

Review Article

Is There an Implication of Nutrition and Lifestyle Habits in Glaucoma Disease? A Systematic Review

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Citation: Vlachogianni IC, et al. Is There an Implication of Nutrition and Lifestyle Habits in Glaucoma Disease? A Systematic Review. J Ophthalmol Adv Res. 2024;5(1):1-12. <https://doi.org/10.46889/JOAR.2024.5105>

Received Date: 13-02-2024

Accepted Date: 17-03-2024

Published Date: 25-03-2024



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Abstract

Purpose: Glaucoma is a leading cause of blindness in the western world with an estimate to increase the disease's prevalence. Ophthalmologists can handle the disease with medication, but the implication of nutrition is still neglected due to lack of data. With this review we try to elucidate the relationship between nutritional components and glaucoma disease.

Methods: We compiled relevant articles from 1990 until March 2021. From a total of 1334 articles that matched the keywords, we finally included 92 researches.

Results: Literature data were reviewed extensively for studies concerning glaucoma patient's nutritional habits, that also investigated nutrients with antioxidant properties such as vitamins, other components like omega-fatty acids or medicinal plants, lifestyle habits like smoking, physical activity or coffee consumption and body mass index range.

Conclusion: It is important to outline to patients that they should follow a diet rich in colorful fruits, vegetables, olive oil and fatty fish. These foods are sources of Vitamins A, C, E, D and minerals. Also smoking cessation, moderate caffeine consumption, frequent physical activity like walking and maintenance of normal BMI should be encouraged. However, further clinical researches are needed for definite conclusions on the implication of diet and medicinal plants in glaucoma.

Keywords: Glaucoma; Intraocular Pressure; Lifestyle; Nutrition; Vitamins

Introduction

Glaucoma is a leading cause of irreversible blindness worldwide; almost half of the glaucoma cases are undiagnosed and the prevalence is increasing over time [1,2]. The most common type of glaucoma diagnosis is Primary Open Angle Glaucoma (POAG) [3]. The research community knows that there are some risk factors such as age (above 60 years old), family history, steroid usage, diabetes, high myopia, hypertension, central cornea thickness and eye injury. Epidemiological data predict that patients with glaucoma will reach 111.8 million worldwide by 2040 [4].

It is known that glaucoma is a chronic disease with a genetic background, but these days environmental factors also seem to play an important role in the disease's progress. It is well known that nutrition correlates to low incidence of chronic diseases such as cardiovascular disease, which may also affect POAG prevalence. Healthy nutritional habits and a general healthy lifestyle are strongly correlated with better health and lower incidence of chronic diseases. For this reason, researchers have tried to examine the possible role of nutritional habits in glaucoma progress.

The scope of this study is to summarize the evidence regarding environmentally modifiable factors such as nutrition, exercise and lifestyle habits and discover whether these properties could affect glaucoma [5].

Methodology

This systematic review was performed according to the guidelines presented in the PRISMA 2020 statement [6]. The literature search was conducted using the PubMed database for articles published from 1990 until March of 2021. The search terms used in PubMed included (glaucoma and nutrition) or (glaucoma and diet) or (glaucoma and vitamins) or (glaucoma and medicinal plants) or (glaucoma and lifestyle habits) or (glaucoma and physical activity), applied mainly in humans. The included entries had to have an available abstract in English. Studies were only eligible if there were peer-reviewed. Titles and abstracts were scanned from the retrieved studies. Next, the full text of the remaining studies was read. In addition, the reference list from all identified studies was scanned in a similar fashion. Studies for dietary consumption should have used food frequency questionnaire or a 24-hr recall interview. Moreover, we included studies mentioning the type of glaucoma. In this review we included researches about Primary Open-Angle Glaucoma (POAG), Normal-Tension Glaucoma (NTG) and pseudoexfoliation glaucoma. First, we searched which nutrients affect glaucoma and then we categorized them in vitamins, minerals and fatty acids. We described the possible mechanism, the food source rich in the specific nutrient component, serum or blood levels if data was available, analysis of the effect of a nutrient after supplementation and finally we tried to present an overview of association. Secondly, we searched the effect of medicinal plants that affect the intraocular pressure or glaucoma progression. Thirdly, we collected data for the correlation between lifestyle habits such as alcohol, coffee and tea consumption, smoking, body mass index and physical activity. Finally, we tried to include the most common nutritional and lifestyle habits.

Results

The search terms in PubMed included a total of 1334 papers: 493 for 'glaucoma and nutrition', 160 for 'glaucoma and diet', 318 for 'glaucoma and vitamins', 29 for 'glaucoma and medicinal plants', 14 for 'glaucoma and lifestyle habits' and 320 for 'glaucoma and physical activity'. After adding the criteria of Review/ Systematic Review, 357 articles remained and with Clinical Studies, Randomized Clinical Trials (RCT) filters 55 articles were available with full text. The abstracts of these were scanned and 70 were selected. The reference lists of the included articles were scanned which resulted in 22 additional studies. Eventually, a total of 92 articles were included (Fig. 1).

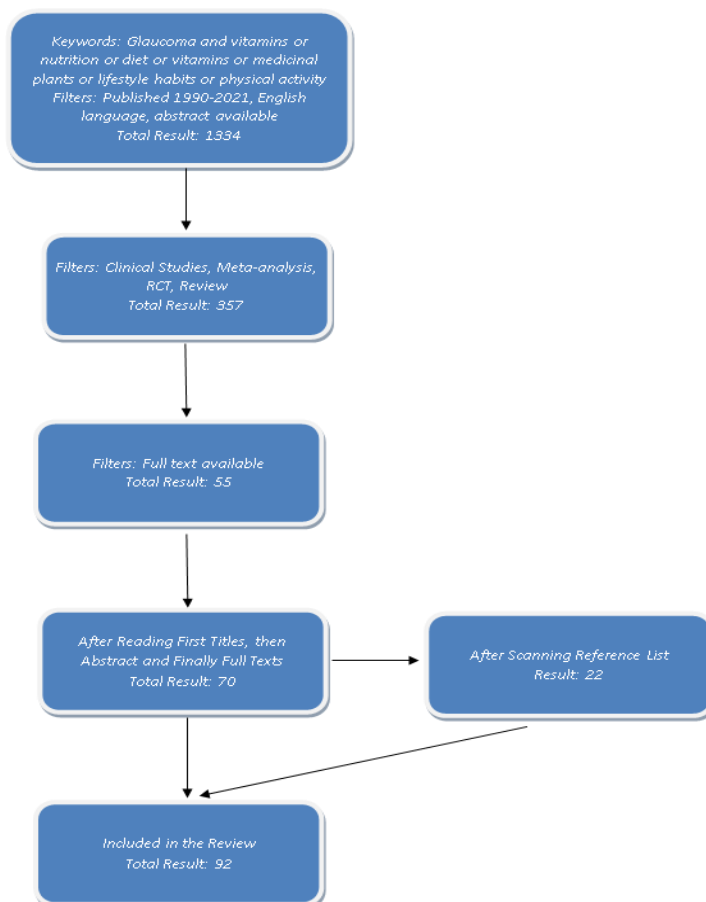


Figure 1: Flow diagram visualize the steps followed in this review.

Vitamins and Other Nutritional Components

Scientific data concerning vitamin supplements usage in glaucoma are few. The considerable amount of researches that suggest the connection between Oxidative Stress (OS) and glaucoma progression, strongly indicate the possible role of vitamins in disease through OS reduction [7]. Oxidative stress is a condition with excess amount of free radicals in the human body; the endogenous antioxidant system cannot amend this condition and systemic stress becomes chronic. Thus, vitamins and especially antioxidant vitamins could have a potential role in the progression of the disease [8].

Vitamin B Complex

Vitamin B3

The precursors of Nicotinamide Adenine Dinucleotide (NAD⁺) like nicotinic acid and other isoforms are niacin or vitamin B3. NAD⁺ is an essential cofactor for ATP generation in mitochondria which plays a vital role in ageing and stress. Although its role in stress could affect ageing and neurodegenerative diseases. Food rich in vitamin B3 are meat, legumes and cereals (<https://www.usda.gov/>). It has been reported that patients with POAG have reduced serum levels, indicating the potentially important role of the vitamin in the disease's progression [9]. Evidence from other researchers related a lower risk of glaucoma with higher intake of Riboflavin (B2) and Niacin (B3) [10]. Oral supplementation of B3 (1.5 mg and 3 mg, for 6 weeks) could improve retinal function in patients with glaucoma [11].

Vitamin B6, Vitamin B12

Studies have identified that hyperhomocysteinemia is a possible risk factor for ocular diseases. The theory behind the role of Homocystein (Hcy) in ocular diseases is that it induces apoptosis to retinal ganglion cells, in addition to the role of B complex vitamins in the metabolism of Hcy [12]. Dietary sources rich in these vitamins like fish, poultry and nuts must be consumed for the regulation of Hcy serum levels. The results for serum levels and the association with the risk of the disease remain controversial. It has been found that high serum levels of vitamins Pyridoxine (B6) or Cobalamin (B12) associate with high risk of glaucoma, although recent data from a meta-analysis revealed that there is no connection between B6, B12 levels in serum and glaucoma [13,14]. Especially for B12 the serum levels did not differ between glaucoma patients and a control group according to Atalay K, et al., [15].

Most researchers agree that in POAG patients the serum levels of these vitamins vary considerably, which is explained by variances in nutritional status, lifestyle habits and type of diet, different populations and methods of detection [14].

Vitamin A

Vitamin A is known for its important function in the retina. Vitamin A-based photoreceptor proteins are called opsins, like rhodopsin. Rhodopsin is found in the retina and is involved in phototransduction and antioxidant protection [16]. According to some researches the results are controversial. There are positive effects for dietary consumption of vitamins, but results from Nurses' Health Study, Health Professionals Follow-up Study and NHANES, did not find a significant correlation between vitamin A serum levels and glaucoma [8]. Another study, with older African-American women, showed that those who consume fruits and vegetables rich in vitamin A have a lower incidence for glaucoma [17]. Other data have shown that, low vitamin A and vegetable fat intake is correlated with an increased risk of glaucoma in a Japanese population (61 patients from a total of 581 participants), living in Los Angeles [18]. Dietary source of Vitamin A is also cod liver oil, which may have beneficial effects, but further studies are needed [19]. Research conducted at patients supplementing their diet with Vitamin A, couldn't find a correlation neither with the disease nor with serum levels [20]. It is important to notice that Vitamin A has an important role in retina function, but there is no detected correlation of vitamin's consumption with the risk of the disease.

Vitamin C

Vitamin C is an essential nutrient involved in tissue repair and is also a micronutrient with a strong antioxidant effect. It is true that glaucoma is linked with oxidative stress, which means production of reactive oxygen, nitrogen species and protein carbonylation [21]. Vitamin C in high doses has been found to reduce Intraocular Pressure (IOP) via its osmotic effect [22]. Also, its metabolites, like O-methylascorbate have a significant lowering effect in IOP [23].

Between the dietary intake of Vitamin C and risk of glaucoma the results are controversial [17]. Epidemiological data show that women who consumed 3 servings per day or more of foods high in Vitamin C (as fruits/vegetables, broccoli, strawberries etc),

had lower possibility of having glaucoma [17]. In detail, the consumption of dietary sources of Vitamin C like green leafy vegetables, positively correlates with the disease [17,24]. A specific type of diet, the Mediterranean, reduced the risk of glaucoma and other causes of blindness [25]. Higher intake of food rich in Vitamin C and a general low cholesterol diet may have an antioxidant effect in eye diseases like glaucoma [26]. Vitamin C which comes from fruits and vegetables and not from supplements has a positive effect on the disease [27]. In another study researchers suggest the idea that low levels of ascorbic acid may compromise lysosomal degradation and have an important role to the pathogenesis of glaucoma [28]. Supplementary low or high dose intake of Vitamin C and not serum levels, correlate with low odds of glaucoma [20,29]. Patients newly diagnosed with Normal Tension Glaucoma (NTG) had lower serum levels of Vitamin C in comparison with healthy control group [30]. Two genetic polymorphisms were linked with the risk of glaucoma and also with the low serum levels of the vitamin C [31]. There are studies that revealed the association of blood levels of vitamin C and glaucoma especially Normal Tension Glaucoma (NTG). In those patients it has been reported that they have lower serum levels of vitamin C compared to control group [8]. After analysis of Multi locus Genetic Risk Score (GRS) in Mediterranean population, a link between oxidative stress and primary open angle glaucoma was found, but there is no relationship between GRS and low levels of vitamin C [32]. In overall, studies results support the proposal for consumption of food rich in Vitamin C, because of its high antioxidant effect.

Vitamin D

Vitamin D serum levels are crucial for optimal function of optic chiasm in elderly people. Its deficiency is associated with reduced mean Ganglion Cell Complex (GCC) thickness, which can represent an early stage of optic nerve damage, prior to retinal nerve fiber layer (RNFL) loss [33]. Food rich in vitamin D are dairy products, cheese, salmon, cod liver oil and fatty fish. Researchers from South Korea, found in 2014, a correlation between vitamin D status and risk for open-angle glaucoma. They suggest that there is a reverse J-shaped association between 25(OH)D levels and the risk of OAG, with significantly elevated risk at lower 25(OH)D [34]. Vitamin D, according to our knowledge, has no correlation between vitamin levels and the risk of glaucoma. One possible explanation is the diversity of serum levels, weaknesses in the design or limited number of studies [14]. Results from a Korean National Health study show that osteoporosis was associated with age-related macular degeneration in women and not with other age-related eye diseases [35]. Vuković, et al., found that women with glaucoma had lower Vitamin D levels (mean value: 32.31 nmol/L) in comparison with control group (mean value: 64.17 nmol/L) [36]. This is an agreement with the results of a big cross-sectional study which concluded that lower 25(OH)D levels were significantly associated with an elevated risk of glaucoma in women [37]. In another case-control study on 150 glaucoma patients and 164 healthy individuals, the results revealed that vitamin D serum status is associated with the presence of the disease but not with its severity. Insufficiency of vitamin D was defined as 25OHD $\leq$ 75 nmol/L [38]. In a study conducted in African population, a correlation was found between severity and vitamin D serum levels. In more detail patients with advanced glaucoma had lower serum levels of vitamin D compared to early glaucoma and normal subjects [39]. Recently Atalay K, et al., proved that in glaucoma patients the serum levels of Vitamin D are lower compared to controls [15]. On the other hand, in a recent study the researchers did not find a statistically significant result, but serum levels of vitamin D were lower in patients with glaucoma than control group [40]. Vitamin D metabolites have been detected in patient's plasma which means a different lipid profile [41]. The measurement of metabolites (Metabolomics) may be an approach for personalized therapeutic options. Some compounds and ratios related with glaucoma are palmitoylcarnitine, sphingolipids, vitamin D-related compounds, steroid precursors, glutamine-glutamate/creatine and N-acetylaspartate/choline ratio [42].

A case-control study concludes that there is no connection between serum vitamin D levels and intraocular pressure. The second part of the study was intervention; participants with low serum levels consumed 20,000 IU twice per week or placebo for 6 months. The reduction in IOP does not significantly differ between the groups [43]. It has also been shown that calcitriol, the biologically active form of vitamin D, inhibits angiogenesis both in cultured endothelial cells and in retinas from guinea pigs with retinoblastoma or oxygen-induced ischemic retinopathy [44]. Genetic factors have also been associated with risk factors of glaucoma [45]. There is also evidence that topical application of vitamin D analogs reduces intraocular pressure [46]. These data support the theory that vitamin D supplementation may be a therapy for ocular diseases.

Vitamin E

Glaucoma pathogenesis is not well known yet, but there is growing awareness that some vitamins may be implicated. Few studies suggest that Extracellular Matrix (ECM) remodeling is correlated with increased intraocular pressure in POAG. It is true that ECM is influenced exogenously by water-soluble antioxidants and endogenously by lipid soluble constituents like Vitamin

E [47]. He, et al., proposed that mitochondrial complex I defect is associated with the degeneration of trabecular meshwork cells in patients with POAG. Antioxidants and mitochondrial permeability transition inhibitors can reduce the progression of this condition [48]. The best way to enrich your diet with Vitamin E, is the systematic consumption of plant-based oils such as olive oil and nuts.

Zanon-Moreno V, et al., found a correlation between low serum levels of vitamin E and glaucoma patients [31]. Some years later the same team analyzed the genetic risk score but didn't find a correlation of antioxidant vitamins with glaucoma [32]. Glaucoma is linked with higher protein carbonylation, decreased total reactive antioxidant capacity and lower organ concentration of Vitamin E [21]. Experiments in ganglion cell lines with microspheres from Vitamin E, show a protecting effect in glaucoma for up 11 weeks [49]. NTG patients have lower levels of Vitamin E, reinforcing the aspect that oxidative stress plays a role in the course of the disease [50]. An intervention in a rat-model of induced glaucoma, showed that Vit E-deficient diet with surgically induced intraocular pressure elevation induced significantly more retinal ganglion cells death than rats fed by a normal diet. This phenomenon may be related to the increased level of lipid peroxidation in Vit E-deficient rats [51]. Data link the antioxidants like Vitamin E and carotenoids with a potentially beneficial role in glaucoma treatment [52].

Lipid peroxidation happens in glaucoma in a systematic basis, for this reason Vitamin E activity as a neuroprotective agent is important [53]. Vitamin E has been recorded as a protective factor for elastin apoptosis and remodeling [54]. An intervention study with 3 groups Group A, without tocopherol supplementation, Groups B and C with 300 and 600 alpha-tocopherol acetate mg per day respectively, showed a higher antioxidant activity in Group C suggesting the alpha tocopherol's beneficial effects, for protecting retina from glaucomatous damage [55]. A diet rich in antioxidants should be a target for the prevention of vision deterioration [56].

Fatty Acids

There is evidence that fatty acids could influence optic nerve blood velocity and red blood cell aggregability in POAG. Fatty acids EPA and DHA could modulate systemic microcirculation, this could be beneficial in glaucoma, which is a disease that is highly characterized by main physiological changes in ocular blood flow and optic neuropathy. Abnormalities in the normal function of optic nerve or red blood cell aggregation could be correlated with glaucoma. Foods rich in omega 3 fatty acids are fish, nuts and plants like flaxseed and avocado.

Usage of drugs based in ingredients derived from prostaglandins like PGF2a could influence ocular blood flow in positive or negative direction. There are drugs with short- and long-term effects, which will result in an increased ocular perfusion pressure leading to an improvement of ocular hemodynamics [57].

Research with glaucoma and control groups, measured lower levels of Eicosapentaenoic (EPA), Docosahexaenoic (DHA) fatty acids and total omega-3 Long-Chain Polyunsaturated Fatty Acids (LCPUFA) in red cells and in plasma of glaucomatous patients [58].

A diet with increased omega-3 and decreased omega-6 fatty acids could thus favor an increase in intraocular pressure reducing synthesis of PG-F2, leading to a decrease in uveoscleral outflow. The fact is that for many nutritional factors further studies are required to clarify real implications [54].

Minerals

Minerals are important for homeostasis regulation, hydrodynamic balance and co-factors of enzymatic reactions. Minerals like Sodium (Na), Potassium (K), Magnesium (Mg) are involved in biomineralization and intercellular interaction at drainage areas [59].

In order to enrich your diet with these minerals one must consume green vegetables, fruits like orange, banana and seafood. There is evidence that calcium blockers could help NTG patients. Gaspar AZ, et al., evaluated the effect of supplementary intake of 121.5 mg magnesium, a blocker of N-methyl-D-aspartate (NMDA) receptor-related to calcium, two times per day for a month. The result showed that magnesium (Mg) improves peripheral circulation in patients with vasospasm [60]. Also, Ekici F, et al., considered that Mg consumption may improve blood flow by modifying Endothelin-1 (ET-1) and endothelial Nitric Oxide (NO)

pathways [61]. Lee JY, et al., found in Korean population that insufficient dietary intake of minerals such as potassium, calcium and phosphorus may be associated with an increased risk of the disease [62].

Medicinal Plants and Citicoline

There is some evidence about marijuana usage in glaucoma. The results showed that this plant was effective in lowering IOP, to 60-65% of the users. Marijuana has been used for lowering IOP, but the results lasted for up to 3-4 hours, thus it required a daily dose of 6-8 times for a therapeutic effect [63]. The statement of the American Glaucoma Society in 2010, points out that therapeutic effects are short term and adverse effects could appear, but it is clear that more studies are required to clarify extended use as a therapy.

Ginkgo Biloba has also been studied for its actions in Glaucoma, because of its antioxidant, anti-inflammatory, neuroprotective and vasorelaxating effects [63]. Ginkgo biloba extract has been proposed as a therapeutic agent, because of its actions and few adverse effects. Medicinal fruit like Bilberry, with a high content in anthocyanins, show antioxidant and anti-inflammatory actions and may be effective for patients [22,64]. Side effects have only been reported in the case of overdose [63].

Citicoline

Citicoline (cytidine 5'-diphosphocholine) is a naturally produced endogenous compound, which has a background of experimental and clinical studies and has been investigated as a novel therapeutic agent for the management of glaucoma [65]. Citicoline is a dietary source of choline and cytidine. Based on USDA database good food sources of choline are eggs, meat, organ meats (like liver) and seafood (<https://www.usda.gov/>). However, according to Gandolfi S, et al., a safer and more effective option to elevate citicoline levels, is by food supplements instead of an increase of consumption in choline rich food [65].

Because glaucoma affects retina which is a part of the Central Nervous System (CNS) it probably has similarities with other neurodegenerative diseases like Parkinson's. Citicoline has well known beneficial effects for these kinds of diseases, thus it is not surprising that it has been also suggested as an neuroprotective agent in glaucoma [65].

On 2003 Rejdak, et al., showed that oral consumption of 1 g per day citicoline in 21 patients with OAG reduced Visual Evoked Potentials (VEP) latency and increased VEP amplitude [66]. In another study 41 patients with glaucoma were taking an oral solution of citicoline for 2 years and the results showed that citicoline could significantly reduce the progression of the disease [67]. Parisi, et al., determined that oral consumption of 1.6 g citicoline for 8 years, stabilized and improved the electrophysiological and visual ability in glaucoma, confirming their previous results [68]. Results from a pilot study showed that Citicoline Therapy (CT) was effective in slowing POAG progression. More specifically 500 mg of citilocene per day for 4 months with 60 days of wash out, a 4 times repetition and follow up after 12 months; seem to stabilize the beneficial effects of citicoline. Further studies are needed on a larger population and with a longer follow-up time to confirm the findings of the pilot study [69]. People at high risk of developing glaucoma, had either citicoline deficiency or increased requirements, although there is a lack of evidence for beneficial effects after supplementation. Due to the different dosages of citicoline, ways of consumption (oral solution/ tablet) and duration of therapy, further examination is required to determine the pathophysiology of the disease.

Lifestyle Habits

Smoking

Genetics factors for glaucoma and exposure to environmental stress factors such as smoking, corticosteroids and diabetes may contribute to manifestation of glaucoma at an earlier age. Especially male smokers have a higher risk to establish the disease [70]. Cessation of smoking may help glaucoma progress insomuch there is evidence for a stronger link between current smoking and POAG. Heavy smoking may be more aggravating [71]. These results are in harmony with the fact that there is a direct association between the disease and the number of cigarette packs per year. This association could not be proved for former or passive smokers [72].

One third of the glaucomatous patients visiting an ophthalmologist have elevated blood pressure [73]. Smoking is characterized from decreased blood flow in vessels and capillaries. Also, higher intensity of smoking was significantly associated with decreased optic nerve head microvasculature [74]. On the other hand, researchers concluded that there is no need to control smoking in order to delay glaucoma progression. This is based on evidence that vessel density is not affected from acute smoking

a cigarette or by the duration after the last cigarette [75]. Among cigarette smokers, heavy smoking (>32.9 pack-years) defined a high number of packs of cigarettes smoked per day associated with higher odds of glaucoma. Health care providers should include this association when counseling patients on their smoking habit [76].

Alcohol Consumption

Moderate alcohol consumption is linked with many beneficial health effects and is a modifiable lifestyle factor which is linked with eye diseases. There are studies that relate alcohol consumption with known genetic polymorphisms. Excessive drinking should be avoided regardless of polymorphisms [77]. The effect of alcohol consumption on IOP was investigated on Korean population. Drinking more than 2 times per week was associated with increased IOP in men without OAG, while in women with OAG drinking alcohol more than 4 times per week was associated with increased IOP [78].

Coffee and Tea Consumption

Caffeine (1,3,7-trimethylxanthine) is a common ingredient in several beverages such as coffee, tea and beverages. A regular cup of coffee (236 mL) contains 135-150 mg of caffeine. Caffeine could affect the IOP but there is no strong evidence to establish a correlation [79, 80]. In detail caffeine sources such as coffee and tea also contain flavonoids and other molecules with high antioxidant activity. Moderate coffee and tea consumption, has been correlated with a decrease in mortality in adults. Health scientists must give guidelines about which beverages which contain caffeine [81]. Heavy drinking should be avoided, while moderate consumption (1 cup coffee or 2 cups tea per day) should be encouraged [82].

Body Mass Index

It is not well known how body composition could affect POAG progression, but some theories exist; A higher BMI relates to a decreased prevalence of POAG, especially in women. There is a hypothesis that a higher intracranial pressure, which is linked to a higher BMI, may protect against optic nerve damage [83,84]. Also, lower BMI (<19 kg/m²) remained adversely related to glaucoma in women [85]. It is essential for all glaucoma patients to maintain a healthy body weight.

Physical Activity

It is well known that moderate physical activity correlates only with beneficial health effects. Physical activity is inversely associated with the risk for developing glaucoma [86,87]. Wang YX, et al., showed that the physical activity level was statistically independent from glaucoma [88]. It is important to keep in mind that glaucoma patients exhibit mental and physiological problems which may also improve with physical exercise, moreover patients at severe stage of the disease, may have a positive effect by physical activity [89,90]. If the correlation between physical exercise and glaucoma is defined, it may serve as an available preventative factor for the disease in the future [91,92].

Discussion

In this review we summarized the most relevant studies concerning the association between nutritional factors and glaucoma. We thoroughly searched the literature to clarify the correlation between nutrition and glaucoma. We focused on studies with participants with NTG, OAG or increased risk of developing the disease. Vitamins such as vitamin A are well known for their role on retina. The studies are controversial, there is evidence that people who consume fruits rich in vitamin A have low incidence of the disease, but this hypothesis wasn't confirmed via serum analysis. For example, Kang, et al., analyzed 474 self-reported glaucoma cases confirmed by medical chart review that have primary open-angle glaucoma with visual field loss and checked many vitamins with antioxidant action in serum, but they didn't find a correlation [92].

Vitamins B6 or B12, have also been linked to the disease, but other studies did not confirm this relation. Vitamin D, a well-studied vitamin for its beneficial effects has also been studied for glaucoma. Vitamin D is implicated in the glaucoma progress, because there is evidence for a correlation between its deficiency and a high risk for glaucoma. The analysis of serum levels and dietary supplementation may be encouraged. According to current literature, it is obvious that oxidative stress plays an important role in the pathogenesis of glaucoma. For this reason, many researchers focus on the implication of antioxidants vitamins. Vitamin C, a vitamin well known for its antioxidant action, seems to have a positive effect. The consumption of sources high in ascorbic acid and normal serum levels, are correlated with low incidence of the disease. Also, vitamin E consumption in humans, as a lipid soluble vitamin, support theories which show that its antioxidant activity could affect mitochondrial permeability, reduces lipid peroxidation and protein cardonylation. The inhibition of these reactions may play a protective role

in the progression of glaucoma.

Medicinal foods also have role for their antioxidant and anti-inflammatory effect. Foods like bilberry and Gingko Biloba have been studied and proposed as a therapeutic agent. Also, omega 3 fatty acids, like EPA and DHA, are anti-inflammatory agents. These fatty acids, impaired in microcirculation so may have beneficial role in intraocular pressure. There are studies which show the implication, but more studies are needed.

Last but not least, we have to mention that recent studies revealed the importance of a healthy lifestyle for the progression of the glaucoma, are many. The avoidance of smoking, the moderate consumption of alcohol/ coffee, the weekly physical activity and the maintenance of a healthy body weight, are some of the healthy advice for glaucoma patients. According to the current review, a patient with OAG should be encouraged to follow a healthy lifestyle with a diet plan rich in food sources of antioxidant vitamins, omega 3 fatty acids, normal BMI, moderate physical activity and avoidance of smoking. This approach can help to improve the patient-physician relationship and perhaps positively influence the patient adherence to IOP-lowering medications, both of which will improve glaucoma care.

Personalized medicine and nutritional care may be a nice combination for a holistic suggestion to those patients. Glaucoma patients will live with the disease, so it will be a nice approach to encourage them to check their nutritional status. The serum levels of important antioxidant vitamins like C, E and Vitamin D levels are some of the parameters that should be considered. Also, it is important to support those people with dietary advice, concerning foods which are high in those vitamins. In this way health scientists will be able to give personalized instructions for glaucoma care.

Conclusion

In conclusion, although there is broad evidence that oxidative stress plays an important role in the pathogenesis of different types of glaucoma, studies on the effect of dietary intake of nutrients on glaucoma are few. With our current knowledge, it is difficult to give a patient with glaucoma clear nutritional guidelines.

Conflict of Interests

The authors have no conflict of interest to declare.

Declaration of Interest

The authors have no relevant affiliations or financial involvement with any organization in the manuscript.

Funding Statement

This research received no specific grant from any funding agency.

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