# Stroke and Nutrition: A Review of Studies

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## ABSTRACT

**Background:** Stroke is one of the leading causes of death and certainly the major cause of disability in the world. Diet and nutrient has an effective role in prevention and control of the risk of stroke. The aim of this study was to review the studies on the relationship between dietary intake and stroke incidence.

**Methods:** In this study, the terms of "Fat", "cholesterol", "antioxidant", "vitamins", "salt", "potassium", "calcium", "carbohydrate", "vegetables", "fruits", "meat", "tea", "whole grains", "sugar-sweetened beverages", "Mediterranean diet", "dietary approaches to stop hypertension diet (DASH diet)", "Western diet", and "stroke"were searched in Pubmed search engine. The observational studies, cohort studies, clinical trial studies, systemic review, and meta-analysis reviews are also included in this study.

**Results:** The study revealed that adherence to theimprovements in nutrition and diet canreducethe incidence ofstroke. Higher antioxidant, vitamins, potassium, calcium, vegetables, fruits, whole grain intake, and adherence to the Mediterranean dietor DASH diet can lower stroke incidence.

**Conclusions:** Adherence to Mediterranean diet or DASH diet and increasing the consumption of antioxidant, vitamins, potassium, calcium food sources, vegetables, fruits, and whole grains intake can lower the risk of stroke. Healthy diet is effective in reducing risk of stroke, however, more studies need to be carried out in this area.

**Keywords:** Diet, nutrition, stroke

Review Article

## INTRODUCTION

Stroke is one of the most leading reasons of disabilities and death all over the world. The incidence of stroke in high income countries descended from 163-94 cases per 100,000 person years, between 1970 and 2008.[1] This decrease coincided with increased public awareness of the dangers to health, which is posed by elevated blood pressure, high blood cholesterol, cigarette smoking, and reduced prevalence of these risk-factors in the population.[2] The estimation of the World health organization that between 1990 and 2020, the stroke mortality will enhance by 78% in woman and 106%

in man.[3] Nutrition plays much more important role in the stroke prevention than it is appreciated by most physicians and nutritionists.[4] The aim of the present paper is to explain the evidences, which link nutrition to the stroke risk.

## METHODS

In this study, the key words "fat", "cholesterol", "antioxidant", "vitamins", "salt", "potassium", "calcium", "carbohydrate", "vegetables", "fruit", "meat", "tea", "whole grains", "sugar-sweetened beverages (SSBs)", "Mediterranean diet", "dietary approaches to stop hypertension diet (DASH diet)", "Western diet" and "stroke" were searched in Pubmed search engine. The observational studies, cohort studies, clinical trial studies, systemic review and meta-analysis reviews and studies with large samples size were included in this study. These studies were included in the study, which was conducted from 1990 to 2012.

### Which nutrients affect the risk of stroke?

#### *Fat and cholesterol*

High serum cholesterol is a risk-factor for ischemic stroke. A recent Asian study showed that higher total cholesterol and systolic blood pressure is accompanied with eight times higher ischemic stroke risk. However, there is no evidence of an increase in hemorrhagic stroke risk with the combination of low total cholesterol level and hypertension and hence if there is an association, it is smaller than indicated in several previous cohorts.[5]

The levels of dietary saturated fatty acid (SFA) consumption is correlated positively with stroke mortality rates in both sexes.[6] An observational study of 43,732 men in the USA showed that the risk of ischemic stroke did not increase in people with the highest quintile of intake of total fat, dietary cholesterol, vegetable fat, animal fat, saturated fat, mono-unsaturated fat, and trans fatty acids in the comparison of the lowest quintile of consumption.[7] No relationship between dietary fat and ischemic or hemorrhagic stroke incidence was observed after follow-up for 4 years. Intakes of red meats, high fat dairy products, nuts, and eggs were not related the stroke risk.[8] There is a descending trend in risk of coronary heart disease with low consumptions of trans fatty acids and saturated fat[9] and type of fat intake may be more relevant for cardiometabolic health than the proportion of calories consumed from total fat.[10,11]

#### *Saturated fatty acid*

A meta-analysis of eight observational studies found that intake of the highest quintile of saturated fat in comparison with the lowest quintile was not associated with an increased risk of stroke.[12] However, Framingham Heart Study should that the intake of total and monounsaturated fat was associated with reduced risk of ischemic stroke.[13]

#### *Polyunsaturated fatty acids*

No reliable study showed the positive association between PUFA consumption and stroke risk. Several observational studies and randomized clinical trials suggest that the consumption of PUFA instead of SFA can reduce the incidence of coronary heart diseases.[9]

Marine-derived omega-3 fatty acids source include, eicosapentaenoic acid (EPA) (20:5 omega-3) and decosahexaenoic acid (DHA) (22:6 omega-3) from oily fish such as salmon, herring, trout, and sardines.[14] Many studies suggest that the disproportion in the consumption of n-6 and n-3 fatty acids in the diet can lead to the development of chronic diseases.

Global recommendations of n-3 fatty acids for primary prevention of coronary diseases correspond to regular intake of two servings of fish per week, which is equivalent to 1 g of EPA and DHA combination.[15] A meta-analysis of 11 randomized clinical trials including 39,044 patients showed that patients with EPA or DHA consumption can reduce the cardiovascular deaths, sudden cardiac death, all-cause mortalities, and non-fatal cardiovascular events.[16] A large clinical trials, such as diet and reinfarction trial and the Gruppo Italiano per lo Studio della Sopravivenza nell Miocardico Infarction Prevenzione showed that there are benefits of n-3 PUFA in reducing total mortality and sudden death. On the other hand, the results of controlled clinical trials are inconsistent with the consumption of n-3 and stroke risk.[17,18]

Plant-derived n-3 PUFA like α-linolenic acid (ALA) is an essential fatty acid, which is found mainly in vegetable oils such as soybean, canola, and flaxseed, and walnuts.[19] An observational

study of 20,069 Dutch adults showed that participants in high quintiles of ALA intake had a 35-50% lower risk of incidence of stroke in comparison to the lowest quintile (<1 g/day).[20] Studies that assess the relation between fat intake and stroke risk is shown in Table 1.

***Antioxidant and vitamins***

The oxidation hypothesis of atherosclerosis explains that oxidation of low-density lipoprotein (LDL) cholesterol allows it to accumulate in artery walls and promote atherosclerosis. Several studies of antioxidant vitamins in the prevention of stroke and death were performed.[21] A meta-analysis of 68 randomized trials of antioxidant supplements versus placebo in 232,605 participants showed that antioxidants had no effect on mortality rate.[22]

***Vitamin A and β-carotene***

Carotenoids, the pigments responsible for the yellow to red color of fruits and vegetables, have been implicated as beneficial substances; they are found in roots, leaves, shoots, seeds, fruits, and flowers.[23] Rissanen *et al*., in the Kuopio Ischaemic Heart Disease Risk-Factor

**Table 1:** Characteristics of various studies that evaluated the relationship between stroke and nutrition

| Author | Year | Country | Study design | Sample size | Duration of study (years) | Determination of status/ intervention | Results |
|---|---|---|---|---|---|---|---|
| He *et al*.[7] | 2003 | USA | Prospective cohort | 43,732 | 14 | FFQ | Not support association between intake of total fat |
| Howard *et al*.[8] | 2006 | USA | Cross-sectional | 48,835 | 8.1 | FFQ | Not support association between intake of total fat |
| Patty W Siri-Tarino *et al*.[11] | 2010 | USA | Meta-analysis | 347,747 | 5-23 | FFQ | No association between saturated fat with an increased risk of CHD or CVD |
| Gillman *et al*.[12] | 1997 | USA | Cohort study | 832 men | 20 | 24-hour dietary recall | Intakes of fat, were associated with reduced risk of ischemic stroke in men |
| Mozaffarian *et al*.[13] | 2010 | USA | Meta-analysis clinical trial | 13,614 | 1 | Supplement omega-3 | Consuming PUFA instead of SFA reduces CHD events in RCTs |
| Marik *et al*.[16] | 2009 | USA | Systematic review | 39,044 | 2.2±1.2 | Supplementation with omega-3 | Dietary supplementation with omega-3 fatty acids should be considered in the secondary prevention of cardiovascular events |
| Burr *et al*.[17] | 1989 | UK | Randomised controlled trial | 2033 men | 2 | Fat, fish, and fiber intakes | Intake of fatty fish reduce mortality in men who have recovered from MI |
| Galan *et al*.[18] | 2010 | France | Controlledtrial | 2501 patients | 4.7 | B vitamins and omega3 fattyacids | Not support the routine use of dietary supplements omega-3 after ischemic stroke |
| de Goede *et al*.[20] | 2011 | Netherlands | Cross-sectional | 20,069 | 8-13 | FFQ | ALA intake was not associated with incident CHD |

FFQ=Food frequency questionnaire, CHD=Coronary heart disease, CVD=Cardiovascular disease, PUFA=Poly unsaturated fatty acids, RCTs=Randomized clinical trials, MI=Mayo cardiac infarction, ALA=α-linolenic acids

Study showed that men in the lowest quarter of lycopene intake had a 3.3-fold risk of acute coronary heart events and stroke. These findings suggest that lycopene might have a role in the prevention of coronary events and stroke.[24] In three randomized trial observed that lycopene consumption can not affect the stroke rates. However, eight randomized trials of 138,113 participants show that lycopene can increase all-cause of mortality and cardiovascular mortality.[25]

***Vitamin C***

The relation between plasma vitamin C and risk of stroke remains unclear. Although, clinical trials showed no significant benefit of vitamin C supplementation in reducing stroke risk, they were not able to examine the relation between plasma vitamin C concentrations and stroke risk in a general population. Observational studies suggest that increased dietary intake and plasma concentrations of vitamin C are associated with reduced rates of stroke,[26,27] large randomized trials show no benefit of vitamin C supplementation in preventing stroke, and other clinical outcomes.[28,29]

***Vitamin E***

Vitamin E is a fat-soluble vitamin and an antioxidant in fats and oils that may provide protection against heart diseases and cancers. In 2010, a meta-analysis of seven randomized trials with 116,567 individuals revealed that vitamin E had no effect on risk of incident of total stroke but it can increase the risk of hemorrhagic stroke incidence and vitamin E intake can reduce the risk of incidence of ischemic stroke.[30] A vitamin E and Beta-carotene supplement trial suggest that 50 mg vitamin E daily intake may reduce the ischemic stroke among hypertensive patients. However, taking 600 IU of natural-source of vitamin E per day, provided no overall benefit on ischemic or hemorrhagic stroke risk.[31] It should be mentioned that there was a positive association between vitamin E supplementation and risk of subarachnoid hemorrhage in a trial.[32] Studies that assess the relation of antioxidant consumption and risk of stroke is shown in Table 2.

***B vitamins***

The findings of several observational studies showed that increased serum concentration of total homocysteine has been associated with an increased risk of all types of stroke and ischemic stroke, large artery diseases, small artery diseases, and embolism.[33]

In regards to the beneficial effects of folic acid on blood pressure and homocysteine level, a prospective, nested case-referent study reflect that plasma folate level has an inverse linear association with risk of hemorrhagic stroke. There was no relationship between folate intake and ischemic stroke risk.[34,35] Some studies show that the risk of stroke can lower by up to 25% with folic acid supplement intake and by 7% with vitamin B12 intake. It should be mentioned that these relation can be based on folic acid effects on lowering homocysteine level. However, the results of some of the randomized trials showed that supplementation with folic acid had no significant effect on risk of stroke.[36,37]

Cerebral venous thrombosis is an uncommon disorder, which often occurs in pregnant woman.

Apart from increased risk from genetic based thrombophilic abnormalities, and oral contraceptives, recent case-control studies have reported the association between cerebral venous thrombosis with hyper-homocysteinemia and low folic acid and B12 intake. Whether cerebral venous thrombosis stroke during pregnancy is due to the poor folate intake, and whether folate supplement could be useful in preventing this kind of stroke, deserve prospective investigations.[38,39] Subgroup analyses from randomized trials raise the hypothesis that use of high-doses of vitamin B12 inpeople who are folate-replete however, vitamin B12 deficient could substantially lower total homocysteine and risk of stroke.[40,41]

Moreover, there is experimental evidence, which demonstrate that Vitamin D exerts neuroprotective effects, quenching oxidative hyperactivity and regulating neuronal death, as well as antithrombotic properties.[42] The vitamin D and OmegA-3 Trial is currently randomly assigning 20,000 people to receive 2000 IU of vitamin D3 (cholecalciferol) per day or placebo, as well as 1 g of marine omega-3 fatty acids per day or placebo, for 5 years.[43] It is plausible that vitamin D supplementation could be a beneficial intervention for the prevention and/or treatment of cerebrovascular diseases, by decreasing the cerebrovascular risk-factors and simultaneously by improving neurologic and cognitive functions

**Table 2:** Studies of the relation of antioxidant consumption and risk of stroke

| Author | Year | Country | Study design | Sample size | Duration of study (years) | Determination of status/ intervention | Association |
|---|---|---|---|---|---|---|---|
| Bjelakovic, *et al*.[23] | 2007 | Denmark | Meta-analysis | 232,606 | 1 | Beta carotene, vitamin a, vitamin c (ascorbic acid), vitamin e, and selenium supplementation | Treatment with beta carotene, vitamin A, and vitamin E may increase mortality |
| Rissanen *et al*.[24] | 2001 | Finland | Cross-sectional | 725 men | 2 | Serum folate, beta-carotene and plasma vitamin c suppelmention | Lowserum level of lycopene is associated with an increased risk of atherosclerotic vascular events |
| Vivekananthan *et al*.[25] | 2003 | USA | Meta-analysis of randomised trials | 81788 | 1.4-12 | Vitamin e was 50-800 iu, and for beta carotene was 15-50 mg | The lack of a salutary effect was seen consistently for various doses of vitamins in diverse populations |
| Myint *et al*.[26] | 2008 | UK | Prospective population study | 20,649 men and women | 4 | Serum vitamin c | Plasma vitamin C concentrations may serve as a biological marker of lifestyle or other factors associated with reduced strokerisk |
| Kubota *et al*.[27] | 2011 | Japan | Cohort | 859,962 | 16.5 | FFQ | Vitamin C intake is inversely associated with mortality from cardiovascular disease |
| Heart Protection Study Collaborative Group[28] | 2002 | UK | Randomized placebo-controlled trial | 20,536 | 5 | 600 mg vitamin E, 250 mg vitamin C, and 20 mg beta-carotene daily | Did not produce any significant reductions in the 5-year mortality from, or incidence of, any type of vascular disease, cancer, or other major outcome |
| Cook *et al*.[29] | 2007 | USA | Randomized factorial trial | 1450 women | 9.4 | Ascorbic acid (500 mg/d), vitamin e (600 iu every other day), and betacarotene (50 mg every other day) | There were no overall effects of ascorbic acid, vitamin E, or betacarotene on cardiovascularevents among women at high risk for CVD |
| Schürks *et al*.[30] | 2010 | USA | Meta-analysis | 118,765 | ≥1 | Vitamin E suppelment | Vitamin E increased the risk for haemorrhagicstroke by 22% and reduced the risk of ischaemicstroke by 10% |
| Lee *et al*.[31] | 2005 | USA | Randomized controlled trial | 39,876 | 10 | 600 Iu of natural-source vitamin e | Do not support recommending vitamin E supplementation for cardiovascular disease or cancer prevention among healthy women |
| Leppälä *et al*.[32] | 2000 | Finland | Factorial design trial | 29,133 | 6 | Alpha tocopherol, 50 mg; beta carotene, 20 mg; both; or placebo | Vitamin E supplementation may prevent ischemic stroke in high-risk hypertensive patients |

FFQ=Food frequency questionnaire, CVD=Cardiovascular disease

can reduce falls and fractures in post-stroke patients.[19] Studies of the relation of vitamin B intake and stroke risk is shown in Table 3.

### *Salt*

Salt is an essential substance that we can see the important role of it through the records of human history.[44] Most populations around the world have average daily salt intakes of higher than 6 g, and many in Eastern Europe and Asia regions of more than 12 g, mostly from processed foods.[44] Reducing dietary salt intake by 6 g/day reduces systolic and diastolic blood pressure by 4 mmHg and 2 mmHg, respectively, in people without hypertension, 7 mmHg and 4 mmHg, respectively, in those with hypertension.[45]

Recent meta-analysis has clearly show that higher salt intake is associated with a greater incidence of stroke and cardiovascular events. This systematic review identified 13 studies, which were published from 1996 to 2008, on 170,000 people contributing for more than 10,000 vascular events.[46]

Excess salt intake might increase cardiovascular and stroke risks by increasing blood pressure and causing fibrosis in the heart, kidneys, and arteries tissue.[47] Observational studies show that sustained high daily salt intake of 5 g is associated with a 23% greater risk of stroke.[48] The findings of many studies, which assess the associations between dietary exposures and cardiovascular or stroke risk are controversial, because most studies are epidemiological and prone to methodological challenges of bias and measurement errors.

### *Potassium*

A lower stroke mortality rate has been found with higher potassium intake, and higher stroke rate with low daily potassium consumption.[49] A higher potassium intake of 42 mmol/L (1·64 g) per day was associated with a 21% reduced risk of stroke after 5-19 years of follow-up of 247,510 adults in 11 observational studies.[50]

### *Calcium*

It has been suggested that a higher calcium intake might favorably modify cardiovascular risk-factors. Interventional studies show that calcium supplements improve some risk-factors for stroke incidence such as blood pressure, high bodyweight, and serum-lipid concentrations.[51,52] However, findings of an ultimately decreased risk of cardiovascular disease (CVD) are limited. Instead, recent evidence warns that taking calcium supplements might increase myocardial infarction (MI) and stroke risk.[53] A recent observational study of 34,670 women reported that increasing calcium intake was not associated with altered risk of any type of stroke, however, it was associated with an increased risk of hemorrhagic stroke.[54] Studies that assess the relation between salt, potassium, calcium intake, and stroke risk is shown in Table 4.

### *Carbohydrate*

Carbohydrates are the main source of energy for the body and daily nutrient recommendations are based on the Dietary Reference Intakes by age and gender. The Dietary Guidelines for Americans suggest that about half (45-65%) of your daily calories should come from carbohydrates (starches, fiber, and sugars). As a result of over-nutrition, there has been a world-wide increase of obesity. Obesity is a risk-factor for developing type II diabetes and diabetes is a known risk-factor for stroke.[55] Foods with a high glycemic index, such as sugar sweetened beverages, and refined carbohydrates, and starches increase fasting blood glucose level. Beverages and foods with high glycemic load, including added sugars, increase bodyweight.[56] Increased dietary fiber reduces blood pressure, blood glucose, serum triglycerides, and LDL cholesterol however, no reliable data on its effect on risk of stroke and stroke subtypes are available.[57] Studies that assess the relation between carbohydrate intake and stroke risk is shown in Table 5.

## Which foods and beverages affect the risk of stroke?

### *Vegetables and fruits*

Consuming a variety of fruits and vegetables provides many different micronutrients and bioactive compounds. All of the contributed roles between the beneficial association of fruits and vegetables and incidence of CHD and stroke is unknown. Epidemiological studies suggest that intake of green and yellow vegetables and fruits, fiber and whole grains but not refined grains can be protective against ischemic stroke.[58] Increased fruit and vegetable intake (more than five servings per day) was associated with a lower risk of stroke than intake of fewer than three servings of fruits

**Table 3:** Studies of the relation of vitamin B and stroke

| Author | Year | Country | Study design | Sample size | Duration of study (years) | Determination of status/ intervention | Association |
|---|---|---|---|---|---|---|---|
| Forman *et al*.[34] | 2005 | USA | Cohort | 93,803 | 4 | FFQ | Higher total folate intake was associated with a decreased risk of incident hypertension, particularly in younger women |
| Van Guelpen *et al*.[35] | 2005 | Sweden | Prospective, nested case-referent study | 334 ischemic and 62 hemorrhagic stroke | 1 | Assessment of folate, vitamin B12 plasma | Protective role for folate, possibly in addition to its effects on homocysteine status, in hemorrhagic but not ischemic stroke |
| Homocysteine Lowering Trialists' Collaboration[36] | 2005 | USA | Meta-analysis of randomized trials | 2596 | - | Assessed the effect on plasma homocysteine concentrations of different doses of folic acid and of the addition of vitamins B-12 and B-6 | Doses of 0.2 and 0.4 mg are associated with 60% and 90%, respectively, of this maximal effect |
| Clarke *et al*.[37] | 2010 | UK | Meta-analysis of 8 randomized trials | 37,485 | 5 | Folic acid supplementation | Dietary supplementation with folic acid to lower homocysteine levels had no significant effects within 5 years on cardiovascular events or on overall cancer or mortality in the populations studied |
| Cantu *et al*.[39] | 2004 | Mexico | Case-control | 135 | - | Plasma levels of homocysteine (fasting and after methionine load), folate, and vitamin B12 were measured | High plasma concentrations of homocysteine and low plasma folate levels were associated with an increased risk of CVT |
| Spence *et al*.[40] | 2005 | Canada | Efficacy analysis | 2155 | | B12 supplemention | Higher doses of B12, and other treatments to lower total homocysteine may be needed for some patients |
| Flicker *et al*.[41] | 2006 | Australia | Clinical trial | 299 men | 2 | 2 mg of folate, 25 mg of B6, and 400 micro g of B12 or placebo | The tHcy-lowering effect of B vitamins was maximal in those who had low B12 or high tHcy levels. Community-dwelling oldermen, who are likely to be deficient in B12 or have hyperhomocysteinemia, may be most likely to benefit from treatment with B vitamins |
| Wang *et al*.[44] | 2010 | USA | Systematic review | 13,000 | - | Supplementation vitamin D | Vitamin D supplements at moderate to high doses may reduce CVD risk, whereas calcium supplements seem to have minimal cardiovascular effects |

FFQ=Food frequency questionnaire, CVD=Cardiovascular disease, CVT=Cardiovascular thrombosis

and vegetables per day in 257,551 individuals followed-up for 13 years.[59] Studies that assess the relation between vegetables and fruits consumption and stroke risk is shown in Table 6.

***Meats***

Red meat consumption has been positively associated with blood pressure, incidence of hyper-tension, metabolic syndrome, and inflammation.[60-63] Although, red meat consumption may be a risk-factor for stroke, epidemiologic studies of red meat consumption in relation to the stroke incidence and mortality rate are sparse and results are inconsistent. We recently reported on the associations of red and processed meat consumption with stroke incidence in the Swedish Mammography Cohort study.[12] In that cohort, a high processed meat consumption was associated with a statistically

**Table 4:** Studies of the relation of salt, potassium, calcium

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/ intervention | Association |
|---|---|---|---|---|---|---|---|
| He *et al*.[47] | 2002 | UK | Meta-analysis of randomized trials | 2220 | 4 or more weeks | Reduction in salt intake | Long-term reduction in population salt intake would be predicted to reduce stroke deaths immediately |
| Strazzullo *et al*.[50] | 2009 | Italy | Meta-analysis of prospective studies | 177,025 | 3.5-19 years | FFQ | High salt intake is associated with significantly increased risk of stroke |
| Khaw *et al*.[51] | 1987 | USA | 12-Year prospective population study | 859 | 12 years | 4-hour dietary potassium intake at base line and subsequent stroke | High intake of potassium from food sources may protect against stroke-associated death |
| D'Elia *et al*.[52] | 2011 | Italy | Meta-analysis of prospective studies | 247,510 | Follow-up of at least 4 years | FFQ | Higher dietary potassium intake is associated with lower rates of stroke |
| Li *et al*.[55] | 2012 | Germany | Prospective | 23,980 | 11 years | FFQ | Increasing calcium intake from diet might not confer significant cardiovascular benefit |
| Larsson *et al*.[56] | 2011 | Sweden | Cohort | 34,670 | 10.4 | FFQ | Calcium intake was positively associated with risk of intracerebral hemorrhage |

FFQ=Food frequency questionnaire

**Table 5:** Studies of the relation of carbohydrate and stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Whelton *et al*.[60] | 2005 | USA | Meta-analysis of randomized, controlled clinical trials | 230,000 | 1 year or more | Supplementation fiber | Increased dietary fiber reduces blood pressure, blood glucose, serum triglycerides, and LDL cholesterol |

LDL=low-density lipoprotein

**Table 6:** Studies of the relation of vegetables and fruits with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Sauvaget *et al*.[62] | 2003 | JAPAN | Cohort | 257,551 | 13 years | FFQ | The protective effect of vegetables and fruits |

FFQ=Food frequency questionnaire

significant increased risk of stroke. To our knowledge, only two previous studies, one in the United States and one in Japan, have examined the relation between red meat consumption and stroke incidence[10] or mortality.[64,65] Studies that assess the relation between meat consumption and stroke risk is shown in Table 7.

***Tea***

Tea is the second most consumed beverage in the world, after water. Given its popularity, even small health benefits of tea could have considerable public-health implications. Tea is generally consumed in the forms of black, green, and oolong, all of which originate from the leaves of the plant Camellia sinensis.[66] There is a great deal of evidence that tea has been associated with a reduced risk of hyper-tension, diabetes, and atherosclerosis and all of which are major risk-factors of stroke.[67,68] A meta-analysis of nine observational studies of 194,965 individuals reported that consumption of three or more cups of tea (green or black) per day was associated with a 21% lower risk of stroke than in those who consumed less than one cup a day.[69]

Studies that assess the relation between tea consumption and stroke risk is shown in Table 8.

***Sugar-sweetened beverages or soft drinks***

SSBs, or soft drinks, include carbonated and non-carbonated beverages that contain sugar-based caloric sweeteners and are flavored with fruit juice or natural or artificial flavors. A higher consumption of SSBs has been linked to an increased risk of developing type 2 diabetes.[70] Limited data are available linking SSBs intake to the risk of stroke. In a case control study in Iran, no statistically significant association was found between habitual intakes of SSBs and stroke risk.[71] The Nurses' Health Study, a prospective cohort study of 84,085 women followed for 28 years (1980-2008), and the health professionals follow-Up Study, a prospective cohort study of 43,371 men followed for 22 years (1986-2008) provided data on soda consumption and incidence of stroke. Greater consumption of sugar-sweetened and low-calorie sodas were associated with a significantly higher risk of stroke. This risk may be reduced by substituting alternative beverages for soda.[72] Studies that assess the relation between SSBs or soft drinks consumption and stroke risk is shown in Table 9.

***Whole grains***

Higher whole-grain and fiber intakes are associated with greater insulin sensitivity, lower BMI, and lower risk of diabetes and metabolic syndrome. The most recent (2005) Dietary Guidelines for Americans recommend the consumption of ≥3 Oz equivalents (85 g) of whole-grain products per day and that ≥50% of grains be consumed as whole grains.[73,74] The effect of grain on ischemic stroke is less certain. Whole grain was reported to decrease ischemic stroke in a prospective study by Mozaffarian *et al*., who followed 3588 men and women aged 65 years and more, at baseline and followed for 8.6 years to determine the association between fiber consumption from fruits, vegetables and

**Table 7:** Studies the relation of meat with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Sauvaget *et al*.[67] | 2003 | Japan | Cohort | 257,551 | 13 years | FFQ | Relation between red meat consumption and stroke incidence |

FFQ=Food frequency questionnaire

**Table 8:** Studies of the relation of tea with stroke

| Author | Year | Country | Study design | Sample size | Duration of study (months) | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Hodgso *et al*.[70] | 2012 | Australia | Randomized controlled trial | 45 | 6 | 3 cups/d of either 1493-mg powdered black tea | Consumption of black decrease blood pressure |
| Hooper *et al*.[72] | 2008 | UK | Meta-analysis of randomized controlled trials | 220,000 | 8 | Black and green tea consumption | Black and green tea decrease blood pressure |

cereal sources and incident cerebrovascular diseases, which is defined as combined incidence stroke, fatal and non-fatal MI, and coronary heart disease death.[75]

White rice-based foods, which are high in refined carbohydrates, are widely consumed in the world. A case-control study was conducted to investigate the association between white rice-based food consumption and the risk of ischemic stroke in the Southern-Chinese population. Information on diet and life-style was obtained from 374 incident ischemic stroke patients and 464 hospital-based controls. The results provide evidence of a positive association between habitual rice food consumption and the risk of ischemic stroke in Chinese adults.[76] However, rice intake was not associated with risk of stroke in a study that followed 83,752 Japanese adults for a median of 14.1 years.[77] Studies that assess the relation whole grain consumption and stroke risk is shown in Table 10.

***Dietary pattern and stroke***

Evaluating the impact of nutrition at the food group and dietary pattern level will provide greater insight into the role of nutrition in stroke risk. In a systematic review, adherence to DASH, Mediterranean, and prudent dietary patterns reduced the risk of stroke, whereas, the Western dietary pattern was associated with increased stroke risk. Low-fat diet was not found to have a protective effect.[78]

***Dietary approaches to stop hypertension diet***

The DASH diet has been shown to lower blood pressure, however, little is known about its long-term effect on cardiovascular end points. In prospective cohort study, diet was assessed 7 times during 24 years of follow-up (1980-2004) with validated food frequency questionnaires. A DASH score based on eight food and nutrient components (fruits, vegetables, whole grains, nuts and legumes, low-fat dairies, red and processed meats, sweetened beverages, and sodium) was calculated. In this study, documented 2129 cases of incident non-fatal MI, 976 CHD deaths, and 2317 cases of stroke. Adherence to the DASH-style diet is associated with a lower risk of CHD and stroke among middle-aged women during

**Table 9:** Studies of the relation of sugar-sweetened beverages or soft drinks with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Niknam *et al*.[75] | 2013 | Iran | Case-control | 2000 | - | FFQ | No statistically significant association was found between habitual intakes of SSBs and stroke |
| Bernstein *et al*.[76] | 2012 | USA | Prospective cohort study | 84,085 | 28 years | FFQ | Greater consumption of sugar-sweetened and low-calorie sodas were associated with a significantly higher risk of stroke |

FFQ=Food frequency questionnaire, SSBs=Sugar-sweetened beverages

**Table 10:** Studies of the relation of whole grain with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Mozaffarian *et al*.[79] | 2003 | USA | Prospective cohort study | 3588 | 10 years | FFQ | Cereal fiber consumption late in life is associated with lower risk of incident stroke |
| Liang *et al*.[80] | 2010 | Australia | Case-control study | 374 incident ischemic stroke patients and 464 hospital-based controls | - | FFQ | Positive association between habitual rice food consumption and the risk of ischemic stroke |
| Eshak *et al*.[81] | 2011 | Japan | Prospective study | 83,752 | 14.1 years | FFQ | Rice was not associated with reduced risk of mortality from CVD |

FFQ=Food frequency questionnaire, CVD=Cardiovascular disease

24 years of follow-up.[79] Studies of the relation of DASH diet with stroke are shown in Table 11.

***Mediterranean diet***

The traditional Mediterranean diet is characterized by a high intake of monounsaturated fat, plant proteins, whole grains, fish, moderate intake of alcohol, and low consumption of red meat, refined grains, and sweets.[80] In case control study, during 2009-2010, 500 participants were enrolled; 250 were consecutive patients (77 ± 9 years, 55.6% men) with a first ischemic stroke and 250 population-based, control participants, matched to the patients by age and sex. Adherence to the Mediterranean diet was assessed by the validated Med Diet Score (theoretical range: 0-55). After various adjustments, each 1/55 unit increase in the Med Diet Score was associated with 17% lower likelihood of having an ischemic stroke.[81] In Northern-Manhattan Study as a population-based cohort study, (mean ± SD age of participants: 69 ± 10 years; 64% women; 55% Hispanic, 21% white, and 24% black) diet was assessed at baseline by using a food-frequency questionnaire in 2568 participants and a higher score on a 0-9 scale represented increased adherence to an Mediterranean diet. The Med Diet score was inversely associated with risk of the composite outcome of ischemic stroke, MI, or vascular death (P-trend=0.04) and with vascular death specifically (P-trend = 0.02).[82] A meta-analysis of 18 observational studies involving 2,190,627 people showed that a two-point increase in adherence to the Mediterranean diet was associated with a significant reduction of overall mortality (relative risk 0.92, 95% confidence interval [CI] 0.9-0.94) and cardiovascular incidence or mortality (0.9, 0.87-0.93) over 4-20 years of follow-up.[83] Studies of the relation of Mediterranean diet with stroke risk are shown in Table 12.

***Western diet***

High prudent pattern scores represented high intakes of vegetables, fruits, legumes, fish, poultry, and whole grains, whereas, western dietary pattern seems to include overconsumption of fructose and soft drinks, lower consumption of fiber, overconsumption of meat or saturated fat and cholesterol, lower consumption of fish or omega-3 fatty acids or PUFA and lower consumption of some vitamins, which may indicate a below the recommended consumption of vegetables and an unbalanced diet in general.[84] In a prospective cohort study, during 18 years of follow-up, 6011 deaths occurred, including 1154 cardiovascular deaths and 3139 cancer deaths. After multivariable adjustment,

**Table 11:** Studies of the relation of DASH diet with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Fung *et al*.[83] | 2008 | USA | Prospective cohort study | 88,517 | 24 years | FFQ | Adherence to the DASH-style diet is associated with a lower risk of CHD and stroke |

CHT=Coronary heart disease, FFQ=Food frequency questionnaire

**Table 12:** Studies of the relation of Mediterranean diet with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Kastorini *et al*.[85] | 2012 | Greece | Case/case-control study | 500 | - | FFQ | Highlights the cardioprotective benefits from the adoption of the mediterranean diet |
| Gardener *et al*.[86] | 2011 | USA | Population-based cohort | 2568 | 9 years | FFQ | Higher consumption of a mediterranean diet was associated with decreased risk of vascular events |
| Sofi *et al*.[87] | 2010 | Italy | Meta-analysis cohort study | 320,000 | - | FFQ | Higher consumption of a mediterranean diet was associated with decreased risk of vascular events |

FFQ=Food frequency questionnaire

**Table 13:** Studies of western diet with stroke

| Author | Year | Country | Study design | Sample size | Duration of study | Determination of status/intervention | Association |
|---|---|---|---|---|---|---|---|
| Fung *et al*.[89] | 2004 | USA | Prospective study | 71,768 women | 14 years | FFQ | Western diet increase stroke risk |

FFQ=Food frequency questionnaire

the highest quintile of prudent diet adherence in comparison with the lowest quintile of adherence showed a 28% lower risk of cardiovascular mortality (95% CI, 13-40) and a 17% lower risk of all-cause mortality (95% CI, 10-24). In contrast, the western pattern was associated with a higher risk of mortality from CVD (22%; 95% CI, 1-48), cancer (16%; 95% CI, 3-30), and all causes of death.[85,86] Studies of the relation of western diet with stroke risk are shown in Table 13.

## CONCLUSIONS

Observational studies have shown that stroke risk-factors can be managed by improving nutritional intake. Most interventional studies have failed to achieve meaningful clinical outcomes. More research is needed to improve the quality of evidence, relating to the association of many nutrients, foods, and dietary patterns with stroke risk. To establish a causative role for specific nutrients, foods, and dietary patterns in the pathogenesis of stroke, adequately powered, large randomized trials are needed in which the patient population and intervention are carefully described and the outcomes not only, include all strokes but also, distinguish first-ever and recurrent stroke, and pathological, and etiological subtypes of stroke. To examine, the effects of interactions between different genetic and environmental factors, large genetic epidemiological studies that minimize bias, confounding, measurement errors, and random errors are needed.

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