DOI: 10.5958/2319-5886.2015.00028.4

International Journal of Medical Research & Health Sciences

www.ijmrhs.com Volume 4 Issue 1 Coden: IJMRHS Copyright @2014 ISSN: 2319-5886

Received: 26th Nov 2014 Revised: 16thDec 2014 Accepted: 25th Dec 2014

Research article

DOES BODY MASS INDEX INFLUENCE NASAL MUCOCILIARY CLEARANCE?

*Tamilselvan K, Latha R, Nirmala N, Susiganeshkumar E, Thananjayam A

Department of Physiology, Sri Venkateshwaraa Medical College, Hospital and Research Centre, Ariyur,Puducherry, India

*Corresponding author email: ktamilselvan10@gmail.com

ABSTRACT

Background: The respiratory system is constantly exposed to particulate matter suspended in the inhaled air and one among the efficient mechanisms to trap and expel the particulate substances is the nasal and bronchial mucociliary clearance mechanism. This mucociliary clearance mechanism is influenced by both physiological and pathological factors that alter the functioning of the respiratory cilia and the overlying mucosal layer that traps the particulate agents. As Body mass index (BMI) determines the health of a person by influencing various physiological parameters, this study has been planned to study the effect of normal and abnormal BMI (overweight and obese range) on the nasal mucociliaryclearance (NMC). **Aim:** To evaluate the effect of BMI on nasal mucociliary clearance (NMC). **Materials &Methods:** NMC was measured in 20 volunteers with normal BMI (18.5-22.9 Kg/m^2) and 20 volunteers with BMI in overweight and obese range (23 Kg/m^2 and above). The NMC time was recorded by the time the volunteers appreciated the sweet taste following the placement of ¼ of saccharin tablet (1mm x 1mm) in the nostril referred as saccharin transit time(STT).**Results:** NMC was found to be prolonged in overweight and obese population and BMI has positive correlation with NMC as calculated by Pearson correlation with r value of 0.591 and p value 0.001 which is statistically significant. **Conclusion:**NMC time is prolonged in abnormal BMI referring to the impairment in the mucociliary escalator mechanism thus predisposing to disease states.

Keywords: Body mass index, Nasal mucociliary clearance

INTRODUCTION

The respiratory function of the lungs demands perpetual exposure of the respiratory epithelium to the inhaled air which is the source of oxygen as well as the suspended particulate matter which includes dust, allergen, toxins and pathogens. The suspended particulates risk the infection and inflammation of the respiratory apparatus and can finally lead to functional impairment of the respiratory system as a consequence of the system's pathologies.

The respiratory apparatus' defence mechanisms: As a measure of protection the respiratory system is well equipped with an array of defence mechanisms from the nostrils to the respiratory units, the alveoli. The anatomical barriers constituted by the upper airways and the major bronchi are associated with defence mechanisms of coughreflex, mucociliary escalator mechanism, secreted immunoglobulin A (IgA)and the network of dentriticcells under the superficial mucosal layer which scans for pathogenic invasion and brings the victims of their surveillance to the draining lymph nodes. Beyond the respiratory bronchioles the protection is conferred by the local macrophages, IgG, complement factors, surfactant and fibronectin. Recriutment of neutrophils and lymphocytes, in times of need further enhances local defence in these regions [1].

Mucociliary Clearance Mechanism: Clearance of the airborne particulates of the size 2-10 µm is effectively carried out by the mucociliary clearance mechanism. This mucociliary escalator system is constituted of the cilia of the respiratory epithelium and the overlying mucus. The superficial mucus layer constituting the gel layer is secreted by the mucus glands of the bronchus and the goblet cells. The underlying aqueous sol layer is secreted by Clara cells. The cilia beat in a coordinated manner in the aqueous sol layer moving the overlying gel layer towards the oropharynx to be cleared to the exterior or to be swallowed[1]. The direction of ciliarymovement in nasal passage mirrors the bronchial mucociliary clearance thus both attempting to clear thetrappedparticulate matter towards the pharynx [2]. The mucociliary clearance is influenced by physiological factors like age, gender, sleep, exercise and posture thatalter the normal functioning of the mucociliary escalator. Impairment of the mucociliary clearance due to any cause that deranges either ciliary movement or the hydration of the airway surface leads to stasis of sinonasal and respiratory tract secretions predisposing to infection, inflammation and finally impairing the pulmonary functions leading to pathological states[3]. Environmental pollutants and local pathologies of the respiratory system like immotile cilia syndrome, asthma, bronchiectasis, cystic fibrosis and many pathologies have negative influence on the clearance mechanism[4]. Recent observations report that nasal mucociliary clearance (NMC) is impaired in hypertension and diabetes mellitus, the world's leading causes of morbidity and mortality[5]. Significant linear relation exists between increased BMI and the above two disease states [6]. Overweight and obesity also foster the risk of other cardiovascular disease conditions, cerebrovascular accidents, certain types of cancer and arthritis [7]. Obesity is also implicated in the development of several respiratory diseases like obstructive sleep apnoea (OSA), obesity-hypoventilation syndrome (OHS) and bronchial hyper-responsiveness associated with asthma[8]. A Polish epidemiological study revealed that children with BMI above 25 Kg/m^{2}have a greater risk of becoming susceptible to acute respiratory infections than their normal counterparts [9]. Though extensive literature exists for the relevance of BMI and various diseases,very minimal information exists for the relation between BMI and nasal mucociliary clearance .The pioneering study by Valdez et al. carried out in 2009 on 30 subjects, uncovered the fact that underweight and obese individuals tend to have a prolonged mucus transit time when compared to those with BMI in normal range[10]. This observation makes us infer that abnormal BMI impairs the NMC thus prolonging the mucus transit time predisposing to disease states. As the information about the influence of BMI on NMC is scarce this study is designed to evaluate the relation between body weight i.e. BMI and nasal mucociliary clearance.

METHODS

This cross sectional study was conducted on 40 randomly selected volunteers (20 volunteers with normal BMI for control group and 20 subjects in overweight and obese range for cases) after obtaining the Institutional ethical Clearance. Of the volunteers recruited 10 were male and the other were10 female in each group.Volunteers were between the age of 18 and 45years. The duration of the study was two months. The study was carried out in the department of Physiology, Sri Venkateshwaraa Medical College Hospital and Research Centreand the study subjects were students and staffs of the institution. The volunteers were chosen after excluding the history of nasal surgery, smoking, nasal abnormality (sinusitis, allergic rhinitis, nasal polyps,deviated nasal septum),asthma, topical nasal medication or systemic anticholinergics use. Those with history of diabetes, hypertension and those who were pregnant were also excluded. The procedure was then explained to the participants and an informed written consent was obtained from them.

Calculation of BMI: Anthropometric measures of height and weight were recorded to calculate the BMI and the subjects were classified into case and control groups based on the revised BMI classification scoring for Asian population [11,12]. BMI was calculated using the formula (BMI) = weight in Kg/ height in m^2.The control group comprised of 20 volunteers with normal BMI (BMI 18.5 - 22.9 Kg/m^2) and case group with 20 volunteers with BMI in overweight and obese range (BMI 23 Kg/m^2 and above) based on the revised values by the Union Health Ministry of India, 2008. According to the recent BMI classification for Asian population as recommended by WHO, the normal BMI is 18.5 - 22.9

kg/m^2,underweight <18.5 kg/m^2, overweight 23.0 - 24.9 kg/m^2 and ≥25 kg/m^2 obesity[11].

Measurement of Nasal mucociliary clearance: NMC was measured by the saccharin transit time (STT),i.e., the time taken for the saccharin molecule placed in the nostril to reach the nasopharynx by ciliary beat function. It was studied using the saccharin method of Anderson et al.[13]. A 1 X 1 mm particle of saccharin (quarter tablet of sweetex (saccharin sodium)) was placed on the floor of the nose, just behind the anterior end of the inferior turbinate and the test was carried out in sitting position with neck slightly flexed and the time required by the subject to perceive the sweet taste was noted in minutes. (As saccharin crystals were unavailable quarter tablet of artificial sweetner (Sweetex) was used similar to the method of R.J.L.Valdez et al. who used *Equal* tablets.) The test was carried out in both the nostrils with an interval of half an hour. The time of mucociliary clearance ie the saccharin transit time (STT) of each nostril was noted separately. Nasal mucociliary clearance time is the average time of the mucosal clearance of both the nostrils. The subjects were advised to avoid nasal manipulation, sniff, cough, inhale or exhale forcefully during the test, and were told to report the perception of any taste by raising their hand. Subjects were blinded about the nature of particle. (The subjects were informed that some harmless edible particle would be placed in the nostril and they were not informed about its taste nature.) A single examiner performed the test in all subjects to avoid inter-observer variability. The saccharin test is a simple and inexpensive technique to screen abnormal mucocilairy clearance, and its results are comparablewith those obtained using a radioactively labelled particle [14].

Statistics: The results were analysed using Statistical Package for Social Sciences (SPSS) version 17 and statistical evaluation was done using unpaired t-test for comparison of STT between case and control groups. To find the correlation between BMI and STT Pearson correlation was used. P≤ 0.05 was considered statistically significant.

RESULTS

Age distribution: The mean age of the female volunteers is 30.1± 9.8 years and that of the male volunteers is 29.4 ± 9.7 years. There is no significant difference in age between male and female population as the p value is 0.821.

Comparison of BMI and NMC between case and controls

Table 1: Comparison of BMI and Saccharin Transit Time between the groups

	Control group	**Case group**	**t value**	**p value**
BMI (Kg/m^2)	20.58±1.36	28.3±2.47	12.28	0.0001 ***
STT (min)	5.74±2.35	9.77±3.02	4.72	0.0001 ***

*** (P-Value < 0.001) Highly Significant,

STT: Saccharin Transit Time

From table 1 it could be inferred that the mean BMI value and mean Nasal Mucociliary Clearance (NMC)value measured by saccharin transit time (STT) differed between the case and control groups. The differences are statistically significant with p value 0.0001.

Correlation between BMI and STT:

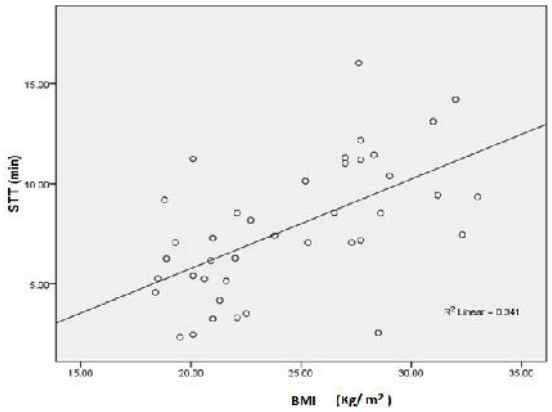

Fig 1:Correlation between BMI and STT

Fig 1shows a postitive correlation between BMI and STT as calculated by Pearson corrrelation with r value of 0.584 and p value 0.0001 which is statistically significant.

DISCUSSION

Nasal mucociliary clearance is influenced by many factors like age, sex, posture, sleep, exercise, environmental factors etc, in both health as well as in disease[4]. But the influence of BMI on NMC is not well established as there is a paucity of literature on this topic. In recent times the pioneering effort was initiated by Valdezet al in 2009 who in their study "Nasal Mucociliary Clearance (Mucus transit time) andAbnormal body Mass index (Underweight and

obese) in filipino Adult Volunteers" observed that the NMC is prolonged in people with abnormal BMI (underweight and overweight and obese category when compared to those with normal BMI). Similar to their observation we found that STT is increased with increase in BMI in our study. The difference is statistically significant. Though the values of NMC found in our study differed from the reference study of Valdez et al. the difference could be attributed to the influence of ethnicity. The correlation of BMI with NMC was significant and therefore it could be inferred that BMI has an influence on nasal mucociliary clearance and the relation is linear when the BMI is in overweight and obese range (as inferred from our results and with that of the former's observation) .Valdez et al. also observed that NMC is prolonged in underweight subjects, inferring an impairment in the mechanism. From the observations made it is made clear that BMI influences respiratory health with its deleterious effect in extreme conditions of over-nourished and under-nourished states by impairing the nasal mucociliary clearance, an inherent defence mechanism of the respiratory tract that prevents the accumulation of secretions. Impairment of the clearance mechanism leads to stasis of the respiratory secretions predisposing to infection and inflammation and in turn it leads to respiratory pathologies. Significant decline in the lung functions associated with obesity was observed by Bharat Thyagarajan et al. and Ling Yang et al.made the observation that low BMI is an unexplained correlate of COPD[15,16]. As no proper mechanism is established to the cause of ciliary dysfunction, it could be held with suspect that the same mechanism of oxidative stress mediated functional derangement in the obesity could be a cause for ciliary action dysfunction in case of overweight and obesity as studies proved a decline in the antioxidant capacity in people with above conditions for longerduration[17]. The derangement in the lung functions in the case of obesity is also attributed to an elevated level of cytokines and decreased levels of adiponectin thereby leading to functional impairment[15]. Further studies are needed to establish the relation between the suspected causes and the ciliary dysfunction.

CONCLUSION

It could be thus concluded from our observation that BMI influences nasal mucociliary clearance with a linear relation reflecting the slowing of the mucous clearing function of the nasal cilia whereby the mucous transit slows down leading to accumulation of the secretions and its sequel of respiratory infections.

Limitations of study: The study hypothesis could have been better addressed had the study groups involved a larger population and the assessment of biomarkers of oxidative stress could have added a better insight into systemic inflammation that is implicated as a suspected cause of ciliary motility impairment. But the assessment being an invasive procedure of blood collection, just on evaluation basis (not diagnostic) the feasibility of participant co-operation was less.

Acknowledgement: We thank the participants for their cooperation and the ICMR for its funding and motivation. We thank the management of our Institution for the financial support and encouragement.

Conflict of Interest: Nil

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