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Research Article

A study of body mass index and nasal mucociliary clearance in healthy South Indian adult volunteers

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ABSTRACT

Background: Overweight and obesity are associated with a variety of diseases including respiratory disorders like asthma, COPD and breathing disorders which can reduce the quality of life. Nasal mucociliary clearance (NMC) is a defence mechanism of the upper airways whereby mucus secreted by the mucociliary apparatus traps inhaled particulate matter and transports it to the pharynx where it is swallowed. The nasal mucociliary epithelium is a mirror image of the bronchial mucosa and is affected by various factors. Little is known about the effect of Body Mass Index (BMI) on respiratory epithelium function. Aim of the study was to evaluate the effect of BMI on nasal mucociliary clearance.
Methods: NMC was measured in 60 healthy adult volunteers of age ranging from 20 - 35 years. The time taken to experience sweet taste at posterior nasopharynx following the placement of saccharin crystal in the nostril was recorded as NMC time. The height and weight of the subjects was recorded and BMI computed.
Results: Average NMC time (STTav) was 7.00 mins in the normal BMI category. However, we could not demonstrate much of a difference between this value and the mean in the overweight and obese categories, which were 7.16 and 5.81minutes respectively. Consistently, we observed faster clearance in the obese category compared to the normal and overweight, though the difference was not found to be statistically significant.
Conclusions: Our study did not demonstrate appreciable increase in NMC time among the overweight and obese compared to the normal BMI group.

Key words: Body masss index, Nasal mucociliary clearance, Obese, Overweight

INTRODUCTION

Obesity is the global pandemic of recent times, bringing in its wake a heavy burden of disease. In India too, as more and more of the populace, particularly the younger ones, turn to a more urbanized, fast-paced, consumerist and westernized way of life, sedentary habits and fast food are exacting a heavy toll in terms of health and productivity. Overweight and obesity are on the rise in the general population and, more worryingly, among children as well.[1]

Obesity is known to be an important risk factor for several diseases like coronary artery disease, hypertension, stroke, type II diabetes mellitus, dyslipidemia, metabolic syndrome, sleep apnea, infertility, gallstones, arthritis and even cancer. It has been implicated in the pathogenesis of many respiratory diseases such as asthma, COPD and breathing disorders like sleep apnea and obesity hypoventilation syndrome, which can reduce the quality of life and affect longevity.[2,3]

Respiratory health depends on consistent clearance of airway secretions by (1) the mucociliary clearance (MCC) system and (2) coughing. The MCC apparatus, an important defense mechanism for clearing the lung of bacteria and foreign particulate matter, consists of airway secretory cells that produce mucus and ciliated cells that propel the mucus out of the lung towards the mouth.[4]

The nasal mucociliary clearance (NMC) system transports mucus covering the nasal epithelium towards the nasopharynx by ciliary beating. It is controlled by physiological, anatomic and biochemical variables.[5] Certain chemicals, drugs, tobacco smoke and environmental pollutants are known to depress NMC and thus may lead to various respiratory diseases.[6,7]

Impaired NMC results in stasis of respiratory secretions and reduced lung defenses resulting in inflammation and infections.[8] NMC is thus a biomarker reflecting nasal mucosal function. Being the mirror image of bronchial MCC, it is a convenient index of lung mucociliary function and can be easily assessed using the simple, quick and non-invasive saccharine clearance method.[9]

Body-mass index (BMI) is an easy method to measure obesity and has been directly related to diverse health risks. It is defined as the individual's body mass in kg divided by the square of their height in metres.

The WHO classifies BMI as follows:

Less than 18.5 – Underweight, 18.5 to 24.9 - Normal weight, 25 to 29.9 –Overweight, 30 and above - Obese. As BMI increases, especially from values equal to or greater than 30, health risks increase. Increased adiposity can lead to mechanical abnormalities in ventilation and produce inflammation, reducing respiratory well-being.[10] Impaired mucociliary clearance could be an additional factor contributing to increased susceptibility to respiratory disease among overweight and obese individuals.

Though studies abound on MCC, very little information is available on the effect of BMI on nasal mucociliary clearance. Understanding the influence of BMI on NMC may advance our knowledge of pathogenesis of respiratory diseases in overweight / obese individuals. This study was done to evaluate the influence of BMI on nasal mucociliary clearance and to find out whether factors other than BMI such as gender, literacy status and socio economic status may have an effect on the nasal mucociliary clearance.

METHODS

This was a cross sectional study conducted among subjects of a suburban population of Chennai and was carried out at our institution during the year 2014. Ethical clearance was obtained from the Institutional Ethics Committee and the proposal was approved and cleared by the same (Ref: No SP No 1/IEC NO:2/ May 2014).

A total of 82 subjects were screened and detailed history regarding allergies, respiratory disorders, systemic disease, local pathology, impairment of taste sensation and use of medication was obtained from each using a screening Questionnaire. On the basis of the exclusion criteria 20 were excluded. They included smokers, passive smokers, tobacco chewers, snuff users, those with local pathology like deviated nasal septum, nasal polyp, nasal allergy and rhinosinusitis, those who had respiratory illness within the preceding two weeks, those with self-reported diabetes / other chronic or systemic diseases and those taking any kind of medication.

Two refused to participate in the study citing personal reasons. Sixty apparently healthy subjects of ages ranging from 20 to 35 were included in the study. This age group was selected to nullify the effect of age on NMC as previous studies have shown that age has an influence on NMC.[11,12]

Data collection:

The study questionnaire included questions regarding occupation, education, income and housing type and served to obtain the general socio-demographic profile of the subject. Anthropometric measurements were taken and noted. Height was recorded in metres by standardized (Stadiometer) meter scale. Weight in kg was obtained by standardized weighing machine. Waist and hip circumferences were measured in cm using standardized measuring tape.

BMI was computed from height and weight values using the formula wt in kg/ ht. in m^2. NMC was assessed using the Saccharine Transit Test devised by Anderson et al.[9] This is a non-invasive, simple and reproducible method that has been established as a standard investigation. A 1 mm x 1 mm x 1 mm crystal of saccharine was placed in the nose, just behind the inferior turbinate with the subject sitting and keeping the neck slightly flexed. By ciliary action the crystal moved to the nasopharynx, where the subject was able to make out its sweet taste.

The time taken by the subject to sense the taste of saccharine at posterior nasopharynx was noted as saccharine transit time (STT). The test was carried out on the left and right sides at an interval of half an hour and the values were recorded as STTL and STTR. The average of these two values (STTav) was computed and taken as nasal mucociliary clearance time. The subjects were advised to avoid nasal handling, sniffing and forceful breathing during the test. They were not informed about the nature of the particle and were simply told to report the taste perceived. The test was performed by a single investigator in all the study subjects so as to avoid inter-observer variability.

Statistical analysis: Data was entered in Excel sheet. Data analysis was done using EPI INFO software. Statistical analysis was performed using appropriate tests such as ANOVA.

RESULTS

This cross sectional study was conducted among healthy south Indian volunteers at Chennai. Eighty two were screened and 60 were included in the study. Using a study questionnaire subject details were recorded. NMC was assessed by the Saccharine Transit Test. Study subjects were grouped into three categories for analysis - Normal group having BMI >18.5 to < 24.99, Over weight group with BMI >25 to <29.99 and Obese group with BMI ≥ 30. There were 24 subjects in the Normal category, 23 in the Overweight and 13 in the obese category (Table 1).

Table 1: Descriptive characteristics of the study population.

Variables		Normal BMI	Percentage	Over weight	Percentage	Obese	Percentage
Total no. of subjects		24		23		13	
Gender	Male	16	66.6	12	52.1	8	61.5
	Female	8	33.3	11	47.8	5	38.4
Occupation	Employed	12	50	11	47.8	8	61.5
	Unemployed	12	50	12	52.1	5	38.4
Education	College graduate	13	54.1	12	52.1	10	76.9
	School level	11	45.8	11	47.8	3	23
Housing	Pucca	21	87.5	16	69.5	12	92.3
	Semi pucca	3	12.5	7	30.4	1	7.6
Annual income (INR)	<50,000	7	29.1	8	34.7	2	15.3
	>50,000	17	70.8	15	65.2	11	84.6

Table 2: Comparison of saccharine transit time between the three BMI Categories.

	Body Mass Index	N	Mean (mins)	Std. Deviation
STT-average	Normal	24	7.00	3.55
	Overweight	23	7.16	3.23
	Obese	13	5.81	1.24
STT-Left	Normal	24	6.06	3.24
	Overweight	23	7.07	4.96
	Obese	13	5.16	2.00
STT-Right	Normal	24	7.95	5.03
	Overweight	23	6.68	1.90
	Obese	13	6.46	2.13

STT- Saccharine transit time

Comparison of saccharine transit time (STT) between the Normal, Overweight and the Obese BMI groups was done using EPI INFO. Significance was taken as $p<0.05$ (Table 2 and Figure 1). All the three values STT-left, STT-right and STT-average were found to be higher in the normal BMI group when compared to the obese. This decrease in STT with increasing BMI was not found to be statistically significant.

Saccharine Transit Time: average (STTav) is the average calculated from STT values obtained on the right and left sides of the nose. This value serves to reduce the effect of nasal cycle on nasal mucociliary clearance. Mean STTav was found to be 7.00 mins in the normal BMI group, in the overweight it was 7.16 mins and in the obese it was 5.81 mins. These differences were not found to be statistically significant.

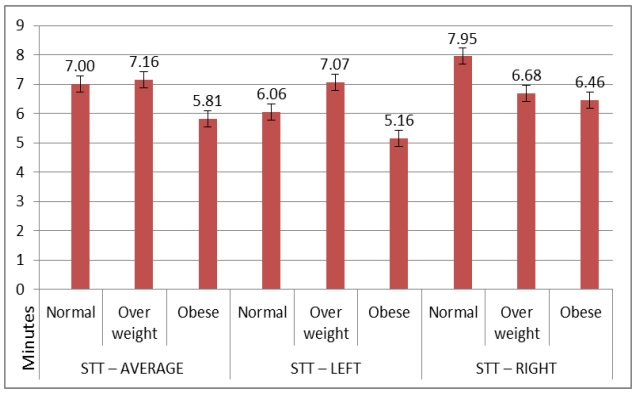

Figure 1: Comparison of saccharine transit time among the three BMI categories.

On the right side, mean STT was found to be 7.95 mins in the normal BMI group, 6.68 mins in the overweight group and 6.46 mins in the obese group. This difference in STT with BMI was not found to be statistically significant. On the left side, the mean STT was found to be 6.06 mins in the normal BMI group, 7.07 mins in the overweight group and 5.16 mins in the obese group. The decrease in STT with BMI was not found to be statistically significant. Using EPI INFO, Saccharine Transit Time-average values were compared among the

different sub categories of the three BMI groups (Table 3 and Figure 2).The mean STT was found to be higher among the normal BMI categories when compared to the overweight and the obese groups. In the normal BMI category, the employed group of volunteers had a mean STT of 7.77 mins, while those unemployed timed 6.35 mins. In the overweight group, the employed mean STT was 7.54 mins and among the unemployed it was 6.66 mins. In the obese group, the employed mean STT was 5.53 mins and among the unemployed it was 6.26 mins. People living in semi pucca houses showed a higher STT compared to those that lived in pucca houses. This was true of the overweight categories and the difference in the overweight group was found to be statistically significant. Among the different socioeconomic categories, the higher income group had a higher STT compared to the lower income group in all the three categories.

Table 3: Comparison of saccharin transit time among different sub categories of the BMI groups.

Saccharine transit time										
Parameters		Normal BMI (>18.5 to <24.99)			Over weight (>25 to <29.99)			Obese (≥30)		
		N	Mean (mins)	SD	N	Mean (mins)	SD	N	Mean (mins)	Sd
Gender	Male	16	6.19	1.66	12	6.19	1.66	8	6.19	2.86
	Female	8	9.90	4.79	11	7.86	4.36	5	5.58	1.48
Occupation	Employed	12	7.77	5.14	11	7.54	2.77	8	5.53	1.47
	Unemployed	12	6.35	1.05	12	6.66	3.51	5	6.26	0.64
Education	College graduate	13	7.60	4.70	12	7.54	2.89	10	5.77	1.41
	School level	11	6.39	1.14	11	7.01	3.53	3	5.93	0.55
House	Pucca	21	6.18	1.96	16	6.31	2.30	12	5.87	1.29
	Semi pucca	3	12.76	7.03	11	9.11*	4.31	1	5.32	-
Income (INR)	<50,000	7	6.46	3.08	8	6.94	3.28	2	4.40	0.57
	>50,000	17	7.49	3.99	15	7.20	3.35	11	6.05	1.23

*p< 0.05

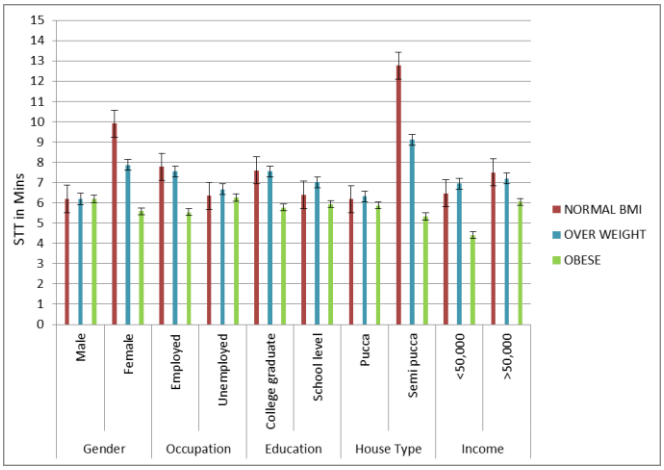

Figure 2: Comparison of saccharine transit time among the subgroups of the three BMI categories.

DISCUSSION

Obesity is known to be an important risk factor for several cardiovascular, reproductive and endocrine disorders. It can affect the respiratory system as well. Increased adiposity can lead to mechanical abnormalities in ventilation and impair pulmonary function, the extent of impairment being dependent on the distribution of body fat.[10] In addition, adipose tissue acts as endocrine organ and has metabolic effects on the body.[13] This could result in impairment of mucociliary clearance which could be an additional factor contributing to increased susceptibility to respiratory disease among overweight and obese individuals. Very little literature exists on the effect of body mass index on mucociliary function.

Present study showed an average NMC time (STTav) of 7.00 seconds in the normal BMI category, which is similar to that reported by other studies such as Yadav J, Golhar S and Golhar and Arora.[14-16] However, we could not demonstrate much of a difference between this value and the mean in the overweight and obese categories, which were found to be 7.16 and 5.81 mins respectively. STT on the left side showed an increased mean NMC time of 7.07 mins among the overweight category compared to 6.06 mins in the normal category. On the right side, mean STT was found to be 7.95 mins in the normal group, 6.68 mins among the overweight and 6.46 mins among the obese. All the values fall well within the normal range for a South Indian population and we observed no appreciable increase in NMC time among the overweight and obese compared to the normal BMI group.[12]

Among different subcategories of the BMI groups also, we found the mean saccharine transit time to be well

within the normal range of values expected. Unexpectedly, we found STT to be shorter in the obese category in all the subgroups. The unemployed, the less-educated and the lower income groups alone showed a slightly higher mean NMC time in the overweight category, but this difference was not found to be statistically significant.

In their study on 30 Philippino adult volunteers, whose BMI ranged from <18 to >30, Valdez et al showed that NMC time of underweight and overweight to obese was significantly longer than that of normal subjects. In their study, subjects with BMI in the normal range had a mean STT of 16.2 minutes, while underweight subjects averaged 20.5 mins and the overweight and obese showed a transit time of more than 30 mins.[17]

Among overweight and obese individuals, causes for a reduction in respiratory well-being could be many and varied. Impairment of pulmonary function and respiratory muscle strength has been well documented in many studies.[2] Additionally, an impaired mucociliary clearance system may compromise the defense system of the lung and airways and result in increased propensity to respiratory disease.

The increased NMC time signifying a decline in mucociliary clearance could be attributed to a variety of anatomical, physiological and biochemical changes in the mucociliary apparatus. Anatomical factors such as abnormal ultrastructure of the cilia, physiological factors like uncoordinated ciliary action, altered ciliary beat frequency, quantitative and qualitative alterations in the respiratory mucus and biochemical factors like increased oxidative stress potential have been suggested to be causes of impaired NMC.[7] Obesity is akin to a low grade inflammatory state. Imbalance in the production of several metabolic products, adipokines and cytokines may result in a variety of local and peripheral effects.[13] Some of the cytokines have been suggested to cause a systemic inflammation and these could be responsible for MCC impairment.

Fat deposition in the pharynx has been implicated as the cause for repetitive closure of airways in obese people during sleep.[13] Theoretically this could be another factor causing mechanical disruption of the clearance mechanism in the nose and paranasal sinuses. It is therefore clear that structural or functional changes in the airways are associated with increasing body mass index and this could be one of the causes of NMC impairment.[10] Another potential factor that could affect mucociliary clearance, directly or indirectly, in individuals having abnormal BMI could be 'deconditioning' resulting from the inability of people in this category to exercise as well as their poor respiratory muscle strength. Going by the study of Valdez et al, we expected the saccharine transit time, which negatively reflects the efficiency of NMC, to increase with increasing BMI. But our study has thrown up conflicting and interesting results. We have observed a consistently faster clearance among the obese category compared to the overweight and normal groups. Findings among the overweight category were variable with some subgroups showing increased STT and others a decrease.

The duration of overweight and obesity has not been considered in our study. It might be that a shorter duration of overweight and obesity does not cause noticeable impairment of NMC, but rather causes a short term improvement of NMC in these subjects, perhaps attributable to metabolic effects. This could explain the consistently faster nasal mucociliary clearance observed among the obese subjects in our study. This could also account for the variable results observed among the overweight, the variability being due to variation in duration of being overweight. Continued follow up of these subjects longitudinally may reveal NMC impairment at a later date.

In present study group, the number of obese subjects was lower than those in the normal and overweight categories and this could have influenced our results. A sample where all three BMI categories are nearly equally represented may yield more conclusive results. Present study also found that in the normal and overweight categories, NMC time was higher among the employed group compared to the unemployed group which comprised mainly students and homemakers. This could be attributed to greater exposure to dust among the working category as dust and suspended particulate matter are known to negatively affect MCC.[18]

Among residents of pucca and semi pucca houses, our study showed a higher NMC time for semi pucca residents in the normal and overweight categories and this difference was found to be statistically significant. This could be attributed to poor nutritional and health status and unhealthy living conditions in addition to dust and particulate matter exposure as people who live in semipucca houses are more likely to use biomass fuels like wood, coal and coke for cooking.[18]

In both the employment and housing categories, the same finding was not observed in the obese category probably because of smaller sample size in that category. In the income groups, those with higher income showed higher STT signifying less efficient clearance compared to those with lower income in all the three BMI categories and the difference was maximal in the obese category. Potential factors that could result in this finding include higher stress levels in the more affluent group.

Genderwise, present study found that in the normal and overweight categories, males showed a lower NMC time compared to females. In the obese category alone, females showed a lower NMC time though the difference was minimal. The influence of gender on NMC has not been conclusively established. Some studies have found no difference whereas Svartengren et al reported that

MCC was faster in females.[19,20] Our study suggests that NMC is faster in males. This could be because in the young age group that we have accessed for our study, the males have better nutritional and health status compared to the females.

CONCLUSION

This study was undertaken with the aim of assessing the effect of BMI on nasal mucociliary clearance in healthy young adults. Present study showed an average NMC time of 7.00 minutes in the normal BMI category. However, we could not demonstrate much of a difference between this value and the mean in the overweight and obese categories, which were found to be 7.16 and 5.81 minutes respectively. All the values fall well within the normal range for a South Indian population and we observed no appreciable increase in NMC time among the overweight and obese compared to the normal BMI group.

Present results could have been influenced by two factors i.e. the duration of overweight and obesity has not been considered in our study and in present study group, the number of obese subjects was lower than those in the normal and overweight categories.

A longitudinal study following up these subjects over a period of time may reveal NMC impairment in the overweight and obese categories compared to the normal, if the duration of obesity could be a factor in the development of NMC impairment. Moreover, a study population where all three BMI categories are nearly equally represented might yield more conclusive results. As of date, there are many unknown factors that may affect mucociliary clearance. Continued research is the key to unravelling details regarding the mechanisms underlying the impairment of mucociliary clearance.

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