

Nasomucociliary Clearance Time among Healthy Nigerians

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ABSTRACT

Background: Mucociliary clearance is an important defence mechanism in the human respiratory system.

Objective: To determine reference values for Nasal Mucociliary Clearance Time (NMCT) among healthy Nigerian population using the saccharine test.

Methods: This was a prospective, cross-sectional, descriptive study that was carried in a Nigerian tertiary hospital using consented healthy relative of patients, hospital staffs, students and civil servants as participants after ethical approval from the institution. Using questionnaire, Information retrieved included socio-demographic profile and saccharine transit time. All information were entered into SPSS version 20.0 and analysed.

Results: one hundred and eighty eight (188) of the 200 volunteers screened satisfy the inclusion. Eighty five (85) male and 103 females, M: F of 1: 1.2. Age range was 10-85years, modal age group was 18-40years, mean age was 31.01years. Minimum NMCT recorded was 6 minutes and maximum was 43minutes with Mean NMCT 15.5minutes.

Conclusion: NMCT among healthy Nigerians was in the range of 12.5 minutes-18.5 minutes with a mean duration of 15.5 minutes, slightly higher in females than the males and NMCT increases with age.

KEYWORDS: Nasomucociliary clearance; Clearance time; Healthy Nigerians

Introduction

Mucociliary clearance is defined as the backward movement of the mucous secretion from the nose through the ciliary action towards the pharynx until it is swallowed. It is an important defence mechanism in the human respiratory system.

Its impairment, either acquired or genetically

determined, can lead to stagnation of secretions and secondary infection of the upper and lower respiratory tract.^{1,3} Normal mucociliary clearance is possible only when there is good ciliary movement and an adequate mucous blanket.² However nasal mucociliary clearance time is the time required for the mucous secretions to flow from the nasal cavity to the pharynx. From literature, the cilia of the nasal mucosa beat at a frequency of 12-16Hz (10-15beats/second) at the nasal temperature of 30°C. This produces a streaming movement of the overlying mucus at a rate of 0.25-0.75cm/min. The movement, as a general rule, is more rapid in the posterior two thirds of the nasal chambers than in the anterior third, and more active in the protected meatal recesses than on the exposed surfaces of the turbinate and the septum⁴. Provided the normal functional efficiency of the ciliated

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epithelium is maintained, the entire mucous blanket of the nose can be propelled into the pharynx every 20-30 minutes. The mucous covering of the paranasal sinuses is cleared in less than 10 minutes⁴.

Different factors and conditions of clinical relevance such as changes in humidity, temperature or exposure to environmental pollutants such as tobacco smoke, polluted air in large cities, oxygen therapy and anaesthetic agents have been found to affect the nasal mucociliary clearance time⁵. So also is the respiratory diseases such as chronic obstructive pulmonary disease, cystic fibrosis,⁶ primary ciliary dyskinesia, bronchiectasis, and asthma can as well alter the value. Knowledge of mucociliary clearance time would also help in the assessment of whether therapeutic measures in general have a positive or negative effect on clearance of respiratory secretions².

Several studies have been published on ciliary function in ageing,⁷ respiratory diseases using different methods of assessment. The authors looked at healthy individuals to define the limits of normal nasomucociliary clearance time using the saccharine test according to age and sex in Nigeria.

Several techniques have been utilized to measure mucociliary clearance; Andersen's saccharine test, visible dyes or particles, small metal discs (imaged by fluoroscopy) and radioactive labelled particles (detected by gamma scintigraphy)³. Andersen's test has become the most useful screening test in clinical practice and compares favourably with the imaging studies. It has no known toxicity, does not contain radioactive labelled ingredients, besides it is cheap, no need for sophisticated equipment, readily available, easy to learn and well tolerated by participants, its results are reproducible in clinical setting^{4,8}. The most sensitive and specific may be the most complex and least widely available which is the electron

microscopy method to demonstrate dynein arm deficiency, the most frequent cause of primary ciliary dyskinesia⁸, whereas the methods that are easier to perform which is the mucociliary transport test using saccharine to diagnose PCD was therefore 100% sensitive and the specificity was only 55% from previous studies.^{8,9} However previous researchers have criticize the use of saccharine particles for determining mucosal transport in view of its solubility in the nasal mucosal secretions compared to the inert object that are deposited in both the upper and lower respiratory tract^{9,10}.

The use of saccharine for the assessment of the mucociliary clearance time from previous studies has established Naso-Mucociliary clearance test as a valid and reliable measure of mucociliary clearance^{3,11}.

The objective of this study was to determine reference values (upper and lower limits of normal) for NMCT determined by the saccharine test according to sex and age group among healthy Nigerians.

Methods

This was a prospective, cross-sectional, descriptive study that was carried out at the family medicine and Otorhinolaryngology clinics of Kogi State Specialist Hospital, Lokoja, North-Central Nigeria between March and May 2016.

Ethical clearance was obtained from the Ethical review committee of the hospital, and written informed consent was obtained from participants.

All patients, staffs, students and medical workers which included nurses and resident doctors who consented to be part of the study and satisfy the inclusion criteria were recruited. Exclusion criteria were used with a view to limit the factors that might affect the nasal MCT. The authors excluded individuals with anatomic abnormalities of the upper



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respiratory tract, history of nasal surgery or nasal trauma, chronic nasal or respiratory disease, acute respiratory tract disease either upper or lower tract infections within 6 weeks prior to the test, altered taste, smokers, those chewing tobacco or taking snuffs or those addicted to other drugs, and those receiving medications that might influence mucociliary clearance (antihistaminics, adrenergic agents, anticholinergics, topical decongestants, and mucolytics). Pregnant women were also excluded from the study because of the increased body fluid with the anticipated nasal blockage.

The participants, all of whom were healthy, adequately nourished individuals with no history of smoking, taking snuff or substance abuse or bouts of fever, were studied at similar room temperatures and relative humidities and in the same posture. A non-smoker was defined as an individual who had never smoked, smoked less than a cigarette a day for less than 6 months, or had not smoked in the last 5 years prior to the start of the study⁹.

All participants were evaluated with endoscopic nasal examination using 2.7mm slender (to reduce nasal irritation) without anaesthesia and spirometry.

The same investigator undertook all examinations and tried to minimize possible observational variation by ensuring that relative humidity was between 40% and 70% and that the room temperature was between 18°C and 30°C. The stopwatch was checked from time to time to ensure that it was working properly. The calibration of the spirometer used to assess lung function was also monitored.

During the selection phase, all participants were made to complete a modified version of the health questionnaire described in the Epidemiology Standardization Project¹² where the principles for assessing the state of

respiratory health were established. For all the participants, a demographic data and a complete medical history was also taken and they underwent heart and lung auscultation in the outpatients consulting room, anterior rhinoscopy, and nasal patency test were carried out as well as measurement of exhaled carbon monoxide (non-smokers were considered as those with levels below 6 ppm), and forced spirometry using a Schiller Spirovit SP-1 spirometer (Schiller AG Spain). Nasal Mucociliary Clearance Time was measured by the saccharine test according to the standard technique described by Andersen et al in 1974¹³ and modified by Rutland & Cole¹⁴. It is considered to be the standard technique of measurement of NMCT which is reproducible.¹⁵

Saccharine Test Method

A particle of sodium saccharine measuring 1mm across was placed on the surface of the inferior nasal concha, 1 cm behind its head to avoid contact with the area of squamous epithelium. The participants were asked to sit head upright with their head tipped slightly forward while breathing normally through the nose with their mouth closed (not forced), without sneezing or blowing their nose, and without taking any substances that might interfere with the test and to swallow every 30 s. The exact time of saccharine placement or introduction was noted and recorded. They were told to indicate when they noted any particular taste. The actual taste they were to expect was not specified in order to avoid false positives. The saccharine particle was carried by means of ciliary transport along the entire nostril until it reached the oropharynx, whereupon a characteristic sweet taste could be perceived. The time elapsed was recorded to the nearest minute and the test was considered complete. The most patent nostril with least resistance to physiological airflow was chosen. The apparatus needed to perform the test is very rudimentary and consists of a battery powered LED headlight, a 2-blade thudicum nasal speculum to expose



the nasal cavity, a Jansen Bayonet nasal forceps to place the particle in the nasal cavity, and a stopwatch. All information were entered into SPSS version 20.0 and analysed.

Results

A total of 200 participants filled the modified respiratory health questionnaire, 188 met the inclusion criteria and underwent the naso-mucociliary test. Of the 12 excluded, 5 had URTI, 3 smokers, 2 deviated nasal septum and 2 failed to fill the respiratory health questionnaire. There are 85 males and 103 Females with M:F ratio of 1:1.2 (fig.1). The age ranged from 10-85years. The participants were divided into four age groups which were adolescence (10-17years), young adult (18-40years), Middle age group (41-64years) and the elderly 65years. The mean age for the studied population was 31.01years, the median age was 29.0 years and the modal age group was 18-40years which constituted

about 56.4% (Table 1). From this study, the minimum time for the naso-mucociliary clearance time was 6 minutes and the maximum time was 43 minutes with a mean time of 15.5minutes and standard deviation ($SD=5.89\pm 0.43$). The naso-mucociliary clearance time frequency table showed that about 54.2% of the participants had NMCT of 11-15 minutes and about 80% of the participants had NMCT less than 20 minutes about 0.5%had NMCT greater than 40 minutes (Table 2). From the cross-tabulation of age-sex to the NMCT, the minimum NMCT was observed in a 34year old female and the maximum NMCT was in a 79year old male and majority of the participants who had NMCT above 20minutes were females and it constituted 7.4% while the males constituted 5.9% (Table 3). It was observed that NMCT increases with advancing age (Table 4).

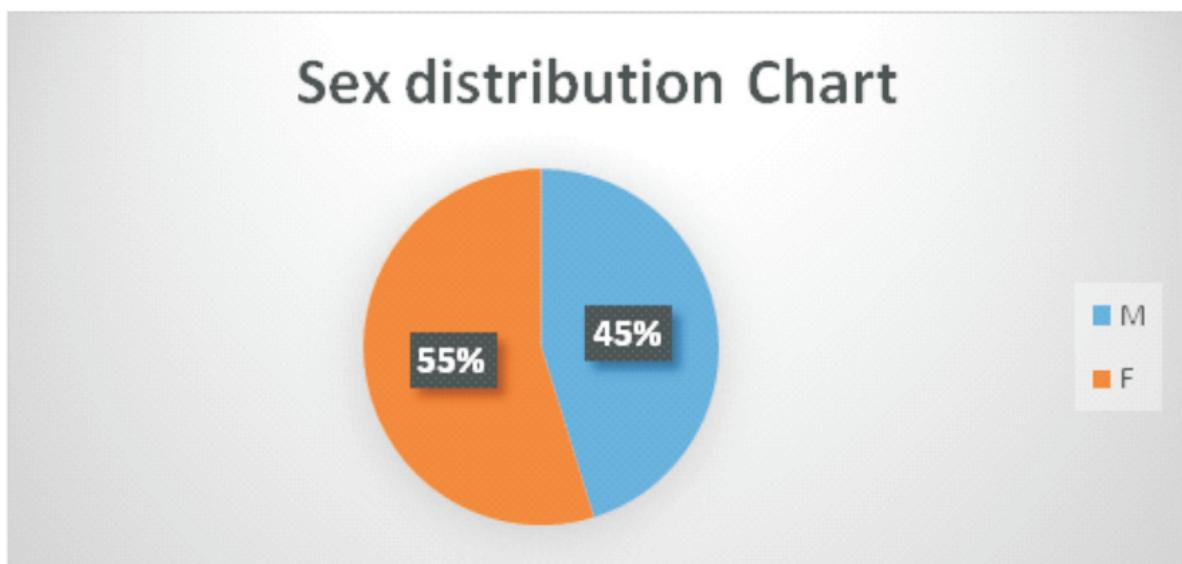


Fig. 1: Pie-chart for the sex distribution for NMCT (n= 188)

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Table 1: Socio-demographic characteristics (n = 188)

Age (years)	Frequency (%)
10-17	40 (21.3)
18-40	106 (56.4)
41-64	34 (18.1)
65	08 (4.2)
Total	188 (100)
Occupation	Frequency (%)
Students	64 (34)
Civil servants	56 (29.8)
Unemployed	30 (16)
Artisans	14 (7.4)
Trading	13 (6.9)
Pensioner	8 (4.3)
Housewife	3 (1.3)
Total	188 (100)
Educational Levels	Frequency (%)
None	1 (0.5)
Primary	20 (10.6)
Secondary	57 (30.3)
Tertiary	110 (58.5)
Total	188 (100)

Table 2: Naso-mucociliary Clearance Time (n = 188)

Time (Minutes)	Frequency
6-10	27 (14.4)
11-15	102 (54.2)
16-20	34 (18.1)
21-25	18 (9.5)
26-30	2 (1.1)
31-35	2 (1.1)
36-40	2 (1.1)
41-45	1 (0.5)
Total	188 (100)



Table 3: Cross-tabulation of NMCT with Age and Sex of the population (n = 188)

AGE (YRS) NMCT (MIN)	10-17		18-40		41-64		65		Total	
	M	F	M	F	M	F	M	F	M	F
6-10	11	0	4	2	2	7	1	0	18	9
11-15	17	12	25	37	2	9	0	0	44	58
16-20	0	0	9	20	3	2	0	0	12	22
21-25	0	1	0	7	5	1	1	3	6	12
26-30	0	0	0	1	1	0	1	0	2	1
31-35	0	0	0	0	0	0	0	0	0	0
36-40	0	0	0	0	1	0	1	0	2	0
41-45	0	0	0	0	0	1	1	0	1	1
Total	28	13	40	66	14	20	5	3	85	103

Table 4: Age group with their Mean NMCT

Age group (years)	Mean NMCT(Minutes)
10-17years	11.98minutes
18-40years	15.73minutes
41-64years	16.62minutes
65years	28.00minutes

Discussion

The mucociliary mechanism is the natural best air cleaner, protecting the upper and lower respiratory tracts and the susceptible alveoli. The mucociliary mechanism constitutes the initial line of the airway defence system against harmful particles and other agents in the air¹⁶. The authors looked at the healthy population. The analysis of the NMCT will assist or complement early recognition and diagnosis of ciliary dyskinesia and will ensure early commencement of an appropriate treatment and thus reduce the rate of decline in pulmonary function^{17, 18}. Population based nasomucociliary clearance time assessment was done among the Spanish population⁹ however ours was done in the hospital environment to forestall any form of hypersensitivity reaction to sodium saccharine which can be easily managed and also to control the environmental condition such as humidity, temperature that can affect the clearance of this agent from the nasal cavity³.

The method used in this study was introduced by Andersen et al¹³ in 1974 and since then has been employed in many studies as a method for assessing mucociliary clearance.

The median age in our study was 29.0 years which is comparable to a study in Kenya⁴ with a median age of 27years. The Male to female ratio was 1:1.2 in our study.

Although our study objective does not include relationship between occupation and nasomucociliary clearance, however most of the participants were students constituting one-third of the study population while the least were the fulltime house wives constituting about 1.5%, thus the relationship between NMCT and socioeconomic status cannot be established based on hospital based data therefore a community based studies in a larger population may be required to establish this. This can be compared in future with the NMCT to see if there is any variation



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with patient's occupation.

The NMCT was between 6 minutes and 43 minutes with a mean slightly higher in females (15.84 minutes) than males (15.07 minutes), when subjected to a statistical test it is not statistically significant with the p value less than 0.05, however the reason for this could not be deduced from our study however earlier studies does not revealed any gender differences^{7,9}. The mean NMCT in this study was 15.5 minutes, though within normal value^{2, 19, 20}, it was higher than the Kenyan study (7.51 minutes)⁴ however the reason for this cannot be deduced, thus the need for population based study.

The findings of age relate disruption of NMCT was similar to the Indian study²¹ which may be due to impaired lung defence by the mucociliary clearance mechanism.

There was a statistically significant correlation between age and NMCT ($p<0.001$), this was also reported by some researchers^{22,23,24}.

A NMCT of more than 60 minutes is generally regarded as abnormal and therefore a further evaluation to rule out mucociliary system disease may be required²⁵, in this study only 2 had NMCT greater than 40 minutes and the maximum time of nasomucociliary clearance from our study was 45minutes.

In conclusion, the average nasal mucociliary clearance time in healthy Nigerians is 15.5 minutes.

However a community based larger group study may be required to substantiate this report.

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