Is Dietary Intervention a Viable Method for Improving Outcomes in Adult Patients with Asthma?

Jennifer Grolimund

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Cynthia Goodrich, Ed.D., M.S.N., RN, CNE
Thesis Chair

_____
Chad Magnuson, Ph.D.
Committee Member

_____
Lucinda Drohn, M.S.N., RN
Committee Member

_____
James H. Nutter, D.A.
Honors Director

_____
Date

Abstract

Asthma is a disease process characterized by episodic inflammation of the lower airway in response to various triggers. Those with asthma have trouble breathing effectively during an acute episode, making asthma a potentially life threatening condition. Standard medical treatment of asthma, including medications and environmental changes, can be effective at reducing or eliminating negative outcomes in patients with asthma. However, a holistic approach to patient care, including an examination of dietary influence, may also be useful for patients trying to manage the course of their illness. Variations in intake of individual nutrients or in total dietary patterns may play a role in how people with asthma experience symptoms. Two issues that need to be addressed regarding dietary intervention as a component of asthma management are (a) identifying what dietary elements are effective at improving asthma management; (b) implementing interventions that will facilitate appropriate dietary changes in an adult asthmatic patient population.

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Overview of Asthma

Asthma is a disease process characterized by episodic inflammation and narrowing of the lower airway in structures called bronchioles. This process limits movement of air in and out of the lungs and makes effective breathing difficult for those experiencing symptoms. Episodes of asthma, also called asthma attacks, can be life threatening and may be triggered by a variety of environmental, physiological, and psychological factors. These factors can include, but are not limited to: allergies, air quality, environmental temperature, physical stress, and emotional stress. While standard medical treatment of asthma can be effective at stabilizing critical symptoms and reducing or eliminating negative outcomes for those with asthma, a holistic approach to patient care, including an examination of dietary influence, may also be beneficial in achieving positive patient outcomes (Chih-HungGuo, Po-Jen, Kuan-Pin, & Pei-Chung, 2012; Garcia-Larsen et al., 2011; Kligler et al., 2011; McKeever et al., 2010; Roberston-Malt, 2010; Sexton et al., 2013). If dietary intervention is to become a well-established component of asthma management, key issues that need to be addressed include (a) identifying what dietary elements are effective at improving asthma management; (b) implementing interventions that will facilitate appropriate dietary changes in an adult asthmatic patient population.

Impact of Nutrition

Two areas of interest in relation to dietary research are the influence of individual nutrients and the influence of total dietary patterns on respiratory health in patients with asthma. Studies have been conducted on polyunsaturated fatty acids (PUFAs), vitamins, carotenoids, and antioxidants in order to evaluate specific effects on asthma (Barros et al., 2011; di Giuseppe, 2012; Schöttker et al., 2013; Thyagarajan et al., 2011; Wood et al., 2012; Yang, Xun, & He, 2013). Omega-3 (n-3) PUFA is generally associated with a decrease in inflammation, but intervention studies have produced inconclusive results as to the efficacy of dietary n-3 PUFA in improving outcomes for patients with asthma. A low ratio of omega-6 (n-6) PUFA to n-3 PUFA, which is not found in the typical Western diet of processed foods, may improve asthma control, though studies surrounding this nutritional influence on asthma are also inconclusive (Barros et al., 2011; Yang et al., 2013).

Polyunsaturated Fatty Acids

Fatty acids, including n-6 PUFAs, n-3 PUFAs, and saturated fatty acids (SFAs) are involved in the metabolism, structure, and function of cells in the human body and are essential to several key processes in the body. SFAs like lauric acid contribute to cellular processes that promote inflammation. N-6 and n-3 PUFAs are also important in regulation of inflammation in the body. N-6 PUFAs, including arachidonic acid, are used in production of pro-inflammatory mediators like prostaglandins, thromboxanes, and leukotrienes. N-3 PUFAs, chiefly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are used in production of anti-inflammatory mediators or pro-inflammatory mediators that are less potent than those produced with omega-6 PUFAs. EPA in

particular uses cyclooxygenase and 5-lipooxygenase pathways, the same chemical pathways as arachidonic acid, thus competing with the n-6 PUFA for the same resources and decreasing the amount of pro-inflammatory mediators that can be produced from arachidonic acid (Calder, 2012; Fetterman & Zdanowicz, 2009).

Both n-3 and n-6 PUFAs are normal components of certain cell membranes. Usually, the concentration of n-6 PUFAs in the cell membranes is higher than the concentration of n-3 PUFAs. However, numerous studies identified by Calder (2012) show that increasing dietary intake of EPA and DHA, n-3 PUFAs, leads to dose dependent, gradual increases in n-3 PUFA concentrations in the cells over a period of days to weeks. These increases in n-3 PUFA concentration also correspond with a decrease in arachidonic acid availability. Since n-6 PUFAs contribute to producing stronger pro-inflammatory mediators than n-3 PUFA produces, this shift in concentrations decreased the availability of components conducive to inflammation. The net effect of this shift is that the body produces a more moderate inflammatory response after supplementation with n-3 PUFAs (Calder, 2012).

Although studies are still inconsistent as to how much these cellular changes translate into mediating symptom severity and incidence, shifts in PUFA concentrations from dietary supplementation may be beneficial in diseases with excessive inflammatory response as a component. As previously noted, asthma is one of these diseases. Multiple published reviews of research literature show that consistent supplementation with n-3 PUFAs, EPA and DHA, over time may help improve symptoms and over lung function in people with asthma by altering the inflammatory response (Calder, 2012; Fetterman & Zdanowicz, 2009).

The pathophysiology of asthma is characterized by airway hyper-reactivity, bronchoconstriction, and airway edema. In other words, the lungs of asthmatic patients are easily irritated and prone to a level of inflammation that exceeds what is beneficial for maintaining a healthy airway. When inflammation is triggered, the asthmatic airway becomes smaller and starts to accumulate fluid, increasing the work of breathing and potentially occluding the airway to the point where the asthmatic patient cannot breathe at all. The inflammatory process of asthma starts with increased involvement of interleukin-4, immunoglobulin E, and mast cells; then as inflammatory mediators are produced, blood vessels dilate and allow various cells and mediators into the area of inflammation, leading to bronchoconstriction and mucus accumulation (Kaufman, 2014). The main idea behind supplementation with fatty acids in asthmatic patients is that the shift in production of inflammatory substances, including interleukins, will limit the severity of the inflammatory response and help asthmatic patients to regain some control over their condition and have improved quality of life (Calder, 2012; Fetterman & Zdanowicz, 2009; Kaufman, 2014; Kitz et al., 2010; Kligler et al., 2011).

One study in 2010 focused on how concentrations of PUFAs in the body correlated with the response of adult asthmatic participants to a known allergen, grass pollen. This study found that participants with asthma generally had significantly lower ratios of n-3:n-6 PUFAs in their bodies compared to the healthy control group. There was also a strong positive correlation between low n-3:n-6 PUFA ratio and stronger inflammatory response in asthmatic participants, as shown by bronchial constriction. Participants with high levels of n-3 PUFA relative to n-6 PUFA had less severe responses to a known asthma trigger than participants with low n-3 PUFA. This study concluded

that n-3 PUFA was beneficial for the participants of this study and suggested that other people with asthma might benefit from increasing n-3 PUFA dietary intake, although the small sample size and the inclusion of only one phenotype of asthma limits how much these results can be generalized to the larger population of people with asthma. Another limitation is that the design of this study can only result in identifying correlations, not causation (Kitz et al., 2010).

Another study in 2011 examined lung function, asthma control, and dietary intake of fatty acids in 174 people with asthma, looking for any significant causal or correlational relationship between dietary fatty acids and asthma. This study found that participants with more asthma control tended to have lower n-6:n-3 ratios than participants with poor asthma control. The results of this study also showed a positive correlation between high asthma control and high concentrations of n-3, alpha-linoleic acid (ALA), EPA, DHA from dietary intake. Researchers concluded that diets high in n-3 PUFAs might improve patient chances of having good asthma control and reduction in symptoms. However, the small sample size and convenience sampling method limit the generalizability of this study, and the lack of an intervention or control group means that the results cannot prove a cause-effect relationship between dietary fatty acids and asthma control (Barros et al., 2011).

Some studies assess impact of dietary fatty acids by incorporating n-3 PUFA supplementation into more comprehensive interventions, making it difficult to link health benefits directly to the effects of n-3 PUFA. One such study by Kligler et al. (2011) tested the effectiveness of adding multiple complementary therapies to asthma patients receiving standard medical management for their condition. Participants in the control

group received only the standard medical treatment of asthma, while participants in the intervention group received various complementary therapies in addition to the standard medical treatment. Among these interventions was regular supplementation of fish oil, a substance high in n-3 PUFAs EPA and DHAs. This study also included group sessions of yoga, journaling, dietary counseling, and supplements of vitamin C and hops extract. The study lasted for 6 months and showed improved quality of life and reduced symptom incidences as reported by the participants; however, there was no significant change in lung function as measured by spirometry, forced vital capacity (FVC), or forced expiratory volume in the first second (FEV1). While this study demonstrated some level of effectiveness of group-oriented holistic care programs for patients with asthma, the results were inconclusive as to the asthma-related health benefits of dietary n-3 PUFA supplementation (Kligler et al., 2011). Another study focused only on dietary supplementation, but included vitamin A, vitamin C, vitamin E, various antioxidants, zinc, selenium, and calcium in addition to supplementation with fish oil. Patients in this two-month study had significant improvement in asthma control and statistically insignificant improvement in lung function tests, but specific benefits could not be linked directly to fish oil supplementation (Chih-HungGuo et al., 2012).

Systematic reviews showing inconsistent results across studies. In general, research literature pertaining to fatty acids and asthma frequently indicates that n-3 PUFAs might be beneficial in asthma, but fails to show consistent results that suggest a measurable impact of dietary n-3 PUFA on adult asthma patients. A systematic review and meta-analysis done by Yang et al. (2013) analyzed 11 prospective cohort studies and 4 randomized control trials pertaining to asthma and dietary intake of fish oil. Several of

the studies considered in this review process were not included in the final analysis because of flaws in how they reported their data, and some of the randomized control trials that were included had small sample sizes that make generalizing results difficult. The finished review indicated that intake of fish oil may be beneficial for reducing the risk of getting asthma in children, but that no reliable conclusions could be drawn from the research pertaining to adults (Yang et al., 2013).

An overview of 23 Cochrane meta-analyses looking at the effectiveness of various complementary therapies, including dietary supplementation with n-3 PUFAs, also concluded that available research fails to establish consistent, reliable, and generalizable data about dietary n-3 PFUAs and asthma. This overview identified that small sample sizes, flawed research designs, and inadequate reporting of study results are prevalent in the research literature on these therapies. These research issues limit the medical professional's ability to draw up clinical guidelines and implement potentially helpful therapeutic interventions, despite pervasive hints at the potential effectiveness of these therapies in asthmatic patients (Roberston-Malt, 2010).

Possible causes of inconsistent results and areas for further research. In addition to small study sample sizes and problems with reporting data, other potential reasons for inconsistent results with PUFA supplementation on adult asthmatic patients might be tied to different methods of assessing dietary intake and response to intervention. Some studies use food frequency questionnaires and similar participant reported measures of dietary intake, while other studies analyze blood samples to determine concentrations of different diet-derived substances in the body (Barros et al., 2011; Kitz et al., 2010). Studies can also use a wide variety of methods to measure asthma control, lung function,

and symptom response to intervention, potentially making comparison between studies difficult. Questionnaires rely on patients' perceptions of symptoms, but studies can also include tests like exhaled nitric oxide, FVC, FEV1, spirometry, peak flow meter, or metacholine levels to help determine the overall picture of an asthmatic patient's condition (Barros et al., 2011; Kitz et al., 2010; Kligler et al., 2011).

Other considerations that warrant further research and may account for inconclusive results in the literature include: variations in supplement quality, duration, and dosage levels, and genetic or physiologic variations in asthma presentation causing differences in response to nutritional intervention (Barros et al., 2011; Calder, 2012; Fetterman & Zdanowicz, 2009; Kitz et al., 2010; Mickleborough & Lindley, 2013; Wendell, Baffi, & Holguin, 2014). The last consideration is especially interesting, as further research into asthma phenotypes and polymorphisms might allow clinicians to tailor dietary supplements to specific patients based on genetics and the etiology of a patient's condition (Fetterman & Zdanowicz, 2009; Mickleborough & Lindley, 2013; Wendell et al., 2014).

The literature review conducted by Mickleborough and Lindley (2013) looked at the effectiveness of different dosage schedules and concentrations for n-3 PUFA supplementation as utilized in some studies. For dosages of fish oil, this review identified that supplementation with 3.2 g EPA and 2.2 g DHA daily for three weeks decreased pro-inflammatory mediators in one study of asthmatic participants, and that some other studies suggest similar dosages might compare with the asthma drug Montelukast in mediating inflammation and bronchoconstriction long-term (Mickleborough & Lindley, 2013), although not every study shows favorable results for short term supplementation

with EPA and DHA (Brannan et al., 2015). The Mickleborough and Lindley review also identified studies where smaller doses of EPA and DHA, anywhere from 120 mg to 1 gram daily, were effective at improving FEV1 in small amounts if taken consistently for 10-12 months (Mickleborough & Lindley, 2013). With such a wide range of potentially effective doses, this review suggested that n-3 PUFA supplementation might be most effective if the dose is tailored to specific patient response (Mickleborough & Lindley, 2013).

Tailoring n-3 PUFA doses might be easier with further research into asthma phenotypes and polymorphisms, which various reviews identify as possible reasons for varied participant responses to n-3 PUFA supplementation. A phenotype is an observable characteristic in the body, and in asthma the term is used to differentiate between the variations of triggers. For example, exercise-induced asthma would be a different phenotype than allergy-induced asthma. A polymorphism is a common genetic variation, and some asthma research suggests that responses to dietary intake of fatty acids may be influenced by polymorphisms in the 5-lipoxygenase pathway, which takes arachidonic acid or n-3 PUFAs and produces inflammatory mediators (Calder, 2012; Fetterman & Zdanowicz, 2009; Mickleborough & Lindley, 2013; Wendell et al., 2014).

Further research into the effectiveness of dietary fatty acid supplementation, including how genetics and phenotypes impact asthma response to n-3 PUFAs, might allow for clinicians to eventually develop standards of practice for inclusion of n-3 PUFA as a supplement to current asthma treatment methods. Until that time comes, however, the specific benefits of implementing dietary changes with n-3 PUFAs are unclear for an adult asthmatic patient population. Patient decisions regarding n-3 PUFA

supplementation should be made in light of this uncertainty, noting that the main adverse effects of fish oil, a widely used n-3 PUFA supplement, are only a slight fishy aftertaste and the possibility of mild gastrointestinal upset (Fetterman & Zdanowicz, 2009; Mickleborough & Lindley, 2013; Roberston-Malt, 2010).

Vitamin D

Vitamin D is a fat-soluble vitamin that has a known role in regulating bone health and the levels of calcium and phosphorus in the body. There are two types of this vitamin and two ways to increase vitamin D levels in the body. Vitamin D_2, also known as ergocalciferol, is taken from the diet. Vitamin D_3, also known as cholecalciferol, is produced within the body when skin is exposed to sunlight (Lehne, 2012a; Lehne 2012b).

Although vitamin D is usually associated with bone health, it may also influence a variety of other body systems, including the respiratory system. One extensive longitudinal study in Germany showed an inverse correlation between levels of vitamin D and risk of mortality related to general health and to cardiovascular, cancer, and respiratory disorders. Participants with low levels of vitamin D tended to have a greater risk of mortality in all disease categories. This study defined vitamin D deficiency as < 30 nmol/L and vitamin D insufficiency as between 30 and 50 nmol/L (ng/mL), and suggested that vitamin D levels > 75 nmol/L might decrease overall risk of death (Schöttker et al., 2013). In addition to those results, a 2013 cross-sectional study done by Khan, Xiao-Mei, and Yue found that low levels of vitamin D were associated with decreased FEV1 and FVC values in overweight and obese participants. While these two studies are not directly tied to asthma, they support the idea that adequate amounts of

vitamin D may have some protective effect on respiratory health (Khan et al., 2013; Schöttker et al., 2013).

The specifics of how and whether vitamin D concentrations in the body impact people with asthma is still largely unclear. There is not a great deal of research looking into this possible relationship. The research that does exist is inconclusive as to how much dietary supplementation with vitamin D might aid asthma patients, although there is evidence to suggest this might be possible. One cross-sectional study done in 2011 looked at blood levels of vitamin D and lung function in 435 Chinese adults who had recently received a diagnosis of asthma. Over 80% of the participants had vitamin D deficiency of <50 nmol/L (ng/mL). There was no control group to compare results to non-asthmatic patients and the study only assessed existing status of the participants, instead of implementing an intervention to test participant response to vitamin D. Despite these limitations, however, this study found a strong positive correlation between vitamin D levels and lung function, as measured by FEV1 and FVC (Li et al., 2011).

The results of other, smaller cross-sectional studies done between 2010 and 2013 are consistent with this picture of vitamin D levels and asthma. A 2010 study looked at vitamin D levels, airway hyper-reactivity, and patient response to corticosteroids for treatment of asthma. This study identified a strong association between vitamin D less than 30 ng/mL (nmol/L) and increased airway hyper-reactivity in response to inhaled methacholine challenge. This study also found an association between low vitamin D levels and a decrease in effectiveness of glucocorticoids used in the treatment of asthma (Sutherland, Goleva, Jackson, Stevens, & Leung, 2010). A 2013 study found similar associations between inadequate vitamin D levels and poor asthma control, although it

did not examine response to asthma medications (Korn, Hübner, Jung, Blettner, & Buhl, 2013). While these cross-sectional studies provide a rationale for potential effectiveness of vitamin D supplementation, experimental studies are needed to establish a cause-effect relationship (Korn et al., 2013; Li et al., 2011; Sutherland et al., 2010).

One randomized control study performed in 2014 aimed to identify how vitamin D supplementation compared to placebo-administration in improving the effectiveness of corticosteroid therapy for adult asthma patients. The researchers hypothesized that vitamin D supplementation might improve participants' asthma control. The primary focus of the study was looking at time until the first failure of treatment, defined as an exacerbation of asthma resulting in a need for increased medication. The results showed no difference in this measurement between the group that received vitamin D supplements and the group that received the placebo. This study did find that the group with vitamin D supplementation had a small but statistically significant drop in the corticosteroid doses necessary for maintaining lung function and asthma control, with a difference of roughly 15 μg/d between the final required dose of the intervention group and the placebo group; however, further research is necessary before clinical recommendations can be made for vitamin D supplementation as a component of asthma management (Castro et al., 2014).

Other areas where further research can be directed include how genetic factors of vitamin D absorption, metabolism, and function in the body might influence the risk for developing asthma or experiencing poor symptom control. Polymorphic variations in the genes that influence vitamin D levels might partly explain how different people or people groups can experience varied asthma outcomes and treatment responses. One genetic

analysis of 207 participants from the Chinese Hans ethnic population looked at two polymorphisms of the vitamin D receptor gene. This study found no significant association between the genetic variations and the risk for developing asthma (Fang et al., 2009). Another genetic analysis, this time done with 1,064 French-Canadian participants, looked at 11 genes and 87 single-nucleotide-polymorphisms related to vitamin D in the body. This study found that variations in the IL10, CYP24A1, CYP2R1, ILIRL1, and CD86 genes had a small association with increased incidence of atopic diseases, including asthma (Bossé et al., 2009).

Overall, the effectiveness of vitamin D supplementation as a complementary therapy for asthma control is still unclear. There may be beneficial respiratory effects of maintaining adequate amounts of vitamin D, and not having enough vitamin D from diet or sunlight exposure might have detrimental effects on respiratory health, including in asthma. However, current research literature is mainly focused on correlational studies, and studies trying to establish causal relationships between vitamin D levels and asthma are inconclusive. Research into how polymorphisms might influence vitamin D levels and asthma is promising, but at this point in time, no clear recommendations can be made for incorporating vitamin D nutritional supplementation into a treatment regimen for people with asthma. Maintaining adequate vitamin D levels, however, would not be detrimental to health (Bossé et al., 2009; Castro et al., 2014; Khan et al., 2013; Korn et al., 2013; Li et al., 2011; Schöttker et al., 2013; Sutherland et al., 2010).

Antioxidants

Carotenoids, including beta-cryptoxanthin, alpha-carotene, beta-carotene, lutein, and lycopene, are dietary components that have antioxidant properties and may be

beneficial for respiratory health. These nutrients can be found in vegetables and fruits, particularly carrots and tomatoes. In 2011, a prospective cohort study by Thyagarajan et al. aimed to examine a possible association between serum carotenoids and lung function changes, with the hypothesis that participants with high serum carotenoid concentrations would tend to show greater peak and slower decline in lung function over the 20-year study compared to participants with low serum carotenoid concentrations. The participants, 2,701 in total, were between the ages of 18 and 30 years. Results showed a significant positive correlation between initial high levels of alpha-carotene, beta-carotene, and beta-cryptoxanthin and greater peak lung function. This study also found a significant inverse association between alpha-carotene, beta-carotene, beta-cryptoxanthin, and lutein levels and rate of lung function decline, and specifically found that a dietary increase in these carotenoids over 15 years had a significant positive correlation with slower declines in lung function (Thyagarajan et al., 2011).

A limitation to this study by Thyagarajan et al. (2011) is that causal relationships between carotenoid intake and lung function cannot be established in a longitudinal cohort study, so only correlation can be established between the different factors. Another problem identified in this study is that variations in participant metabolism of the carotenoids might cause variations in the association of carotenoids with lung function. The variability of carotenoid metabolism may limit the development of generalizable dietary recommendations for asthma therapy, though carotenoids may be considered for inclusion in broader dietary interventions. Further research into carotenoids and lung function is needed to establish possible causal relationships and clear clinical guidelines (Thyagarajan et al., 2011).

Total antioxidant intake is another dietary factor that may be beneficial for maintaining or improving respiratory health. Although the study by Thyagarajan et al. (2011) examined one subset of antioxidants, the carotenoids, studies looking at overall antioxidant intake address how the various antioxidants might interact with each other to create a total effect on respiratory health. In 2012, di Giuseppe et al. observed significant benefits of high total antioxidant intake on lung function. By analyzing the dietary intake and respiratory values of 11,672 participants over a period of 4 years, this study found a significant positive correlation between high antioxidant intake and good lung function. However, the correlation was only statistically significant in participants who were premenopausal women with no smoking history, possibly because this subset of the participant population experienced the least oxidative stress. This study could not establish causality, only correlation between the factors studied (di Giuseppe et al., 2012).

A randomized-controlled trial by Wood et al. (2012) found that participants assigned to a diet high in antioxidants achieved higher FEV, greater vital capacity, and reduced incidence of asthma symptom exacerbation than participants assigned to a diet low in antioxidants. This study included 137 asthmatic adults and lasted for 14 days. Although the small number of participants limits the generalizability of the results, this study suggests that eating a diet rich in antioxidants can improve symptom severity and management in patients with asthma. This study also compared the effects of an antioxidants supplement to the effects of a placebo in the control group, and found that there was no significant difference between the two interventions. Beneficial effects on asthma were only seen in participants assigned to the high antioxidant diet, which included whole foods rather than supplements (Wood et al., 2012). Although research by

Chih-HungGuo et al. (2012) shows that nutritional supplements may improve asthma control and quality of life, the Wood et al. (2012) study suggests that altering the diet to include lots of fruits and vegetables is more effective at achieving positive patient outcomes in adult asthmatics than adding nutritional supplements to normal dietary intake patterns.

Nutritional Intake Trends and Specialized Diets

Analyzing overall diet with reference to respiratory health is also a focus of asthma-related research. One cross-sectional study done by McKeever et al. (2010) looked at the dietary patterns and lung function of 12,648 adult participants in the Netherlands. Diets high in red meats, potato, boiled vegetables, added fat, coffee, and beer had a strong negative correlation with lung function tests and a strong positive correlation with prevalence of chronic obstructive pulmonary disease. These correlations were the most significant for high alcohol and added fat intake. Diets high in refined foods and low in fresh vegetables, fruit, and whole grains were also strongly linked with decline in lung function, though further research is needed before any claims of causation can be made. Also of note, this study found that diets high in vegetables, white meats, wine, and rice and low in dairy products had a small positive correlation between that diet and wheeze in asthmatic patients, with no significant decreases in lung function tests. This diet pattern was also identified as being rich in vitamin C and beta-carotene, while the other diets mentioned were low in vitamin C (McKeever et al., 2010).

Another cross-sectional study done by Rosenkranz, Rosenkranz, & Neessen (2012) looked at dietary trends, asthma diagnosis, and hay fever diagnosis in 156,035 Australian participants. Of these participants, 12% had a diagnosis of asthma and 23%

had a dual diagnosis of both asthma and hay fever. For the male participants, diets high in red meats, cheeses, and white meats had a significant positive association with a diagnosis of asthma or a combined diagnosis of asthma and hay fever. For female participants, a similar relationship between meat intake and asthma diagnosis was detected, but results also showed that high intake of cheeses and carbohydrates had a negative correlation with these diagnoses. The findings of this study suggest a possible protective effect of carbohydrates and dairy products for women at risk for developing asthma, but the cross-sectional nature of this study limits inference of a cause-and-effect relationship (Rosenkranz, Rosenkranz, & Neessen, 2012).

Specially designed diets like the Mediterranean diet and the Dietary Approaches to Stop Hypertension (DASH) may also help to improve asthma control and reduce symptoms when used in conjunction with standard medical treatment. These diets emphasize fresh fruits, fresh vegetables, whole grains, and fish while limiting overly processed, sodium-rich, and saturated fatty acid-rich foods. While these diets hold potential for improving asthma status, research into their implementation in the adult asthmatic patient population is either ongoing, as is the case for the DASH diet, or requires more extensive research before definitive guidelines can be reached for incorporating these diets into standard clinical practice for asthma management (Ma et al., 2013; Sexton et al., 2013).

One randomized trial with 38 adult asthmatic participants examined the effects of adopting a Mediterranean diet on lung function, quality of life, and frequency of asthmatic symptoms. Participants in the high-intervention group received 41 hours of nutritional counseling, those in the low-intervention group received 2 hours of nutritional

counseling, and those in the control group received recipes and an offer for a single session with a dietician. All participants in the group were provided with food vouchers to facilitate access to foods in the Mediterranean diet and to reduce possible socioeconomic compounding factors. The high-intervention group reported greater adherence to the Mediterranean diet than the other groups, eating more fish and fruit and reducing intake of red meats and chicken than those in the low-intervention or control group, suggesting that frequent access to a dietician or equivalent healthcare resource improves a person's likelihood of implementing long-term dietary changes. The high-intervention group reported increased quality of life, but the results were not statistically significant, and there were no significant changes in lung function in any of the participant groups. The small sample size of this study may have limited its ability to obtain statistically significant results. An area for future research is to further examine how adhering to the Mediterranean diet may influence asthma in a more extensive group of participants (Sexton et al., 2013).

Implementing Dietary Changes

Knowledge of dietary influences on patients with asthma may be helpful for managing asthma, but an understanding of what motivates a person to make life changes is also key to implementing effective dietary interventions. Financial stress and access to a limited range of food options may negatively influence food selection by discouraging healthy food choices (Nguyen, Shuval, Bertmann, & Yaroch, 2015). Insufficient understanding of nutrition, insufficient motivation, established eating habits, and convenience may also factor into poor decision making when it comes to food selection and asthma management (Calder, Davidson, & Ho, 2011). Patients also might not change

their dietary intake if they are unaware that certain changes might help to improve or control their condition, so it is important for healthcare providers to be familiar with and properly educate patients about relevant, accurate, and up to date information regarding all aspects of treatment (Argüder, Yilmaz, Ateş, Misirligil, & Bavbek, 2012; Kligler et al., 2011; Tapp et al., 2014; Zoellner, Van Horn, Gleason, & Boushey, 2015).

The protection motivation theory and the ordered protection motivation theory both involve the ways that a person appraises the severity and likelihood of threats. These two theories emphasize that coping appraisal is more significant than threat appraisal in making dietary decisions. In other words, a person's dietary decisions are influenced by that person's self-identified ability to adapt and that person's confidence in the effectiveness of a change. This means that a person's dietary choices will improve if he or she feels capable of implementing change and if he or she is confident that the change will actually help reduce the threat. While identifying health threats is important, health education is most effective when the focus is on empowering and equipping people for change. Health promotion education materials should thus include health risks while focusing on how to implement dietary changes and how effective the change will be (Calder et al., 2011).

Another important aspect of implementing dietary change is how well information translates from research into evidence-based practice in a clinical setting. If the healthcare team providing care to an asthma patient is unaware of or not implementing the latest advances in nutritional management of this condition, then the patient may not learn of or benefit from the potentially helpful interventions supported in the research literature. This omission could be especially impactful for asthma patients with poor

response to medications and other standard asthma interventions, as these patients might benefit from additional support measures to improve quality of life and symptom control (Argüder et al., 2012; Kligler et al., 2011; Tapp et al., 2014; Zoellner et al., 2015).

Delays in applying conclusive results from sound research to actual clinical practice are common and can sometimes take over a decade before they benefit actual patients. The more efficiently research is translated into practice, the quicker it can improve patient care. There are multiple methods of trying to organize this translation process; these methods generally include a focus on identifying effective interventions, spreading accurate information about those interventions to the physicians, dieticians, and other care providers, and consistently evaluating implementation of research so that organizations can adapt methods and continuously improve patient care. When developing a new program based on research, one way to help improve effectiveness of the program is to involve the key stakeholders: the target patient population, the community, and health care providers from multiple disciplines (Argüder et al., 2012; Tapp et al., 2014; Zoellner et al., 2015).

In situations involving complementary and alternative medicine (CAM), which can include nutrition changes, the level of familiarity and knowledge a care provider has with these interventions can influence patient education and implementation. A study done by Argüder et al. (2012) surveyed 242 physicians who worked with allergy and asthma patients. The survey asked about the physicians' familiarity with CAM and how comfortable the physicians' felt referring patients to CAM oriented treatments. The CAM referrals included nutrition referrals for asthma patients. This study found that more than half of the physicians surveyed reported having insufficient knowledge about CAM to

meet patient needs, despite having a desire to learn about CAM. The survey reports also found that physicians who felt prepared with adequate information were more likely to share this information with their patients, while those who felt unprepared were more likely to omit CAM referrals from day-to-day practice. While this study has a small sample size and non-experimental design, it provides an opening for questions about how to provide proper information to healthcare providers so that those providers can transmit that information to patients (Argüder et al., 2012).

One ongoing study in North Carolina is looking at various ways to spread information about asthma treatment interventions to primary care clinics using Medicaid and existing research networks. The methods under examination include a method of once-yearly educational events for staff with handouts versus a more intensive method of 12 consecutive weeks of one-hour training sessions for staff on how to use resources for asthma treatment. This study also has a control group of clinics with no specified changes in the method for providing information to staff. The research team conducting this study hypothesizes that the weekly program will be the most effective program at increasing shared-decision making, with medical staff facilitating involvement of patients in developing plans of care. Subsequently, the research team predicts that increasing patient involvement in health care decisions will improve asthma exacerbations and increase patient satisfaction with care. While conclusions cannot be drawn from this study until data collection and analysis is complete, this study is one example of current and future research trends into asthma management and working with patients to identify what they are willing to change in order to improve their condition (Tapp et al., 2014).

Method

Articles were included in the review if they had publishing dates between 2009 and 2016. Articles published prior to 2009 were excluded unless they represented research that remains fundamental to the subject. Preference for inclusion in this review was given to quantitative research; however, applicable qualitative studies and clinical expertise were included. To be included in the review, articles had to be peer reviewed and the authors had to hold an advanced degree in the area of study. Articles were gathered using EBSCO host and related databases. Key search words included: asthma, diet, nutrition, inflammation, omega-3, omega-6, arachidonic acid, EPA, DHA, polyunsaturated fatty acids, fatty acids, linoleic acid, fish oil, antioxidants, and intervention.

Summary

PUFA, vitamins, antioxidants, and total dietary patterns may influence respiratory health and symptoms in asthma patients. Although further research is needed, diets high in refined or processed foods tend to be associated with poor respiratory health while diets high in fresh fruit, fresh vegetables, whole grains, and fish tend to be associated with good respiratory health or improvement in respiratory health. The role of individual nutrients in respiratory health is not well defined and further research is required to establish clinical guidelines involving standardized doses, quantified therapeutic responses, and the impact of polymorphisms on patient response to various dietary supplementations.

People are more likely to go through with dietary alterations if they perceive that they are capable of enacting change and that the change will be directly beneficial to

them, as opposed to if they simply perceive the risks of an unaltered diet. Also, since nutrients are generally not consumed in isolation from each other, total diet interventions are likely to be more effective at improving health than single nutrient interventions. Education on dietary change should focus on how to implement the new diet and what definitive improvements will result from the change. Though understanding the risks of certain diet patterns is important for patient motivation, patients are more likely to succeed at altering their diet if they feel competent and confident about the effectiveness of their changes.

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