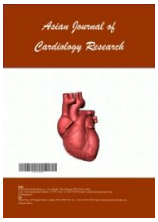

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Impact of Diet on Cardiovascular Diseases: Hypertension and Stroke

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Diet is a major modifiable factor in the prevention and management of cardiovascular diseases. An optimal body weight with a BMI between 20 kg/m^2 and 24.9 kg/m^2 (18.5 kg/m^2 to 24.9 kg/m^2 for Asians), and a diet rich in non-starchy vegetables, fruits, whole grains, and legumes; moderate in consumption of nuts, seafood, lean meats, low-fat dairy products, and unsaturated vegetable oil, and limited or missing in trans-fats, saturated fats, sodium, red meat, refined carbohydrates, and sugar-sweetened beverages is cardiovascular protective. Dairy, coffee, tea, and chocolate may also be vascular friendly. Alcohol has a U-shaped relationship, where low to moderate intake is cardiovascular healthy, while heavy intake is harmful. Some minerals and vitamins are also helpful in the prevention and management of hypertension and stroke. Hypertension is a major global health burden. It has a causal relationship with several cardiovascular diseases and is related to more cardiovascular events than any other modifiable risk factor. It causes substantial disability and is a leading cause of premature deaths. It is estimated that several million people globally have hypertension, but only about one-half of these people achieve control. Diet, especially salt restriction, plays an important role in its prevention and therapeutic reduction. Stroke is increasing in incidence and prevalence in low- and middle-income countries. It is associated with severe disability and is the second leading cause of death globally. Diet also plays an important role in its prevention. The impact of a healthy diet on both these disorders, hypertension, and stroke, are discussed in this manuscript.

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ABBREVIATION

CVD : Cardiovascular Disease;
BMI : Body Mass Index;
HTN : Hypertension;
BP : Blood Pressure;
CHD : Coronary Heart Disease;
QOL : Quality of Life;
RR : Risk Ratio;
DASH : Dietary Approaches to Stop Hypertension;
Mg : Magnesium;
ARIC : Atherosclerosis Risk in Communities;
HOPE-2 : Heart Outcomes Prevention Evaluation -2.

1. INTRODUCTION

Diet is a major global health issue [1]. Even in developed countries like the United States of America, out of the seven metrics of cardiovascular health, a healthy diet scores the poorest [2]. Overweight and obesity have a significant negative impact on cardiovascular diseases (CVDs) [3]. An ideal body mass index or BMI (calculated as the weight in kilograms divided by the height in meters squared) should be 18.5 to 24.9 kg/m^2 [4]. Visceral obesity represents excessive fat collection in the abdomen, and this is also harmful, even if the BMI is normal [5]. Several other anthropometric measurements, primarily to diagnose visceral obesity, such as waist circumference, waist to hip ratio, and waist to height ratio are. therefore, also, important in cardiovascular care [6]. A calorie-restricted diet, along with exercise, is an important intervention for preventing overweight/obesity [7].

The quality of food intake in addition to quantity also has a significant effect on the risk for several cardiovascular diseases [8]. A healthy diet is rich in non-starchy vegetables, fruits, whole grains, and legumes; moderate in consumption of nuts, seafood, lean meats, low-fat dairy products, and unsaturated vegetable oil, and limited or missing in trans-fats, saturated fats, sodium, red meat, refined carbohydrates, and sugar-sweetened beverages [9]. It is low in salt, (<2,300 mg per day) [10] and limits alcohol to 2 drinks or less in a day for men or 1 drink or less in a day for women [11]. This manuscript discusses the impact of diet on two major cardiovascular diseases – hypertension (HTN) and stroke.

2. DISCUSSION

Hypertension and stroke are two common vascular diseases [12]. According to reports of the World Health Organization, the global prevalence of hypertension was about 22% among adults in 2014 [13] and the prevalence is projected to rise to 29.2% in 2025 if there is no intervention [14]. Besides stroke [15], hypertension has been strongly associated with the risk of ischemic heart disease [16]. It is estimated that a 5 mm Hg reduction in blood pressure (BP) results in a 34% lower risk of stroke and a 21 % lower risk of ischemic heart disease [17]. The incidence of stroke is on the rise, especially in developing countries [18]. Globally, approximately three-fourths of strokes are ischemic, followed by intracranial hemorrhage and subarachnoid hemorrhage [19,20]. Stroke is also an independent risk factor for the development of dementia [21]. It is a leading cause of long-term disability [22] and a major cause of death [23].

Globally, cardiovascular diseases (CVDs) are the leading cause of death and one of the major health concerns [24,25]. In the United States, the prevalence of CVDs (coronary heart disease [CHD], heart failure, stroke, and hypertension) is 48.0% [26]. The World Health Organization estimated that three-quarters of deaths due to CVDs could be prevented by controlling lifestyle risk factors such as an unhealthy diet [27]. Diet is an established changeable risk factor involved in the developing, preventing, and managing of CVDs [28]. Healthy dietary patterns are associated with lowered cardiovascular morbidity [29], lower disability [30], and improved quality of life (QOL) [31]. It also reduces mortality [32].

2.1 Diet and CVD Risk: Hypertension

Hypertension is defined as systolic blood pressure >139 mm Hg or diastolic blood pressure >89 mm Hg [33]. The impact of elevated blood pressure (BP) is tremendous – it is estimated that even a 2-mmHg increase in BP increases mortality from stroke by 10 percent and coronary artery disease by 7 percent [34,35]. Besides stroke, it is also a major risk factor for other CVDs [36] and renal disease [37].

Clinical trials and observational studies have shown that a healthy diet is associated with a reduced incidence of new onset hypertension

[38,39] and can help lower blood pressure in existing hypertensives [40]. Plant-based foods, whole grains, low-fat dairy products, and sodium intake within normal limits not only help prevent but are also therapeutically effective [41]. A diet rich in fruits, vegetables, whole grains, low-fat dairy products, and reduced saturated and total fat should reduce systolic BP by 11 mm Hg and diastolic BP by 3mm Hg [42]. The 2010 Dietary Guidelines for Americans have recommended that a healthy diet should include at least 9 servings of fruits, and vegetables per day, 4 servings of fruits and 5 servings of vegetables [43].

The most effective dietary intervention to reduce BP is a restriction in salt intake [44,45]. This reduction in BP has been noted both in hypertensive and normotensive individuals, irrespective of any other confounding factors [44,45]. In patients with mild HTN, the effect of a lowering systolic BP by 8 mmHg and diastolic BP by 4 mmHg is like that achieved by a single drug therapy [46]. Carey and colleagues estimated that for a 1000 mg reduction in sodium intake in adults, one can expect a 1–3 mm Hg reduction in systolic BP [47]. Filippini et al found, in a meta-analysis based on 81 clinical trials with a minimum duration of 4 weeks that a 100 mmol/day (1800 mg/day) reduction in sodium resulted in a 5.43 mm Hg systolic reduction in BP [48]. According to the major US cardiology associations, the optimal goal is should be <1500 mg/day ingestion, with at least a 1000-mg/d reduction in most adults [49]. The consequent reduction in BP should be -5/6 mm Hg systolic and -2/3 mm Hg diastolic [50]. The major outcome with salt restriction, in addition to the drop in BP, is an associated reduction in morbidity and mortality from cardiovascular diseases [51]. Besides salt intake, dietary constituents also play a major role in maintaining a normal BP [52]. A meta-analysis of 25 studies with 334,468 patients showed that when comparing the highest with the lowest consumption of vegetables and fruits, the pooled relative risks of hypertension were 0.812, or a reduction in 17.8% [53]. In this study, fruits decreased the relative risk to 0.732 while vegetables decreased it to 0.970 [53]. On the other hand, meat intake, both unprocessed and processed, has a harmful association with HTN [54]. In a meta-analysis of 7 studies with 97,745 incident hypertension cases, Schwingshack et al. reported that red meat intake increased the risk of HTN with a risk ratio (RR) of 1.15 when extreme categories were compared [55]. They estimated that for each additional daily 100-g red-meat intake, there was a 14% increased risk of hypertension [55]. The authors reported in the same manuscript, that when 5 studies with 97,441 incident hypertension cases were studied, an increased RR of 1.12 was noted when extreme opposing categories of processed-meat intake were compared [55]. Zhang and Zhang in a meta-analysis of six studies related to poultry consumption found an increased risk of HTN with a RR of 1.15 [56]. Switching to a vegetarian diet in these individuals helps lower blood pressure [57]. One a day egg intake does not appear to raise BP [58-62]. Zhang and Zhang reported that egg consumption may be associated with a decreased incidence of HTN, with a RR of 0.79 [56]. The effect of whole-grain intake on HTN appears to be equivocal or mildly beneficial [55]. In a study looking at three studies with 18,842 incident hypertension cases, when the highest intake category was compared with the lowest intake category, the RR was 0.95 [55]. An increase in refined-grain intake by 30 g/d revealed an RR of 0.99 [55]. In six studies with 80,871 incident hypertension cases, a comparison of extreme intake categories revealed an inverse association between the risk of hypertension and legume intake (RR=0.92) [55]. The same authors found that when four studies with 11,962 incident hypertension cases, analysis of extreme intake categories showed an inverse association between the risk of hypertension and nut intake with an RR of 0.85 [55]. Studies have also reported that an increase in dietary fiber is associated with a reduction in hypertension [63-66].

Alcohol intake in excessive amounts is associated with HTN [67] and an increased risk for several harmful cardiovascular outcomes [68]. The ideal intake recommended by the American Society of Hypertension and the International Society of Hypertension is no more than 2 drinks a day in men and no more than 1 drink a day in women [69]. Caffeine is widely consumed, and although it may acutely elevate BP in occasional coffee drinkers [70]. habitual use has no BP elevating effects [71]. Chocolate consumption, especially dark chocolate, has been associated with BP reduction [72,73]. Licorice, often used as a flavoring agent in candies, may raise mineralocorticoid levels and cause an elevation in blood pressure [74]. Sugar-sweetened beverages also increase the risk of HTN with a RR of 1.12 when comparing extreme categories [55]. Obesity is closely linked with HTN [75,76]. The American Heart Association estimates that

every 1-kilogram (2.2 lbs.) weight reduction will result in about a 1 mm Hg reduction in systolic BP [75]. Bariatric surgery-induced weight loss also improves BP [76]. The Dietary Approaches to Stop Hypertension (DASH) Trial found that low-fat/fat-free dairy foods were beneficial in lowering BP [77]. In a recent meta-analysis, with sixteen studies reviewed, an inverse association between total dairy product consumption (RR=0.90), low-fat dairy products (RR=0.86), milk (RR=0.94), and fermented dairy (RR=0.95) was found with the risk of HTN [78].

Blood pressure reducing effects of potassium have been noted by several meta-analytic studies [79,80]. and the anticipated BP reduction is about 4/5 mm Hg systolic and 2 mm Hg diastolic [75]. However, potassium supplementation is only recommended in hypokalemic patients and adequate potassium intake should be maintained via dietary intake of potassium-rich foods [81]. A 500–1000 mg/day of magnesium (Mg) supplementation has been shown to reduce systolic/diastolic blood pressure as much as 5.6/2.8 mm Hg [82]. However, a Cochrane review in 2006 suggested that Mg supplementation in HTN is not advised [83]. Calcium is found mainly in dairy products like milk, cheese, and yogurt [84]. Some studies have suggested that low calcium intake in patients with high salt intake results in a higher BP [85] and that increasing dietary calcium intake helps counteract the hypertensive effects of salt [86,87]. Again, supplementation with this mineral is not recommended for BP control [88]. In studies, the DASH diet reduces systolic and diastolic blood pressures by 5.5 and 3.0mm Hg, respectively [89], while the Mediterranean diet results in 4.0–4.3 mm Hg lower systolic, and 1.9 mm Hg lower diastolic blood pressures [90]. The Nordic diets [91] and Vegetarian diets [92] have also been demonstrated to significantly lower systolic and diastolic blood pressures.

In summary, a diet low in sodium intake, rich in plant-based foods, whole grains, low-fat dairy products, is effective in the prevention and management of HTN [93].

2.2 Diet and CVD Risk: Stroke

Hypertension is the most important modifiable risk factor for stroke [94]. In the INTERSTROKE study, HTN accounted for 47.9% overall, 45.7% ischemic, and 56.4% of hemorrhagic stroke risk [94]. Several studies have shown that high fruit and vegetable intake significantly decrease the risk of stroke [95-97]. Eight studies (94,772 incident hypertension cases) included in a meta-analysis comparing extreme intake categories, showed an inverse association between the risk of hypertension and vegetable intake [55]. A more recent study analyzed data on 418,329 men and women from nine European countries, with an average of 12.7 years of follow-up - lower risks were observed with higher consumption of fruit and vegetable combined [98]. One cup of green leafy vegetables provides about 60 mg of vegetable nitrate – consumption of about this amount daily is associated in a reduction in the risk of ischemic stroke by 17% [99]. The deleterious link between consumption of processed and unprocessed red meat and the risk of stroke is significant [100]. The ARIC prospective study (cohort of 11,601 adults amongst whom 699 incident strokes were diagnosed during 22.7 years of follow-up, confirmed a positive association between red meat consumption and stroke incidence (Hazard Ratio 1.38) [101]. Using data from this study, Haring et al. estimated that the consumption of approximately one serving per day of unprocessed and processed red meat was associated with 41% and 24% increased risk of stroke, respectively [102]. In a review of several studies (254,742 participants), Kim et al found that pooled relative risks were increased for red meat consumption and stroke incidence, being 1.11 for red meat intake and 1.17 for processed meat intake [103]. Tong et al. analyzed the data of 418,329 men and women from nine European countries (12.7 years of follow-up) and reported a higher risk of stroke with higher red meat consumption [98]. White meat may, however, be stroke protective [103]. In (138,761 participants) comparing the highest versus the lowest categories of white meat consumption, there was a 4% to 22% decrease in stroke [103]. Fish consumption is associated with a reduction of stroke risk [104,105]. In a meta-analysis of five prospective studies, comparing the highest category of intake with the lowest category, the summary relative risk was 0.88 for fatty fish intake and 0.81for lean fish intake [106]. Whole-grain intake also has a favorable effect on stroke [55,107]. Even when confounding other known coronary artery disease risk factors are excluded, whole grain consumption reduces the risk of ischemic stroke, when comparing the highest with the lowest quintile of intake [107]. In a review of four studies with 28,069 incident hypertension cases, an inverse association was observed between the risk of hypertension and whole-grain intake (RR= 0.86) [55]. An increase

in whole-grain intake by 30 g/d decreased the risk of HTN by 8% [55]. In a meta-analysis of 29 studies, for every 28 grams/day increase in nut intake, there was associated with a 7% decrease in the risk of stroke [108]. Qin et al. found that dairy intake was associated with a 13% lower risk of stroke as compared to individuals with no or a low dairy consumption [109]. This had been noted in several earlier studies [110,111]. Hu et al. found a non-linear dose–response relationship, with the highest risk reduction of 7–8% with a milk intake of 200–300 ml/day [112]. In a meta-analysis, Alexander et al. found that a high intake of cheese was associated with a 13% lower risk of stroke [113]. Two recent reports reached similar conclusions - dairy food intake was associated with decreased risk of stroke [114,115]. Some researchers suggest that egg yolk should be avoided to reduce the risk of stroke [116,117]. However, summary associations indicate that intake of up to 1 egg daily is safe [118]. Further, among Asians, egg intake may be associated with a reduced risk of total stroke [119]. Greater dietary fiber intake is significantly associated with a lower risk of first stroke [98,120-123]. Higher intakes of whole grains result in a 26% reduction in the prevalence of ischemic strokes when the highest quintile intake of dietary fiber or whole grains were compared to those with the lowest quintile intake [121,122]. In another study from the Swedish Mammography Cohort and the Cohort of Swedish Men (69,677 participants, aged 45-83 years) showed that high intakes of total fiber and fiber from fruits and vegetables but not from cereals were inversely associated with risk of stroke [123]. High fiber intake also helps reduce the risk of stroke in smokers [124]. In a more recent study that analyzed data on 418,329 men and women from nine European countries, (12.7 years average follow-up) the risk of ischemic stroke was inversely associated with consumption of dietary fiber98. The relationship between alcohol and stroke is well known. In a systemic review and meta-analysis of 27 prospective studies [125-127]. Larsson et al. reported that light to moderate alcohol consumption (1-2 drinks/day) was associated with a lower risk of ischemic stroke, whereas high (>2-4 drinks/day) and heavy drinking (>4 drinks/day) was associated with an increased risk, especially of hemorrhagic stroke [128]. Coffee intake also appears to be stroke protective [129,130]. Coffee consumption, especially 3-4 cups a day, reduces stroke by 21% in a review that involved 21 studies, including 30 independent cohorts (2.4 million participants) [130]. There was no further reduction in stroke risk observed with increasing levels of coffee consumption beyond this amount [130]. A benefit has also been seen with tea intake [131,132]. In a meta-analysis of 9 studies involving 4378 strokes among 194,965 individuals, Arab et al. found that individuals consuming >3 cups of tea per day had a 21% lower risk of stroke than those consuming <1 cup per day [131]. They surmised that daily consumption of either green or black tea equaling 3 cups per day could prevent the onset of ischemic stroke [131]. In a more recent umbrella review, data from 23 systematic reviews suggest that 2 cups of non-sweetened tea per day has the potential to decrease the risk for stroke [132]. Similarly, chocolate consumption also helps in the primary prevention of stroke [133,134]. In a meta-analysis of 14 prospective studies with 508,705 participants, during a follow-up period ranging from 5 to 16 years, a RR of 0.84 was noted for stroke reduction, when the highest versus lowest chocolate consumption groups were compared [133]. In another meta-analysis, Ren et al, (23 studies including 405.304 participants) found that the relative risk (RR) per 20 g/week increase in chocolate consumption was: 0.956 for total stroke, 0.952 for cerebral infarction, and 0.931 for hemorrhagic stroke: 0. 931, indicating a beneficial effect [134]. However, intake of >100 g/week of chocolate may negate the health benefits and induce adverse effects due to the increased sugar consumption [134]. Narnia et al. reviewed seven prospective cohort studies with 308,420 participants (age range 34-5 years) and concluded that there was a greater risk of stroke (RR=1.13) with an incremental increase in sugar-sweetened beverage consumption [135]. They also noted an increased risk (RR=1.08) with the intake of artificially sweetened beverages [135]. Obesity is also detrimental and increases the risk for stroke and stroke-related increases mortality [136,137]. It is estimated that each 5 kg/m^2 increase in BMI (within the range of 25–50 kg/m^2) results in an approximately 40% higher stroke mortality [137]. A calorie-restricted diet along with exercise helps weight loss [138]. Certain vitamin supplements have been shown to reduce the risk of stroke [139-141]. A 25% reduction in stroke with folic acid (B9) was noted in the China Stroke Primary Prevention Trial [139,140], while the HOPE-2 trial reported a significant 23% reduction in stroke with B vitamins [141]. Several well-known diets have been noted to protect stroke [142-145]. The DASH diet has been estimated to reduce stroke by approximately 27% [89]. The Mediterranean

diet, with extra virgin olive oil and mixed nuts, reduced the risk of stroke by 42% after one year [143]. The Nordic diet results in a reduction in stroke by 14% [146], while the vegetarian diet [147] has also been shown to reduce the risk of hemorrhagic, ischemic, and total stroke

3. CONCLUSION

A healthy lifestyle, incorporating a calorie-controlled balanced diet, reasonable physical activity, moderate alcohol consumption, and abstinence from smoking, is beneficial for preventing and managing hypertension and stroke. A prudent diet is important. Ideally, the diet should be plant-based, rich in fruits, vegetables, whole grains, nuts, fish, unsaturated oils, with occasional lean meat intake and low in sugar, salt, saturated fats, red meat, both processed and unprocessed, and avoids trans fats and sugar-sweetened drinks. Coffee, tea, and low to moderate intake of alcohol are also beneficial. Several common diets, such as the DASH diet, Mediterranean diet, Nordic diet, and the vegetarian diet have HTN and stroke preventive effects. The reduction in blood pressure is instrumental in reducing several other cardiovascular diseases, and their outcomes. The collateral benefits include a reduction in body weight, diabetes mellitus, and lipids. These effects translate into a healthier, more disease-free, and overall longer life.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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