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Association of Nicotine Dependence with Respiratory Muscle Strength and Six Minute Walk Distance in Adult Smokers

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ABSTRACT

Background: Cigarette smoking is the leading cause of preventable death in the world. It has deleterious effects on various body systems, especially respiratory system, that leads to reduction in respiratory muscle strength and functional capacity. Due to lack of evidence of the effects of nicotine dependence on these two aspects, there was a need felt to conduct a study to find the association of nicotine dependence on respiratory muscle strength and 6 minute walk distance in adult smokers.
Design: It was a cross-sectional observational study.
Participants: 108 healthy adult smokers participated in the study with the age between 20-40 years, who smoked for more than 1 year, with minimum consumption of 1 cigarette per day. Subjects with BMI of more than 30kg/m^2, who had undergone recent surgeries, who suffered from other respiratory conditions and who were engaged in other strength and endurance workout were excluded from the study.
Methodology: Nicotine dependence was determined by Fagerstrom test of Nicotine dependence, Respiratory muscle strength was measured by MicroRPM and Functional capacity was determined by 6 minute walk distance.
Results: The association of Nicotine dependence with respiratory muscle strength and 6 minute walk distance was determined by Spearman correlation coefficient. There was weak positive correlation between nicotine dependence and maximal inspiratory pressure which was statistically significant. There was weak negative correlation between nicotine dependence and 6 minute walk distance which was statistically significant.
Conclusion: This study showed that there was weak positive correlation between nicotine dependence and Maximal inspiratory pressure and weak negative correlation between nicotine dependence and 6 minute walk distance in adult smokers.

Key Words: Cigarette smoking, maximal inspiratory pressure, maximal expiratory pressure, Fagerstrom test for nicotine dependence, six minute walk distance.

INTRODUCTION

Cigarette smoking is the leading cause of preventable death in the world[1,2,3]. About 30% of Indians who are older than 15 years of age use different forms of tobacco, out of which cigarettes, cigars, snuff and chewing tobacco are common[4]. Many young adults start smoking at very early age and the rate of cigarette smoking in this population is increasing steadily[2,5] making them prone for greater nicotine dependence with the early initiation of smoking[6]. Nicotine dependence is thought to be the central process, which underlies the reason why people continue to smoke and experience greater difficulty in stopping it[7].

There are various scales used to assess nicotine dependence. Fagerstrom test for nicotine dependence (FTND) is a widely used test and is globally adapted to measure physical dependence on nicotine, as it is easy to understand and can be applied rapidly on physiological and behavioural basis[8,9].

Cigarette smoking has major health risk factors especially respiratory and cardiovascular morbidities. Decreased respiratory muscle strength due to smoking may indicate deterioration of respiratory system even before onset of clinical symptoms. Respiratory muscle strength (RMS) is based on the lung mechanics i.e. expansion during inspiration and recoil during expiration[10]**.** Respiratory muscle strength is tested as maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP)[11]. MIP and MEP are easily measured indices of respiratory muscle strength on the basis of their simplicity, convenience and these are non-invasive parameters of respiratory muscle strength, and have diagnostic and prognostic values[5,11]. Weakening of these respiratory muscles can be the risk factor for the cardio-pulmonary diseases, as these muscles play a major role in reducing the pressure of lower abdomen during respiration[12].

Functional capacity assessment is described as the ability to perform activities of daily living that require sustained aerobic metabolism[13]. Functional capacity assessment is important to understand the impact of a particular disease and development of disease management methodologies[14] and there are several objective tests used to assess it[15]. Six minute walk test is a simple test, easy to administer, better tolerated and is more reflective of daily activities[15]. It has been used often in various disease population. It is stated that smokers have lower functional capacity than non-smokers, and they also had bad hemodynamic repercussion in six minute walk test (Rafaella et.al)[16].

Tobacco smoking has its deleterious effects on various body systems, especially respiratory system, which leads to reduction in lung volumes and respiratory muscle strength (Shahid Hasan et.al)[2]. Several studies shows effect of tobacco smoking on lung volumes in young smokers, but there are limited studies done to show its impact on respiratory muscle strength. Also there is lack of evidence of the effect of smoking on the functional capacity. So based on the dependency of smoking we tried to correlate with respiratory muscle strength and six minute walk distance. There is widespread belief that light smokers are not at any health risk. Therefore, screening of this class of smokers holds a huge importance for the individuals themselves as well as for the society, so as to spread its awareness.

MATERIALS AND METHODS

It was a cross-sectional observational study, which was set up in community. The duration of study was 1 year. 108 adult male and female smokers participated in the study, with the inclusion criteria of age group between 20-40 years, minimum duration of smoking of 1-3 years and minimum consumption of 1-5 cigarette per day. Exclusion criteria were BMI of more than 30kg/m^2, recent abdominal or thoracic surgeries done, subjects with other respiratory conditions and subjects engaged in strength and endurance workout.

The clearance from ethical committee was taken. The subjects were randomly allocated for the study. The subjects were also asked to fill the questionnaire of Fagerstrom test of nicotine dependence. The total score and the severity of nicotine dependence was determined according to the points from the questionnaire.

Respiratory muscle strength was assessed in the form of Maximal inspiratory pressure (MIP) and Maximal expiratory pressure (MEP) by the help of MicroRPM. MIP was taken with the subject seated upright, subject was asked to exhale to RV, empty the lungs, followed by a Mueller maneouvre, i.e. a forced inhalation against the MicroRPM with as much effort as

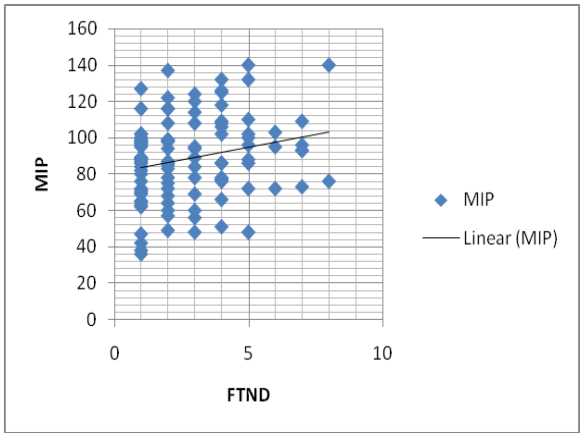
possible. The display reported the result, the maximum average inspiratory pressure sustained over a 1 second period of test, in centimeters of water (cmH_2O). For MEP, subject inhaled to TLC, then performed Valsalva maneouvre, and forcefully exhaled against the MicroRPM with as much effort as possible for as long as possible. Reading was noted. Both the maneouvres were performed three times and best value was selected. Nose clip was used to avoid air passage through nose in both tests. The normal values of both the MIP and MEP were taken as the reference values to access the respiratory muscle strength.

Functional capacity was taken with the help of 6MWD according to the guidelines of ATS. In this test, the subject was seated in a chair and clinical parameters i.e. heart rate, respiratory rate, rate of perceived exertion, blood pressure and SpO2 were noted. Lap counter was set to 0 and timer to 6 minutes was set. The subject was instructed to walk as fast as possible for 6 minutes on a 30m walkway at his comfortable speed. After the test was done, the clinical parameters were again taken. Number of laps and the distance were recorded. The predicted distance was calculated by the regression equation, and the actual distance was compared with the predicted distance, so as to get the percentage of distance walked.

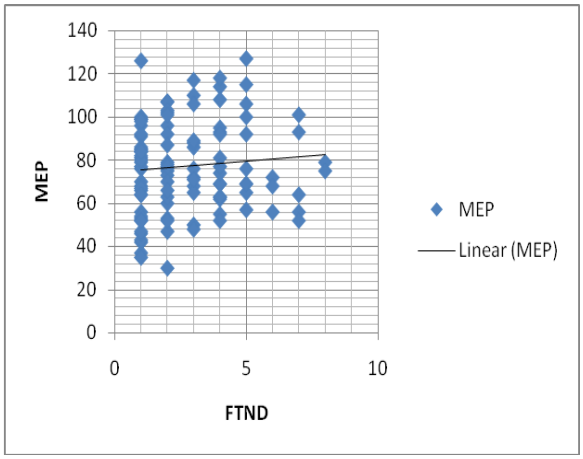
Statistical analysis: Spearman rank order correlation coefficient was used as a statistical test to determine the correlation of nicotine dependence with respiratory muscle strength and 6 minute walk distance. The data was analysed by using SPSS version.

RESULTS

Graph no.1 shows the correlation of nicotine dependence with MIP. The r value of maximal inspiratory pressure is 0.221 and p value is 0.021, which shows there is weak positive correlation of nicotine dependence with maximal inspiratory pressure, which is statistically significant.

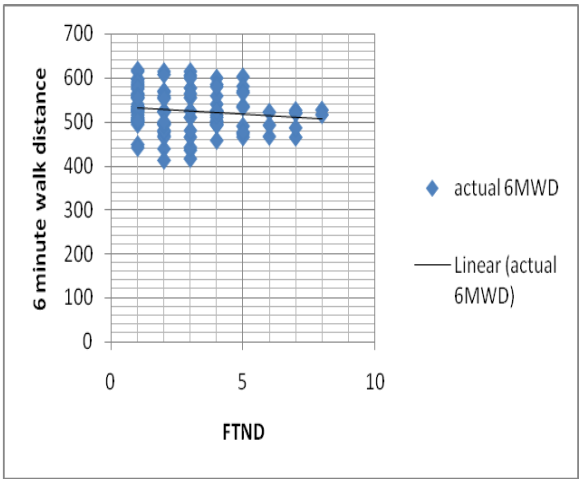


Graph no.1



Graph no.2

Graph no.2 shows the correlation of nicotine dependence with maximal expiratory pressure. The r value of maximal expiratory pressure is 0.096 and p value is 0.323, which shows there is weak positive correlation of nicotine dependence with maximal expiratory pressure which is not statistically significant.



Graph no.3

Graph no.3 shows the correlation of nicotine dependence with 6MWD. The r value of 6 minute walk distance is -0.192 and p value is 0.046, which shows there is weak negative correlation of nicotine dependence with 6 minute walk distance which is statistically significant.

DISCUSSION

This study evaluated association of nicotine dependence with respiratory muscle strength and six minute walk distance. Cigarette smoking leads to dysfunction of all the skeletal muscles, including the respiratory muscles. The 2 main types of skeletal muscles involved in respiration are pump muscles and airway muscles. The pump muscles mainly consist of the skeletal muscles and the airway muscles are the combination of skeletal and smooth muscles. Smoking leads to affection of both the structures. The pump muscles are said to undergo plasticity depending upon various environmental, physiological and pathological conditions. Smoking might also cause certain plasticity in the respiratory muscles (Heather M. Gransee et.al)[17].

In this study, there is weak positive correlation between the maximal inspiratory pressure and nicotine dependence. Joaquim Gea et.al. in a study of COPD patients stated that there are structural and metabolic changes in the respiratory muscles which lead to certain paradox effects on the respiratory muscles, i.e. increase in the strength of the respiratory muscles due to smoking. These changes are seen in the initial phase of COPD which could be a bodily adjustment to cope up with the increased demands. This is due to the fact that striated muscles are very sensitive to modifications in their environment, as they are extraordinarily capable of changing their phenotype to adapt to the ongoing conditions[18]. The structural adaptations in the diaphragm and intercostals muscles also cause various changes in its molecular level. There is reduction in sarcomere length, increase in capillary contact per fiber, increase in mitochondrial density and activity, increase in different enzyme activity, participating in the oxidative pathways, modifications in the expression of structural protein like myosin heavy chain (MyHC) isoforms and increase in aerobic enzyme capacity[18,19]. There is also increased capillary density, which could be one of the aerobic adaptations observed in these muscles. The diaphragm and intercostal muscles show increase in the proportion of type I fibers (slow-twitch contraction, aerobic metabolism and fatigue resistant)[18]. These could lead to preservation of their function. Similar effect is seen in intercostals muscles as well.

This study showed decreased maximal inspiratory pressure in smokers as compared to their predicted values as their nicotine dependence increased. The subjects were also chronic smokers based on their duration of smoking without symptoms. COPD is usually detected late. The main reason for it is, the individual feels the symptoms could be because of smoking. Body first tries to adapt to the changes as paradox effect explained above, but finally it gives off, leading to symptoms. Similar changes were seen in this study, people with higher nicotine dependence score had better maximal inspiratory pressures as compared to low nicotine dependence scores.

According to Hans Degens et.al the muscles of non-symptomatic smokers are said to have weak and less fatigue resistance than non-smokers. Evidence suggests smoking reduces force generating capacity and fatigue resistance in skeletal muscles which can be further explained by molecular mechanisms causing imbalance between protein production and degradation ultimately leading to muscle dysfunction. Evidence shows there is increased expression of muscle atrophy F-box (MAFBx) in quadriceps which is required for proteolysis. There is increased expression of myostatin which inhibits muscle growth by inactivation of protein kinase B (Akt), a promoter of protein synthesis, and by hampering muscle cell

renewal[20]. In peripheral muscles, there is decreased capillary density, decrease in the number of mitochondria and their function. Peripheral muscles have less enzyme activity in their aerobic pathways, with maintenance or increase in glycolytic enzymes. The peripheral muscles also have a higher proportion of type II fibers (fast-twitch contraction, predominantly anaerobic metabolism)[18]. These changes are more evitable in COPD patients but smokers are not exception to it. Smoking leads to chronic changes in the body which are detected quite late when symptoms start showing, but by then it is too late as the disease has already progressed.

Muscle fatigue resistance is defined as the ability of a muscle to maintain a given force or power output. It is related to the oxidative capacity of muscle. In smokers, there is fiber type transition from type l to type ll, which causes reduction in fatigue resistance. The disuse of muscles leads to slow to fast fiber type transition. Therefore, smoking along with lack of physical activity induces the transition of one fiber type to another fiber type. Another factor responsible for the reduced fatigue resistance is decrease in the oxygen delivery to mitochondria or their impairment to use oxygen[20].

In this study, correlation between Fagerstrom test for nicotine dependence and 6 minute walk distance was found. The possible mechanisms for this could be because of inflammatory mediators released in skeletal muscles leading to reduction in fatigue resistance, impairment of force generating capacity, muscle wasting. Inflammatory mediators released due to smoking bring about structural & molecular changes, which is the possible reason for it[20]. Six minute walk test requires good endurance of lower limb muscles & cardiovascular system to perform the test. If peripheral muscles are affected because of inflammatory process its performance is going to be affected. Fatigue resistance and impaired force generating capacity of peripheral muscle could have contributed to decrease in 6 minute walk distance.

Laura Miranda et.al stated in their study that in smokers, muscle wasting is responsible for the reduction in the muscle function as well as exercise capacity. Muscle wasting is mainly due to increase in protein degradation, with simultaneous decrease in protein synthesis[21], and release of cytokines[20]. This occurs in dose dependent and duration dependent manner[20], i.e. more the dose and duration of smoking, more is the affection. Cigarette smoking causes increase in proinflammatory cytokines in blood, especially TNF-α and IL-6. They increase proteolysis and inhibit protein synthesis, which ultimately leads to muscle wasting[20].

This study shows more affection of peripheral muscles as compared to respiratory muscles. Although direct assessment of peripheral muscle strength was not taken into consideration. Subjects in the study had low smoke load which has contributed to change in peripheral muscles, which is reflected in 6 minute walk distance. This can be explained by the study of Rob C.I. Wust et.al. which stated that the peripheral muscles of smokers are more fatigable than the non-smokers, despite of the absence in the changes in contractile properties and muscle weakness. Fatigability increases with the increase in smoking volume[22].

CONCLUSION

This study shows the association of nicotine dependence with respiratory muscle strength and 6 minute walk distance in adult smokers. This study shows early affection of 6 minute walk distance in adult smokers as compared to respiratory muscle strength.

Clinical Implications:

Functional capacity training in smokers can be carried out. Regular respiratory muscle strength can be evaluated in smokers, which might identify the onset of respiratory disease. Strength training of respiratory and peripheral muscles in

smokers can be done, so as to prevent the delirious effects of smoking.

Limitations:

In this study, most of the subjects were between the age of 20-25 years. Therefore, observation in the subjects of other age groups was not done. Peripheral muscle strength was not measured in the study. Most of the subjects had low nicotine dependence.

Future Scope:

Evaluation of respiratory muscle strength and 6 minute walk distance can be done in subjects with high nicotine dependence. Evaluation of respiratory muscle strength and 6 minute walk distance in age groups below 20 years and above 40 years can be done. Effects of different treatment strategies for training respiratory and peripheral muscles in smokers can be done.

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