EFFECT OF UPPER EXTREMITY PNF WITH RESISTANCE BAND ON RESPIRATORY MUSCLE STRENGTH AND PEFR IN UNDERWEIGHT YOUNG ADULTS: A RANDOMIZED CLINICAL TRIAL

GEETANJALI KOLI[1], MRUNALI PATEL[2]

[1]Physiotherapy Intern, [2]Assistant Professor of Cardiovascular and Respiratory Physiotherapy,
College of Physiotherapy,Wanless Hospital Miraj.

- **Abstract: Background: A person is considered as underweight whose BMI is <18.5 Kg/m2 and whose body weight is too low to be healthy. Respiratory muscle strength is responsible for respiratory mechanics that cause expansion during inspiration and recoiling during expiration. The subjects lying in underweight category has lower absolute lean body mass and depletion of body resources of proteins and calories which cause 60% reduction in Respiratory muscle strength which shared equally among inspiratory and expiratory muscles. The lower body fat in Underweight individuals is responsible for lower PEFR. This results in reduced lung functions in underweights. There is evidence that states that Expiratory muscle strength training exercises improves PEFR. Resistance training with elastic band and PNF pattern shows increase in mobility and improves strength and upper extremity PNF activates accessory respiratory muscle. Breathing technique with elastic band simultaneously contracts external and internal oblique and rectus abdominal muscles . Hence it can be effective tool to help improve RMS and PEFR in underweight young adults**.
- **Purpose: To study the effect of Upper Extremity PNF with resistance band on Respiratory muscle strength and PEFR in underweight young adults.**
- **Methodology: Participants were explained about the nature of study and the intervention. Their informed written consent was taken. 37 participants were selected based on the selection criteria. Prior and after the treatment outcome measures; MIP, MEP, PEFR, and Upper extremity muscle strength were measured. The upper extremity PNF was performed with participant sitting parallel to side of railing on chair and resistance band was tied perpendicular to railing. Reversal of antagonist technique was used with pattern and Breathing technique was incorporated along with resistance exercise. Training consisted of total 4 weeks protocol, 3 session a week and each session consisted of 3 x 10 repetitions, with 60 sec rest interval between each sets.**
- **Results: Statistical Analysis was done using Paired t-test. Based on the results of the test analysis at 5% significance level, there is significant statistical reliable difference between pre and post treatment values with p-value less than the 5% significance level (<0.05) in the study and therefore it justifies the improvements in health outcome post intervention.**
- **Conclusion: Upper Extremity PNF along with Resistance band exercise is effective in improving MIP, MEP and PEFR in underweight young adults.**

- **Keywords: Underweight young adults, PEFR, MIP, MEP, Respiratory muscle strength, Upper extremity PNF with resistance band, Breathing technique.**

I. INTRODUCTION

An underweight person is a person whose body weight is considered too low to be healthy. A person who is underweight is malnourished. [8] The prevalence of underweight women in 2019 is higher in rural areas (26.7%) though the union territories belonging to central (25.35-28.3%) and Eastern regions (21.3%-31.5%) of India show higher prevalence of underweight. [9]

Being underweight with acute respiratory disease is associated with high mortality, especially for patient with acute lung injury and ARDS, due to their relatively poor basal respiratory function.[10]

BMI- WHO criteria for screening underweight

Category	BMI (kg/m2)
Underweight (severe)	< 16.0
Underweight (moderate)	16.0 - 16.9
Underweight (mild)	17.0 – 18.4
Normal weight	18.5 – 24.9
Overweight	25.0 – 29.9
Obese	≥ 30.0

Poor nutrition or underlying health condition can result in adults being underweight. The various causes of being underweight includes anorexia nervosa, cognitive behavior (anxiety, depression) and picky eating habits, which results in insufficient calories intake for extended periods of time. Slow eating and lack of exercise were also associated with being underweight. [11]

Work stress, as indicated by job strain and low job control increases weight loss among lean men who have no need for weight reduction.[12]

Respiratory muscle strength (RMS) is responsible for respiratory mechanics. Expansion during inspiration and recoiling during expiration is totally depend on respiratory muscle strength. The RMS is measured as MIP (maximum inspiratory pressure) and MEP (maximum expiratory pressure) which are pressure values produced by deep inspiration and forced expiration respectively.[2] MIP and MEP are measured by volitional test by digital manometer. MIP is widely used measure for Inspiratory muscle strength in this the measured pressure is a composite of the pressure generated by inspiratory muscles and recoil pressure of the lungs and chest wall. MEP is most widely used measure of expiratory muscle strength. MEP can be measured from Total lung capacity and forced residual capacity.[20]

In underweights, depletion of body resources of proteins and calories is associated with wasting of respiratory muscles, hence the lower absolute lean body mass cause poor respiratory muscle strength, may result in reduced lung funvtions.[2]

Peak expiratory flow rate (PEFR) gives measure of maximal expiratory flow rate sustained by a subject for at least 10 milliseconds expressed in liter per minute. PEFR in an individual is according to age, sex and anthropometric variables. Malnutrition (BMI below the normal range for age) is also associated with impairment of PEFR because of slow growth of larger airways. Lower body fat and strength of expiratory muscle and elastic recoil of lungs in underweight is responsible for lower PEFR values in underweight. [1]

Proprioceptive neuromuscular facilitation (PNF) is an approach to exercise therapy that uses specific movement pattern in diagonal and spiral direction together with specific technique that facilitate the increase in strength in muscle function. PNF could be applied in pulmonary rehabilitation program because it acts on trunk and neck muscles that are closely linked to respiratory function and also activates accessory respiratory muscle.[3]

D2 flexion and extension pattern activates the sternal portion of pectoralis major muscle and serratus anterior muscle and PNF possibly stimulated main respiratory muscle i.e. diaphragm and intercostals.[18] PNF also produces changes in muscle fibers type IIA to IIB so increase in respiratory muscle strength is related to changes in type of muscle fibers of respiratory muscles.[16]

Resistance exercise training produces several changes in muscle, such as hypertrophy, increased oxidative capacity, and changes in muscle fiber type, thus specific respiratory muscle training, which applies linear resistance pressures during spontaneous breathing, has had significant effects on respiratory muscle strength and endurance, so conversely upper extremity exercises improve respiratory muscle strength.[7]

Resistance training with elastic bands has been shown to increase mobility and improve muscle strength and are easy to use and inexpensive and PNF pattern used in this study activates the accessory respiratory muscles, pectoralis major and serratus anterior and breathing technique with elastic band exercise simultaneously contracts external and internal oblique and rectus abdominal muscles and may possibly have an effect on increase in respiratory muscle activity.[3][7]

MATERIALS AND METHODOLOGY

- Chair with back rest
- Weighing machine
- Wall measuring tape
- Digital manometer – with rubber mouthpiece and plastic tube

- Pocket peak flow meter
- Elastic band (Yellow, Red, Green, Blue, Black, silver, Gold)

METHODOLOGY

1. Study type: Experimental study
2. Study design: Randomized clinical trial
3. Study duration: 6 months
4. Type of sampling: Simple random sampling
5. Sample size: 37
6. Study setting: Wanless Hospital, Miraj Physiotherapy Department.

OUTCOME MEASURES

1. **Body Mass Index**: WHO criteria for screening underweights population

Category	BMI (kg/m2)
Underweight (severe)	< 16.0
Underweight (moderate)	16.0 - 16.9
Underweight (mild)	17.0 – 18.4
Normal weight	18.5 – 24.9
Overweight	25.0 – 29.9
Obese	≥ 30.0

- Standing height is recorded without shoes, with light clothes on a wall by measuring tape. Weight is recorded without shoes and with light clothes on weighing machine.
- BMI is calculated: BMI= weight in kg / height in m2.

2. **MEASUREMENT OF RESPIRATORY MUSCLE STRENGHT**

- DIGITAL MANOMETER- assessment of respiratory muscle strength by measuring Maximum Inspiratory Pressure and Maximum expiratory pressure.
- Subjects are instructed to be in seated position. A demonstration of maneuvers was given and then performed by subjects after a placement of nose clip. The subjects were instructed to keep their lips sealed tightly around the mouth piece. MIP values were obtained by inspiration from residual volume which was repeated at least three times with one minute interval between repetitions.
- Normal values for Maximum inspiratory pressure (MIP)
- Female MIP- 63.1 +/-20 cmH2O Male MIP – 86.8 +/- 28cmH2O
- MEP was then obtained by expiration from total lung capacity, using the same methodology applied in inspiration.
- Normal values for Maximum expiratory pressure (MEP)
- Female MEP values- 78 +/- 24 cmH2O
- Male MEP values- 115+/- 37 cmH2O
- ICC for MIP – 0.998
- ICC for MEP – 0.999
- The ICC of digital manometer is above 0.75 thresholds of good reliability.

3. **MEASUREMENT OF PEFR**

- Pocket peak flow meter is used to assess PEFR
- PEFR is measured in standing position with standard pocket peak flow meter. The subject was instructed to take maximum inspiration and blow into mouthpiece as rapidly, forcefully and completely as possible. They were instructed to maintain a tight sealing between lips and mouthpiece of the peak flow meter.

- Normal value of PEFR –
  Female-320-470 L/min
  Male-450550 L/min
- The pocket peak flow meter has specificity of 94%.

4. SELECTION OF RESISTANCE BAND

- The 1-RM test with elastic resistance band (Thera-Band) is carried out with participants sitting parallel to side of apparatus where elastic band was positioned
- All bands were 0.5m long, and tied according to manufacturer's instructions. The other end of band was then placed on participants hand, leaving free hand to ensure that standard PNF was performed correctly
- The elastic band used in study were Yellow, Red, Green, Blue, Black, silver, Gold. Each individual began the 1-RM test with the lowest elastic load (yellow color) and increase the elastic load to prevent the performance of movement, due to difficulty of imposing a fixed load, a lighter band was used for training, with approximation values between 71 and 86% of 1-RM.
- The calculation of the percentage of elongation was as follow:
- % elongation = [(final length – initial length) / (initial length)] X 100.
- Elongation percentage was obtained through the values at each load produced in a specific color range
- Reliability – [ICC 0.98]
- Validity – [ICC 0.96]

INCLUSION CRITERIA

1. Age group: 18-26 years
2. Both male and female
3. BMI <18.5 (kg/m2)
4. Subjects with MIP, MEP, and PEFR less than normal
5. Participant who are willing to participate and cooperative

EXCLUSION CRITERIA

1. Subjects with presence of any neurological impairment, hormonal disorders, metabolic disorders, significant cardiopulmonary or musculoskeletal disorders or impairments above pelvic region.
2. Subjects with thoracic injuries less than 2 weeks.
3. Pregnant females.
4. Subjects who are smokers and substance addictive.
5. Subjects who engaged in regular physical training and sports activity.
6. Participants who are unable to perform 100% of 1RM with elastic band.

RESULTS

Statistical analysis was done using paired sample t test.

Table no. 1: Normality test using Shapiro-Wilk

Variable	Time Frame	z-value	p-value
MIP (CmH20)	Pre	0.929	0.052
	Post	0.960	0.200
MEP (CmH2O)	Pre	0.952	0.113
	Post	0.974	0.535
PEFR (L/min)	Pre	0.945	0.065
	Post	0.956	0.150
LOAD OF RESISTANCE BAND (lbs.)	Pre	0.805	0.050
	Post	0.837	0.051

Table no. 2: Shows descriptive statistics of frequency of both genders

Gender	Frequency	Percent
Male	14	38%
Female	23	62%
Total	37	100%

In this group, the maximum number of patient's are females i.e. 23 females (62%) and minimum number of patient's are males i.e. 14 males (38%).

Graph no. 1: Shows gender distribution among experimental group

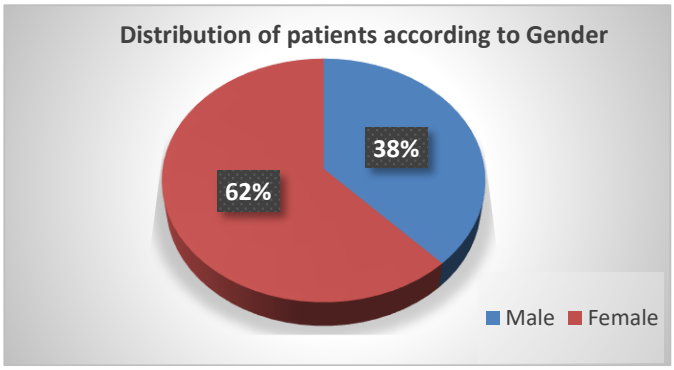


Table no. 3: Distribution of patients according to age group:

AGE	Frequency	Percent
18 - 20	17	45.95%
21 - 23	14	37.84%
24 - 26	6	16.21%
Total	37	100%

In this group the maximum no. of patient's i.e. 17 patient's (46%) belonged to age group 18-20 years, 14 patient's (38%) were having age between 21-23 years and 6 patient's (16%) were seen with the age between 24-26 years.

Graph no. 2: Represent age distribution among experimental group

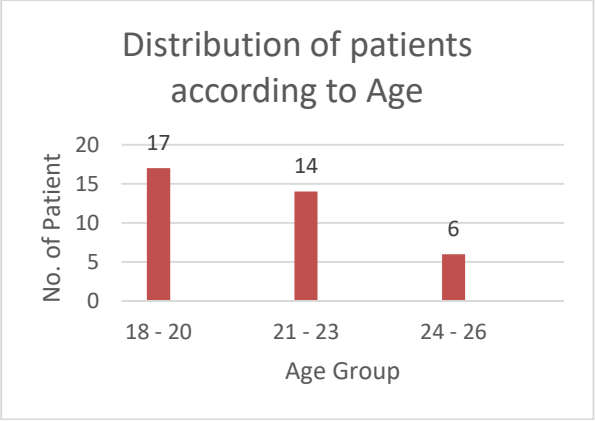


Table no. 4: Distribution of patients according to BMI Category

BMI	Frequency	Percent
16.0 - 16.9	12	32.43%
17.0 - 17.9	17	45.95%
18.0 - 18.9	8	21.62%
Total	37	100%

In this group, maximum number i.e., 17 patients (46%) were of 17.0-17.9 BMI, 12 patients (32%) were of 16.0-16.9 BMI and the remaining 8 patients (22%) were having BMI of 18.0-18.9.

Graph no. 3:

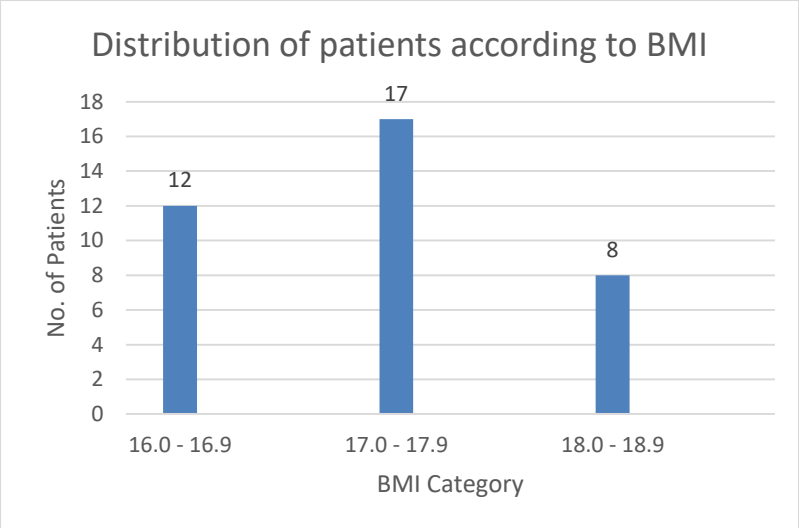


Table no. 5: Comparison of pre-test and post-test scores of MIP (CmH20) by paired sample t test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	38.91	11.18	41.20	10.03	4.11	24.975	**0.001**
Post	80.11	13.20					

The mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the limited consistency with post treatment value which is more than pre value. The effect size or Cohen's D indicates 4.11 value which is assumed to be high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level**, there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e., 0.001 < 0.05) in the study and therefore it justifies the improvements in MIP post intervention**.

Graph no. 4: Comparison of pre and post values for MIP:

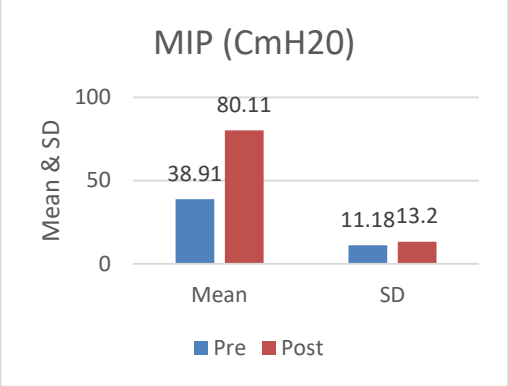


Table no. 6: Comparison of pre-test and post-test scores of MEP (CmH2O) by paired sample t test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	46.61	10.92	42.14	10.29	4.10	24.919	**0.001**
Post	88.75	11.27					

In this group mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the limited consistency with post treatment value which is more than pre value. The effect size or Cohen's D indicates 4.10 value which is assumed to be high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, **there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e., 0.001 < 0.05) in the study and therefore it justifies the improvements in MEP post intervention.**

Graph no. 5: Comparison of pre and post values for MEP.

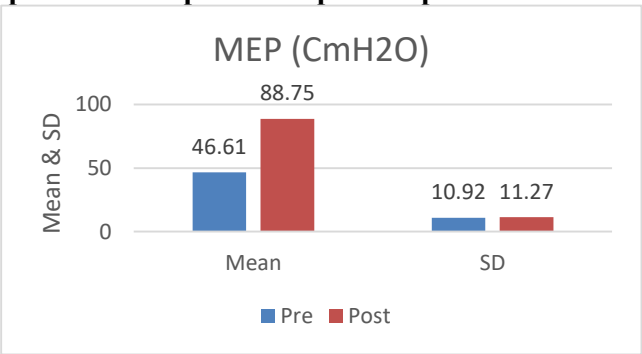


Table no. 7: Comparison of pre-test and post-test scores of PEFR (L/min) by paired sample t test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	228.92	55.62	154.32	24.67	6.26	38.053	**0.001**
Post	383.24	54.98					

In this group mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the consistency with post treatment value which is less than pre value. The effect size or Cohen's D indicates 6.26 value which is assumed to be high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, **there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e., 0.001 < 0.05) in the study and therefore it justifies the improvements in PEFR post intervention.**

Graph no. 6: Comparison of pre and post values for PEFR:

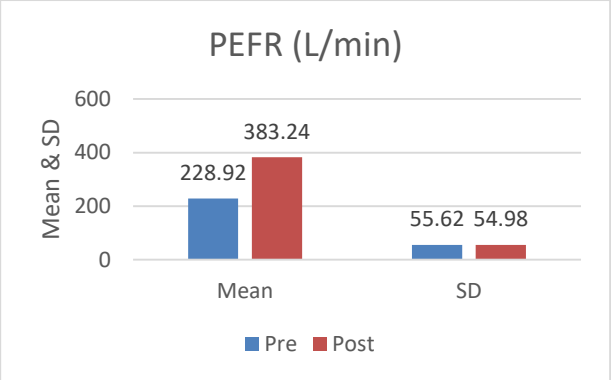
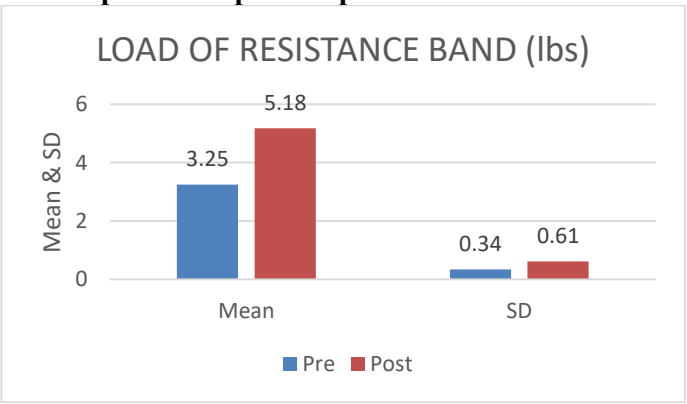


Table no. 8: Comparison of pre-test and post-test scores of LOADS OF RESISTANCE BAND (lbs) by paired sample t test

Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	t-value	p-value
Pre	3.25	0.34	1.94	0.47	4.13	25.151	**0.001**
Post	5.18	0.61					

The mean value indicated changes post treatment and higher values are recorded for post treatment outcome and also the standard deviation shows the limited consistency with post treatment value which is more than pre value. The effect size or Cohen's D indicates 4.13 value which is assumed to be high in effect size as per the standard parameters of reference. Based on the results of the test analysis at 5% significance level, **there is a significant statistical reliable difference between the pre & post treatment values with p-value is less than the 5% significance level (i.e., 0.001 < 0.05) in the study and therefore it justifies the improvements in upper extremity strength post intervention**.

Graph no. 7: Comparison of pre and post values of load of resistance band:



Therefore, there is sufficient evidence to conclude that, with upper extremity PNF along with resistance band exercise, there is significant improvement in Respiratory Muscle Strength, Peak Expiratory flow rate and upper extremity strength in underweight young adults.

DISCUSSION:

The purpose of this study was to find out the effectiveness of upper extremity PNF along with resistance bands on respiratory muscle strength and PEFR on underweight young adults. It was an experimental study.

This study was conducted on 37 subjects. In which there are 23 females and 14 males. We wanted to include both males and female but prevalence of underweight in females were more than in males in India due to lower education, lower

economic status, fear of being obese, and iron deficiency or anemia. So, in this study, we have maximum numbers of females i.e., 62%, and a minimum no. of males i.e., 38% All the subjects were within the age group of 18-26 years because the highest prevalence of underweight was found among young adults. A possible reason for this is food insecurity issues, an increase in eating disorder attitude, less than daily intake of fruit and vegetables, more intake of fried food and aerated drinks. In this study maximum subjects were from age of 18-20 years i.e., 46% minimum subjects were from the age group of 24-26 years i.e., 16%, and rest were from the age group of 21-26 years i.e., 38%
This study includes the subjects whose was < 18.5 kg/m2, as per WHO criteria for screening underweight the BMI should be <18.5kg/m2, Underweight subjects are divided into 3 categories according to BMI. The subjects whose BMI ranges from 17.0-18.4 kg/m2 are considered mildly underweight, 16.0-16.9 are considered moderately underweight, and <16.0 are considered severely underweight. In this study the maximum subjects have BMI ranging from 17.0-17.9kg/m2 i.e., 46%, minimum subject has BMI ranging from 18.0-18.4 kg/m2 i.e., 22%, and others have BMI ranging from 16.0-16.9kg/m2 i.e., 32%

All subjects were screened according to inclusion criteria Subjects were evaluated for affected MIP and MEP using a digital manometer and affected PEFR using a pocket peak flow meter. The subject was also assessed for upper extremity strength for a load of resistance band using the 1 RM technique. The subject was given Upper Extremity PNF with resistance band exercise for 3 days/week for 4 weeks each session consisted of 3X10 repetitions with 60sec rest interval between each set.
The present study demonstrates that RMS and PEFR were significantly improved after 4 weeks of upper extremity PNF along with resistance band exercise.
The study shows significant improvement in MIP post-intervention with a P value of less than 5% significant level (i.e., 0.001<0.05). The mean baseline value for MIP before intervention is 38.91 and after intervention is 80.11 mean difference between pre and post-intervention is 41.20. The comparison between pre and post-test mean value of MIP indicated changes post-treatment and higher values are recorded for post-treatment outcome. This probable result can be due to accessories muscle of inspiration (sternocleidomastoid, scalene, trapezius, lower pectorals) are activated in flexion and extension diagonals patterns of upper limb PNF.[3] **Morales et al** also used EMG to study upper limb muscle irradiation using PNF and found an increase in electrical activity of the contralateral muscle.[18] Also, the increased capacity of respiration from upper extremity movement pattern may be associated with increased extension and elevation of trunk movement resistance training with the band has increased mobility and improved muscle strength.[18]
According to this study, the mean baseline value for MEP before intervention is 46.61 after intervention is 88.75. The mean difference between pre and post-intervention is 42.14. The comparison between pre and post-test mean values of MEP indicated changes post-treatment and higher values are recorded for post-treatment outcome. The study shows significant improvement in MEP post-intervention with p value of less than 5% significant level (i.e., 0.001<0.05). This probable reason for the improvement is that **Kyung-Hwan Him et al** have proved upper extremity PNF pattern D2 extension and flexion pattern activates internal and external oblique in a sitting position.[16] The elastic band exercise with breathing technique simultaneously contracted the respiratory muscles that are used during peak expiration namely external and internal obliques and rectus abdominis. The thickness and activation of abdominal muscle also increase.[7] Hence the MEP also increased after post intervention.
The study shows significant improvement in PEFR post-intervention with p-values less than 5% significance level (i.e., 0.001<0.05). the mean baseline value for PEFR before intervention is 228.92. After the intervention is 383.24 the comparison between pre and post-test mean values of PEFR indicated changes post-treatment and higher values are recorded for post treatment outcomes. This result is due to improvement in expiratory muscle strength due to resistance exercise with PNF pattern. An increase in MEP conversely improves PEFR. **Sang-Yeol lee et al** had proved that the respiratory intervention that combines respiration with the reverse direction of the PNF upper extremity pattern may provide the respiratory muscle with an additional resistance which results in higher PEFR.[17]
The study also shows improvement in Upper Extremity Muscle strength. The mean baseline value for load of resistance before intervention is 3.25, and after intervention is 5.18. The comparison between pre and post-test mean values of load of resistance indicated changes post-treatment and higher values are recorded for post-treatment outcome. Thus, the study shows significant improvement in Upper extremity strength post-intervention with a P-value less than 5% significance level (i.e., 0.001<0.05).
Hence the results of this study revealed that the Upper Extremity PNF along with a resistance band by a specific breathing technique had a positive effect on Respiratory Muscle Strength, PEFR, and upper extremity strength in underweight young adults. The intervention method used in this study can therefore be used as an exercise regime for improvement in pulmonary function during the planning of clinical protocol.

CONCLUSION

In conclusion, the study suggests that upper extremity PNF along with resistance band exercise significantly increases

the Respiratory muscle strength and Peak expiratory flow rate of Underweight young adults.

Limitations:

1. No follow-up was done to evaluate the long-term effects of Upper extremity PNF along with resistance band exercise.
2. Proper distributions of males and females can be done.
3. Only young underweight adults were included

ACKNOWLEDGEMENT

I would like to extend my sincere and heartfelt thanks to all those who have helped me in making this study successful. I would like to express my special thanks of gratitude to my guide, Dr. Mrunali Patel, for her valuable guidance as well as for mentoring me, taking an active interest throughout the study, sharing her insights on the topic, and being a constant source of inspiration. I would also like to express my deepest gratitude to our Principal sir, Dr. Fredrick John, for giving me a good guideline for this study and providing me with all the facilities that were required.

I would also like to thank my father Mr. Prashant Koli, my mother Mrs. Manisha Koli, and my younger brother Mast. Vinit Koli their constant encouragement, patience, and understanding have been the pillars of my success. My teaching and non-teaching staff of Miraj Medical Center, College of Physiotherapy, thank you for shaping this study and enhancing my learning experience, and providing me with the necessary resources and guidance. I am especially grateful to the subjects who participated in this study and gave their precious time. I want to thank my friends for always encouraging me throughout my journey.

Praise and Glory to the God Almighty who is the source of strength, the foundation of my knowledge, and the source of inspiration in every walk of life.

REFERENCES:

1. Study of Peak Expiratory Flow Rate in Underweight and Overweight Young

   Adults... European Journal of Molecular & Clinical Medicine, 2022; 9(3): 10801-10804.
2. ASSESSMENT OF RESPIRATORY MUSCLE STRENGTH IN HEALTHY YOUNG INDIVIDUALS ACCORDING TO THE CLASSIFICATION OF BODY MASS INDEX"
   Miss. Aarya Mehta1 , Dr. Reshma Rajendra Kolase2 (Bpth) Final year1 , Assistant Professor2 , Department of Cardiovascular and Respiratory Sciences at DVVPF'S college of Physiotherapy, Ahmednagar, INDIA.
3. Areas G, Borghi-Silva A, Lobato AN, Silva AA, Freire Jr RC, Areas FZ. Effect of upper extremity proprioceptive neuromuscular facilitation combined with elastic resistance bands on respiratory muscle strength: a randomized controlled trial. Brazilian journal of physical therapy. 2013 Nov; 17:541-6.
4. Yan Q, Sun Y. Quantitative research for improving respiratory muscle contraction by breathing exercise. Chin Med J (Engl). 1996 Oct;109(10):771-5. PMID: 9275353.
5. Torres-Castro R, Sepúlveda-Cáceres N, Garrido-Baquedano R, Barros-Poblete M, Otto- Yáñez M, Vasconcello L, Vera-Uribe R, Puppo H, Fregonezi G. Agreement between clinical and non-clinical digital manometer for assessing maximal respiratory pressures in healthy subjects. PLoS One. 2019 Oct 24; 14(10):e0224357. doi: 10.1371/journal.pone.0224357. PMID: 31648267; PMCID: PMC6812781
6. Dekker FW, Schrier AC, Sterk PJ, Dijkman JH. Validity of peak expiratory flow measurement in assessing reversibility of airflow obstruction. Thorax. 1992 Mar;47(3):162-6. doi: 10.1136/thx.47.3.162. PMID: 1519192; PMCID: PMC1021004.
7. Kim K, Han JW, Kim YM. Effects of elastic band resistance exercises with breathing techniques on pulmonary function in female seniors. J Exerc Rehabil. 2019 Jun 30;15(3):419-423. doi: 10.12965/jer.1938070.035. PMID: 31316935; PMCID
8. Wikipedia contributors. (2023, February 2). Underweight. In Wikipedia, The Free Encyclopedia. Retrieved 12:58, April 2, 2023, from
9. Smita Asthana, Dishank Rawat, Satyanarayana Labani, Comparison of underweight, overweight and obesity prevalence among Indian women in different national health surveys, Current Medicine Research and Practice, Volume 9, Issue 4,
10. Do JG, Park CH, Lee YT, Yoon KJ. Association between underweight and pulmonary function in 282,135 healthy adults: A cross-sectional study in Korean population. Sci Rep. 2019 Oct 4;9(1):14308. doi: 10.1038/s41598-019-50488-3. PMID: 31586079; PMCID: PMC6778122.
11. Liang C, Lee PF, Yeh PC. Relationship between regular leisure-time physical activity and underweight and overweight status in Taiwanese young adults: A cross-sectional study. International Journal of Environmental Research and Public Health. 2022 Dec 24;20(1):284.
12. Kivimäki, M., Head, J., Ferrie, J. et al. Work stress, weight gain and weight loss: evidence for bidirectional effects of

job strain on body mass index in the Whitehall II study. Int J Obes **30**, 982–987 (2006). https://doi.org/10.1038/sj.ijo.0803229

13. Andersen LL, Vinstrup J, Jakobsen MD, Sundstrup E. Validity and reliability of elastic resistance bands for measuring shoulder muscle strength. Scandinavian journal of medicine & science in sports. 2017 Aug;27(8):887-94.

14. DWELLING ELDERLY Uchida MC, Nishida MM, Sampaio RA, Moritani T, Arai H. Thera-band (®) elastic band tension: reference values for physical activity. J Phys Ther Sci. 2016 Apr;28(4):1266-71. doi: 10.1589/jpts.28.1266. Epub 2016 Apr 28. PMID: 27190465; PMCID: PMC4868225

15. https://ijcrt.org/papers/IJCRT2004330.pdf EFFECT OF EXPIRATORY MUSCLE STRENGTH TRAINING ON PEFR AMONG COMMUNITYRURAL POPULATION

16. The Effects of PNF Patterns on Trunk Muscle Activity According to Position Changes Kyung-Hwan Kim†·Hye-Jin Youn·Sung-Hun Park·Jin-Woo LimDepartment of
PhysicalTherapy, Bonifacio Hospital Rehabilitation Center
Received: March 14, 2016 / Revised: April 22, 2016 / Accepted: April 25, 2016

17. 17. Lee SY. Effects of Inspiration and Expiration Exercise Combined with Upper Extremity Proprioceptive Neuromuscular Facilitation on Forced Volume Vital and Peak Expiratory Flow. PNF and Movement. 2020;18(2):297-303.

18. 18. Sullivan PE, Portney LG. Electromyographic activity of shoulder muscles during unilateral upper extremity proprioceptive neuromuscular facilitation patterns. Physical therapy. 1980 Mar 1;60(3):283-8.

19. 19. Pengpid S, Peltzer K. Prevalence and correlates of underweight and overweight/obesity among women in India: results from the National Family Health Survey 2015-2016. Diabetes Metab Syndr Obes. 2019 May 3;12:647-653. doi: 10.2147/DMSO.S206855. PMID: 31118726; PMCID: PMC6506572.

20. 20. Caruso P, Albuquerque AL, Santana PV, Cardenas LZ, Ferreira JG, Prina E, Trevizan PF, Pereira MC, Iamonti V, Pletsch R, Macchione MC, Carvalho CR. Diagnostic methods to assess inspiratory and expiratory muscle strength. J Bras Pneumol. 2015 Mar-Apr;41(2):110-23. doi: 10.1590/S1806-37132015000004474. PMID: 25972965; PMCID: PMC4428848.