International Journal of Health Sciences and Research
[Indexed, Peer-Reviewed Journal]
Volume 15; Issue: 7; July 2025
Website: www.ijhsr.org
Original Research Article ISSN: 2249-9571

Relation of FEV1 & FVC Value in Quadriplegic and Paraplegic Patients Due To Spinal Cord Injury in Supine Position with Their ADLs: An Observational Study

Jyotiranjan Paltasingh[1], Pratyush Ranjan Biswal[2]

[1]Assistant Professor, Br Nath Pai College of Physiotherapy, MIDC area, Kudal, Sindhudurg, Maharashtra 456550
[2]Assistant Professor, Br Nath Pai College of Physiotherapy, MIDC Area, Kudal, Sindhudurg, Maharashtra 456550

Corresponding Author: Pratyush Ranjan Biswal

DOI: https://doi.org/10.52403/ijhsr.20250718

ABSTRACT

INTRODUCTION: Traumatic spinal cord injuries (TSCI) are increasingly recognised as a major health concern worldwide. The incidence reported varies between 12.1 to 57.8 cases per million people in high-income countries, while in low-income countries, it ranges from 12.7 to 29.7. A spinal cord injury (SCI) refers to damage to the spinal cord that leads to either temporary or lasting changes in its function. Sleep-related respiratory issues in SCI patients are primarily due to respiratory motor control issues caused by paresis, paralysis, and muscle stiffness, assessed through the pulmonary function test. For those who have suffered spinal cord injuries (SCI), pulmonary problems are a leading cause of morbidity and death. Patients with acute traumatic cervical or upper thoracic spinal cord injury (SCI) exhibit alterations in pulmonary function that are suggestive of restricted ventilation dysfunction. Restrictive ventilatory changes brought on by spinal cord injury (SCI) include decreases in expiratory reserve volume, functional residual capacity, and vital capacity.
OBJECTIVES: This study aims to find out the relation between the Supine position with the value of FVC & FEV1 in Quadriplegic & paraplegic Patients due to Spinal Cord Injury.
METHODOLOGY: 20 Patients were divided into two groups included with Group A-9 consisting of quadriplegics and Group B-11 consisting of paraplegics, studied in an Observational method.
OUTCOME MEASURES: Pulmonary function Test (FVC & FEV_1)
RESULTS: The forced vital capacity and FEV_1 of the spinal cord-damaged subjects were measured in supine lying. Quadriplegic subjects show larger FVC value in supine lying as compared to Paraplegics, but in the case of FEV_1, Paraplegics show higher value than the Quadriplegics.
CONCLUSIONS: Respiratory dysfunction occurs in patients with spinal cord injury. It shows a typical pattern of restrictive pulmonary impairment as observed by respiratory function tests. The severity of respiratory dysfunction in Spinal Cord Injury is affected by the different levels of cord transection and is postural dependent.

KEYWORDS: FVC, FEV_1, SCI, Quadriplegia, Paraplegia

INTRODUCTION

Traumatic spinal cord injuries (TSCI) are becoming more acknowledged as a significant global health issue across the globe. The reported incidence varies from 12.1 to 57.8 cases per million individuals in high-income nations, while in low-income nations, it ranges from 12.7 to 29.7 **[1].** Damage to the spinal cord that results in either temporary or permanent changes in its function is known as spinal cord injury (SCI). This disorder is common, expensive, and produces a high rate of impairment at a young age **[2].** Both mechanical disruption (referred to as primary injury) and a series of harmful pathophysiological events (referred to as secondary injury) can cause damage to the spinal cord **[3].**

For people and their families, spinal cord injury (SCI) is a debilitating illness with far-reaching effects. SCI significantly strains economies and healthcare systems due to lost output and astronomically high lifetime healthcare expenses **[4].** Increases in central fat, reduced mobility from muscle paralysis, and recurring infections, primarily related to skin ulcers and urinary tract infections, are some of the clinical features of SCI, a chronic medical illness, that are linked to systemic inflammation **[5].**

Total weakening of all four limbs is referred to as quadriplegia or tetraplegia. This condition can be caused by an upper motor neuron type or, less frequently, a lower motor neuron type. Acute Atraumatic quadriplegia is difficult to anatomically localise, and a wide differential diagnosis encompasses conditions affecting the lower motor neurons, such as acute motor neuropathy or neuromuscular junction disease, as well as conditions affecting the upper motor neurons in the brainstem or, more frequently, the cervical spinal cord **[6].**

According to an arm crank ergometry test, about 25% of people with paraplegia are unable to consume enough oxygen to carry out several daily living activities. Some reports categorise individuals with paraplegia as either above (high paraplegia) or below T5/6 (low paraplegia), or they treat all paraplegics as a single study group. However, SCIs below T5/6 include multiple levels of thoracic, lumbar, and sacral injury that manifest with distinct neurological outcomes and varying degrees of somatic and sympathetic dysfunction **[7].**

One of the main causes of morbidity and death for SCI patients is respiratory dysfunction. Additionally, People with SCI are more likely to experience respiratory problems during sleep. Deficits in respiratory motor control linked to paresis, paralysis, and stiffness of the trunk and respiratory muscles are major causes of this dysfunction. Respiratory motor performance is assessed using the pulmonary function test (PFT) in both routine clinical practice and research.[8]

In a variety of clinical settings, including those with risk factors for lung illness, occupational exposures, and pulmonary toxicity, pulmonary function tests (PFTs) enable doctors to assess their patients' respiratory health **[8].** Interpreting pulmonary function tests (PFTs) entails contrasting measured and anticipated lung function metrics. The values used to predict pulmonary function are from healthy people, who are those who have never used tobacco or experienced any respiratory symptoms. According to guidelines from the American Thoracic Society (ATS) and the European Respiratory Society (ERS), reference equations created by the Global Lung Function Initiative (GLI) in 2012 should be used to calculate projected pulmonary function based on age, standing height, sex, and race **[9].**

Since forced expiratory volume in one second (FEV1) is linked to health outcomes and is more likely to be completed successfully in older adults than forced vital capacity, it is the most commonly used metric to assess spirometric function across time **[10].** When cardiopulmonary disease develops and worsens, a decrease in FEV1 frequently occurs, primarily affecting middle-aged and older adults. However, as people age, their FEV1 may also drop as a result of their chest wall becoming stiffer and their lungs' elastic recoil decreasing **[11].**

For those who have suffered spinal cord injuries (SCI), pulmonary problems are a leading cause of morbidity and death. The extent of the injury sustained determines how much respiratory impairment results from SCI**[12].** Forced Vital Capacity, or FVC, only the Residual Volume remains after the individual makes a maximal inspiration to TLC and a maximal forced expiratory effort. In a typical individual, the FEV1/FVC ratio exceeds 0.8; individuals with obstructive lung diseases like asthma or COPD exhibit a lowered FEV1/FVC. The FEV1/FVC ratio is believed to reflect resistance in the larger airways. Decreased FEV1/FVC (<70%) is an indicator of potential postoperative respiratory issues, such as the need for long-term oxygen therapy and atelectasis following lung resection surgery **[13].**

MATERIALS & METHODS

It is an observational study with convenient sampling. After obtaining institutional ethical committee approval, the study was initiated. Based on selection criteria, a total of 20 participants were chosen according to the inclusion & exclusion criteria of diagnosed cases of Spinal Cord Injury. It includes both genders, aged between 20-55 years. After taking informed consent from the patients, they were divided into two groups. Group A includes 9 Quadriplegic patients, and Group B includes 11 Paraplegic patients. All Patients' vitals were stable, with chest injuries and pneumonia resolved before pulmonary function testing. None had utilised the IPPB (intermittent positive pressure breathing) or Incentive spirometry in the course of assessment. The post-traumatic interval of all the subjects was over 6 months. During the period of this investigation, all the subjects were free from any cardio-pulmonary problem.

The Demographic data, such as Age, gender, history of Pneumonia, tracheostomy, Aetiology and level of spinal cord injury, were taken. Respiratory function test was performed with 'Winspiro PRO Spirometry'. Each subject was studied in supine lying. No subjects in this study were using a spinal brace. Pulmonary function testing included Forced vital capacity (FVC) & forced expiratory volume in 1st second (FEV_1), which is the most common form of pulmonary function test. It measures lung function, specifically the amount (volume) and speed (flow) of the air that can be inhaled or exhaled. Spirometer test was performed using a spirometer. It displays a graph such as

1. A volume time curve showing volume along the Y axis and time along the X axis.
2. A flow volume loop depicts the rate of air flow on the Y axis and the total volume inspired or expired on the X axis.

PROCEDURES

Collection of data the patients were interviewed and the information gathered about their demographic data of patients including name, age, gender, occupation, any history of systemic diseases and medications. Assessment of Spinal cord injury including respiratory diseases interference. After the consent from the patient, demonstration of the procedure was given to avoid difficulties during the procedure. Patient is asked to breathe deeply, then exhale into the sensor as hard and as fast as possible, preferably for 6 seconds. The test was preceded by a period of quiet breathing in and out from the sensor (Tidal Volume), or a rapid breath in (forced inspiratory part) was followed by forced expiration. A short nose clip was used to prevent air from escaping through the nose. The collected data was noted separately after the 3 consecutive trails of PFT and the best result was taken for statistical analysis.

STATISTICAL ANALYSIS

The acquired data were tabulated, and data analysis was performed using the International Business Machine (IBM) Statistical Program for Social Science (SPSS) version 20 for Windows. The Kolmogorov-Smirnov test was used to determine the normality of the obtained demographic and outcome data (KS test) for Equality of Variances. The Pearson correlation test has been used to demonstrate statistical significance in the two Groups.

OUTCOME MEASURES

Pulmonary function Test (FVC & FEV_1) demonstrate strong reliability (0.999), particularly when conducted following standardized procedures and with sufficient patient cooperation **[19].**

RESULTS

The forced vital capacity and FEV_1 of the spinal cord-damaged subjects were measured in the supine lying. Quadriplegic subjects show larger FVC value in supine lying as compared to Paraplegics, but in the case of FEV_1, Paraplegics show higher value than the Quadriplegics. Among the 10 Quadriplegic patients, 3 of them showed normal PFT values, whereas 50% of the patients in the Quadriplegic group showed a mild restrictive pattern in supine position and 20% had having moderate restrictive pattern, and 10% of them had a severe restrictive pattern in group A. Similarly, in Group B, paraplegic patients, only 1 of them had normal PFT value, whereas 10% of them showed mild restriction & 70% of them showed a moderate restrictive pattern. The statistical analysis showed there was a significant relation within the group itself, but not significant between the groups.

GROUP-A (QUADRIPLEGIC PATIENT WITH SUPINE POSITION)

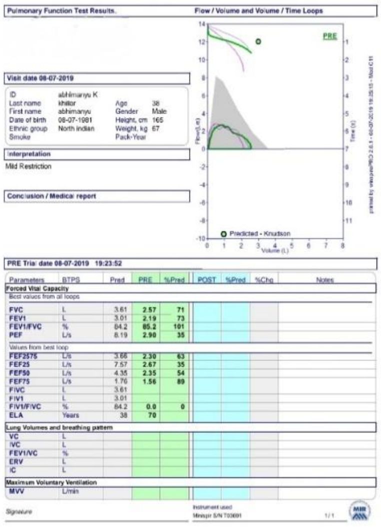

Fig.1

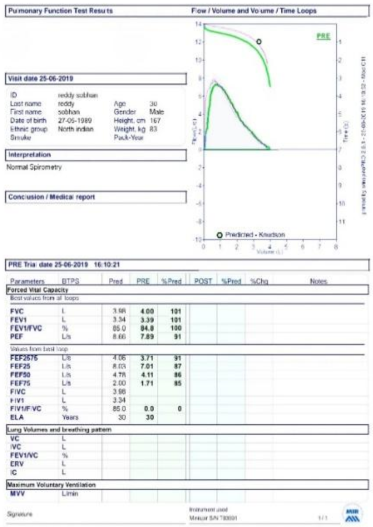

Fig.2

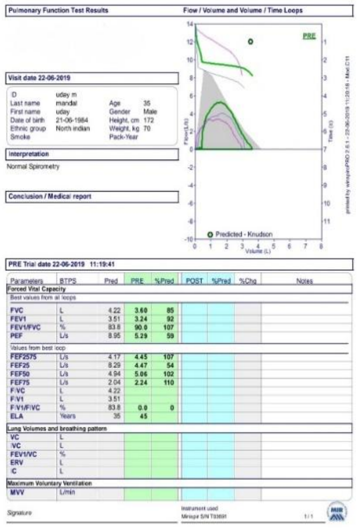

Fig.3

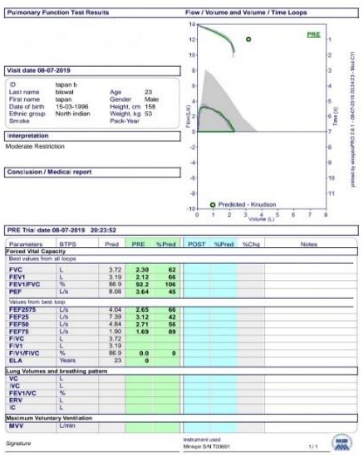

Fig.4

Fig.5

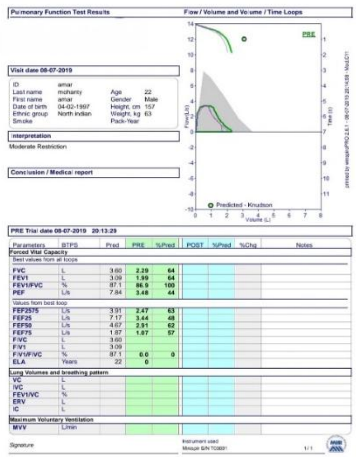

Fig.6

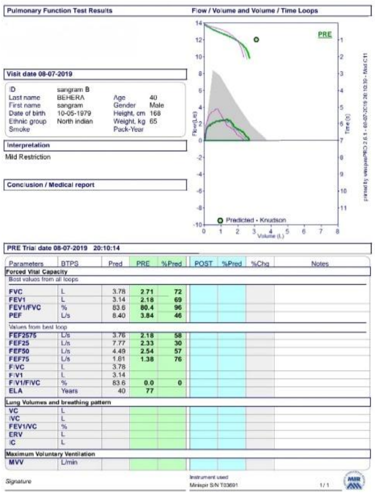

Fig.7

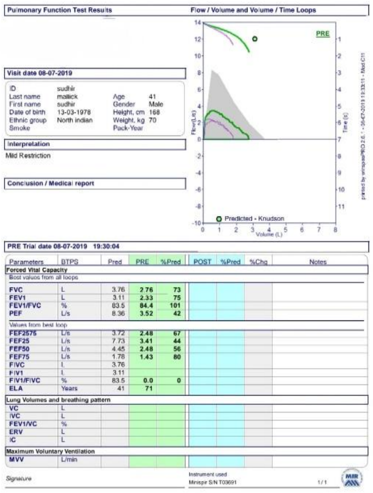

Fig. 8

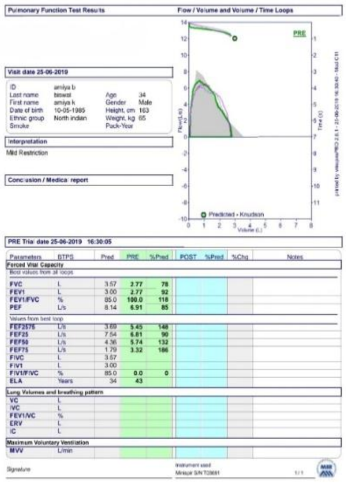

Fig.9

GROUP-B (PARAPLEGIC PATIENT WITH SUPINE POSITION)

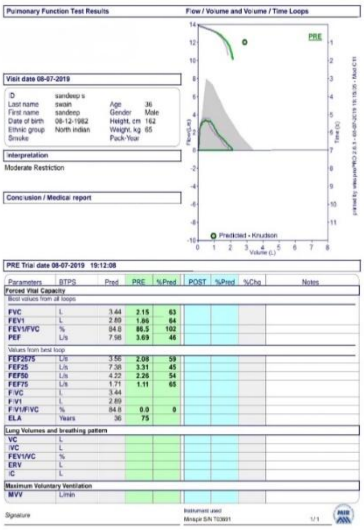

Fig.1

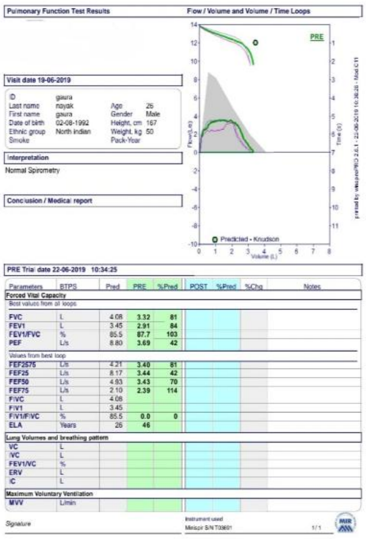

Fig.2

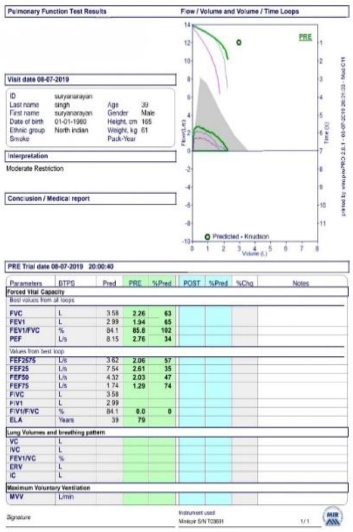

Fig.3

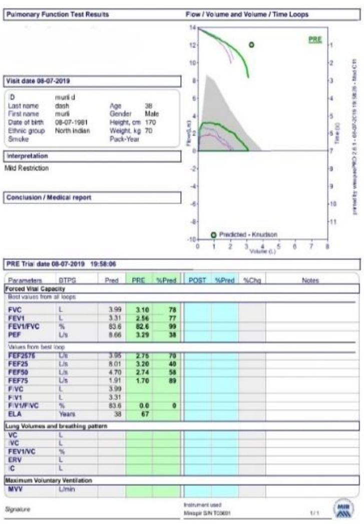

Fig.4

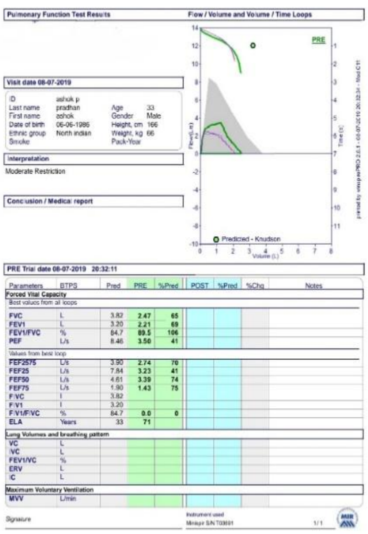

Fig.5

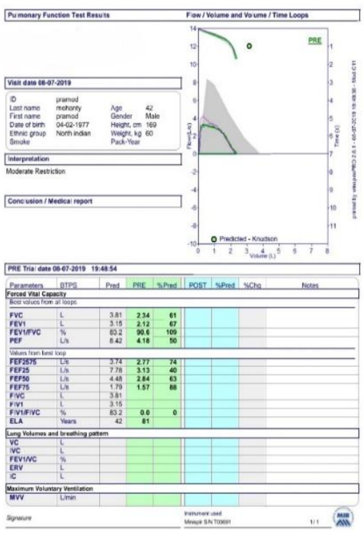

Fig.6

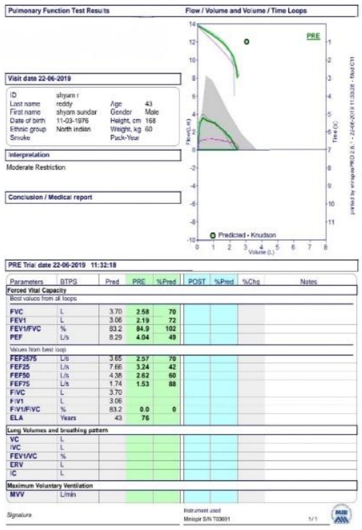

Fig.7

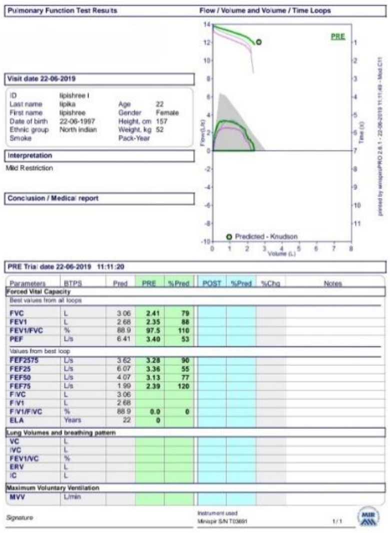

Fig.8

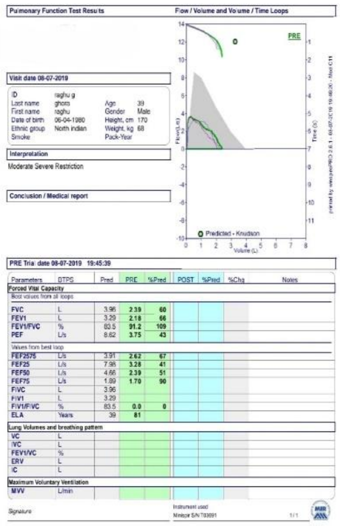

Fig.9

DISCUSSION

The present study aims to find out the relation between the Supine position with the value of FVC & FEV1 in Quadriplegic & paraplegic Patients due to Spinal Cord Injury. This study included 9 Quadriplegic and 11 paraplegic Patients as participants. The statistical analysis displays that there is no significant improvement ('p' value=0.853) in overall scoring between the groups. The finding results do not support the H_0 hypothesis that there is no significant distinction between the FEV_1 & FVC values in both the Quadriplegic and Paraplegic SCI patients. The degree and severity of SCI were not directly correlated with longitudinal changes in FEV1 and FVC; rather, these changes were caused by age and possibly controllable variables. These findings imply that efforts to strengthen respiratory muscles, quit smoking, regulate weight, and conduct studies aimed at identifying and treating wheezing may all help to halt the loss in lung function following SCI **[14].**

One study shows regardless of SCI level and severity of damage, BMI, and other variables, plasma CRP and IL-6 are adversely correlated with FEV1 and FVC in people with chronic SCI, the possibility that decreased lung function is a result of systemic inflammation linked to chronic SCI **[15].**

Long-term SCI patients, the Pulmonary function initially rises but decreases over time, dropping below baseline levels after 6 years. Additional analysis with more comprehensive datasets is necessary to clarify the elements affecting these alterations **[16].**

Even when individuals with **spinal cord injury (SCI)**, who often have weakened breathing muscles and impaired lung function, perform spirometry tests reliably, their results might not meet the standard criteria set by the American Thoracic Society (ATS). Excluding these individuals from research would create bias in studies on respiratory function in SCI. To get a more accurate understanding, we should modify spirometry testing standards to accept efforts with **End-of-Breath Exhaled Volume (EBEV)** and a 0.5-second plateau if the total exhalation is less than 6 seconds. This would help reduce potential bias **[17].**

In individuals with paraplegia**,** chest expansion tended to be larger, but this wasn't a statistically significant difference. However, tetraplegics showed significantly reduced lung function across several spirometry measures, specifically vital capacity (VC)**,** forced vital capacity (FVC)**,** inspiratory capacity (IC)**,** inspiratory reserve volume (IRV), and expiratory reserve volume (ERV)**.** Further analysis revealed that VC was strongly linked to all other pulmonary function test results. Interestingly, despite this strong objective correlation, patients' subjective reports of their breathing problems didn't seem to align with their VC measurements **[18].**

CONCLUSION

Respiratory dysfunction occurs in patients with spinal cord injury. It shows a typical pattern of restrictive pulmonary impairment as observed by respiratory function tests. The severity of respiratory dysfunction in Spinal Cord Injury is affected by the different levels of cord transection and is posture-dependent.

LIMITATIONS

The sample size was limited. Therefore, clinical findings need to be confirmed with larger studies. The study examined only FVC & FEV_1 in patients with quadriplegia and Paraplegic patients in supine lying. For these subjects, we cannot be certain how other positions give the result. Lesser study duration, no follow-up sessions, so the study cannot be certain that the differences remain the same in the long term.

Recommendations

The same study can be done with a longer study duration and increased sample size. Follow-up studies can be done in future to document the long-term effects of such provided study. The same FVC & FEV_1 can be used for other conditions related to Complete or incomplete spinal cord injury patients. The same study can be done with a comparison with the control group. It can be compared with other Neuromusculoskeletal or Neurological disorders, such as Guillain-Barré syndrome, Motor neuron disorder and other diseases in which who seek long-term bed rest to determine which values give the best benefit in supine lying.

Declaration By Authors Ethical Approval

Before the commencement of the study, Ethical committee approval was obtained from Br. Nath Pai College of Physiotherapy, Kudal, Maharashtra, India. Informed consent taken from the participants.

Acknowledgement: The Authors Acknowledge Br. Nath Pai College of Physiotherapy, Kudal for their valuable support throughout the study, Professors and Staff members of the Physiotherapy department and who helped in the study.

Source Of Funding: None

Conflict Of Interest: Nil

REFERENCES

1. Barbiellini Amidei C, Salmaso L, Bellio S, Saia M. Epidemiology of traumatic spinal cord injury: a large population-based study. Spinal Cord. 2022 Sep;60(9):812-9.
2. Hu X, Xu W, Ren Y, Wang Z, He X, Huang R, Ma B, Zhao J, Zhu R, Cheng L. Spinal cord injury: molecular mechanisms and therapeutic interventions. Signal transduction and targeted therapy. 2023 Jun 26;8(1):245.
3. Bourguignon L, Tong B, Geisler F, Schubert M, Röhrich F, Saur M, Weidner N, Rupp R, Kalke YB, Abel R, Maier D. International surveillance study in acute spinal cord injury confirms viability of multinational clinical trials. BMC Medicine. 2022 Jun 14;20(1):225.
4. Zhu H, Guest JD, Dunlop S, Xie JX, Gao S, Luo Z, Springer JE, Wu W, Young W, Poon WS, Liu S. Surgical intervention combined with weight-bearing walking training promotes recovery in patients with chronic spinal cord injury: a randomized controlled study. Neural regeneration research. 2024 Dec 1;19(12):2773-84.
5. Hart JE, Goldstein R, Walia P, Teylan M, Lazzari A, Tun CG, Garshick E. FEV 1 and FVC and systemic inflammation in a spinal cord injury cohort. BMC Pulmonary Medicine. 2017 Dec;17:1-9.
6. Zedde M, Grisendi I, Pezzella FR, Napoli M, Moratti C, Valzania F, Pascarella R. Acute Onset Quadriplegia and Stroke: Look at the Brainstem, Look at the Midline. Journal of Clinical Medicine. 2022 Dec 4;11(23):7205.
7. Farkas GJ, Gordon PS, Swartz AM, Berg AS, Gater DR. Influence of mid and low paraplegia on cardiorespiratory fitness and energy expenditure. Spinal cord series and cases. 2020 Dec 16;6(1):110.
8. de Paleville DG, Sayenko DG, Aslan SC, Folz RJ, McKay WB, Ovechkin AV. Respiratory motor function in seated and

supine positions in individuals with chronic spinal cord injury. Respiratory physiology & neurobiology. 2014 Nov 1;203:9-14.
9. Badr El-Din NK, Shabana SM, Abdulmajeed BA, Ghoneum M. A novel kefir product (PFT) inhibits Ehrlich ascites carcinoma in mice via induction of apoptosis and immunomodulation. BMC complementary medicine and therapies. 2020 Dec;20:1-2.
10. Moffett AT, Bowerman C, Stanojevic S, Eneanya ND, Halpern SD, Weissman GE. Global, race-neutral reference equations and pulmonary function test interpretation. JAMA Network Open. 2023 Jun 1;6(6): e2316174-.
11. Vaz Fragoso CA, McAvay G, Van Ness PH, Metter EJ, Ferrucci L, Yaggi HK, Concato J, Gill TM. Ageing-related considerations when evaluating the forced expiratory volume in 1 second (FEV1) over time. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2016 Jul 1;71(7):929-34.
12. Demirel G, Demirel S, Yilmaz H, Kesiktas N, Akkaya V. Pulmonary function in spinal cord injury: a clinical and spirometric study. Journal of Neurologic Rehabilitation. 1997 Sep;11(3):159-68.
13. Sparling JL, Melo MF. Pulmonary Pathophysiology and Lung Mechanics in Anesthesiology. InCohen's Comprehensive Thoracic Anaesthesia 2022 Jan 1 (pp. 66-87). Elsevier.
14. Stolzmann KL, Gagnon DR, Brown R, Tun CG, Garshick E. Longitudinal change in FEV1 and FVC in chronic spinal cord injury. American journal of respiratory and critical care medicine. 2008 Apr 1;177(7):781-6.
15. Hart JE, Goldstein R, Walia P, Teylan M, Lazzari A, Tun CG, Garshick E. FEV 1 and FVC and systemic inflammation in a spinal cord injury cohort. BMC Pulmonary Medicine. 2017 Dec;17:1-9.
16. Sho KY, Mun C, Lim JC, Kim O, Lee JW. Long-Term Pulmonary Function Postspinal Cord Injury. Archives of physical medicine and rehabilitation. 2024 Nov 1;105(11): 2142-9.
17. Kelley A, Garshick E, Gross ER, Lieberman SL, Tun CG, Brown R. Spirometry testing standards in spinal cord injury. Chest. 2003 Mar 1;123(3):725-30.
18. Demirel G, Demirel S, Yilmaz H, Kesiktas N, Akkaya V. Pulmonary function in spinal cord injury: a clinical and spirometric study. Journal of Neurologic Rehabilitation. 1997 Sep;11(3):159-68.
19. Uygun MN, Ann JM, Woo BH, Park HM, Kim HI, Park DS, Jeong IB. The Reliability and Validity of a Portable Hand-held Spirometer for the Measurement of Various Lung Functions in Healthy Adults. Physical Therapy Rehabilitation Science. 2024;13(2): 179-86.

How to cite this article: Jyotiranjan Paltasingh, Pratyush Ranjan Biswal. Relation of FEV1 & FVC value in quadriplegic and paraplegic patients due to spinal cord injury in supine position with their ADLs: an observational study. *Int J Health Sci Res.* 2025; 15(7):153-160. DOI: *https://doi.org/10.52403/ijhsr.20250718*

******