Correlation between Forward Head Posture and Peak Expiratory Flow Rate in Undergraduate Students using Peak Flow Meter: A Correlational Study

Dr. Hritika Chavan[1], Dr. Shruti Mulaokar[2]

[1]BPTH, Late Shree Fakirbhai Pansare Education Foundation's College of Physiotherapy, Nigdi, Pune, Maharashtra, India

[2]Associate Professor, School of Physiotherapy, Bharati Vidyapeeth Deemed to be University, Pune, Maharashtra, India

Abstract: ***Background**: Forward head posture (FHP) is a prevalent postural deviation associated with cervical spine strain, musculoskeletal disorders and compromised respiratory mechanics. Among undergraduate students, prolonged study sessions and sedentary behaviors may exacerbate FHP, potentially affecting respiratory function. **Objectives**: This study aims to explore the correlation between FHP, measured using craniovertebral angle (CVA), and peak expiratory flow rate (PEFR), a critical indicator of pulmonary function. **Methods**: An observational study was conducted on 100 undergraduate students ages 18-25 years. FHP was quantified via CVA measured using Kinovea software, while PEFR was recorded using a Mini-Wright peak flow meter. Participants performed three PEFR tests, and the highest reading was used for analysis. Pearson correlation coefficient and p-values were calculated to assess the relationship between FHP and PEFR. **Results**: The correlation coefficient (r=0.156, p=0.12) indicated a weak positive relationship between FHP and PEFR, though not statistically significant. Variability in PEFR results was attributed to factors such as circadian rhythms, physical fitness and stress levels, which were not controlled during the study. **Conclusion**: Although the study revealed a weak positive correlation between FHP and PEFR, it underscores the importance of addressing postural deviations in improving respiratory function. Further research involving larger sample sizes and controlled variables is warranted to validate these findings and evaluate the impact of postural correction interventions on pulmonary health.*

Keywords: Forward Head Posture, Craniovertebral Angle, Peak Expiratory Flow Rate, Pulmonary Function

1. Introduction

Forward head posture (FHP) is a poor habitual neck posture that is defined by hyperextension of the upper cervical vertebrae and forward translation of the cervical vertebrae.[1]

Changes in biomechanics due to forward head posture (FHP) result in neck pain, headaches, and cervical spine dysfunction. Additionally, FHP significantly impacts respiratory function by weakening the respiratory muscles.[2]

When the head comes forward, there is a contraction of the muscles in the front of the neck and immediately below the back of the neck, namely, the complex structure of the scalene muscle, the sternocleidomastoid muscle and the auricularis posterior muscle.[3]

Neck flexor muscles, such as the scalene and sternocleidomastoid, play a crucial role in the postural control of the neck while also functioning as accessory inspiratory muscles. As a result, these muscles are involved not only in the functional movements of the neck but also in the process of breathing.[3]

An imbalance of these muscles brought on by tension may be the cause of the obstruction of regular breathing. Therefore, regular FHP weakens and shortens these muscles, which results in affected breathing.[3]

As the severity of FHP increased, the maximum voluntary isometric contraction of the neck extensors dramatically decreased. Additionally, Oliveira and Silva found a strong correlation between neck pain, FHP, and the endurance of the neck muscles (deep neck flexor and neck extensor), supporting the effect of FHP on muscle contractile function and the length-force relationship.[4]

The cervical muscles, the majority of which are involved in the process of labored breathing will be significantly impacted by the presence of FHP. Additionally, the cervical bones protrusion will lead to adaptive changes in the thoracic vertebrae, which will also modify the rib cage. The intercostal musculature, which also includes the diaphragm in the lowest costal bones, would then be impacted by all of these changes, leading to a net effect of changes in both quiet and labored breathing.[5]

Peak expiratory flow rate (PEFR) measures the degree of airflow as well as the strength and health of the respiratory muscles. Peak expiratory flow measures how much air enters and exits the lungs during different breathing techniques. When the lungs are fully inflated, it measures the peak expiratory flow rate, which is the maximum airflow attained during a forceful expiratory maneuver.[6]

Undergraduate students, especially those involved in competitive exams, are more likely to have forward head posture as a result of their improper sitting habits for studying for extended time. This improper posture might lead to musculoskeletal problems such as cervical dysfunction, as well as impaired respiratory function due to weakened diaphragm and respiratory muscles. FHP also disrupts normal biomechanics, making it necessary to rely on accessory muscles for breathing which can reduce pulmonary efficiency even further.[7] While previous research has shown that posture has an impact on respiratory function, specific research aimed at young adult students is still scarce. As a result, this study seeks to investigate the relationship between forward head posture (FHP) and peak expiratory flow rate (PEFR) in this population, as there is currently a lack of data on young adult students.

2. Methodology

Type of study: Observational study

Sample Population: Undergraduate students preparing for competitive exams in PCMC

Sample Size: 100

Inclusion Criteria	Exclusion Criteria
Age group: 18-25 years	Any history of neck injury or surgery
Gender: Male and Female	Any existing or past cardio-respiratory conditions
Undergraduate students preparing for competitive exams	Participants with any structural musculoskeletal deformity
FHP identified through CVA ≤50º-53º (measured using Kinovea software)	Participants with post COVID 19

Procedure: After Ethical committee approval

Participants were screened based on the inclusion and exclusion criteria

↓

They were briefed about the study procedure and the informed consent was taken.

↓

CVA was assessed using a mobile camera and analysed using Kinovea software to quantify forward head posture.

↓

Participants were instructed to sit upright on a chair with their heads in a neutral position while a lateral view picture was taken

↓

Peak Expiratory Flow Rate (PEFR) was measured using a portable Mini wright Peak Flow

↓

Participants were instructed on the correct usage of the device.

↓

Three PEFR readings were taken, with rest intervals between attempts and the best value was recorded.

↓

PEFR values were compared to the predicted normal values using height and age-based equations.

↓

PEF in L/min (male) = −1.807 (Age) + 3.206 (Height)
PEF in L/min (female) = −1.454 (Age) + 2.368 (Height)

↓

The data was analysed using STATA Version 17.0 software and Microsoft Excel 2007.

3. Outcome Measures

Craniovertebral Angle (CVA) Measurement

The craniovertebral angle (CVA) is a reliable and valid tool used to quantify forward head posture. It is measured as the angle formed between a horizontal line passing through the spinous process of the C7 vertebra and a line extending from the tragus of the ear.[8] A reduced CVA indicated a more pronounced forward head posture. Photographs were taken in the lateral (sagittal) view while participants were seated upright with a neutral head position. These images were analysed using Kinovea software, a validated tool for precise angle measurements (ICC=1).[9]

Peak Expiratory Flow Rate (PEFR)

PEFR was measured using a Mini-Wright Peak Flow Meter, a portable and reliable device (accuracy 8.5L/min) commonly used for assessing respiratory function.[10] Participants were instructed to sit upright, take a deep breath and blow forcefully into the mouthpiece. The procedure was repeated three times with adequate rest intervals, and the highest value was recorded as the PEFR measurement.[11] The results were compared with predicted values using gender-and-height-based reference efficiency that are

PEF in L/min (male) = −1.807 (Age) + 3.206 (Height)

PEF in L/min (female) = −1.454 (Age) + 2.368 (Height)[12]

4. Results and Statistical Analysis

The statistical analysis was done on STATA Version 17.0 software.

A Pearson correlation coefficient (r) was calculated to assess the strength and direction of the relationship between forward

Paper ID: SR25409212807 DOI: https://dx.doi.org/10.21275/SR25409212807

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

head posture (CVA angle) and peak expiratory flow rate (PEFR).

The correlation coefficient (r) was found to be 0.156, indicating a positive correlation between forward head posture and peak expiratory flow rate.

The p-value associated with this correlation was 0.12, which is above the commonly accepted significance level of 0.05.

The p-value indicates that the correlation is not statistically significant, as it exceeds the threshold of 0.05.

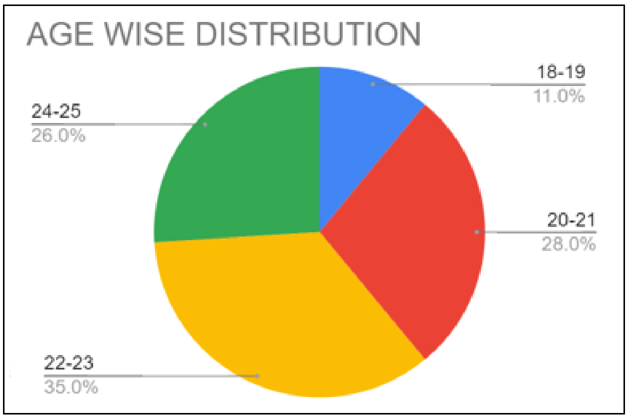
While the correlation is positive, it is weak, meaning that forward head posture does have some influence on peak expiratory flow rate.

Demographic distribution

Graph 1: Age distribution of participants:

Age	% Distribution
18-19 YEARS	11
20-21 YEARS	28
22-23 YEARS	35
24-25 YEARS	26

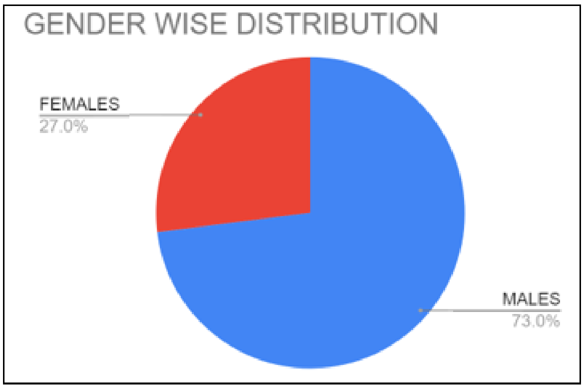
This data demonstrates a balanced representation of age groups, with the majority of students falling in the 22-23 years category.



Graph 1

Graph 2: The gender distribution

Gender	% Distribution
Female	27
Male	73

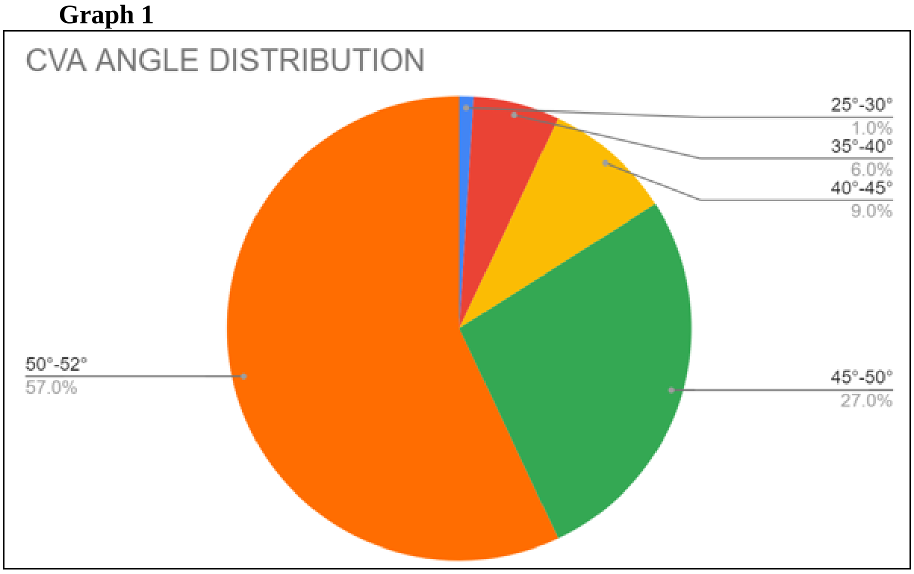


Graph 2

Craniovertebral angle (CVA) and forward head posture

Graph 3: Distribution of participants based on their CVA angle

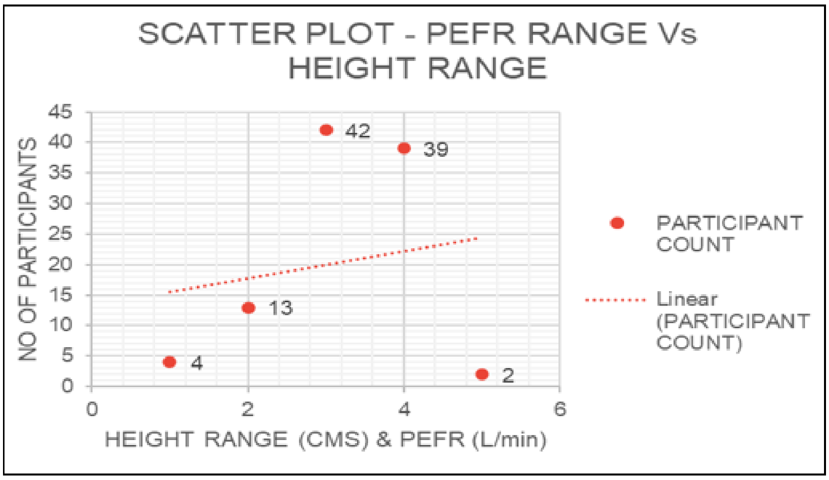
Degree of CVA angle	Participants % Distribution
25-30 degrees	1
35-40 degrees	6
40-45 degrees	9
45-50 degrees	27
50-52 degrees	57



Graph 3

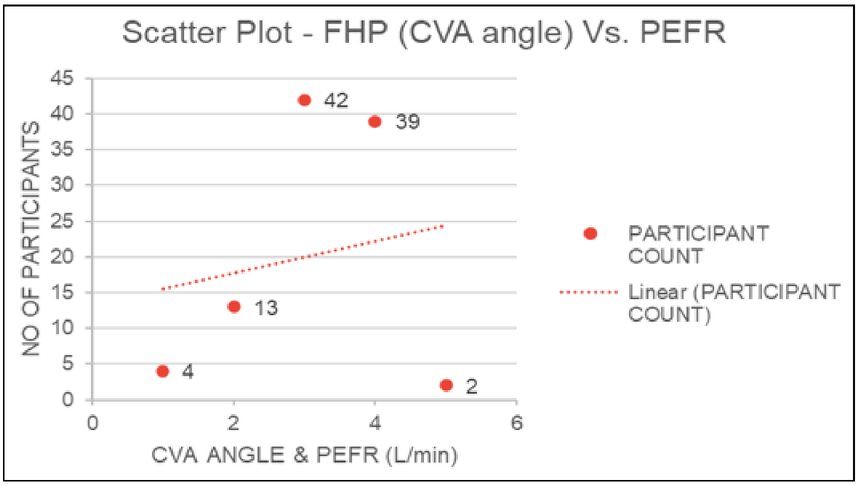
Correlation between forward head posture and peak expiratory flow rate

Graph 4: Illustrates the relationship between height and PEFR, showing a weak positive correlation.



Graph 4

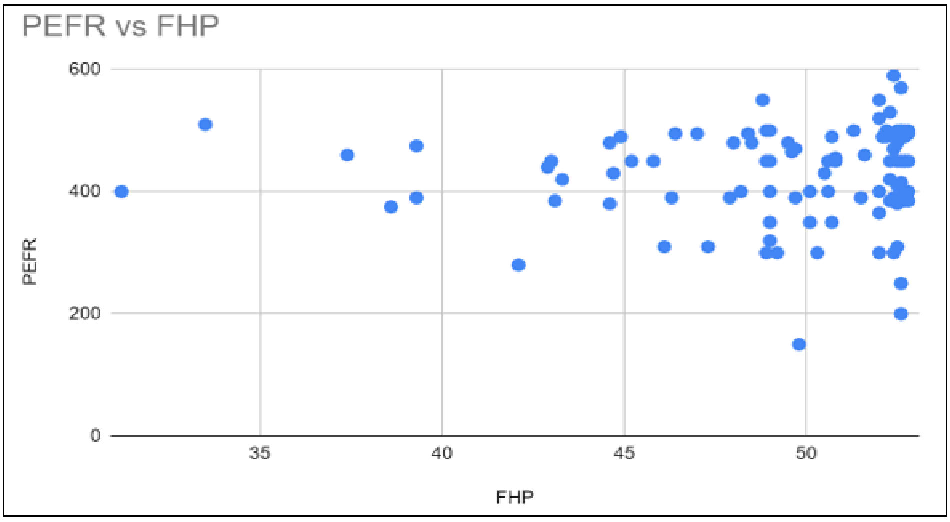
Graph 5: Presents the relationship between CA angle and PEFR. The upward slope of the trend line indicates a slight positive correlation between FHP and PEFR. However, the dispersion of data points highlights variability, pointing to a weak correlation.



Graph 5

Graph 6: This further confirms this weak positive correlation, as the slight upward slope between FHP and PEFR is evident, but not strongly pronounced. The Pearson correlation coefficient (r=0.156) reflects this weak positive relationship, where students with a more pronounced forward head posture tend to have slightly lower PEFR values.

PEFR and FHP	
PEARSON r	r=0.156
p-value	p=0.12



Graph 6

5. Discussion

The results of this study, with a Pearson correlation coefficient (r=0.156), show a weak positive relationship between FHP and PEFR. This finding suggests that postural alignment, particularly of the head and neck, has some influence on respiratory function. However, the p-value of 0.12 indicates that this correlation is not statistically significant, implying that, while the relationship exists, it may not be robust enough in this sample size.

Although the correlation between FHP and PEFR in this study was weak, the results highlight the importance of posture in respiratory health. Students, particularly those who study for long periods of time in seated positions, are more likely to develop FHP as a result of prolonged forward leaning postures while using computers or reading. This prolonged posture can cause adaptive shortening of the muscles and weakness of the posterior muscles, resulting in decreased thoracic mobility and impaired diaphragmatic function.

The weak correlation between FHP and PEFR is likely due to FHP's effect on respiratory function, which is moderated by other factors including the actions that an individual with FHP may take. Furthermore, environmental factors such as air quality, time of day and participants' varying levels of physical activity and stress could have influenced the PEFR readings, resulting in variability in the results. Stress can also indirectly influence PEFR. high stress levels frequently cause increased tension in the neck and shoulder muscles, including the trapezius and sternocleidomastoid. This tension can worsen forward head posture and reduce thoracic mobility, compromising diaphragm function and breathing mechanics.

As a result, stress-induced muscle tightness may indirectly lower PEFR values, adding to the data's variability and contributing to the observed weak positive correlation. Kumar et al.'s (2016) article, "Effect of Stress on Respiratory Parameters," discusses how stress affects muscle tension and respiratory function, providing evidence for the link between stress, muscle tightness, and decreased pulmonary function.

This reasoning is consistent with the biomechanics of respiration and the role of posture in pulmonary function, as supported by previous research (Koseki et al., 2019; Indonesian Journal of Physical Medicine and rehabilitation, 2019). Both studies emphasise the mechanical disadvantage of FHP on the diaphragm, as well as the compensatory overuse of accessory muscles, which leads to decreased respiratory efficiency.

Another factor to consider in this relationship is the impact of circadian rhythms on PEFR, as highlighted in the study "Circadian Rhythm of Peak Expiratory Flow Rate in Healthy North Indian Men" by Goyal et al. (2020). This study found that PEFR varies throughout the day, peaking in the late afternoon, implying that the time of day may have a significant impact on the respiratory measurements collected during the study.

These circadian changes may add to the variability in the PEFR readings because the study participants were probably going to have different activities and stress levels throughout the day. For example, the association between FHP and PEFR may be muddled if PEFR assessments were performed at different times for each participant.

Another relevant study, "The Impact of Forward Head Posture on Respiratory Mechanics and Pulmonary Function," published in the Indonesian Journal of Physical Medicines and Rehabilitation (2019), also concludes that FHP reduces diaphragm efficiency and increases reliance on an accessory muscle such as the sternocleidomastoid and scalene. This overreliance on secondary respiratory muscles leads to inefficient breathing patterns and lower PEFR values, which are consistent with the findings of the current study.

Similar connections between FHP and compromised respiratory function have been noted in earlier research. For example, Koseki et al. (2019) discovered that people with FHP have decreased dynamic lung volumes, such as forced expiratory volume (FEV1) and forced vital capacity (FVC). These decreases most likely result from the diaphragm's mechanical disadvantage when the thorax is constrained by bad posture. The hypothesis that FHP changes thoracic alignment and reduces respiratory efficiency is supported by a study by Koseki et. al. that was published in the Bulletin of the Faculty of Physical Therapy.

The weak correlation found in this study is consistent with existing literature. Koseki et al. (2019), in their study "The Effect of Forward Head Posture on Dynamic Lung Volumes in Young Adults," reported similar findings, noting that individuals with FHP had reduced lung volumes and respiratory function due to altered diaphragm mechanics. This study provides evidence to support the idea that FHP affects the efficiency of respiratory muscles, including the diaphragm, which is essential for generating maximum expiratory flow. Furthermore, the Indonesian Journal of Physical Medicine and Rehabilitation (2019) stated in their article "The Impact of Forward Head Posture on Respiratory Mechanics and Pulmonary Function" that FHP limits thoracic mobility and shifts the burden of breathing onto the accessory muscles, reducing diaphragm engagement.

Given that bad posture reduces diaphragm effectiveness, the study's findings of a weak positive correlation between FHP and PEFR could be biomechanically explained. Other confounding factors, such as individual differences in fitness, respiratory muscle strength, and even participant motivation during PEFR testing, may be the cause of the weak correlation.

While the Pearson correlation of 0.156 may appear low in this context, a biomechanical understanding of posture and respiration supports the relationship it suggests. FHP compresses the upper thoracic region, reducing the diaphragm's ability to expand the ribcage effectively. Over time, this can result in shallow breathing patterns that rely more heavily on accessory muscles such as the sternocleidomastoid and scalene. These muscles are not intended for prolonged respiratory patterns, as highlighted in the review by Garcia et al. (2019), who investigated the impact of posture on diaphragm mechanics and overall pulmonary function.

While the correlation was weak, the data showed an upward trend, suggesting that addressing FHP through posture correction and ergonomic interventions could improve students' PEFR. Given that posture influences respiratory mechanics, even minor improvements in FHP may result in improved pulmonary function, particularly for students who spend long periods of time seated forward leaning.

In summary, while the study discovered only a weak positive correlation between FHP and PER, the results emphasize the importance of maintaining good posture for optimal respiratory function. Further research could look into interventions aimed at correcting FHP and their effects on PEFR, especially in populations such as students who are at risk of developing poor posture as a result of prolonged study habits. The study's limitations included that the testing times for PEFR measurements varied, which may have introduced inconsistencies in the results, as respiratory function naturally fluctuates throughout the day due to circadian rhythm, typically peaking in the late afternoon; and the participants' stress levels and physical fitness were not assessed. Future studies should include larger and more diverse sample sizes to improve generalizability and statistical power. This would allow for stronger conclusions about the relationship between FHP and PEFR. Future research should include variables like body mass index (BMI), physical activity level, and respiratory health history to better understand how they interact with FHP and PEFR. Research into whether postural correction interventions can improve PEFR in students with pronounced FHP could have practical implications for respiratory and musculoskeletal health.

6. Conclusion

The study on the correlation between forward head posture (FHP) and peak expiratory flow rate (PEFR) in 100 undergraduate students found a weak positive relationship ($r=0.156$), though not statistically significant ($p=0.12$). While FHP may modestly impact respiratory function, factors like individual differences in muscle strength and environmental variables likely influenced the results. Despite the weak correlation, the findings suggest that addressing FHP, particularly in competitive exam going students with prolonged seated postures, could improve respiratory function. Future research should focus on posture correction interventions to assess their effect on PEFR.

The weak positive correlation suggests that correcting FHP may have a marginal benefit on pulmonary function. Physiotherapists and clinicians should consider incorporating posture correction exercises in students or individuals who exhibit both FHP and respiratory dysfunction. Since respiratory muscle function may be influenced by posture, pulmonary rehabilitation programs could benefit from incorporating postural education and specific physiotherapy exercises that target both posture correction and respiratory mechanics. Exercises such as diaphragmatic breathing, thoracic mobility exercises, and strengthening of the deep neck flexors and scapular stabilizers (like chin tucks, wall angels and shoulder blade retractions) can improve breathing efficiency. Incorporating stretches for the chest muscles (e.g., pectoral stretches) and strengthening exercises for the back and core muscles can further enhance postural alignment and support better respiratory function, especially in populations with prolonged sedentary behavior or desk work.

Educational programs aimed at preventing the development of FHP in students, particularly those preparing for exams and spending long hours studying, could help mitigate the potential negative impact on respiratory function.

Acknowledgements
I would like to thank the staff of Late Shree Fakirbhai Pansare Education Foundation for all their constant help in our study. I would also like to thank the participants for their keen participation in our study.

References

[1] Taiichi Koseki, Fujiyasu Kakizaki, Shogo Hayashi, Naoya Nishida, and Masahiro Itoh, Effect of forward head posture on thoracic shape and respiratory function, Journal of Physical Therapy Science, 2019 Jan 10, 31(1): 63–68.

[2] ALNK Perera, RKNK De Silva, NS Ariyaratne and VS Thuduvage, Relationship between Craniovertebral Angle with the Long-Term Usage of Electronic Devices among Undergraduates of General Sir John Kotelawala Defence University, Department of Physiotherapy,

Faculty of Allied Health Sciences, General Sir John Kotelawala Defence University, 10290, Sri Lanka, ID 128.

[3] Jeong-Il Kang, PT, PhD, Dae-Keun Jeong, PT, PhD, and Hyun Choi, PT, PhD, Correlation between pulmonary functions and respiratory muscle activity in patients with forward head posture, J Phys Ther Sci. 2018 Jan; 30(1): 132–135.

[4] Guohao Lin, Weijie Wang, and Tracey Wilkinson, Changes in deep neck muscle length from the neutral to forward head posture. A cadaveric study using Thiel cadavers, Clin Anat. 2022 Apr; 35(3): 332–339.

[5] Kevin Triangto, Siti Chandra Widjanantie, Nury Nusdwinuringtyas, Biomechanical Impacts of Forward Head Posture on the Respiratory Function, Indonesian Journal of Physical Medicine & Rehabilitation, Vol.08 - 2nd 50 Edition - December 2019.

[6] Sayad Abdul Hamid and Amrith Pakkala, An Indian Study of Peak Expiratory Flow Rates in a Group of Young Adults, International Journal of Physiology, Vol. 7 No. 3 (2019).

[7] Hamayun Zafar, Ali Albarrati, Ahmad H. Alghadir, and Zaheen A. Iqbal, Effect of Different Head-Neck Postures on the Respiratory Function in Healthy Males, BioMed Research International, vol. 2018, Article ID 4518269, 4 pages, 2018.

[8] Carrasco-Uribarren, Andoni; Marimon Serra, Xavier; Dantony, Flora [et al.]. A computer vision-based application for the assessment of head posture: a validation and reliability study. Applied Sciences, 2023, 13(6), 3910.

[9] Albert Puig-Diví, Carles Escalona-Marfil, Josep Maria Padullés-Riu, Albert Busquets, Xavier Padullés-Chando, Daniel Marcos-Ruiz, Validity and reliability of the Kinovea program in obtaining angles and distances using coordinates in 4 perspectives, PLoS One. 2019; 14(6): e0216448.

[10] Martin R Miller, Scott A Dickinson, David J Hitchings, The accuracy of portable peak flow meters, Thorax 1992 Nov;47(11):904-9.

[11] Alexandra Hough, Physiotherapy in Respiratory Care An evidence-based approach to respiratory and cardiac management, Third Edition, published in 2001, ISBN 0-7487-4037-6.

[12] Kodgule RR, Singh V, Dhar R, Saicharan BG, Madas SJ, Gogtay JA, Salvi SS, Koul PA, Reference values for peak expiratory flow in Indian adult population using a European Union scale peak flow meter, Journal of Postgraduate Medicine April 2014 Vol 60 Issue 2, Page No:123-129.