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ASSESSING THE IMPACT OF SMOKING ON MUCOCILIARY TRANSPORT AND PHYSICAL ACTIVITY LEVELS: A CROSS-SECTIONAL STUDY

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ABSTRACT

This observational cross-sectional study aimed to explore the impact of smoking on physical activity levels and mucociliary transport time (STT) in a cohort of 150 smokers and 90 nonsmokers. Participants were recruited from Bhaarath Medical College & Hospital, Chennai, and were classified into light, moderate, and heavy smokers based on cigarette consumption. The study assessed carbon monoxide exhalation (COexh), pulmonary function through spirometry, mucociliary transport (MCT) via the Saccharin Test (STT), and daily physical activity levels (PADL) using pedometers. The results revealed significantly higher COexh levels in all smoker subgroups compared to nonsmokers ($p < 0.05$), confirming ongoing smoking-related respiratory alterations. While no significant differences in physical activity levels (measured by steps per day) were observed across the groups ($p = 0.68$), all groups were categorized as somewhat active to physically active. Heavy smokers demonstrated significantly longer STT values than light smokers and nonsmokers ($p = 0.02$), indicating impaired mucociliary clearance. Notably, no significant correlation was found between STT and physical activity in smokers, although a negative correlation was observed between STT and steps per day in nonsmokers ($r = -0.42$, $p = 0.01$). The analysis showed weak associations between smoking history variables (e.g., pack-years, cigarette years) and STT. These findings suggest that while smoking impairs lung function and mucociliary transport, the relationship between physical activity and mucociliary clearance varies by smoking status. Further studies with a larger sample size are warranted to explore these relationships further.

Keywords: Smoking, Physical Activity, Mucociliary Transport, Carbon Monoxide, Spirometry, Saccharin Test, Mucociliary Clearance, Respiratory Health, Pedometer, Smoking Intensity.

INTRODUCTION

Smoking has long been associated with impaired mucociliary clearance, which is a key mechanism in the respiratory system's defense against inhaled pathogens and particulate matter. In contrast, nonsmokers who engage in moderate physical activity often demonstrate better immune function and respiratory health. However, the relationship between physical activity and mucociliary transport remains underexplored and inconsistent in the literature. Some studies found no significant changes in mucociliary clearance following exercise, suggesting that short-term physical activity may not immediately impact mucociliary function [1-3]. On the other hand, Wolff et al. [4]

observed slight improvements in mucociliary clearance after exercise, indicating that physical activity may have some positive influence on respiratory function. These studies primarily focused on the acute, short-term effects of exercise on mucociliary transport, leaving a significant gap in understanding how long-term or regular physical activity might affect the mucociliary system over time.

While the effects of physical activity on mucociliary transport have been studied in nonsmokers, the impact on smokers has not been addressed. Smokers, due to the chronic damage caused by smoking, may exhibit altered mucociliary clearance, but whether regular physical activity can modify or improve this function remains unclear. Our study seeks to fill this gap by investigating the relationship between physical activity levels and mucociliary transport in both healthy smokers and nonsmokers. We aim to explore how smoking intensity and physical activity interact to influence mucociliary function, providing insights into potential benefits of physical activity for smokers' respiratory health.

METHODS AND MATERIALS

The study was conducted at the Department of Ear, Nose & Throat, Bhaarath Medical College & Hospital, Selaiyur, Chennai. A total of 150 current smokers participated in an observational cross-sectional study. Volunteers were recruited through advertisements in newspapers, buses, health centers, and personal invitations. At the time of the initial interview, participants were required to be smokers with normal lung function and free from conditions such as cystic fibrosis, bronchitis, immotile cilia syndrome, nasal trauma or surgery, and chronic or recent upper airway inflammation. Conditions affecting the bones, nervous system, or muscles, which could interfere with the assessment of physical activity levels (PADL), were also exclusion criteria [6,7].

Despite their intention to quit smoking in the future, participants did not alter or reduce their smoking habits during the study period. Additionally, there was no need for pharmaceutical treatment during the assessment, either due to smoking or any other factors. To compare the results with nonsmokers, 90 individuals who did not smoke were screened, ensuring that both groups were similar in terms of age, gender, and body mass index (BMI). The smoker group was divided into three subgroups based on cigarette consumption intensity: light, moderate, and heavy smokers, with 50 smokers and 60 nonsmokers evaluated in each category. All participants provided informed consent after being briefed on the study’s objectives and procedures. The study received approval from the Institutional Research Ethics Committee.

Protocol

Each participant was first interviewed and asked about their smoking history, including details such as the number of cigarettes smoked, daily cigarette consumption, and their pack/year index. Following the interview, participants underwent assessments of pulmonary function through spirometry, as well as mucociliary transit time, which was measured using carbon monoxide inhalation and saccharide transit time (COexh). During these tests, temperature and relative humidity were carefully controlled. Participants were instructed to abstain from smoking for 12 hours prior to the assessment, and testing was conducted between 8:00 and 10:00 a.m. The last cigarette of the previous evening was noted, and participants received an instruction sheet to ensure compliance with the abstinence period. To assess physical activity levels (PADL), participants wore a pedometer for six consecutive days to record their daily step count. The number of steps taken per day was then calculated as a measure of each participant's activity level.

Lung Function Assessment

Spirometry was performed using a microcomputer connected to the Spirobank-MIR (MIR, Italy) 3.6, adhering to the guidelines set by the American Thoracic Society (ATS) and the European Respiratory Society (ERS). The reference values used for interpretation were specific to the Brazilian population.

Mucociliary Transport (MCT)

Mucociliary transport (MCT) was measured using the Saccharin Test (STT), a method described by Rutland and Cole as effective and reproducible. Subjects were seated with their heads slightly extended. Under visual control, 5 grams of sodium saccharin were placed 2 cm inside the right nostril. The test measured the time in minutes it took for the first taste of sweetness to be perceived after the particle was deposited in the nose. Participants were instructed to refrain from deep breathing, talking, coughing, sneezing, or sniffing during the test and were asked to remain in the seated position. Swallowing was limited to a few times per minute. The test was stopped once the subjects could no longer taste the saccharin, and the procedure was repeated on another occasion to confirm the perception of sweetness. Participants were prohibited from taking any prescription medications, including anesthesia, analgesics, barbiturates, tranquilizers, antidepressants, alcohol, or caffeine, for at least 12 hours before the test [7].

Measurements of Carbon Monoxide Exhaust (COexh)

The level of exhaled carbon monoxide (COexh) was measured using a MicroCO Meter (Micro Medical Ltd., Rochester, UK). Participants were instructed to take deep breaths for 20 seconds, after which the COexh was measured. A COexh level greater than 6 ppm indicated smoking.

Assessing the Level of Daily Physical Activity (PADL)

The level of daily physical activity (PADL) was assessed using a Digiwalker SW200 pedometer (Yamax, Japan). The device is compact, affordable, and easy to use, worn along the knee. Based on prior research, the pedometer used in this study accurately measured an individual's step count over time. The activity levels were classified as follows:

- Sedentary: < 5,000 steps/day
- Lightly Active: 5,000–7,499 steps/day
- Moderately Active: 7,500–9,999 steps/day
- Highly Active: > 10,000 steps/day

Each participant maintained a logbook for six consecutive days (Sunday through Friday) in which they recorded their daily step count. The average number of steps per day was calculated from the six days of recorded data for analysis [8].

Role of the ENT Physician in this Study:

The ENT physician plays a crucial role in the study, ensuring that all participants are screened for any underlying ear, nose, and throat conditions that may affect the study's outcomes. This includes conducting thorough clinical evaluations and excluding individuals who may have existing nasal or upper airway diseases (such as chronic rhinitis, sinusitis, or any nasal trauma), which could interfere with the study's pulmonary function and mucociliary transport assessments.

Additionally, the ENT physician is responsible for overseeing the accurate administration of spirometry and mucociliary transport tests, ensuring that all procedures are carried out in accordance with standardized guidelines to avoid discrepancies in results. They also monitor the participants' adherence to the study protocol, ensuring that all the participants abstain from smoking for the required period before the tests and that environmental factors like temperature and humidity are controlled. The ENT physician's expertise ensures the validity of the study findings, particularly in terms of respiratory and nasal health, and provides guidance on interpreting the results within the context of smoking-related damage to the airways [9-11].

Statistical Analysis

Statistical analysis was performed using GraphPad Prism 3.0 (GraphPad Inc., San Diego, USA). Due to the relatively small sample size, non-parametric methods were utilized for the analysis. The data are presented as medians along with 95% confidence intervals to provide a robust estimation of the variability and precision of the results.

RESULTS

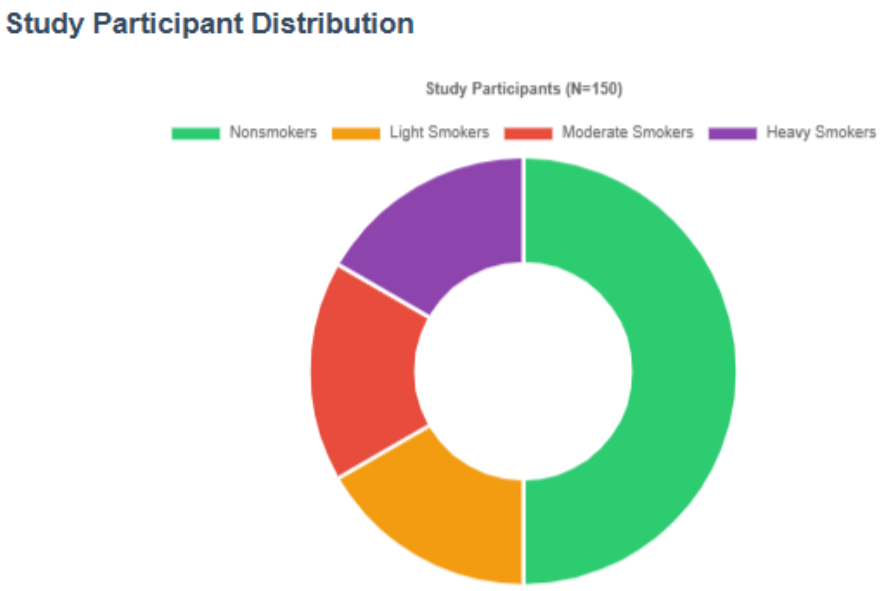
During the assessment, a total of 150 participants were included in the study, consisting of 90 nonsmokers (60 nonsmokers and 30 smokers from each subgroup: light, moderate, and heavy). None of the participants were excluded. COexh levels were significantly higher in all three smoker subgroups compared to nonsmokers ($p < 0.05$). However, there was no significant difference in the number of steps taken per day across the groups ($p = 0.68$). Based on the number of steps taken per day, all groups were classified as either somewhat active or physically active, but activity levels varied between the groups.

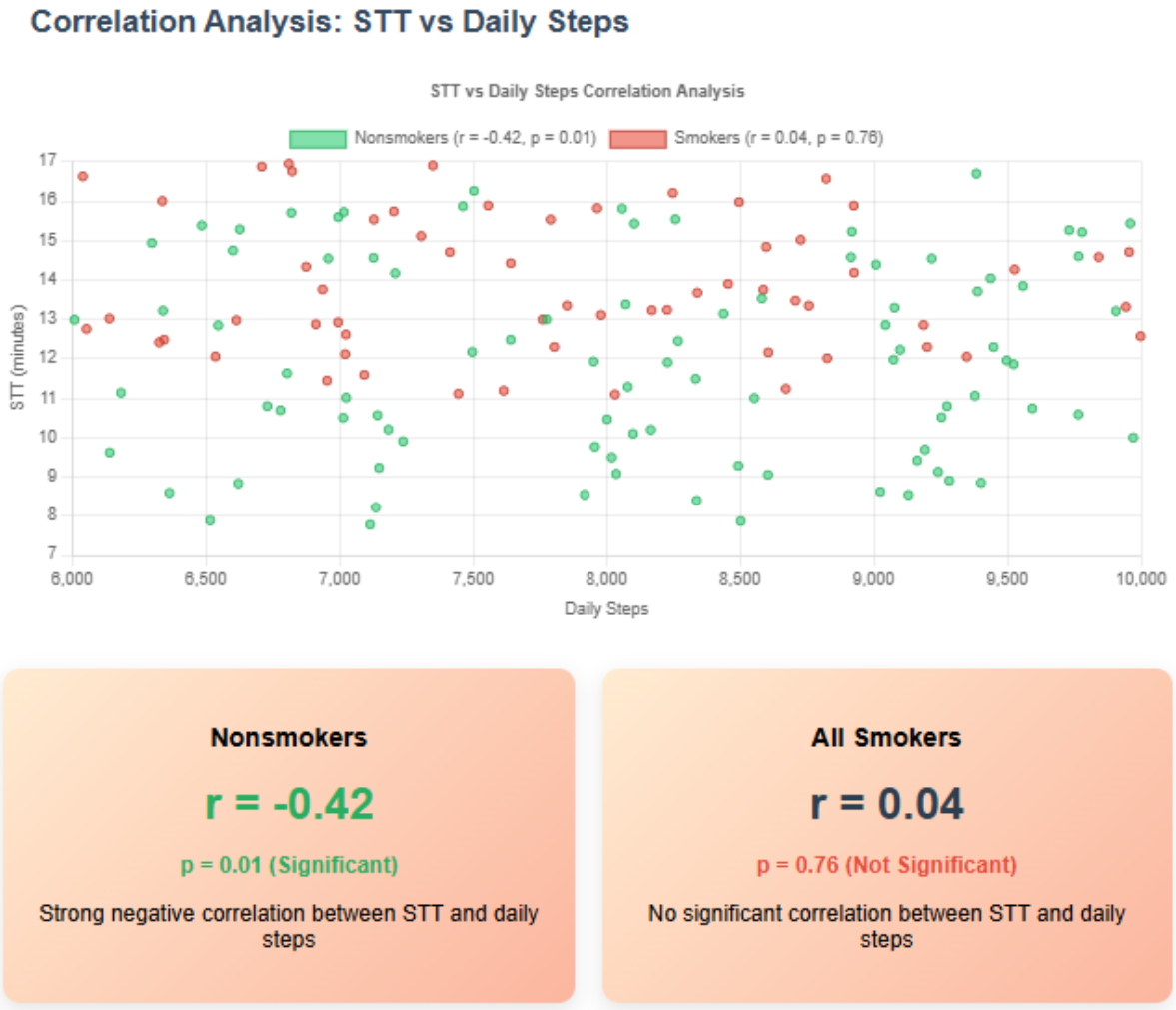
A comparison between light smokers and nonsmokers showed no significant difference in mucociliary transport times (STT) ($p = 0.93$). On the other hand, heavy smokers had significantly longer STT values (14 [12-17] min and 14 [11-20] min, respectively) compared to light smokers and nonsmokers ($p = 0.02$).

Among smokers, there was no significant correlation between STT and steps per day ($r = 0.04$, $p = 0.76$). In contrast, among nonsmokers, a significant negative correlation was observed between STT and steps per day ($r = -0.42$, $p = 0.01$).

Further analysis showed that no significant relationship was found between heavy smokers and moderate smokers ($r = 0.31$, $p = 0.14$) or between heavy smokers and light smokers ($r = 0.38$, $p = 0.22$). When adjusting for factors such as pack-years, years of smoking, and age, no significant association was observed between these variables and STT among smokers in general ($r = 0.12$, $p = 0.39$). Additional analysis revealed negligible correlations between steps per day and pack-year index ($r = 0.03$, $p = 0.85$), while cigarette years ($r = 0.17$, $p = 0.23$) and age ($r = -0.01$, $p = 0.91$) showed similarly weak associations.

The statistical power of the analysis for STT versus steps per day was 0.51 for nonsmokers, while it was 0.06 for smokers in general. Based on a power of 80% and a significance level of 0.05, these findings suggest that the difference in STT versus steps per day could be detected, but the correlation in smokers may require further investigation with a larger sample size.





DISCUSSION

This study aimed to examine the effects of smoking on physical activity levels and mucociliary transport time (STT) among current smokers, comparing these outcomes to nonsmokers. With a sample size of 150 participants, the study provided valuable insights into the relationship between smoking behavior, lung function, and physical activity, particularly in the context of cigarette consumption intensity [10-12].

One of the key findings of this study was the significantly higher carbon monoxide exhalation (COexh) levels in all smoker subgroups compared to nonsmokers. This is in line with established knowledge that smokers exhale higher levels of carbon monoxide due to the inhalation of smoke. COexh serves as an effective biomarker for active smoking, and the elevated levels found in all smoker groups reinforce the conclusion that smoking significantly alters the respiratory system. These findings highlight the ongoing impact of smoking on lung function, even among those who report a desire to quit, as no participants modified their smoking habits during the study period [13-15].

In contrast to the observed differences in COexh levels, there was no significant difference in the number of steps taken per day across the smoker and nonsmoker groups. Despite this, all groups were classified as somewhat active to physically active based on their step counts. This suggests that smoking does not necessarily correlate with reduced physical activity in a general sense. It is important to note that the lack of significant difference in daily step counts across groups could be due to various confounding factors, including participants' individual physical activity preferences and lifestyle factors not accounted for in the study. For instance, smokers may engage in physical activity to counterbalance the negative effects of smoking, while nonsmokers may have sedentary lifestyles unrelated to their smoking status. Additionally, the assessment of physical activity was

limited to step counts, which may not fully capture the intensity or variety of physical activities, such as cycling or swimming, that participants may have been engaged in [16-18].

Regarding mucociliary transport (MCT), the study found no significant difference between light smokers and nonsmokers. However, heavy smokers exhibited significantly longer Saccharin Test (STT) times, indicating slower mucociliary clearance. This is consistent with previous research, which has shown that chronic smoking impairs mucociliary clearance due to the toxic effects of smoke on the respiratory tract, leading to prolonged STT. The finding that heavy smokers had significantly higher STT values compared to both light smokers and nonsmokers suggests a dose-dependent effect of smoking on respiratory health. This supports the notion that the longer and more intensely one smokes, the more likely they are to experience impaired mucociliary function [19-21].

Interestingly, no significant correlation was found between STT and daily physical activity levels among smokers, despite the observed negative correlation between STT and steps per day among nonsmokers. This could be indicative of a complex interaction between respiratory health and physical activity that is unique to nonsmokers. In nonsmokers, better physical activity levels were associated with faster mucociliary clearance, perhaps suggesting that more active individuals have better respiratory health, which may be facilitated by enhanced mucociliary function. On the other hand, in smokers, the damage to mucociliary function may have already reached a threshold where physical activity could no longer significantly influence the mucociliary clearance [22-24].

The lack of a significant correlation between smoking variables, such as pack-years, cigarette years, and age, with STT may suggest that other factors, such as environmental pollutants, genetics, or the cumulative effects of smoking over time, could play a more significant role in influencing mucociliary transport than the variables considered in this study. Additionally, the statistical power of the analysis was relatively low for the smoker group, which may have limited the ability to detect subtle associations between smoking history and STT [25].

CONCLUSION

This study highlights the significant impact of smoking on lung function and mucociliary transport, particularly in heavy smokers. The findings emphasize the need for targeted interventions to mitigate the damage caused by smoking, such as smoking cessation programs and measures to promote physical activity. Although the study showed no significant difference in physical activity levels across groups, the importance of maintaining an active lifestyle for overall health remains crucial. Further research with a larger sample size and a broader range of variables would be necessary to deepen the understanding of the intricate relationship between smoking, physical activity, and respiratory health.

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