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Nutritional and Non-Nutritional Parameters Associated with Chronic Obstructive Pulmonary Disease (COPD): A review

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ABSTRACT

Chronic Obstructive Pulmonary Disease or COPD is the disease that effects the lungs where there is obstruction of the flow of air to the lungs hindering with the normal breathing. A lot of studies have been done, at the national and international level, on the factors associated with the causation and/or treatment of COPD, both nutritional and non-nutritional. In this paper both these aspects have been reviewed. Under the nutritional aspects the effects of high fibre intake and ω-3 fatty acids through dietary sources have been covered. Under non-nutritional aspects, factors covered are cigarette /tobacco smoking, ABH secretor status, age, gender, BMI, MUAC, family history (hereditary factors) and clinical history with special emphasis on childhood respiratory infections. Along with all the above factors, air-pollution is also one of the major concerns for lung health. The respiratory system is affected by air pollutants such as carbon monoxide, ozone, nitrogen dioxide, sulphur dioxide, and particulate matters with particle size 2.5 to 10. In these studies, clinical diagnosis of COPD, was based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD standard) or the COPD guidelines. The GOLD guidelines, advises spirometry as the gold standard as it is accurate and gives the measurement that are repeatable for the lung function. The cut-off according to GOLD criterion as FEV1/FVC should be between 0.6 to 0.8, where FEV1 and FCV are the lung function measurements and FEV1 is the forced expired volume in one second and FVC is the forced vital capacity.

Keywords: Diet, Fibre, Lungs, Obstructive lung disease, Spirometry, GOLD, FEV1, FVC

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD), is believed to be an important cause of morbidity and mortality worldwide [1]. COPD is a disease related to the environmental problems and lifestyle (diet, cigarette smoking, etc.). India is one of the top most countries to be affected by COPD. Chronic Obstructive Pulmonary Disease mainly remains undiagnosed because it progresses slowly and shows the symptoms at a very late stage of progress. The prevalence of COPD varies from 3-8% among Indian males and 2.5-4.5% among Indian Females. It contributes significantly to mortality and morbidity rates in India [1]. Chronic Obstructive Pulmonary Disease is the cause of high death rates, early deaths and substantial cost on health-care system. For the year 2020, the health care projections indicate that COPD will be the 3rd most prominent cause of death world over and 5th most prominent cause of the man-years lost due to early deaths.

The progress of COPD is attributed to a combination of factors such as genetics, lifestyle and environmental factors. Although, cigarette (tobacco) smoke is the single major risk factor for the development of COPD. However, only 20% of the smokers eventually develop COPD. It is therefore, important that lifestyle factors other than smoking may also be looked into, such as diet and physical activity level [2,3].

Objective

A lot of studies have been done, at the national and international level, on the factors associated with the causation and/or treatment of COPD, both nutritional and non-nutritional. To review available literature on the role of nutritional and non-nutritional parameters and their association with COPD.

Methodology

A organised literature search was performed from 1980 until April 2020 in Pubmed and google scholar. A review of studies done on national and international level was conducted, which had reported a relationship between COPD and nutritional and non-nutritional parameters. Research paper containing the following keywords: COPD in conjunction with smoking, vitamins, FEV1, vitamin C, vitamin E, vitamin D, vitamin A, β-carotene and blood group were identified and searched. Other factors such as obesity, BMI, cured meat, omega 3 fatty acids that have been seen to be associated with COPD risk were also considered. The approach was to club together the studies on a particular nutritional and non-nutritional factor and then to assess the effect of these factors on COPD.

COPD Definition

As per WHO, "Chronic Pulmonary Obstructive Disease (COPD) is a lung disease characterized by chronic obstruction of the lung airflow that interferes with normal breathing and is not fully reversible" [4]. The American Thoracic Society defines [5,6]. COPD as a disease state characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema. The air flow obstruction is generally progressive and accompanied by airway hyperactivity and may be partially reversible.

This study proposes to find the parameters that are associated with COPD which may be Nutritional or Non-nutritional. This paper reviews, available literature related to both these aspects.

Nutritional Aspects Associated with COPD

In a study, Haidong, et al. [7], examined the correlation between fibre intake, lung performance and COPD. The study was done on 11,897 men and women, taken from another study (prospective study, Atherosclerosis Risk in Communities). The subjects of the study, taken from four US communities were majorly African-American and/or American, men and women between the age of 44 years to 66 years. The study members were firstly interviewed at their homes and then called for a standard clinical examination (spirometry), during which lung function variables were collected. The results of these along with the dietary data collected during home interviews were used for the cross-sectional analysis. The diet intake of the subjects for the last one year was evaluated using a partially-quantifiable, FFQ (food frequency questionnaire), conducted by trained interviewers. Information regarding frequency of consumption of a particular food item, the range being taken as never to <1 time per month and up-to ≥ 6 times a day. The overall daily nutrient intake along with the total amount of daily fibre were calculated for each subject. Also, BMI for each subject was calculated using weight (Kg)/height (m^2) formula. Through the interviews, information such as, age, sex, gender, ethnicity, occupation, education, smoking, exposure to environmental tobacco smoke, medical history, etc., was also gathered. For smoking history, the subjects were also classified into never smokers, former smokers and current smokers.

In the analysis, a positive correlation between high fibre intake from dietary sources, such as cereals, vegetables and fruits with improved lung function was found along with reduction in COPD related symptoms and mortality thereof. Also, it was observed during the analysis of the results that beneficial effects of high fibre intake were independent of the amount of other nutrients such as Vitamin C, D, E, omega-3 fatty acids, etc. or decreased intake of cured meat. It was also observed through this study that cereal and fruit fibre have better physiological effects that assist in strengthening the respiratory system, thus improving the lung function as compared with vegetable fibre.

In a prospective cohort study by Varraso, et al. [8], the researchers examined 111580, Nurses and health professionals to study the connection between the intake of dietary fibre and occurrence of respiratory diseases with special emphasis on its effect. This study also included 832 persons with recently diagnosed COPD. The study began in the year 1976 and 121,700, female nursing staff within the ages 30 to 55 years, living in USA were asked to answer health questionnaires through mail. In 1986 another study incorporating 51,529, health care professionals aged 40 years to 75 years was started. They responded to questionnaires sent to them via mail, which included questions of medical history, daily regimes and daily diet intake. Every 2 years, both the study groups were sent follow-up questionnaires to know about any changes in lifestyle or dietary patterns and any new medical conditions. The exclusion criteria were any incomplete questionnaires or any persons having very high or very low-calorie intake.

The food frequency questionnaire was created to enable collection and evaluation of average food consumption data for the past one year.

Data from the two studies was clubbed together and adjustments made for age, sex, smoking status, energy intake, body mass index, physical exercise and number of physician visits. Extensive adjustments were made for smokers as it is the one major risk factor for COPD. Also, people who smoke are generally inclined to have diverse food habits as compared to non-smokers.

The results of the two studies indicated that a high intake of fibre, especially from cereals and whole grains, was inversely proportional to the development of COPD, due to its anti-oxidative and ani-inflammatory properties.

A cross-sectional survey on 1921 people was conducted by Hanson, et al. [9], through NHANES (The National Health and Nutrition Examination Surveys) to assess the correlation between fibre intake through diet and lung function. The survey started with the hypothesis that a low fibre intake reduced overall lung function. The participants included in the study were US citizens in the age group of 49-70 who already had a bronchodilator spirometry measurement result with them. Dietary intake was determined by 24- hour recall method through interviews. BMI and total diet intake along with total fibre intake per day was calculated in grams. Fibre supplements were not taken into account. For smoking status was classified into never, former and current smokers. Owing to the fact that smoking being the single major cause of reduced lung function, an analysis of the relationship between fibre intake and smoking status, was also done. From the survey it was concluded that subjects with high fibre intake from sources such as fruits, vegetables and whole grains not only had a lower BMI but also better lung function as indicated through spirometry. Low fibre intake was also seen in smokers. Considerable correlation was found connecting dietary fibre to lung function in both univariate and multivariate models. Also, the beneficial effects of high dietary fibre intake were not influenced by intake of any other nutrient (antioxidants) or food (cured meat).

A prospective cohort study on women was conducted by Szmidt, et al. [10], to establish the connection between fibre intake for long periods, both specific and total fibre intake were taken into account, in correlation with the incidence of chronic obstructive pulmonary disease. Between 1987 and 1990, from central Sweden all women were invited for mammography screening and to fill up a food frequency questionnaire. These women were the part of SMC or the Swedish Mammography Cohort, and the original cohort consisted of 61433 subjects [11]. After 10 years in 1997, another questionnaire was sent with a follow up of the same done between 2002 and 2014, giving a lag period of 4 years. Food frequency questionnaire was used to assess the total and specific fibre intake through dietary sources. The results were found consistent with earlier studies and it was corroborated that women in the top fifth subset of total fibre intake, were at 30% lesser risk of developing COPD as compared to those in the lowest quintile. For specific fibre intake a negative correlation was established between COPD and long-term intake of fruits and cereals. it was also observed that risk reduced for all categories of smoking status with every gram increase in fibre intake. Findings also established the inverse relation was stronger with higher consumption of cereal fibre.

The investigators also stated that dietary fibre played a role in regulating immune system through gut-liver-lung connection. Fibre also has an impact on the gut microbiota which in turn have a crucial role in the immune functions of the host, which in turn could be linked to the fermentation of fibre in the gastro-intestinal tract by microbes to short chain fatty acids or SFCAs ,which have been shown to improve immune system's response. It is also possible that dietary fibre may help in reducing the oxidative stress in the lungs due to its effect as an antioxidant.

Shahar, et al. [12] studied the association between omega-3 fatty acids in diet of 8960 subjects who were current and former smokers. The subjects were asked to answer questionnaires both for dietary intake with emphasis on fatty acid intake and respiratory symptoms. Spirometry was also done to assess presence of COPD.

Although it cannot be said that intake of ω-3 fatty acids has a protective effect against COPD caused due to smoking. But it proves true the hypothesis that omega-3 fatty acids decrease the production of alleged causative substances of pulmonary inflammation.

Out of the 8960 participants, 55% were former smokers and 45% current smokers. 1049 participants were found to be having some symptoms of compromised lung function or COPD. The results showed a strong negative correlation between ω-3 fatty acid intake and COPD and it was concluded that increased intake of omega-3 fatty acids. by cigarette smokers, may be protective against COPD.

One of the study's was done over a period of 14 years, by Vozoris, et al. [13], to determine the association of obesity and COPD and their combined effects on health. From the Canadian National Heath Survey Data (1994- 2007), data

of 65000 subjects was used. Self-reported measures for height in meter square and weight in kilograms were used to calculate Body mass index (BMI ≥ kg/m^2) and identify the presence of obesity.

In a study by Hanson, et al. [14], a positive correlation was found between Obesity, BMI and COPD. The prevalence of other metabolic diseases was also found to be high in COPD patients compared with non-COPD patients. 18% of the patients with COPD in this study had obesity and as the prevalence of obesity decreased the lung function tests improved.

In another study by Marquis, et al. [15], conducted on 38 patients and 34 control subjects with COPD, about 47% patients and 21% control subject showed 3 or more than 3 symptoms associated metabolic syndrome. Those subjects were inducted who had 3 or more features of metabolic syndrome, namely abdominal obesity, atherogenic dyslipidaemia, insulin resistance and high blood pressure. Most patients of COPD had shown more than 3 features of the metabolic syndrome.

Along with other factors body mass composition has also been seen to have an important role for the development of COPD. In a study by Eisner, et al. [16], a higher lean-to-fat ratio, found in women, was seen to be related to better Short Physical Performance Battery Score. The build-up of higher fat mass was more strongly related to decreased lung function. This body composition study was done on a cohort of 355 young adults. It was concluded that body mass composition was an important non-pulmonary factor that affected increase of function restrictions associated with COPD.

In another study by Henrik watz, et al. [17], systemic inflammation and physical inactivity were also found be associated with both COPD and chronic bronchitis, they studied 30 patients having chronic bronchitis and 170 suffering from COPD with varying severity. The frequencies of the metabolic syndrome in patients with chronic bronchitis were 53% and for GOLD stages I, II, III, and IV, 50%, 53%, 37%, and 44%, respectively with an average of 47.5%.

In 2010, a study by Janssens, et al. [18], 414 ex-smokers, enlisted at the university Hospital of Leuven (Belgium), aged above 50 year were studied for assessment of the link between vitamin D status and the presence of COPD. Serum levels of 25-hydroxyvitamin D were measured. A positive correlation between prevalence of vitamin D deficiency, presence and severity of COPD was established. It was therefore concluded that the patients with severe COPD should have a high intake of vitamin D.

However, in another study, done by Shaheen, et al. [19], in 2011, on women and men of ages between 59 to 73 belonging to Hertfordshire Cohort Study in UK, the results did not confirm a positive relationship between COPD and blood levels of 25-hydroxyvitamin D.

A study was done to assess the relationship between polymorphism of Glutamate-Cysteine Ligase Genes (GCLG), loss of lung function due to smoking and effect of vitamin C intake, in Dutch populace. The study was done by Mateusz, et al. [20], in 2007. Genetic effects on lung function level and decline were estimated. It was concluded that smoking along with reduced vitamin C intake increased the burden of body's oxidative stress, which in turn can make the gene GCLG susceptible to decreasing lung function below normal.

Dietary antioxidants have been believed to prevent oxidative damage of the lung tissue, caused by cigarette smoking [21]. 21,148 (8804 men and 12 344 women) Korean adults were included in the study and their data about lung function, comorbidities, nutritional status, health and demographic features were taken from Korean National Health and Nutrition Examination Survey (KNHANES 2007-2014) [12]. Data was collected through health questionnaires, nutrition and screening surveys. These were further classified in to 4 groups based on smoking status, gender and age. The study concluded that antioxidant vitamins have a beneficial effect on the lung function. The beneficial effects, however fluctuated by gender and smoking status.

In a survey, done in 2002, by Vanessa, et al. [22], the corelation between lung function and antioxidant intake through diet was studies for 10 years. The participants were recruited from 3 European countries known as the European Community Respiratory Health Survey (ECRHS), namely, Germany, UK and Norway. A total of 680 subjects were included with a mean age of 43.8 ± 6.6 years. On analysis it was found that fruit and tomato intake, both of these being rich sources of antioxidants, was associated with slower decline in FVC. The study concluded that intake of antioxidant rich foods such as fruits and tomatoes might help in the delay of lung function decline, especially for non-smokers. It was more prominent in people who consumed tomatoes.

Other studies have also indicated the positive correlation between antioxidants such as vitamin A, D, E, C, α and β carotene with lung function. In one such review study done by Tsiligianni, et al. [23], symptoms, exacerbations and pulmonary function improved with increased intake of these vitamins and hospitalization rate decreased.

Non-Nutrition Aspects of COPD

In a study by Cohen, et al. [24], of multidisciplinary risk factors for COPD, impairment of lung function was observed to be more in ABH non-secretors as compared to ABH secretors. This study was conducted on 1017 white adults. (Where ABH represents the "A" and "B" antigens of the ABO blood group system and "H", the heterogenetic substance found in all persons of ABO types including type "O".) The subjects were taken from an ongoing study on COPD at John Hopkins school of Hygiene, along with their relative and neighbours and some teachers from the school. Through this study it was shown that secretor status contributes significantly and must be considered as one of the risk factors for COPD. It is worth considering that ABH antigens or some related factors may have some protective effects on the lungs, It was concluded that although cigarette smoking could be one of the most significant factor in causing lung dysfunction (COPD) but it is important to examine other factors including role of ABH secretor status in the development of COPD.

Marco, et al. [25], conducted a survey from the data collected through ECRHS (European Community Respiratory Health Survey). ECRHS is an international study centre on respiratory diseases. Random samples of 9511, young adults were collected in the 1991 till 1993 from the general population. the data was collected through questionnaire and a detailed clinical examination was done along with spirometry for selected subjects. In stage 2 of the study (19992-2002), out of 9511, 6019 subjects (75%) attended the survey. After applying all exclusion criteria, the cohort consisted of 4636 subjects.

It was found that at the baseline or upon follow-up, respiratory infection in childhood and a family history of asthma, increased the risk of development of COPD considerably.

The major finding, however was that cigarette smoking is the main cause of COPD in young adults. In this study cohort, three out of four new COPD cases were those of smokers and the potential risk of development of COPD was almost double in tobacco smokers as compared to non-smokers. Also, through this study it came to be understood that male gender, underweight people and subject older than 40 years of age, were at a significantly increased risk of developing the disease. It was therefore concluded, that cigarette (tobacco) smoking was the major single risk factor in the development of COPD. Along with this childhood respiratory infections and family history of asthma also played a vital role.

A survey conducted in Korea by Eun-Jung Kim, et al. [26], between 2005 and 2015, to analyse the effect of aging and smoking on the development of COPD. 1427 patients were selected and their status of smoking and occurrence of COPD was evaluated from the data available at Korea National Health and Nutrition Examination Survey (KNHANES) [27]. It was found that severity of COPD in smokers increased with age. Clinically smoking was also ascribed as a factor accelerating the ageing process. This is due to in part be associated with reduced lung function in people between the ages of 30 and above. Age related physical manifestations and changes were found to be more profound in smokers and patients of COPD and these were identified at higher levels of risk. The gender-based difference was not found in this study.

In a study done in a hospital in Taiwan by Lee, et al. [28], to study the relationship between air pollutant levels and admission to hospital, due to COPD in Kaohsiung city in Taiwan, Data for admission to hospital for COPD and environmental air pollution was collected for years from 1996 to 2003. After controlling the variables such as seasonality, day of the week, weather and long-term time trends, the odds ratio of admission to hospital was assessed by means of the cross-over approach. In single-pollutant model a substantial positive correlation was found in all pollutants leaving out sulphur dioxide especially on warm days. On cold days with temperatures less than 25, all pollutants were found to effect lung function considerably and were associated with hospital admissions due to COPD.

CONCLUSION

From the above literature review it was seen that cigarette(tobacco) smoking is the single major risk factor in the development of COPD. In one survey it was found that smoking accelerated aging, reduces lung function and thus,

increasing the severity of the COPD. Other factors being diet; to a major extent a diet low in total fibre and ω-3 fatty acids also contributed majorly to the dangers of COPD development along with male gender, age (40 +), early childhood respiratory diseases, pollutants in the air, ozone, nitrogen dioxide, carbon monoxide, sulphur dioxide, and particulate matters with particle size 2.5 to 10, family history of asthma and BMI. In one study it was also seen that ABH secretor status also may have a role in the occurrence of COPD.

Obesity is a complex metabolic condition which effects the structure and functioning of many organ systems in the body. The fatty tissue is also believed to be a source of chemical mediators that increase systemic inflammation, which is the main feature of COPD. Along with systemic inflammation, physical inactivity was also found to be associated positively with COPD.

Dietary antioxidants, vitamin E and C, were also found to prevent damage due to oxidation of the lung tissue, caused by cigarette smoking. Smoking along with reduced vitamin C intake increased the burden of body's oxidative stress, which in turn can make the gene GCLG susceptible to decreasing lung function below normal. Through the studies antioxidant vitamins were found to have a favourable effect on the functioning of the lungs, this effect, however fluctuated by gender and smoking status.

A positive correlation between prevalence of vitamin D deficiency, presence and severity of COPD has also been seen in some studies. A diet high in vitamin D also should be recommended along with fibre vitamin C and E and omega-3 fatty acids.

DECLARATIONS

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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