension, and hypoxia in endothelial tissue is known to increase nitric oxide production.[4] Bacteria on the tongue extract nitrate from foods as they're consumed. Nitrite is then absorbed in the gastrointestinal tract and enters the circulation, where it's converted to nitric oxide.[5] Nitric oxide also is generated from arginine, nicotinamide adenine dinucleotide phosphate (NADPH), and oxygen through the action of nitric oxide synthase enzymes.[4]

To date, few studies have explored the effects of other nitrate-rich vegetables on blood pressure or determined a dose response for dietary nitrate and blood pressure reduction.

Cocoa

Cocoa is touted for its protective role in cardiovascular health.

A meta-analysis published in 2010 reviewed findings from 15 small clinical trials (n=11 to 45) investigating cocoa consumption and blood pressure.[8] The trials were conducted among normotensive and hypertensive subjects aged 18 to 69 for periods of two to 18 weeks. Subjects consumed daily doses of 6 g to 100 g of dark chocolate (50% to 70% cocoa) or high-flavanol cocoa products providing 30 mg to 1,000 mg flavanols, while controls consumed white chocolate, cocoa-free products, or low-flavanol products containing approximately 6 mg to 40 mg flavanols.8 Compared with controls, subjects who consumed dark chocolate and high-flavanol cocoa products significantly reduced mean systolic blood pressure (-3.2 mm Hg) and mean diastolic blood pressure (-2.0 mm Hg).[8] The effect was greatest for hypertensive subjects, who experienced significant drops in both systolic and diastolic blood pressure (-5.0 mm Hg and -2.7 mm Hg, respectively).[8] Among normotensive subjects, there were small but nonsignificant reductions in systolic and diastolic blood pressure (-1.6 mm Hg and -1.3 mm Hg,

respectively).[8] The authors didn't find evidence for effects of serving size or duration of cocoa consumption in their review.[8]

Cocoa contains large amounts of flavonoids, which possess antioxidant and anti-inflammatory properties and are believed to promote cardiovascular health.[9] The positive effect of cocoa on blood pressure has been attributed to the action of the flavanols catechin and epicatechin, which promote vasodilation through increased nitric oxide production and slow the action of angiotensin-converting enzyme (ACE), a vasoconstrictor that increases blood pressure.[9] Studies have shown that consumption of cocoa beverages containing 176 mg to 185 mg of flavanols can increase circulating nitric oxide levels by 30% or more, and that the activity of ACE may be reduced by 18% after consuming 75 g of dark chocolate.[9]

Nuts

Data from prospective studies have been mixed in demonstrating a link between nut consumption and reduced blood pressure. A study conducted in a large cohort of men (n=15,966) enrolled in the Physicians' Health Study demonstrated a significantly lower incidence of high blood pressure among lean subjects in the highest categories of nut consumption; however, this study didn't control for salt intake or changes in weight during the study.[10] In contrast, the SUN project, a prospective study conducted in Spain among 9,900 graduate students, failed to find any association between nut consumption and blood pressure.[10]

An analysis of 19 clinical trials investigating nut consumption and blood pressure published in 2011 also yielded mixed findings. Most of these studies failed to find any association; however, four studies demonstrated significant reductions in blood pressure among subjects classified as "high risk of CHD [coronary heart disease]" who consumed nuts daily.[10] In three of the four studies, a supplement of 30 g of mixed nuts (walnuts, almonds, and hazelnuts) was added to a Mediterranean-type diet, resulting in significant decreases in systolic and/or diastolic blood pressure.[10] In the fourth study, a significant decline in systolic blood pressure was seen among subjects who consumed 84 g of almonds in addition to a low-calorie diet.[10] The hypotensive effect was greater for systolic blood pressure (p values=0.0001 to 0.03) than diastolic blood pressure (p=0.001 to 0.03, not significant for one study).[10]

The effect of nut consumption on blood pressure may be mediated by biomarkers associated with hypertension. Significant reductions in circulating levels of intercellular adhesion molecules (ICAM), an inflammatory biomarker and measure of endothelial dysfunction, were observed among subjects in four clinical trials who consumed 30 g to 60 g of nuts (walnuts, hazelnuts, or mixed nuts) daily.[10] In addition, significant improvements in arterial vasodilation (measured by ultrasound of the forearm) were noted in subjects consuming 40 g to 65 g of walnuts or 60 g to 100 g of pistachios daily.[10]

Nuts contain a variety of nutrients that may help foster healthy blood pressure. Their high concentrations of mono- and polyunsaturated fatty acids may block the action of thromboxane 2, which stimulates platelet accumulation and vasoconstriction.[10] Nuts also contain large amounts of magnesium and potassium, which promote vasodilation and help regulate the effects of the renin-angiotensin system.[10]

Dairy Foods

Although cross-sectional and prospective studies have suggested that dairy foods may protect against hypertension, uncertainty exists about whether the effect is due to dairy consumption itself or to nutrients found in dairy foods, such as calcium. In addition, controversy exists about the effect of low-fat vs high-fat dairy foods on blood pressure.

A meta-analysis published in 2012 reviewed findings from five cohort studies examining dairy food consumption and elevated blood pressure among 45,000 subjects.[11] Subjects consuming the greatest amounts of total dairy foods (> 3.4 servings per day) had a 13% lower risk of elevated blood pressure, compared with subjects consuming the lowest amounts (< 0.9 servings per day).[11] The effect was greatest for low-fat dairy foods, with a 16% reduction in risk seen among those consuming more than two servings of low-fat dairy foods daily, compared with subjects consuming < 0.2 servings per day.[11] An interesting finding of this review was that intake of fluid dairy foods (low-fat and full-fat milk and yogurt) was associated with an 8% reduction in risk of elevated blood pressure, whereas cheese consumption provided no protective effect.[11] The authors theorize that the higher sodium and saturated fat in cheese may "undo" the beneficial effect of dairy foods.

Because studies have shown that dairy foods are more effective than calcium supplements in lowering blood pressure, the beneficial influence of dairy foods seems to be due to a dietary factor other than calcium.[11] One possible mechanism may involve the production of bioactive peptides known as lactotripeptides by gut bacteria during the digestion of dairy products.[11] These peptides are released into the circulation, where they produce vasodilative effects by blocking the action of ACE.[11]

Probiotic bacteria in dairy foods also may have a positive effect on blood pressure. Studies have shown that fermented milk containing Lactobacillus helveticus significantly reduced systolic or diastolic blood pressure in subjects with hypertension or elevated blood pressure.[12]

Flaxseed

Until recently, evidence supporting an antihypertensive effect for flaxseed came primarily from animal studies. However, findings from a randomized double-blind clinical trial published in 2013 showed that supplementation with flaxseed significantly reduced blood pressure in subjects with peripheral artery disease.[13] A total of 110 patients, 75% of whom had hypertension, participated in the six-month study.[13] The 58 participants assigned to the supplemented group received 30 g of flaxseed per day added to muffins, bagels, biscuits, or pasta, whereas the 52 subjects in the placebo group were given similar products in which flaxseed was replaced with milled wheat.[13] At six months there were significant reductions in both diastolic and systolic blood pressure (-7 mm Hg and -10 mm Hg, respectively) among subjects consuming the products with flaxseed, compared with subjects consuming the placebo.13 In addition, subjects with hypertension (defined as systolic blood pressure > 140 mm Hg) who consumed the flaxseed-enriched foods experienced a significant drop in systolic blood pressure of 15 mm Hg, comparable to the reduction resulting from use of antihypertensive medication.[13]

Several nutrients in flaxseed may be responsible for its antihypertensive effects. Flaxseed is high in fiber (28% of total weight); the antihypertensive effect of dietary fiber has been documented in many studies.[13] Flaxseed is an important source of the omega-3 fatty acid

alpha-linolenic acid (ALA). ALA slows the activity of soluble epoxide hydrolase, an enzyme that produces oxylipins, oxidized fatty acids known to cause vasoconstriction. ALA also may reduce circulating levels of the proinflammatory cytokines interleukin-1 and tumor necrosis factor, which are associated with hypertension.[14] Moreover, flaxseed contains large amounts of the lignans secoisolariciresinol diglucide and secoisolaricresinol, which slow the action of the hormone angiotensin when metabolized.[14] Arginine-rich peptides in flaxseed promote nitric oxide production.[14]

Sesame Oil

Sesame oil is used in cooking and as a flavor enhancer. It's high in polyunsaturated fat (about 42%), most of which is linoleic acid, and is a good source of gamma-tocopherol.[15]

A clinical trial conducted at an outpatient clinic at Alexandria Hospital in Athens, Greece, and published in 2013, explored the effect of sesame oil consumption on endothelial function and inflammatory biomarkers in 30 hypertensive men.[16]

The study was conducted in two phases. During the first ("acute") phase, subjects consumed a meal of vegetable soup prepared with 35 g of sesame oil or 35 g of a "control" oil (either olive or corn).[16] Endothelial function, estimated from arterial dilatation, was measured by ultrasound before and after the soup was consumed.[16] During the second ("chronic") phase, one-half of the participants were asked to use 35 g of sesame oil as a salad dressing for the following two months, whereas one-half were instructed to use their typical oil (usually olive or corn) for the same time period.[16] Ultrasound measurement of endothelial function was performed before beginning the regimen, and three times during the 60-day period.[16]

During both study phases, there were significant improvements in endothelial function among subjects consuming the sesame oil, compared with those using the control oil. There were significant improvements in endothelial function among subjects consuming the sesame oil during both the acute phase ($p=0.001$) and the chronic phase ($p=0.015$ at 15 days, $p=0.005$ at 30 days, $p=0.011$ at 60 days). In addition, blood levels of ICAM were significantly lower in the group using sesame oil, but only during the chronic phase ($p=0.014$).[16]

The authors theorize that the beneficial effect of sesame oil on endothelial function is due to the presence of two antioxidants, sesamin and sesamol, which appear to stimulate nitric oxide production, resulting in vasodilation and decreased ICAM activity.[16]

Tea

Studies throughout the past decade have explored the effects of different types of tea on blood pressure.

Tea is produced from the leaves and buds of the Camellia sinensis plant, and is categorized as one of the following types: fully fermented black tea, semifermented oolong and white teas, and unfermented green tea.[17] Different types of tea contain varying levels of polyphenols that may offer protection against hypertension. In addition, Hibiscus tea, produced from the Hibiscus sabdariffa (HS) plant, is used in many Asian and African cultures as a treatment for high blood pressure.[18] The polyphenol content of all teas may vary with growing conditions, season, and degree of processing.[17]

A meta-analysis published in 2014 reported findings from 11 randomized clinical trials examining black tea consumption and blood pressure.[19] A total of 378 normotensive and

hypertensive adult subjects consumed 400 mL to 1,800 mL of brewed tea daily for a duration of one week to six months.19 Small but significant changes in both systolic and diastolic blood pressure were observed (-1.8 mm Hg and -1.3 mm Hg, respectively).[19]

Black tea is a major source of two types of flavonoids, theaflavins and thearubigins, which result from the oxidation of catechins during fermentation.[17] These seem to increase vasodilation and lower blood pressure by enhancing nitric oxide production.[19] The flavonoid content of the tea consumed in the 11 clinical trials varied from 240 mL to 1,500 mL per day, suggesting that a dose-response effect was absent.19 In addition, blood pressure wasn't affected by the duration of the studies.[19]

Green tea also may have a beneficial effect on blood pressure, through the action of four flavanols: epicatechin, epicatechin-3-gallate, epigallocatechin, and epigallocatechin-3-gallate (EGCG).[20] The most potent of these is EGCG, which blocks the activity of ACE and decreases levels of reactive oxygen molecules in the vascular system through the inhibition of NADPH oxidase.[20] In addition to EGCG, green tea contains gamma-aminobutyric acid, which affects neurotransmitters involved in blood pressure regulation.[20]

A meta-analysis of 20 randomized clinical trials among 1,536 normotensive and hypotensive subjects showed that consumption of green tea extracts significantly reduced systolic blood pressure (-1.94 mm Hg).[20] The maximum response was observed for consumption of extracts containing 200 mg of EGCG (about 5 to 6 cups of tea daily) for a minimum of 12 weeks.[20] No significant effect was seen for diastolic blood pressure.[20]

Extracts from the flowers of HS are used to prepare medicinal teas for treatment of hypertension and hyperlipidemia.[18] The plant contains a variety of phytochemicals responsible for its pharmacologic effects, most notably anthocyanins and catechins.[18]

A review of several randomized clinical trials conducted between 1999 and 2010 found that consumption for a minimum of four weeks of tea prepared from the flowers of HS significantly reduced both diastolic and systolic blood pressure in hypertensive subjects.[18] The prepared teas contained approximately 2 g of HS extract per 240 mL of water, and were consumed one to three times daily.[18] The hypotensive agents in HS are believed to be the anthocyanins delphinidin-3-sambubioside and cyanidin-3-sambubioside.[18] Their effects include increased vasodilation, inhibition of ACE activity, stimulation of blood vessel production, decreased blood viscosity, and slowing of signaling pathways involved in vasoconstriction.[18]

When compared with the action of ACE-inhibitor drugs, HS was found to be more effective than Captopril but less effective than Lisinopril in lowering blood pressure.[18] Although the toxicity of HS is believed to be low, doses of 300 mg/kg/d for three months led to elevated liver enzymes and increased blood uric acid levels in animal studies. The diuretic effect of HS may intensify the effects of the diuretic drug hydrochlorothiazide, leading to disturbances in electrolyte balance.[7] In addition, because HS may increase the elimination of acetaminophen, this medication should be taken three to four hours before drinking tea prepared from HS.[18]

Both oolong and white teas contain polyphenols; however, their effects on blood pressure haven't been closely studied.

Garlic

Recent studies show that garlic is a potent hypotensive agent.

A 12-week randomized double-blind clinical trial involving 79 patients with hypertension (defined by the study investigators as systolic blood pressure > 140 mm Hg) tested the effects of daily garlic supplementation on blood pressure.[21] Subjects received capsules containing 240 mg, 480 mg, or 960 mg of aged garlic extract, or capsules containing placebo.[21] The supplements were prepared from aged garlic vs whole garlic, garlic powder, or garlic oil. The authors note that aged garlic extract is the preferred form of garlic for the treatment of blood pressure because it's chemically stable and contains standardized dosage(s) of the active component S-allylcysteine. Moreover, garlic extract doesn't cause adverse reactions such as bleeding when taken with anticoagulant drugs such as Coumadin.[21]

Compared with placebo, the dose of 480 mg resulted in a significant reduction in diastolic blood pressure (-11.8 mm Hg).[21] A nonsignificant decrease in systolic blood pressure was observed among subjects taking the highest dose (960 mg); the authors theorize that this may have been due to lower compliance, resulting from poor tolerability.[21] No effect was seen on diastolic blood pressure at the lowest dose or for systolic blood pressure.[21]

The bioactive agent in garlic thought to be responsible for its hypotensive effects is S-allylcysteine, a sulfur-containing derivative of the amino acid cysteine.[22] The dose of aged garlic most effective at lowering blood pressure (480 mg) contained 1.2 mg of S-allylcysteine.[21] Like other food constituents that lower blood pressure, S-allylcysteine seems to promote vasodilation by increasing nitric oxide production and blunting the activity of ACE.[21]

In addition to S-allylcysteine, garlic contains other bioactive compounds that may enhance immune function and have antioxidative, hypolipidemic, and procirculatory effects.[22] Consumption of garlic supplements or large amounts of fresh garlic in conjunction with warfarin treatment should be avoided as it may result in bleeding.[21]

Breakfast Cereals

Regular consumption of breakfast cereals has been linked to a variety of health benefits, including decreased risk of cardiovascular disease and diabetes, lower BMI, and improved gastrointestinal function.[23] Research suggests that breakfast cereals also may protect against hypertension.

A prospective study conducted among 13,638 men enrolled in the Physicians Health Study examined the effects of cold cereal consumption on risk of hypertension (defined by the study investigators as systolic blood pressure > 140 mm Hg, diastolic blood pressure > 90 mm Hg, or treatment for elevated blood pressure).[23] During the follow-up period of 16 years, 7,267 subjects developed hypertension. Subjects in the highest cereal consumption category (> 7 servings per week) had a 19% lower risk of hypertension, compared with subjects in the lowest consumption category (0 servings per week).[23] The protective effect was greater for whole-grain cereals (defined as > 25% oat or bran) than refined cereals.[23]

Three randomized, 12-week clinical trials explored the effects of consumption of two servings daily of oat or wheat cereal on blood pressure; one of the studies also included a drink made from 7.7 g of oat B-glucan powder.[23] The studies were conducted among small groups of

subjects (n=36 to 96) with hypertension or elevated systolic and/or diastolic blood pressure (systolic 130 mm Hg to 179 mm Hg, diastolic 85 mm Hg to 109 mm Hg).[23]

Although oat or wheat cereal didn't significantly affect systolic or diastolic blood pressure in two of the studies, the third study showed that consumption of oat cereal was associated with a 73% reduction in the need for hypertensive medication, compared with a 42% decrease among subjects consuming wheat cereals.[23] In addition, subjects consuming the B-glucan supplement had significantly lower systolic blood pressure (-5.6 mm Hg) as well as diastolic blood pressure (-2.3 mm Hg).[23]

It's unclear which components of breakfast cereals may help regulate blood pressure. Whole grains seem to offer the most benefit as they're high in vitamins, minerals, dietary fiber, unsaturated fatty acids, and antioxidants. These nutrients may act independently or synergistically to lower blood pressure.

Berries

Berries are rich in a variety of nutrients, including vitamin C, fiber, and potassium. A study published in 2011 in ***The American Journal of Clinical Nutrition*** found that consumption of anthocyanins, a subclass of flavonoids found abundantly in blueberries, cranberries, and strawberries, was associated with an 8% lower risk of hypertension among subjects in two large prospective cohort studies. The effect was most striking for blueberries; in both studies, consumption of more than one-half cup serving of blueberries per week was associated with a 10% reduction in hypertension. The authors theorize that dietary anthocyanins may promote healthy blood pressure by hindering vasoconstriction.[24]

Soy

Soy foods contain large amounts of isoflavones, polyphenols that appear to enhance cardiovascular health. A randomized crossover study published in 2007 investigated the effects of soy nut consumption on blood pressure in 60 hypertensive (defined by investigators as systolic blood pressure ≤ 140 mm Hg) and normotensive postmenopausal women. Throughout the eight-week study subjects consumed a heart-healthy diet (low in saturated fat, cholesterol, and sodium). Subjects assigned to the intervention group consumed one-half cup of unsalted soy nuts containing 25 g of soy protein daily in addition to the heart-healthy diet. At study completion there were significant reductions in systolic and diastolic blood pressure among hypertensive women (-9.9% mm Hg and -6.8% mm Hg, respectively), as well as significant declines in systolic and diastolic blood pressure among normotensive women (-5.5% mm Hg and -2.7% mm Hg, respectively). The hypotensive effect of soy isoflavones may be due to enhanced vasodilation resulting from increased nitric oxide production.[25] Additional food-related tips for lowering blood pressure can be found **here**.

Dietary Patterns Promoting Healthy Blood Pressure

In addition to the variety of foods that have been shown to improve blood pressure and lower the risk of hypertension, there are certain dietary patterns that also appear to have a favorable influence on blood pressure. In general, diets rich in fruits and vegetables, nuts, legumes, and unsaturated fats and oils, with minimal intakes of meat and high-fat dairy foods, seem to bolster healthy blood pressure. Following is a summary of specific dietary patterns and their potential for managing healthy blood pressure levels.

Vegetarian and Vegan Diets

Research showing support for a protective role of a vegetarian diet on blood pressure began to emerge 30 years ago, with published results from several small clinical trials and cross-sectional studies.[26] Findings from these investigations demonstrated significantly lower diastolic and systolic blood pressure in vegetarians compared with nonvegetarians, and prevalence of hypertension as low as 2% among vegetarians and as high as 26% in omnivores.[27]

Much of the evidence regarding protective effects of a vegetarian diet on blood pressure has come from the Seventh Day Adventists' cohort studies. Initiated in 1960, this series of studies has tracked behaviors and health outcomes for members of the Seventh Day Adventist religious denomination, many of whom adhere to vegetarian or semivegetarian diets.[28]

A study published in 2012 in ***Public Health Nutrition*** examined diet and blood pressure among 500 subjects enrolled in the Adventist Health Study-2, which was conducted from 2002 to 2007.26 Participants were divided into four groups: nonvegetarian (40%); partial-vegetarian, defined as eating red meat, fish, and poultry less than once a week but more than once a month (14%); lacto-ovo vegetarian (36%); and vegan (10%). Compared with nonvegetarians, the three groups of vegetarians had significantly lower systolic and diastolic blood pressure than nonvegetarians, with vegans demonstrating the lowest blood pressure.[26] In addition, the odds ratio of hypertension (defined as systolic blood pressure > 139 mm Hg, diastolic blood pressure > 89 mm Hg, or use of antihypertensive medication) was lowest among vegans: 0.37 vs 0.57 for lacto-ovo vegetarians; 0.92 for partial vegetarians; and 1.7—more than quadruple that of vegans—for omnivores.[26]

Several mechanisms have been proposed for the favorable effects of a vegetarian diet on blood pressure. Plant-based diets offer increased vitamins, polyphenols, potassium, polyunsaturated fat, and dietary fiber, as well as minimal saturated fat and cholesterol. The variety and balance of nutrients vegetarian diets provide may act singly or together to promote vasodilation, help regulate renin, angiotensin, and aldosterone metabolism, and lower blood viscosity.[26] In addition, the significantly lower BMI seen among vegans may contribute to the benefit conferred by a diet composed entirely of plant foods.[28]

Mediterranean Diet

The Mediterranean diet, a traditional dietary pattern consumed in Greece, Italy, and Spain, is characterized by liberal consumption of fruits and vegetables, seafood, legumes, and nuts, and minimal intake of meat, processed grains, and sweets. Olive oil is the primary fat source. The Mediterranean diet has been widely lauded for its role in promoting health and reducing disease risk.[29]

In 2003, researchers in Spain initiated the PREDIMED study, a randomized clinical trial that explored the effects of the Mediterranean diet on cardiovascular disease risk.[29] A study published in 2013 examined the influence of the Mediterranean diet on blood pressure among 7,158 male and female PREDIMED participants, aged 55 to 80, who had at least three risk factors for CHD.[29] The study subjects were assigned either to a control group and instructed to eat a low-fat diet or to one of two groups consuming a Mediterranean-style diet supplemented either with nuts (walnuts, hazelnuts, and almonds) or extra virgin olive oil. After four years of follow-up, participants consuming both variations of the Mediterranean diet had significantly

lower diastolic blood pressure than did subjects in the control group, though no differences were noted in systolic blood pressure.[29]

The Mediterranean diet, like vegetarian diets, is high in potassium and dietary fiber, which may favorably affect sodium metabolism and promote healthy blood pressure. In addition, the polyphenols in olive oil appear to improve endothelial function and facilitate nitric oxide production.[30]

Korean Traditional Diet

The Korean traditional diet is composed chiefly of rice, fermented vegetables such as kimchi, fish, and soyfoods. The diet is typically low in dairy products and red meat, but relatively high in sodium due to the liberal use of sea salt in food preparation.[31] Up until the 1970s, this traditional diet commonly was consumed in Korea and was linked with a low rate of cardiovascular disease in that region. Over time, Western eating habits have replaced traditional dietary patterns in Korea, and the prevalence of cardiovascular risk factors has increased dramatically.[31]

Clinical trials have demonstrated that consumption of traditional Korean foods, particularly kimchi, is associated with significant reductions in systolic and diastolic blood pressure and other cardiovascular risk factors.[32] Kimchi is a fermented vegetable dish prepared from napa cabbage, red pepper, leeks, and garlic. It's a good source of probiotic bacteria, including Lactobacillus plantarum, Lactobacillus brevis, and Streptococcus faecalis; polyphenols; and capsaicin, which may act singly and cooperatively to affect a variety of processes affecting blood pressure regulation, including improved endothelial function and angiotensin regulation.[32]

Miso, a soyfood traditionally consumed in Korea, is an important source of the isoflavones daidzein and genistein, which stimulate vasodilation.[33] Although miso is high in sodium (200 mg to 300 mg per teaspoon), it hasn't been found to raise blood pressure. Researchers speculate that the peptides in miso may block the hypertensive effects associated with the sodium chloride in table salt.[33]

MNT and Hypertension

Emerging research has shown that a variety of foods may reduce systolic and diastolic blood pressure in both hypertensive and healthy subjects, supporting the idea that a "one-size-fits-all" approach is unnecessary for the effective management of hypertension. Even though diet may achieve small decreases in blood pressure, research has shown that even slight reductions may dramatically reduce the risk of heart disease and stroke.[34] This is good news for patients, who now have a variety of healthful and delicious food choices to complement traditional regimens for reducing risk of hypertension. Dietitians should educate their patients about the foods and nutrients that offer the most potential benefit for lowering elevated blood pressure and inform patients about possible drug-nutrient interactions.[35]

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Examination

1. Which of the following types of nuts do researchers suggest may improve systolic blood pressure?
A. Peanuts, pecans, and almonds
B. Walnuts, almonds, and hazelnuts
C. Cashews, pecans, and pistachios
D. Pistachios, walnuts, and hazelnuts

2. Which compound in green tea is believed to be most responsible for its hypotensive activity?
A. Oxylipin
B. Theaflavin
C. Epigallocatechin-3-gallate
D. Gamma-tocopherol

3. What is one of the mechanisms by which S-allylcysteine appears to lower blood pressure?
A. It inhibits the activity of angiotensin-converting enzyme (ACE).
B. It decreases blood levels of intracellular adhesion molecules.
C. It increases circulating levels of interleukin-1.
D. It increases bioactive peptide production.

4. Which of the following is true about tea prepared from *Hibiscus sabdariffa*?
A. It contains compounds that inhibit the ACE activity and the signaling pathways linked with hypertension.
B. It may be safely consumed with diuretic medication.
C. It's prepared by mixing extracts from the plant's roots with water.
D. It increases absorption of acetaminophen.

5. Low levels of nitric oxide in the body may cause which of the following responses?
A. Increased oxygen supply to endothelial tissue
B. Decreased risk of hypertension
C. Impaired vascular function
D. Decreased ACE activity

6. In what way may consumption of low-fat milk and yogurt decrease blood pressure risk?
A. Increased calcium absorption lowers systolic and diastolic blood pressure.
B. Release of bioactive peptides by gut bacteria during digestion of dairy foods may interfere with ACE.
C. Low-fat dairy foods are a natural diuretic.
D. Circulating levels of inflammatory proteins are reduced when low-fat dairy foods are consumed.

7. Which of the following nutrients in flaxseed may help to lower blood pressure?
A. Gamma-aminobutyric acid, epicatechin, and B-glucan
B. Gamma-tocopherol, folic acid, and magnesium
C. Secoisolariciresinol, alpha-linolenic acid, and arginine-containing peptides
D. Linoleic acid, anthocyanin, and sesamol

8. Studies exploring the effect of cocoa consumption on blood pressure have shown which of the following results?
A. Blood pressure reduction was greatest among subjects consuming the largest amounts of cocoa.
B. Catechin and epicatechin are the active compounds in cocoa.
C. High-flavanol cocoa products had no effect on blood pressure.
D. Chocolate products containing less than 50% cocoa significantly lowered blood pressure.

9. The Seventh Day Adventists' studies have shown which of the following findings?
A. Rates of hypertension are the same for all types of vegetarians.
B. The hypotensive effect of vegetarian diets is due primarily to dietary fiber.
C. Nonvegetarians have approximately four times greater risk of hypertension than do vegans.
D. Vegetarian diets lower serum cholesterol levels but have no effect on blood pressure.

10. Which of the following mechanisms plays a role in reducing blood pressure?
A. Increased ACE activity
B. Increased production of reactive oxygen molecules
C. Increased nitric oxide production
D. Stimulation of platelet aggregation in endothelial tissue