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Respiratory Function in Chronic Stroke: Analysis of Breath-Hold Time and Peak Expiratory Flow Rate

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ABSTRACT

Introduction: Stroke patients irrespective of their duration of affection demonstrate alteration in respiratory functions which affects the functional capacity of the patients and even leads to breathlessness and fatigue.

Objective: It is a requisite to evaluate the respiratory capacity in those patients on a regular basis as they go through rehabilitation program then after.

Methods: 25 stroke patients in their chronic phase (>6 months) in which 13 males and 12 females were assessed for anthropometry and then in sitting position for BHT and PEFR. A comparable group even consisted of the same number of participants who were of the same age. The mean of the outcomes were compared using unpaired t-test for the significance.

Results: 13 males and 12 females with chronic stroke had mean age of 60.92 ± 8.11 and 58.16 ± 10.02 respectively were included in the study. The mean height as well as weight of the males and females were 168.92 ± 9.71 and 165.75 ± 8.29 as well as 66.76 ± 2.74 and 64.08 ±3.82, the BMI was 23.59 ±2.70 and 22.98 ±2.22. The BHT was 25.61± 5.51 and 22.5 ±5.82 in males and females whereas PEFR of 206.92±73.41 and 189.16±54.51 respectively ($p<0.0001$). The group was comparable to the age and gender matched healthy cohort with no significance difference between the demographic data but highly significant difference in the outcomes.

Conclusions: The reduced BHT and PEFR was observed concluding a decrease in inspiratory and expiratory capacity of a patient with stroke in their chronic phase.

KEYWORDS: Inspiratory Capacity, Expiratory Capacity, Breath Hold Time, Peak Expiratory Flow Rate, Chronic Stroke Patients

Introduction

Stroke which is defined as a focal death of neurological tissue have a great impact of the quality of life of the individuals. Most of the patients with stroke either die or have to survive with major disability. This is usually dependent on the site, type and extent of affection during the temporary loss of blood supply. [1] During and after this phase there will be major sensory, motor and respiratory changes. The evident disability of motor and sensory functions are tried to be restored by therapeutic treatments but respiratory functions are medically managed in acute phase and almost neglected in the chronic phase.

The functions of the respiratory system which are the flow volume and expiratory flow identified as the basic functions are affected and thus usually evaluated routinely. These diagnostic tests of respiratory

functions are hospital based evaluation procedures that are assessed on a follow-up basis. While during the chronic phase of stroke where the patients are routinely performing their physiotherapy exercise it is very essential to identify the respiratory capacity of the patient so as to efficiently use up oxygen while restoring motor function. The patients of cerebrovascular accident in their later stage even experience reduced strength of their inspiratory and expiratory muscles like any other muscles of the body. [2]

Many studies reported reduced respiratory functions [3, 4, 5] while others reported improving lung functions post various therapeutic exercise.[6] so all the studies are pertaining to the lung functions, therapeutic effects of exercise and even the strength of the respiratory muscles. The most important aspect of respiratory evaluation on a day to day basis prior to rehabilitation which is the individual's capacity to inspire as well as to perform effortless expiration is unseen. It accounts for the respiratory capacity of a person who is neurologically deficit, whose respiratory functions have been deteriorated may be due to aging or due to a recent focal injury in the brain which in turn gets affected even by the reduced activity of the muscles of respiration. Total lung capacity (TLC) is defined as the ability of the lungs to store air for ventilation. This is dependent on the Inspiratory Capacity (IC) and the Functional Residual Capacity (FRC) of an individual. [7] When a patient with stroke is in the phase of rehabilitation it becomes a prerequisite to identify the capacity of the lungs while prescribing various forms of motor training.

These both capacities can be easily evaluated by a simple yet reliable test: the breath hold time (BHT) and peak expiratory flow rate (PEFR). The above two mentioned diagnostic tools measure the capacity of the lungs.

BHT is considered to be an alternative to the spirometry as studied by Vipin Agrawal and colleagues. [8] This test is not invasive, very easy to record as well as a common method to screen the capacities for inspiration in individuals. This BHT is even identified as a marker for BHI which studies the cerebral blood flow. The test is instrument less which makes it more reliable and readily available for anyone to screen the inspiratory capacity. [9] The patient even can monitor himself for his altering lung capacity by measuring the breath hold time. This always begins from the end of inspiratory reserve volume (IRV) and ends at the initiation of the expiration. So it is considered as the inspiratory capacity of the person.

Likewise the PEFR is the peak of expiratory flow rate of a person, as it starts with the beginning of expiratory phase and ends where the IRV phase of respiration starts. This test was initially proposed in 1942 by Hadorn, which was then considered as an index of spirometry and finally accepted as a test for capacity of ventilation. The device used to pen down PEFR is a small, portable, non-battery operated, bedside monitoring and reliable test for measuring expiratory capacity. It is efficient and easy to perform, so can be used by any person in clinics as well as in home base rehab settings.[9]

As age advances it leads to senile changes in the anatomical structures of the body. These changes are even seen in lungs which affects generally after the age of 50. This age is also the most prevalent for the onset of neurological diseases and even stroke. [10] In the patients with neurological affection always the strategies are present for evaluation of their motor functions in terms of balance, strength etc., even on the respiratory functions are focused on in an acute phase only. But while in the chronic phase where the disabilities are over powering the symptoms of aging which are dyspnoea, fatigue, recurrent infection with or without cough it becomes essential enough to identify the lung capacity of an individual. [11]

Particularly in stroke the chances of respiratory failure remain high. Related to the same, a decrease of the excursion in the respiratory muscles on the side of affection was observed in various studies. This reduction is multifactorial that affects the spine, respiratory functions and the thoracic cage mechanics.[12]

The symptoms of respiratory affection also depend on the general health of the individual prior to stroke,

where the sedentary lifestyle, physical fitness, level of inactivity and the occupation all have a major role on the present condition of the patients. As all of these will be varying, the current clinical demonstration of the patient it is important to identify the level and extent of disability. As ventilation in the lungs is a bi-level process which is voluntary and centrally regulated which makes it is the basic necessity to identify the reduction of the lung capacity. Thus inspiratory and expiratory capacity in patients with stroke is important to be measured.

Methodology

The observational study was conducted after obtaining the ethical clearance as the study involved the patients of stroke. A clinical trial registration was conducted at CTRI with the enrolment no: CTRI/2024/01/061911 post which the study was initiated. The chronic stroke subjects were registered in the study after a written informed consent was signed by them which included all the information about the study, its effects and uses as well as the method to assess the subjects in their local language.

This cross sectional study was conducted at the OPD of a physiotherapy college from where 42 stroke participants were sorted for the inclusion and exclusion criteria of the study which are as follows: the subjects with an age of more than 40 years and less than 75 years, with the duration of affection being more than 6 months of stroke, single time affection, no facial muscle occlusion and willing to participate in the study were enrolled while those who were not able to understand the study protocol, with a history of smoking, diagnosed previously with a respiratory disease before stroke, currently with an acute respiratory involvement were all excluded from the study. Finally, a sample of 25 stroke subjects was evaluated who matched the inclusion criteria. A control group of subjects included participants who were age matched, with no respiratory illness or diagnosed with any disease condition not even acute respiratory illness. The age group of the participants was the same as that of the stroke patients of 40 – 75 years.

The age group were sorted as 40-60 years and the others above 60 years of age. Initiation of the procedure was carried out with a thorough demographic detail assessment followed by history taking. The primary outcomes were than measured which was BHT for identifying inspiratory capacity and PEFR which measures the expiratory flow to determine the expiratory capacity. The study even included the identification of saturation of oxygen SpO2 and the duration of stroke of each chronic stroke patients.

The study was commenced by the trained physiotherapist who collected the data for statistical analysis. BHT was then measured when the patient was in a supported upright sitting posture. This was followed with the set of instructions where the patients were asked to inspire deeply starting from the IRV and hold it as long as possible up till the individual's maximal voluntary effort. A stop watch was used to record the time in seconds for the voluntary breath holding. The procedure was conducted thrice with including a rest period of almost 300 seconds so as to encourage enough respiratory muscle efficiency. The readings considered for statistical evaluation was a mean of the 3 readings.

PEFR was then determined using the expiratory flow meter which was wrights peak flow meter. This too was conducted in the same position used for BHT. The patients were asked to ensure a complete seal around the mouth piece of the instrument ensuring a tight seal provided by the lips. The instrument was supported by a caregiver so as to gain maximal patients effort in expiration. The instruction followed as blowing with the maximal effort into the device after the end of IRV. Same considerations for final data and rest period was applied as that described for BHT.

The duration of stroke was assessed in the history taking questionnaire and the SpO2 was measured using a pulse oximeter in the index finger on the subjects before the above mentioned procedures as it might

affect the saturation of oxygen.

Statistical analysis: was performed using the SPSS VERSION 22 to apply t- test in accordance to compute the difference between the means of the outcomes in patients with that of the age as well as gender matched normal healthy individual. The demographic data is represented as mean ± standard deviation.

Results

Twenty five patients with chronic stroke with 13 males and 12 females having a mean age of 60.92 ± 8.11 and 58.16 ± 10.02 respectively were included in the study. The demographic details of the comparable group are described in table 1. There was no significant difference between the means of the two groups addressing to age, height, weight, BMI being comparable in both the groups. ($p<0.05$) this demonstrates the population to be similar for further respiratory evaluation.

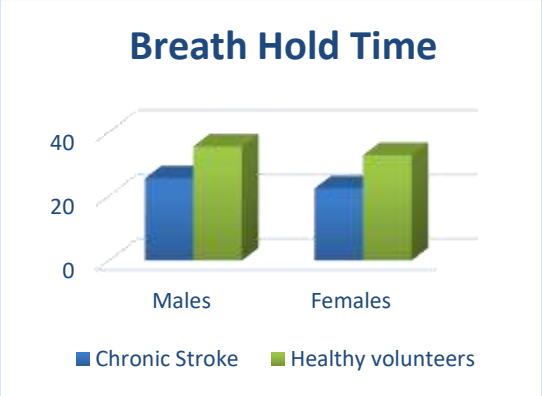
The respiratory capacity in chronic stroke patient was found out to be significantly low with a BHT of 25.61± 5.51 and 22.5 ±5.82 in males and females whereas PEFR of 206.92±73.41 and 189.16±54.51 respectively ($p<0.0001$) (Table 2) as compared to the age and even gender matched participants of the same region. Moreover the mean duration of stroke was 18.83 ± 10.13 months. The mean SpO2 was 96.87 ± 1.22.

Table 1: Descriptive data of the study cohort

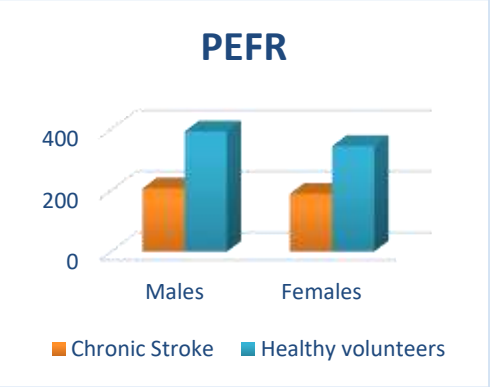
Demographic Details	Chronic Stroke Patients N= 25		Healthy Volunteers N=25		p value	
Gender	Male	Female	Male	Female	Male	Female
Age (years)	60.92 ± 8.11	58.16 ± 10.02	57.23 ±7.22	54.92± 7.18	0.232	0.352
Height (cms)	168.92 ± 9.71	165.75 ± 8.29	165.07± 6.65	163.07 ±3.47	0.249	0.312
Weight (kg)	66.76 ± 2.74	64.08 ±3.82	67.2± 2.31	61.16 3.12	0.662	0.052
BMI (Kg/m^2)	23.59 ±2.70	22.98 ±2.22	24.74 ±1.77	23.58 1.39	0.211	0.435

Table 2: Respiratory capacity in chronic stroke patient

Outcome measures	Chronic Stroke Patients N= 25		Healthy Volunteers N=25		P value	
Gender	Male N=13	Female N=12	Male N=13	Female N=12	Male N=13	Female N=12
BHT (seconds)	25.61± 5.51	22.5 ±5.82	35.57±3.66	32.86±3.11	0.0001	0.0001
PEFR (L/min)	206.92±73.41	189.16±54.51	392.69±71.78	345.08±66.36	0.0001	0.0001



Graph 1: Comparison of Breath Hold Time



Graph 2: Comparison of PEFR

Discussion

Stroke which is the most emerging cause of deaths demonstrate multiple systemic symptoms which includes almost all the major organs of the body. The ongoing study focused on findings related to the respiratory system where it had a major essential identification of the altering lung capacity both inspiratory as well as expiratory in patients exposed with stroke for more than 6 months. [13] The written works have evaluated the respiratory functions in terms of FEV1/ FVC, VC, PEFR, the strength of respiratory muscles, the exercise capacity, etc. but the inspiratory capacity was usually unstudied or not emphasized upon. [13, 14, 15, 16].

The present findings are in a favour of reduced BHT when compared to healthy age and gender matched individual. The difference found was fairly large suggestive of greater affection in the inspiratory capacity of chronic stroke patients. Likewise even PEFR showed deterioration in its values in this cohort as compared to the healthy volunteers. This represents that the expiratory capacity of these subjects is affected too. Meanwhile it is not so advisable to just improve the motor functions of the stroke subjects but even respiratory capacities need to be emphasized on so as to avoid complications related to fatigue, breathlessness and delayed regain of functions. The present finding was in positive accordance of that compared to the one's studies by Ana Lista-Paz in 2023 who have reported a significantly reduced functions of the lung in the chronic phase of stroke. This study even demonstrated restrictive pattern of affection as the reduced lung volumes and capacities depict a similar pattern. Our study too had findings in affirmation with that study where both BHT and PEFR are grossly reduced.

The study findings even had a backbone of the likely reduction in BHT and PEFR in the patients with chr-

onic stroke. The study conducted to evaluate the pattern of respiration affected in the same population by Dr Tvisha Patel in 2024 identified the reduction of BHT and PEFR to be even more as compared to that with patients of obstructive lung disease. This can be due to a dual effect of the central as well as muscular control of the respiration which is affected in people with stroke as the higher respiratory centres get involved too while in the phases of stroke.

According to Drakopanagiotakis F conducted their systemic review in 2024 where the pulmonary function test (PFT) correlated positively with the severity of stroke and the PFT showed better results after respiratory muscle training. These findings are similar to the ones find in the current study as the BHT correlates fairly with the inspiratory parameters of the PFT and the PEFR with the expiratory parameters of the same. The pulmonary function tests are usually conducted in the other phases of stroke which are the initial ones and in the later phase all these functions are neglected while are more important to evaluate. As such tests are always performed in the hospital study the current study thus focuses on the outpatient evaluation tools.

Stroke even leads to cardiovascular comorbidities and the vice-versa is true too. According to Ajaya Kumar A. Unnithan in 2023 published an article on stroke where the results in their complication section concluded the chances of cardiovascular complications to be as much as 4 % post intracranial haemorrhagic stroke.[17]

The study ruled out a significant decrease in breath hold time as compared to the normal age matched healthy population. This even accounts for severe affection of the respiratory system which is observed in respiratory disease. A study conducted by Barbara Lanini et al in 2002 studied the movements of the chest wall in patients with hemiplegia and they observed reduction in the voluntary contractions of the respiratory muscles on the side of hemiparesis. This study analysis proposes it to be essential to emphasize further on the lungs capacity which can alter due to reduced movement of the muscles and decreased kinematics of the thoracic cage. [18]

The p value is highly significant demonstrating the difference between the means of BHT and PEFR in chronic stroke patients compared to age-gender matched healthy volunteers concluding the marked reduction in them.

The current outcomes highlight a significant reduction in the inspiratory capacity which was analysed in terms of BHT and the expiratory capacity in terms of PEFR. This highlights an alarming need to continuously monitor the lung capacities of the stroke patient who receives rehabilitation irrespective of its chronicity.

This makes it inescapable for the importance of respiratory rehab while providing treatment to the person having stroke irrespective of duration.

Limitation: The study has comparatively less sample size due to disease population evaluated and the fatigue level varies from patient to patient.

Conclusion

Respiratory capacities are severely reduced in patients with stroke. Our assessment concluded decrease in the BHT and PEFR both in this cohort.

Clinical Implications and Limitations

Reduced Breath-Hold Time (BHT) and Peak Expiratory Flow Rate (PEFR) in patients with chronic stroke indicate compromised respiratory capacity and respiratory muscle weakness. These findings emphasize

the need for routine respiratory assessment in stroke rehabilitation. Simple bedside tools such as BHT and PEFR can help physiotherapists identify respiratory impairment early and guide appropriate interventions such as breathing exercises and respiratory muscle training. However, the study had limitations including a relatively small sample size and the use of only two respiratory measures. Additionally, factors such as stroke severity, duration, and physical activity levels were not extensively considered, which may influence respiratory performance.

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