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Review Article

Omega 3 fatty acid: A boon for pulmonary health

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ABSTRACT

Nutrition has been recognized as an important factor in health and disease for many years. However, it is only recently that the importance of nutrition in patients with chronic lung disease has come into focus. There has been a profound link between nutrition and lung health. Malnutrition could lead to poor lung development. Various diet such as Mediterranean diet, prudent diet, etc. have reported their protective effect against respiratory diseases while westernized dietary patterns and fast-food intake could cause poor lung health. Fruits and vegetables constituting various vitamins and minerals provide antioxidant shield to the lungs. Apart from this, one leading nutrient omega-3 fatty acids primarily found in sea food is emerging to have beneficial role for the lung's wellbeing. Its anti-inflammatory property helps to combat respiratory diseases such as asthma, cystic fibrosis and COPD. Even in the chronic conditions such as lung cancer it works as an important constituent of nutritional therapy. It also impairs immune responses against various infections and strengthen lungs. To our surprise it has also proven positive effects over smoking cessation also. However, more research is certainly needed to identify the chief role of nutrients involved in managing respiratory diseases and their implications in practicality.

1. Background

Factors related to nutrition are implicated in the pathogenesis of a wide variety of diseases. In striking contrast to the situation pertaining of the relationship between diet, energy imbalance (obesity) and cardiovascular disease, particularly coronary artery disease, the relation between diet and lung disease has not received much attention.[1,2] The critical role of nutrition has been recognized also with regard to chronic disease states of the other organ systems, such as endocrine system (e.g. diabetes), digestive system (e.g. Fatty Liver), Immune system (e.g. Anemia), renal system (e.g. Nephrotic syndrome), Circulatory system (e.g. Hypertension), Skeletal System (e.g. Osteoporosis). The part played by nutrition in the pathogenesis of cancer has also been the subject of extensive research.[3] But the standard texts on nutrition make little or no reference to the respiratory system.[4] This relative neglect is due to the relation between nutrition and the fatal diseases of the respiratory system disease is not directly causal.[1]

However, interesting new evidence which has emerged over the past decade suggests that there might be a significant link between dietary intake of certain nutrients and lung health.[5,6] While there is widespread acknowledgement that malnutrition in pregnant women adversely effects of the lung development of the fetus.[7]

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This process of complex interactions could be better understood with the vicious cycle below in Figure 1 that shows the development of nutritional deficiencies early in life leading to malnutrition and hence poor lung development.

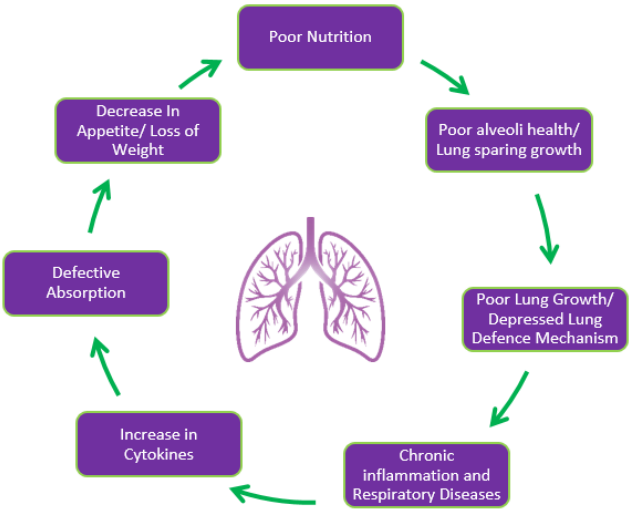

Fig. 1: A model of relationship between Poor Nutrition and lung diseases (developed by authors).

Nutritional status is clearly recognized as a factor that is tightly intertwined in this process, and the temporality of this association has long been debated.

2. Lung Diseases

The number of lung diseases are plentiful, and can break down into three categories:

1. Lung diseases that affect the air sacs,
2. Lung diseases that affect the airways, and
3. Lung diseases that affect the interstitium.

Stephen M. Black has categorized lung diseases into 3 different groups:[Table 1]

3. Aim

The aim of the present review is to summarize the information currently available on the links between nutrition and lung health, addressing the effect of nutrition (and dietary habits) on lung function and disease focusing the role of omega 3 fatty acid on lung health.

3.1. Protective and harmful effects of diet on respiratory diseases

Interesting new evidence is, however, beginning to emerge from sources as varied as molecular biology laboratories and epidemiological units. This suggests that a relation may exist between intake of certain dietary elements and lung disease[9] and that the links may have a practical importance.

The most popular dietary patterns for good lung health are Mediterranean diet and Prudent diet. The Mediterranean diet is based on the regional foods of Greece, Italy, and other nations that border the Mediterranean Sea. The foundation of Mediterranean diet is plant-based foods including whole grain cereals, green vegetables, pulses and legumes, fruits, seeds, nuts, herbs and spices.[10] While the diet pattern of prudent diet has been used to refer to the low-fat, low-cholesterol diet i.e., characterized by a high intake of fruits, vegetables, legumes, fish and whole grain products.[11]

On a contrary note, Traditional Indian diet that emphasizes on a high consumption of plant-based foods like vegetables, fruits, lentils with low intake of meat, is also gaining popularity all around the world and is being promoted for keeping lungs healthy. Not only the diet patterns but also how specific nutrients are responsible for prevention from lung diseases are shown in Table 2.

Diet can not only promote lung health but also can hinder lung function when taken in little or excess amounts of certain unhealthy foods or by following unhealthy food habits. Something similar happens in western diet pattern as well, which is characterized by high intake of refined grains, cured and red meats, sweets, desserts, high fat dairy products, processed foods and pre-packaged foods.[45] While fast foods are high in sugar, salt, saturated fat or trans fats, and calories. It constitutes pre-prepared ingredients, pre-cooked foods, frozen beef patties, vegetables etc. as well as many processed preservatives and ingredients.[46,47] These impart harmful effect on lung health. [Table 3]

3.2. Magnitude of the disease burden

The World Health Organization (WHO) estimates that 6% of all diseases in the world are caused by respiratory infections.[49] The Table 4 below shows the current scenario of respiratory disease burden.

Asthma has affected an estimated number of 262 million people in 2019 and has caused 455,000 deaths.[68] Approximately 9.7% of adult females and 6.2% of adult males have asthma. It is the most common chronic illness among children.[69] Chronic obstructive pulmonary disease (COPD) is the third most common killer in the world, causing 3.23 million fatalities in 2019. Over 70% of instances of COPD in high-income nations are caused by tobacco use.[70] There is a 2% annual decline in TB incidence.[71]

The estimated global incidence of community-acquired pneumonia, which is influenced by the geographical characteristics, the season, and demographic characteristics, ranges from 1.5 to 14 cases per 1,000 person-years.[72] Overall, 3.1% of people self-reported having symptoms of chronic bronchitis, with 3.6% of men and 2.6% of women reporting these symptoms.[73]

Table 1: Categories of respiratory diseases[8]

S.No.	Affecting the Air Sacs	Affecting the Airways	Affecting the Interstitium
1.	Pneumonia	Chronic obstructive pulmonary disease	Interstitial Lung Disease
2.	Lung Cancer	Chronic Bronchitis	Interstitial Pneumonia
3.	Pulmonary Edema	Emphysema	Pulmonary Edemas
4.	Acute Respiratory Distress Syndrome	Acute Bronchitis	
5.	Pulmonary Tuberculosis	Cystic Fibrosis	
6.	Emphysema	Asthma	
7.	Pneumoconiosis		

Pulmonary edema related to cardiac reasons (heart failure) is a diagnosis given to more than 1 million individuals each year.[74] An estimated 190,000 patients are reported with acute lung damage annually.[75] Overall, men have a 1 in 16 lifetime risk of developing lung cancer; women have a 1 in 17 lifetime risk. [76] Currently, 74% of the world's population—or close to 545 million people—live with a chronic respiratory disease.[77]

3.3. What is omega 3

Omega-3 fatty acids (omega-3s) are polyunsaturated fats that perform important functions in human body. Human body does not synthesize the amount of omega-3s needed for survival. So, omega-3 fatty acids are essential fatty acids, which has to be consumed through foods we eat. Omega-3 are essential nutrients that you need to get from your diet.

The three main omega-3 fatty acids are:

1. Alpha-linolenic acid (ALA)
2. Eicosapentaenoic acid (EPA)
3. Docosahexaenoic acid (DHA)

3.4. Sources of omega 3

These diets high in omega-3 fatty acids include both plant and fish-driven [Figure 2]

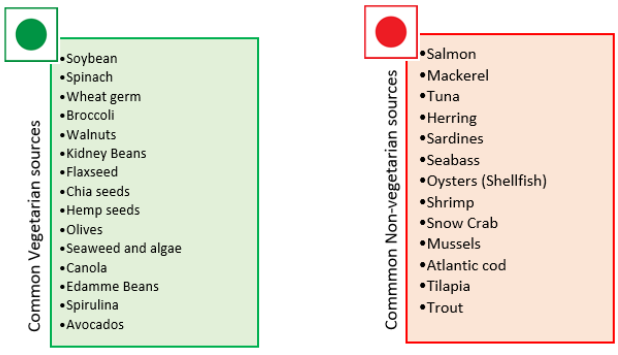

Fig. 2: Sources of Omega 3 fatty acids[78]

4. Role of Omega-3 in Pulmonary Health and Prevention of Respiratory Diseases

Diet is a complex exposure. Omega 3 fatty acids are emerging as prominent yet safe disease-modifying nutrients and are protective in severe critical care conditions including lung injury.[79,80]

Several links have increased intake of ALA, EPA, and DHA with lower incidence respiratory diseases.[81] Omega-3 with its widely known anti-inflammatory nutrient been proposed as a potential "nutraceutical," or food with medicinal properties that may yield beneficial health effects on the pulmonary health.[82–84]

Growing evidences have indicated the beneficial role of omega 3 fatty acid in chronic inflammatory diseases such as pulmonary fibrosis and asthma by reducing inflammatory reaction by changing the contents of lipid membranes and other substrates which are in turn the substrates for eicosanoid production.[85–87] DHA may contribute to the prevention of bleomycin-induced pulmonary fibrosis.[88] Observational data supports the fact that omega-3 PUFAs provide a therapeutic strategy for managing COPD.[89]

EPA- and DHA-specific diets are good dietary options for the management of different types of lung disease progressions.[90] A diet low in omega-3:omega-6 fatty acid ratio might contribute to exacerbation and increased morbidity of asthma and allergic diseases.[91] Low omega-3 fatty acid intake might lead to increased respiratory symptoms such as chronic bronchitis, wheeze, and asthma.[92]

Omega-3 reduces lung pathology, in particular peri-bronchial inflammation and cell death. Omega-3 fatty acid diets decreased overall lung tissue inflammation and cell death, effects against the most common pathogen that causes pneumonia may improve outcomes of patients at risk for pneumonia.[93] Patients with acute respiratory distress syndrome show improved pulmonary function within a few days after omega-3 FA administration.[94] Moreover, omega-3 epoxides counteract the development of Pulmonary hypertension through regulating the vascular remodeling of pulmonary arteries.[95] Based on previous studies, omega-3 fatty acids were able to reduce pulmonary edema and improve oxygenation and bacterial killing.[96–99]

Table 2: Protective effect of Diet and nutrients against respiratory diseases

S.No.	Protective effect of	Source	Protective effect against Diseases	References
1.	Mediterranean Diet	High intake of minimally processed plant foods, namely; fruit, vegetables, breads, cereals, beans, nuts and seeds, low to moderate intake of dairy foods, fish, poultry, wine, low intake of red meat & saturated fat	• Allergic respiratory diseases • Atopy, wheezing and asthma symptoms	12–14
2.	**Prudent Diet**	**Increased intake of fruits, vegetables, legumes, fish whole grain products and other sea foods**	**• Lung function improvement • Reduced risk of COPD**	**15**
3.	Indian Diet	Whole cereals and millets, variety of lentils, wide variety of fruit and vegetables, variety of herbs, spices and flavorings, low saturated fat, dairy foods, high fiber and regionally diverse nuts	• Help to Breathe easily and with comfort • Strengthen lung immunity and fight against infections • Reduces inflammation in lungs • Protect the lung tissues from damage • Boost lung function	16,17
4.	**Fruits and Vegetables**		**• Weaken COPD development • Decreased risk of asthma exacerbation • Reduces the risk of childhood wheezing • Improvement in lung function • Reduces the risk of lung cancer by approximately 25%**	**18,19**
5.	Vitamin C	Fruits: papaya, cantaloupe, citrus fruits, strawberries Vegetables: cauliflower, broccoli, Brussels sprouts, kale, sweet peppers	• A positive association with lung function • Important in COPD pathogenesis and management • Prevent smoke induced emphysema • Restore damaged lung tissue • Inverse relationship with bronchitis	20–23
6.	**Vitamin E**	**Vegetable & seed oils (corn, safflower, soy bean) Eggs Green vegetables**	**• Reduce biomarkers of oxidative stress in COPD patients • Reduces risk of childhood asthma and wheeze**	**24–27**
7.	Provitamin A carotenoids	Liver, Egg yolk, Milk fat, Fish oils	• Early lung development • Conservation of lung function • Partially prevent chronic lung disease • Decreased risk in lung cancer	28,29
8.	**Lycopene**	**Predominant in tomatoes; red, orange and yellow fruits, vegetables: sweet potato, carrots, winter squash, green vegetables**	**• Positively correlated with FEV1 in both asthma and COPD • Suppress neutrophilic airway inflammation in asthma**	30,31
9.	Flavonoids	Apples, lemons, oranges, potatoes, cauliflower, tea, skin of tubers and roots, red wine	• Lessening the development of lung diseases such as COPD, lung cancer, ARDS, and asthma • Ameliorating lung disorders	32
10.	**Vitamin D**	**Sun exposure, milk, mushrooms, egg, fatty fish**	**• Protective role against asthma and COPD • Decrease COPD incidence**	**33,34**
11.	Magnesium	Nuts, legumes Cereal grains Corn, peas, carrots, parsley, spinach, lima beans Brown rice Seafood	• Have beneficial bronchodilator effects in asthma • Lowers risk factor for airway diseases	35,36
12.	**Selenium**	**Animal products, especially organ meats and seafood**	**Inversely associated with risk of asthma in children**	**37,38**
13.	Sulforaphane	Broccoli and wasabi, sprouts, kale, cabbage, cauliflower and curcumin (pigment in turmeric)	• Have beneficial antioxidant properties • Benefits in COPD	39–41
14.	**Branched chain amino acid**	**Whey, milk, and soy proteins, corn, beef, chicken, fish, eggs, baked beans, chickpeas, lentils, whole wheat & brown rice.**	**Associated with positive results in COPD including increases in whole body protein synthesis, body weight, fat free mass and arterial blood oxygen levels**	**42,43**
15.	Cysteine	Cysteine or methionine as precursors of glutathione	Prevent increased susceptibility to lung injury	44

Table 3: Harmful effect of diet leading to respiratory diseases

S.No.	Harmful effect of:	Source	Harmful effect	References
1.	Western Diet	High consumption of refined grains, cured and red meats, desserts and sweets and high-fat dairy products	Increased frequency of asthma exacerbation and is related to COPD risk.	45
2.	Fast Food	Hamburgers, Sandwich, French Fries, Potato chips, Pizza, Processed meat, Bakery products, Sweet drinks, Carbonated drinks, etc.	• Increased risk of COPD • Correlated with the presence of asthma, wheezing and airway hyper responsiveness (AHR)	46–48

Table 4: Current scenario of Global and Indian Respiratory Disease Burden

S.No.	Respiratory problems	Global		Indian		References
		Burden	Deaths/year	Burden	Deaths/year	
1.	**Tuberculosis**	10.6 million	1.6 million	2.59 million	4 lakhs	50–52
2.	**Asthma**	339 million	4.61 lakhs	34.3 million	> 1lakh	53–56
3.	**COPD**	391.9 million	3.23 million	55.3milion	8.48 lakhs	57–59
4.	**Lung Cancer**	2.21 million	1.80 million	14.61 lakhs	8.08 lakhs	60–62
5.	**Pneumonia**	450 million	3.0 million	30 million	1.4 lakhs	63,64
6.	**Tobacco use**	1.7 billion	> 8 million	267 million	1.35 million	65–67

It has also been reported that dietary omega-3 fatty acids impair the immune response against Mycobacterium tuberculosis that causes tuberculosis.[100–103] Omega3 PUFAs intake also interfere in smoking habit as the increase in omega-3 consumption plays a role in prevention or treatment of smoking.[104–106]

Omega-3 polyunsaturated fatty acid supplements for chemoprevention of different types of cancer including lung cancer has been investigated in recent years. Omega-3 PUFAs are considered immune-nutrients, commonly used in the nutritional therapy of cancer patients. Omega-3 PUFAs play essential roles in cell signaling and in cell structure and fluidity of membranes.[107] Dietary intake of omega-3 fatty acids, not only play a role in combating lung diseases but also take part in the normal aging process of the lungs.[108]

5. Conclusion

The present review summarizes the information currently available on the links between nutrition and lung health, addressing interesting relationship between the influence of nutrition on lung health and the tendency to common lung diseases such as COPD, asthma and lung cancer. The exact nature of the nutrients involved, the magnitude of their influence and the practical implications of these influences remain unclear. However, fruits and vegetables rich in vitamins, polyphenols and omega-3 fatty acids work together to provide comprehensive antioxidant protection and modulate inflammatory reactions on which lung health depends on while fast food intake and westernized patterns have adverse associations. The most effective advice to promote lung health still simple i.e., to stop smoking and tobacco use.

In contrast, nutritional therapy has a key role to play in the management of lung diseases decreasing mortality and morbidity from the disease. However, chronic lung disease continues to provide nutritional challenges for the health care team but aggressive nutritional support and an early intervention should have better chances of success. More research is certainly needed not only to better dissect the nutritional factors involved in the lung disease but also (and perhaps more important) to identify effective and safe interventions through systematic controlled trials.

6. Conflict of Interest

The authors declare that there is no conflict of interest.

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