Chapter 2

Alteration in Nasal Cycle Rhythm as an Index of the Diseased Condition

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Additional information is available at the end of the chapter

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Abstract

Breathing is the vital function based on the conductance of air through a system of branching tubes that taper off and eventually connect to the alveoli. Nose act as an interface between atmospheric air and lower respiratory system, constitute the moist respiratory epithelium, which performs various vital physiological functions like filtering the inspired air, warming, and humidifying. Several anatomical and physiological factors are responsible for the passage of airflow in two nostrils, which are asymmetric in nature. The inequality airflow passage in both the nostrils exists for a specific duration. This phenomenon of altering asymmetrical airflow from one nasal passage to the other is called 'nasal cycle'. For every regular interval of time period, the swap of predominant nasal airflow between two nostrils determines the nasal patency. This cycle is controlled by the central regulator located at hypothalamus by coordinating the autonomic nervous system that comprises sympathetic and parasympathetic nerves that clog the nasal mucosa. The nostril decongest when the sympathetic nerves in one nostril become active. In this biorhythm, if the sympathetic nerves of one nostril drop, immediately the parasympathetic nerves take over, so that the other nostril congests. It is unclear why these cycles exist but the total nasal airway resistance is almost unchanged. There are a range of activities and reflexes, which can affect the nasal airway. This biorhythm is categorized under ultradian cycle since the mean duration of nasal cycle is about two and a half hours. In this study, it observed changes in nasal airflow duration, pattern, and rhythm that correspond to various disease states in human.

Keywords: nasal cycle, biorhythm, sympathetic and parasympathetic nerves, ultradian cycle

1. Introduction

Variety of temporal variations is observed in organism, organs, tissues, even in cellular level. Most of these variations are periodicity synchronous with nature rhythms. These periodic variations in human bio-signals are referred as biorhythms. Biorhythms cover broad spectrum ranges from fraction of seconds to even several years. The cycle exists less than a day (~24 hours) is referred as ultradian cycle (e.g., neuron activity, heart rate, respiration rate, rapid eye moment during sleep), equal to a day as circadian cycle (e.g., sleep-wake cycle) and greater than a day as infradian cycle (e.g., menstruation cycle).

The airflow pattern during breathing in both the nostrils will not be same in most of the time. Only one nostril will be dominant for the particular time period, later the dominance shift to other nostril, and this cycle continuous from one nostril to other. This swapping of airflow from one nostril to another for a short duration is called nasal cycle Nasal cycle last for about 25 minutes–4 hours, it varies from person to person; even for the same person, the time periods varies from cycle to cycle. Since the duration of nasal cycle is less than 24 hours, it is classified under ultradian cycle. This chapter completely deals with the analysis of nasal airflow pattern from both the nostrils at healthy and different diseased states.

2. Understanding of nasal cycle

The nasal cycle is an alternating one, with the total resistance in the nose remaining constant. The nasal cycle's value becomes evident when one considers that the function of the nose is to warm, humidify, and filter nasally inspired air. These humidifying and filtering functions are dependent on the presence of moist respiratory epithelium. The presence of two nasal fossae or chambers that function in an alternating pattern prevents excessive drying, crusting, and infection, which are the likely results of a static passage that is open to constant airflow, especially in desert regions. This cycle was believed to be an ultradian rhythm seen in people with normal health.

The swap of predominant nasal airflow between two nostrils determines the nasal patency, "why" we breathe from any one nostril at any point of time, there is no conclusive scientific evidence to answer. The "how" is explained by the presence of sympathetic and parasympathetic nerves that clog the nasal mucosa. When the sympathetic nerves in one nostril become active that nostril decongests. In this biorhythm, if the sympathetic nerves of the one nostril drop, immediately the parasympathetic nerves take over, so that the other nostril congests. This cycle, which is controlled by the autonomic nervous system as described above, had a mean duration of two and a half hours. The periodic congestion and decongestion of cavernous tissue of the nasal mucosa is the cause for nasal cycle [1]. Nasal cycle rhythm pattern is considered to be controlled by the central regulator located in the hypothalamus resulted in the bilateral vasoconstriction of the nasal mucosa [2].

Breathing through alternate nostrils showed effects on brain hemisphere symmetry on EEG topography [3]. There is a significant difference of airflow between left-nostril and right-nostril breathing. Effect of this cycle and manipulation through forced nostril breathing on one side on the endogenous ultradian rhythms of the autonomic and central nervous system [4]. In addition changes in the amount of blood flowing through the cavernous tissues of the nasal conchae was, the way in which the nasal cycle was described [5]. The normal nasal cycle rhythm is disturbed in diseased case, the nasal cycle dominance have been investigated with autism in children [6]. The effect of unilateral nostril breathing is associated with EEG amplitude in contralateral hemisphere [7, 8]; it is reported that left uninostril breathing is associated with enhanced spatial abilities and right uninostril breathing is associated with enhanced verbal abilities [9, 10].

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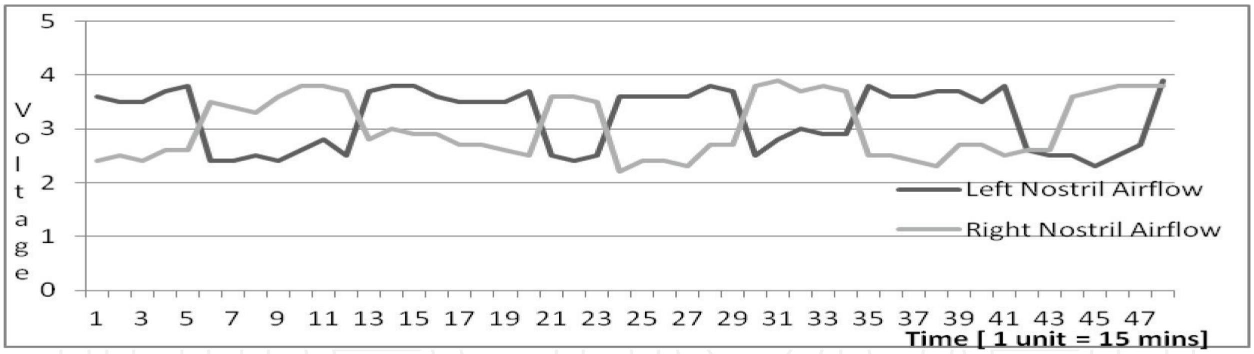


Figure 1. Nasal cycle rhythm between two nostrils for the period of 12 hours.

The exact relationship between uninostril breathing and cerebral hemispheric activity is not known. But, some of the previous studies explain the effect of hyperventilation by the nose on EEG activity in the cortex proposes that it is produced by a neural reflex mechanism in the superior nasal meatus [11].

In this study, the most interesting factor of characteristics of airflow in both the nostrils was analyzed extensively. Airflow in one nostril will be greater and other will be lesser, the nostril with greater quantity of airflow is called as dominant nostril. This dominance will exists only for limited duration (approx. 25 minutes–4 hours), later the dominant airflow found to be exists in the other nostril. This swapping of dominant airflow between one nostril to another is called as nasal cycle as illustrated in **Figure 1**. Graph indicating alteration of left and right dominant airflow measured at every 15 minutes for the period of 12 hours.

Previous study on nasal cycle elaborates the cause for this oscillatory function in different view that nasal cycle is regulated by the autonomic nervous system, such that unilateral sympathetic dominance in one nostril causes vasoconstriction and decongestion, while simultaneously parasympathetic dominance in the other nostril causes vasodilatation and congestion [6].

It is proposed that the periodic congestion and decongestion of nasal venous sinusoids may provide a pump mechanism for the generation of plasma exudate, which is an important component of respiratory defense [12]. Nasal cycle also reported to be regulated by the alternating lateralization of plasma catecholamine's [12].

The nasal cycle is not only observed in human nose, it is also found in rabbit and rat [13], the domestic pig [14], the cat [15], and the dog [16] and seems to be a common phenomenon in all mammals and other animals.

3. Effect of unilateral nostril breathing in various physiological and psychological changes

It is well understood that there exists a strong relation between nasal cycle with physiological and behavioral changes. There is a slight, but significant correlation between the dominant nostril and the relative cognitive performance in free breathing subjects is observed [9]. The vasomotor and secretory activity of the nasal mucosa in healthy volunteers are observed and reported that the nasal secretions over the mucous membrane had a definite relation to the congestion of the turbinal structures [17]. The modification in actual nasal cycle rhythms in terms of change in period length, increase or decrease in strength of the rhythm, or desynchronization, and uncoupling of rhythms are observed in depressed patients [18].

Nasal resistive reflexes, which are anatomically mediated may change the nasal resistance [19]. Studies on nasal cycle prove its importance on clinical aspect that breathing through the right nostril increases blood glucose level significantly whereas through left nostrils decreases [20]. Also, breathing through right nostril increases metabolism whereas breathing through the left nostril decreases sympathetic activity to the sweat glands [21].

Alternative nasal airflow activates alternative hemispheres of the brain, right dominant airflow activates left hemisphere of brain and vice versa, since the right hemisphere of brain is responsible for creative thinking whereas the left hemisphere of brain is responsible for logical thinking. During EEG measurements, rapid eye movement (REM) and non-rapid eye movement (NREM) was noticed and correlated with left and right hemisphere brain activity [22]. It is suggested one can selectively activate a hemisphere depending on which functions are mostly needed at a certain point in time [4, 23].

Nasal cycle has a strong correlation with psychological changes in wake state as well as in sleeping state both for normal and abnormal subjects [24, 25]. Even though many researchers found the origin of the system responsible for this nasal rhythm oscillation [26], the factor which controls this rhythm is still ambiguity [27]. In nineteenth century, German scientist Kayser sparked interest in the nostril cycle [4] studied the nostril cycle and the effects of forced unilateral nostril breathing (FUNB). In this experiment, subjects are instructed to block one nostril and breathe through the other nostril for a period of 1–30 minutes; during the period both physiological and psychological parameters are measured.

The participants' nostrils are categorized to the independent decongested nostril, that is, the nostril with dominant airflow. Nostril dominance is measured by the collection of quantitative data during FUNB to measure nostril dominance, and the corresponding effects on the brain and the heart was recorded. Long-term studies of the nostril cycle have been very limited. One month study was conducted by Funk and Clarke [28], but observed only weak patterns in nostril dominance and failed to identify possible factors responsible for the variability.

To explore the possible effects of the nasal cycle on the brain, it is important to understand the alterations in cognitive processes that are responsible for each cerebral hemisphere. Generally, it is well known that the left hemisphere is responsible for language processing whereas the right hemisphere is for visual processing. Certain research indicates the individual differences in the degree to which one cerebral hemisphere rather than the other in processing the various information [29]. This is referred to as hemispheric dominance.

The qualities assigned to each nostril are assumed to correspond with brain hemispheric dominance. Physiologically, electro-cortical activity in one hemisphere (measured by greater EEG power) relates to contra lateral nostril dominance [7]. This relationship has been intensively analyzed by forced unilateral nostril breathing (FUNB). For example, participants perform better in cognitive tasks that require rational and logical thinking, where tasks associated with the left hemisphere, the right nostril dominance is found. During the left nostril dominance, they perform better in spatial tasks, associated with the right hemisphere [23].

It is noticed that the nostril cycle also has an influence on neurotransmitters and hormones. For example, FUNB has an effect on involuntary blink rates, which are directly related to dopaminergic activity. Blink rates have been significantly increased during left FUNB, which indicates the association between right hemispheric preference and a possible lateralization of dopamine. Studies have also shown that there is a strong relationship between dominant nostril airflow with plasma catecholamines, such as norepinephrine, epinephrine, and dopamine. The ratio of plasma catecholamines from samples taken in each arm correlates with nostril dominance [12].

Furthermore, the effects of nostril cycle are also apparent in the endocrine system. The levels of pituitary hormones (adrenocorticoids, luteinizing hormones) as well as catecholamines varied according to the nasal cycle [30]. The alteration in nasal cycle correlated with autonomic nervous system results with indicating alternating lateralization of catecholamines in one of the two arms [12].

The nasal cycle also supports three general conclusions with respect to brain activity are: (1) nasal cycle dominance correlates with changes in hemispheric EEG differences; (2) in free breathing subjects, relative performance on spatial and verbal tasks is related to nostril dominance; and (3) at least theoretically, unilateral forced nostril breathing (UFBN) may differentially affect the ipsilateral and contralateral cerebral hemispheres, thereby changing relative EEG activity and influencing relative spatial and verbal performance [31].

In addition to the effects of the nostril cycle in psychological effects, research has also explored in many physiological effects, with an emphasis in autonomic activity, especially in human heart. It is evident that heart rate and mean arterial pressure in dogs varies in a cycle that lasts approximately 1.5 hours [32, 33]. From this, researchers have concluded that the internal variations of the heart drive by the sympathetic nervous system [30]. FUNB studies have shown that the nostril cycle affects intraocular blood pressure: right nostril breathing reduces it and left nostril breathing increases. Similarly, nostril dominance has been shown to affect blood glucose level: right FUNB increased blood glucose levels, while left FUNB decreased the levels. Homeostasis of glucose levels is regulated by the autonomic nervous system [20].

During the night sleep, there is synchronization of nasal and sleep cycles in some of the REM phases of sleep, the length of periods of the nasal cycle is one or more length of sleep cycle [34]. From the above literatures, it is clear evident that analyzing the characteristic of nasal cycle becomes most important since there is a strong association between the physiological and psychological changes in human with nasal cycle.

4. Analyzing characteristic of nasal airflow in healthy subjects

From the experiments conducted by recording nasal air flow from two nostrils, there exists predominant airflow in only one nostril that justifies the existence of nasal cycle. Twenty healthy subjects (mean age 21 years) were examined for every 15 minutes for a stretch of 8 hours per day. The same procedure was repeated for 8 days. It is observed that the nasal cycle exists for 90% of the population. **Figure 2** shows the airflow from both the nostrils indicating predominant airflow in left nostril recorded from a healthy subject.

The work was carried out with Hotwire Anemometer method to measure the small temperature difference between inhale and exhale. The output is measured separately and simultaneously from both right and left nostril and can be stored for analysis of breath characteristics. The nasal cycle was recorded and analyzed using data acquisition system model PowerLab 8/35 with LabChart Software from AD Instruments, Australia.

It is estimated from 20 healthy subjects that an average duration of nasal cycle is about 2.45 hours. Rhythm duration varies from person to person in the range of 20 minutes–4.26 hours. Much precaution was taken to measure airflow without disturbing the normal airflow during breathing. Even in the healthy subjects for the same subject, the nasal cycle duration varies from time to time based on physiological and psychological changes. The people with respiratory problem were excluded from the study.

The existence of predominant airflow under normal and different state of forced breathing is illustrated in **Figures 3–7**.

- Normal breathing
- Deep breathing
- Holding breath at exhale condition
- Holding breath at inhale condition
- Holding breath both at exhale and inhale condition

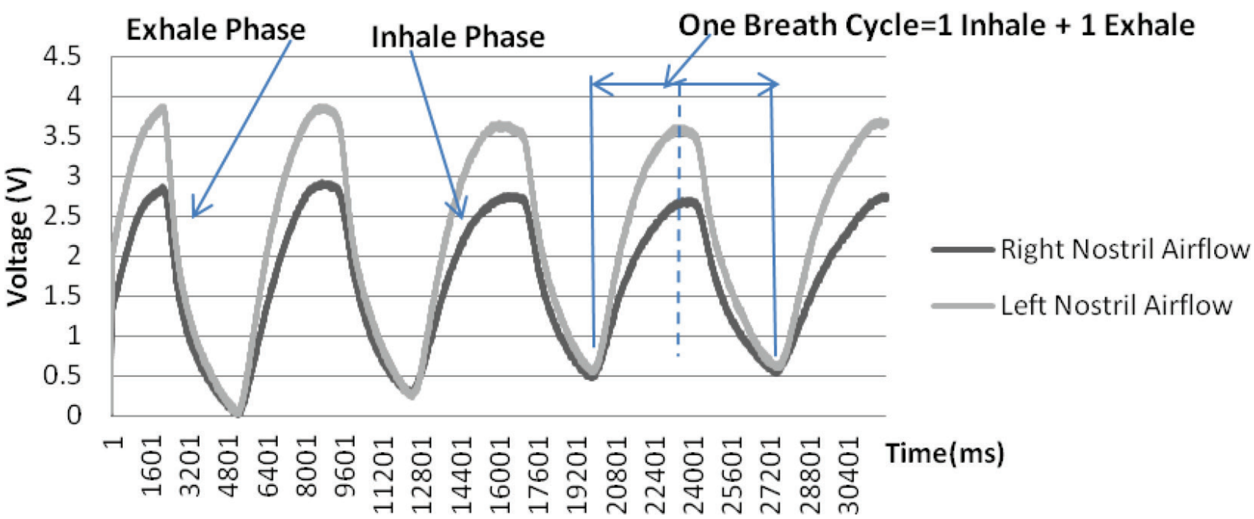


Figure 2. Indicating nasal cycle with predominant airflow in left nostril in a healthy subject.

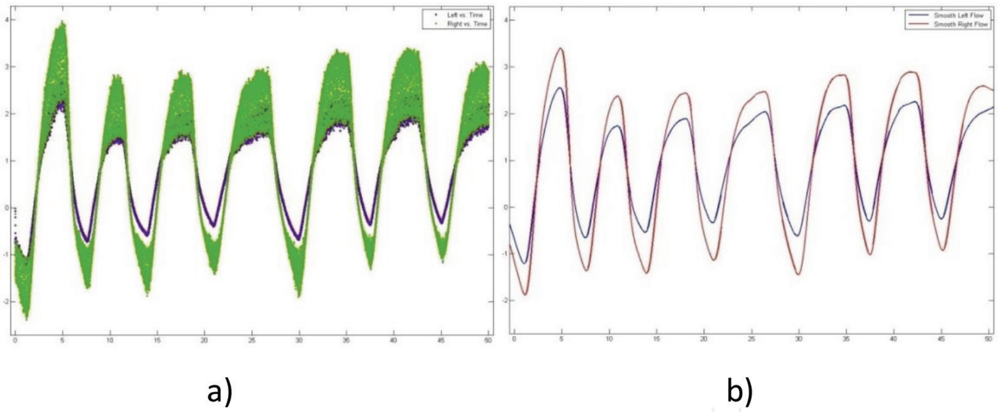


Figure 3. Indicating predominant airflow in right nostril (red line—filtered signal) versus left nostril (blue line—filtered signal) during normal breathing in filtered signal. (a) Raw signal and (b) filtered signal.

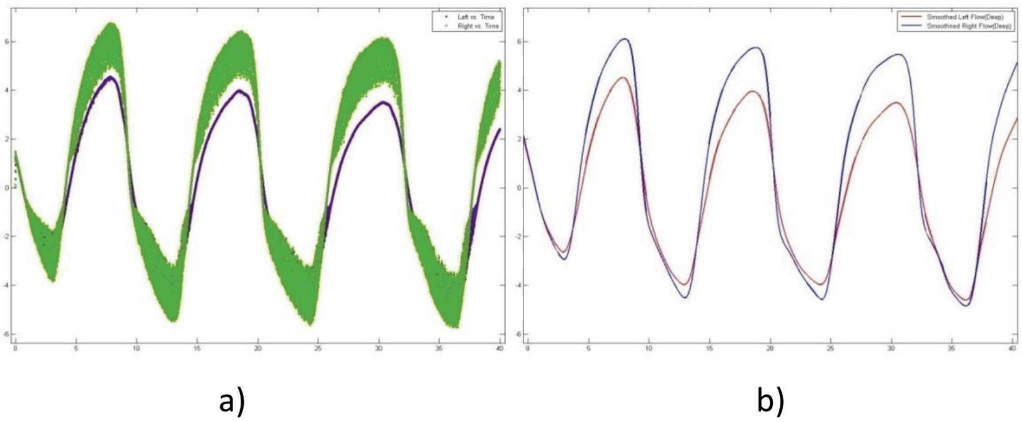


Figure 4. Indicating predominant airflow in right nostril (red line—filtered signal) versus left nostril (blue line—filtered signal) during forced deep breath in filtered signal. (a) Raw signal and (b) filtered signal.

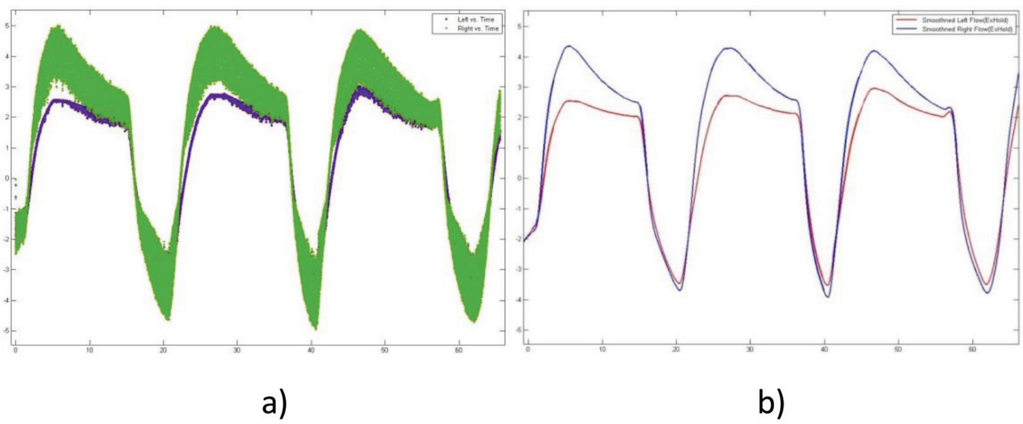
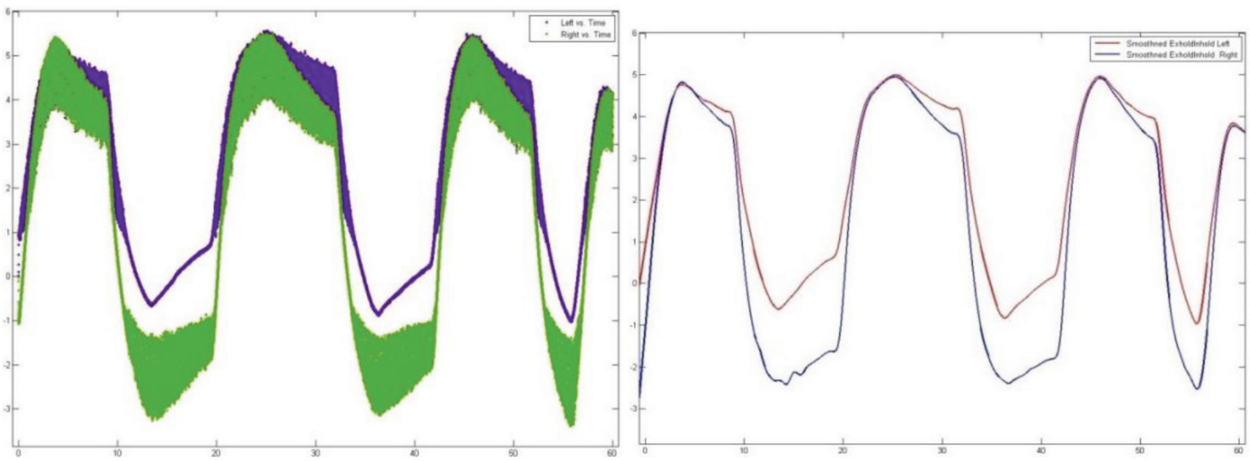
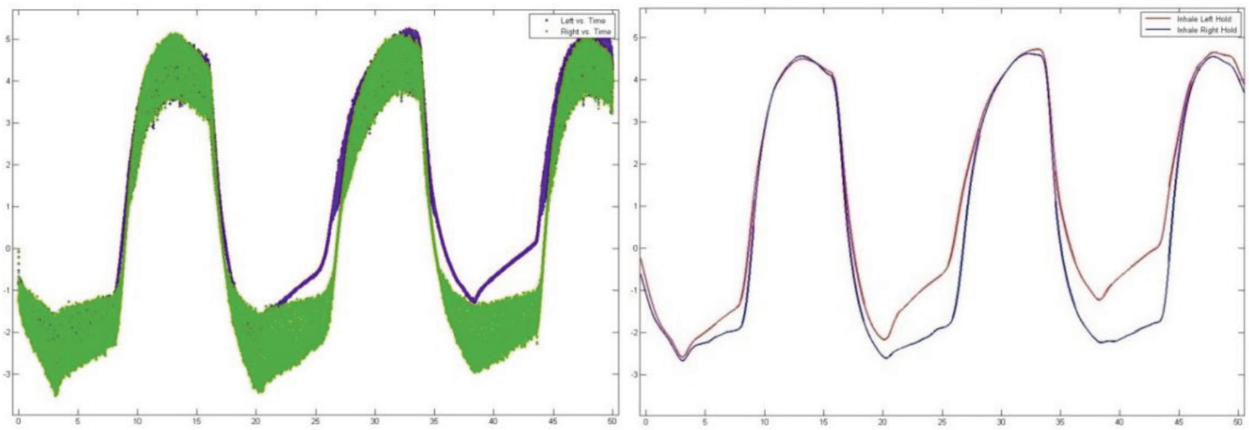


Figure 5. Indicating predominant airflow in right nostril (red line—filtered signal) versus left nostril (blue line—filtered signal) during forced holding of breath after inhale in filtered signal. (a) Raw signal and (b) filtered signal.



a) b)

Figure 6. Indicating predominant airflow in right nostril (red line—filtered signal) versus left nostril (blue line—filtered signal) during forced holding of breath after exhale in filtered signal. (a) Raw signal and (b) filtered signal.



a) b)

Figure 7. Forced exhale hold and inhale hold indicating predominant airflow in right nostril (blue line—filtered signal) in both the cases in filtered signal. (a) Raw signal and (b) filtered signal.

5. Analyzing characteristic of nasal airflow in diseased subjects

The experimental investigation was carried out at Government Siddha Medical College Palayamkottai, Tamil Nadu, India. Totally 260 diseased patients participated in this study from both in-patient and out-patient sections. After receiving a waiver of informed consent form from the Institutional Human Ethical Committee, a retrospective study from various patients is undertaken under the supervision of physician. The nasal airflow for the duration of about 3 minutes is recorded at every 20 minutes to the stretch of 8 hours. Then, the average period of nasal cycle rhythm is calculated. In normal case, the nasal cycle exists for the period of 2–2.5 hours (average) ranges between 20 minutes and 3.6 hours. Whereas in diseased case, the cycle duration greater than 4.5 hours or existence of predominant airflow in particular nostril is very high when compared to the other nostril. The huge multivariate samples are collected with different disease from 260 samples. Out of 260, 154 subjects were classified under first group that belongs to subjects possessing a predominant nasal airflow in right nostril and remaining 106 subjects belong to second group possessing predominant nasal airflow in left nostril.

It is determined that about 87% in group 1 exist a predominant airflow in right nostril and the subjects were suffering from anyone of the following diseases like peptic ulcer, eye diseases, hyper chloride, esopatic, gastritis, diarrhea, insomnia, liver disorder, gastro intestinal disorder, and cardiac diseases. Similarly 92% of group 2 possesses predominant airflow in left nostril and the subjects were suffering from anyone of the following diseases like loss of appetite, tuberculosis, allergy, respiratory disorders like wheezing, and bronchitis asthma.

6. Conclusion

Recently the field of chronobiology attracted many researchers all over the world toward Circaseptan cycle (seven-day weekly cycle). It is commonly noticed in most of the plants, insects, and animals other than humans possessing weekly cycles. Apart from being the key coordinating rhythm for many rhythmic activity in body, seven-day cycle has been found in blood pressure fluctuations, variation in blood acid content, heartbeat, red blood cells, urine chemistry and volume, oral temperature, the ratio between two important neurotransmitters, female breast temperature, norepinephrine and epinephrine, and the rise and fall of several body chemicals such as cortisol, the stress coping hormone.

The research in biological rhythms attracted many scientists especially in the field of chronotherapy, the application of biological rhythm to therapeutic procedures may be achieved by synchronizing drug concentration in drug delivery system with rhythms in disease activity that will improve the healing nature [35]. Furthermore research on this nasal cycle may pave a way for a new diagnostic and therapeutic technique in the medical field. A data base can be maintained for various diseases based on airflow pattern, which can be utilized by the researchers to train the neural network-based disease classification.

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