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Effect of Abdominal Muscle Exercise on Peak Expiratory Flow Rate in Normal Healthy Female Individuals

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ABSTRACT

BACKGROUND: Expiration is a passive process and achieved through the elastic recoil of the lung. During forceful expiration, abdominal muscles are used. They may get weak due to nerve involvement, disuse atrophy, stretch weakness due to parity, diastasis recti etc. In females, Pregnancy and post-natal muscle weakness, successive pregnancies are factors that compromise abdominal muscle strength and endurance. It has been evaluated that person with partial or complete weakness of abdominal muscles is unable to cough and produce forced expiration effectively which affects in clearing secretions from the lungs. Adequate clearance of airway is an essential component. Peak expiratory flow rate is one of the important parameters in pulmonary function testing that evaluate cough strength. Abdominal muscle strengthening exercise is safe and beneficial for any normal individual. Which can improve peak expiratory flow rate which improves quality of life.
MATERIALS AND METHODS: Interventional study with Purposive sampling was done. Females aged between 18 to 40 years and having Fair abdominal muscle endurance (ACSM Abdominal curl up test) were taken. Individual having Recent abdominal surgeries, undergoing any exercise program, , Smokers ,COPD, angina, spinal cord injury, peripheral nerve injury ,Hernia, back pain, Diastasis recti, Pregnant females were excluded. Total there was 4 Weeks of abdominal muscle exercise program given. Before and after exercise program PEFR and abdominal endurance was checked.
RESULTS: Result showed significant improvement of PEFR and abdominal endurance in females.
CONCLUSION: Abdominal muscles exercise may improve pulmonary function performance.

KEY WORDS: Peak expiatory flow rate, abdominal muscle exercise.

INTRODUCTION

Respiration is the process by which oxygen is taken in and carbon dioxide is given out. Respiratory muscles are generally classified into two types: Primary or major respiratory muscles and accessory respiratory muscles. Inspiration is an active process. Primary inspiratory muscles are Diaphragm, External intercostal, interchondral part of internal intercostal muscles. Accessory muscles include sternocleidomastoid, scalene, upper trapezius, and pectoralis major and minor. At rest, expiration is passive process and achieved through the elastic recoil of the lung and thoracic cage but during forceful expiration additional muscles can be used, are abdominals. [1]

The abdominal muscles include: Rectus abdominis, external oblique, internal oblique, transverse abdominis. They are regarded as powerful expiratory muscles. It is suggested that expiratory muscles are prone to fatigue that subsequently impairs pulmonary function. [2]

Abdominal muscle causes the abdominal contents to push up against the diaphragm, which then reduces the vertical diameter of the thorax. It works to raise intraabdominal pressure when sudden expulsion of air is required in maneuvers such as huffing and coughing. It is believed that the abdominal muscles could be strengthened in order to assist the ventilatory process. [3]

Abdominal muscle endurance plays a large role in good posture and fitness performance and better lung functions. Muscular endurance is the muscle's ability to continue to perform for successive exertions or many repetitions. In particular, having abdominal muscles with high endurance helps prevent low-back pain. Simple field tests such as a curl-up (crunch) test that can be performed without rest may be used to evaluate the endurance of the abdominal muscle groups. The American College of Sports Medicine has created a set of guidelines for interpreting the results of this test. [4]

Abdominal muscles may get weak due to nerve involvement, disuse atrophy, and stretch weakness due to parity, diastasis recti and fatigue.[5] It is known that after the 20th week of pregnancy, the anterior abdominal wall enlarges by stretching. [6] The stretch is obvious in both the upper and lower abdominal walls. A continuous stretch of this nature on muscle fibers puts them at a physiological disadvantage with respect to muscle strength. This is because the continuous stretch causes the muscles to become less elastic and to sag. [7]

Adequate clearance of airway secretions is an essential component of the defence mechanism of the respiratory tract against infection. Coughing and huffing are expiratory manoeuvres that use high expiratory pressure and flow rates to aid secretion clearance. In biomechanical terms, during cough mechanism, expiratory muscles play a critical role both during relaxation in the inspiratory phase and during isometric contraction in the compression phase, which allows raising intraabdominal pressure up to 300mmhg. To suspect maximum force expiration, there needs a strong abdominal muscle contraction to exhale forcefully and as quickly as possible to get the maximum force of exhalation.[8] We Physiotherapists encourage patients to cough and huff as part of a strategy to clear these secretions in order to minimize complications. [9]

PEFR-Peak expiratory flow rate is considered to be the reliable, simplest one among the pulmonary function indices which was first introduced by Adorn in 1942 as a measurement of ventilatory function and was accepted in 1949 as an index of spirometry. [10]

Now-a-days as the life style and pollution has direct impact on respiratory system even for normal individuals, the demand will place a greater emphasis on maximizing the patient's independence, minimizing the disabilities and increasing the patient's functional status so their quality of life may improve. [11] In a healthy and asymptomatic population, decline in Lung functions is associated with a high risk of cardiopulmonary diseases and all other causes of death. So it is important to formulate strategies to prevent lung-aging. [8]

Respiratory muscle training has effects on pulmonary function and physical performance in both healthy and cardiopulmonary disease populations. Also Non-respiratory manoeuvres have been found to activate the diaphragm to varying degrees depending on type of exercise. Abdominal muscle strengthening exercises may useful in increasing abdominal muscle endurance, also pulmonary functions and sputum clearance which ultimately improving the lung compliance and general activities of the individuals. Abdominal muscle strengthening exercise is safe and beneficial for any normal individual. Which can improve peak expiratory flow rate which improves quality of life. [12]

Very few studies have been conducted to evaluate non-respiratory exercise and how these effect lung functions, respiratory muscle strength and endurance. It also helps to determine general fitness improvement of

the individual. So the aim will be to find effect of abdominal muscle exercise on Peak Expiratory Flow rate in normal healthy females individuals.

MATERIAL AND METHODS

An Experimental study was conducted at Physiotherapy department Of SBB College of Physiotherapy, SVP Hospital and housing societies of Ahmedabad. Total 45 Females aged between 18-40 years who have Fair Abdominal muscle endurance according to ACSM Abdominal endurance test were included.

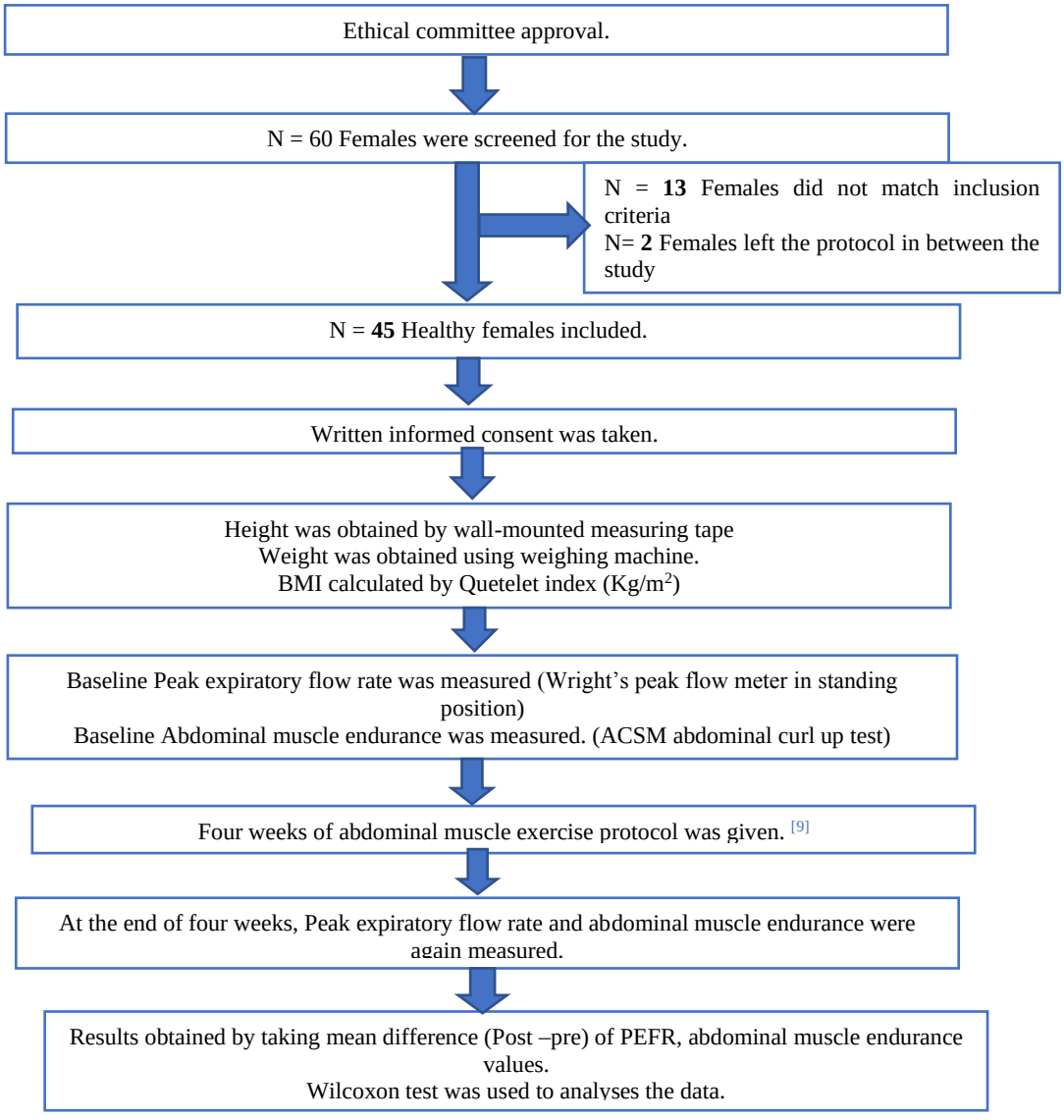
Inclusion criteria

Only females were included
Age group: 18 to 40 years
BMI: Normal (18.5-22.9kg/m^2)
Abdominal muscle Endurance: Minimum it was Fair (6 to 12 repetitions) (According ACSM Abdominal curl up test). [4]
Volunteers who were willing to participate.

Exclusion criteria

Individuals undergoing any other exercise program
Recent abdominal or thoracic surgeries
Smokers
Any cardio respiratory disease like COPD, asthma, Tuberculosis, angina.
Any neurological condition like spinal cord injury, multiple sclerosis, peripheral nerve injury, Hernia, back pain, Diastasis recti
Pregnant females

METHOD (FLOWCHART)



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OUTCOMES MEASURE

Dependent Variable

Peak expiratory flow rate (PEFR)

Independent Variable

Abdominal muscle strengthening exercise

A. PEAK EXPIRATORY FLOW RATE:

The Individual was checked their Peak expiratory flow rate by Wright's peak flow meter in standing position [13]

Picture: 1 Cipla Peak flow meter [5]

. Whole procedure was explained to the subjects before the test.

↓

In wright's peak flow meter, Cursor was at Zero (0)

↓

Mouthpiece was attached to end and firmly held by lips (No air leakage) by the subject.

↓

Then, Peak flow meter was put in mouth in front of eyes and in horizontal position.

↓

Subject was instructed to inhale as deeply as possible and exhale with maximal force into peak flow meter by mouthpiece.

↓

Same procedure was performed three times and best trial was noted. [13]
Before and after exercise protocol same procedure was done

B. ACSM ABDOMINAL CURL UP TEST:

The individual was asked to perform ACSM Abdominal curl up test. [4]

Equipment

Padded floor or mat, two pieces of tape (10 cm apart on the floor), metronome to control the rhythm of each abdominal curl, Stopwatch to monitor time.

Set-Up

Metronome was set for 50 beats per minute. Individual was Lie on back with arms flat to the floor and palms facing down. The middle fingers of each hand touch the first line of tape. Knees were bent with feet flat on the floor, Head was facing the ceiling.

Test

When individual was ready, set the stopwatch for 60 seconds. They Begin to curl the upper part of body until their fingertips touch the second strip of tape. Return to original position with shoulder blades touching the floor or mat. Each movement was performed to the "click" of the metronome. Count of the number of

repetitions were counted during the 60 seconds.

Termination

Terminate was terminated if individual can complete 25 repetitions within the minute or when the minute is over. Also have to terminate if individual is no longer able to keep the beat of the metronome. If individual begin to roll neck forward at any time, need to stop the test.

Gradings

Excellent: 25 repetitions
Very good: 17 to 24 repetitions
Good: 12 to 17 repetitions
Fair: 6 to 12 repetitions
Needs improvement: 6 or less than that.
After the end of the procedure abdominal endurance was derived.
Before and after exercise protocol same procedure was done**.**

C. ABDOMINAL MUSCLE EXERCISE PROGRAM:

Total there was **continuous 4** Weeks of abdominal muscle (upper abs, lower abs, internal oblique, external oblique, and transversus abdominis) exercise program. [9]
For 1st and 2nd week (Total **6** sessions – **3** sessions per week on alternative day)

For First 2 weeks (1st & 2nd week) (6 sessions)

Warm up exercises, Crunch exercise: 10 (rep), Leg lowering exercise: 10 (rep), Side plank: (10 rep), Cool down exercises.
In **1 session 2 sets of exercise** was done. [9]
Total duration: 30 mins
After 2 weeks there was progression in exercise protocol in 3rd & 4th week by increasing number of repetitions and type of exercise.

CRUNCH EXERCISE: Starting position was Crook lying. Subject have to lift the head off the mat. This will cause a stabilizing contraction of abdominal muscle. Lifting the shoulders until the spine of scapulae and thorax clear the mat keeping the arms horizontal. The patient does not come to a full sit up because once the thorax clears the mat the rest of motion is performed by hip flexors. [9]

PICTURE: 2 CRUNCH EXERCISE

LEG LOWERING EXERCISE: The participants were in supine lying position and forearms and elbows were resting on the mat for support. The participant's hips at 90 º and knees extended; then they lowered the leg as far as possible while maintaining stability in lumbar spine (should not increase the lordosis), followed by raising the legs back to 90º. [5]

PICTURE: 3 LEG LOWERING EXERCISE

SIDE PLANK: Subjects assumed a side bridge position with elbow under shoulder and upper arm perpendicular to the ground. Body was resting one lower arm/elbow and foot on same side. [14]

PICTURE 4: SIDE PLANK

For 3rd and 4th week (Total **6** sessions - **3** sessions per week on alternative day)

For next 2 weeks (3rd & 4th week) (6 sessions)
Warm up exercises, Bicycle crunch: (15 rep), Scissors: (15 rep), Heel taps: (15 rep), Cool down exercises.
In **1 session 2 sets of exercise** was done **(13).**
Total duration: 40 mins

Total 12 sessions were done.

BICYCLE CRUNCH: Subject was lie on back on the mat, with knees bent, feet flat, and arms straight up. They keep back flat on the floor as slowly extend left arm and right leg with flexion of opposite extremities. To maintain a strong core and keep low back on the floor is tough. They Return to the starting position, and then they repeat on the other side to complete 1 repetition. [15]

PICTURE 5: BICYCLE CRUNCH

SCISSORS: Subjects were down on back with hands either at sides or underneath glutes for added back support. Extend legs out straight, then they twist them in and out above each other, or straight up and down—either way. They didn't let legs drop to the mat. Make sure, core is engaged and that your lower back is pressed onto mat throughout. Move with slow and controlled movements. [16]

PICTURE 6: SCISSORS

HEEL TAPS: To perform heel touches, starting position was lying face-up on an exercise mat. They Keep back flat and bend knees to a 90-degree angle with feet firmly planted on the floor. They Engaged core, as bend spine to reach right hand toward right ankle. They Repeat this movement on left side, alternating sides between each repetition. [17]

PICTURE 7: HEEL TAP

STATISTICAL ANALYSIS

In this study, Statistical analysis was done using SPSS version 16 and excel 2007. The level of significance was kept at $p < 0.05$ with 95% confidence interval.

As the data did not follow the normal distribution according to Shapiro-Wilk test, Non- parametric Wilcoxon Signed Rank Test was used to compare pre and post values of PEFR and abdominal muscle endurance both.

RESULTS

In present study total 60 females were screened, 13 females did not match inclusion criteria and 2 females left the protocol in between study. So, 45 females included in the study. Which include 23 nulliparous and 22 multiparous females.

Mean age of females in the study was 29.56522 ± 7.347417. Apart from that, Mean BMI was 20.8577 ± 1.2454 which is fall in normal BMI Category (Asian classification of BMI).

Mean Age and Anthropometric characteristics (height, weight) of subjects are detailed in Table 1. Which are in terms of Mean ± SD.

Number of total subjects	**45**
Age (Years)	29.56522 ± 7.347417
Height (Meters)	1.593913 ± 0.061733
Weight (kilogram)	53.8913 ± 4.634308
BMI (kg/m^2)	20.8577 ± 1.2454

Table: 1 Baseline characteristics of the subjects (Mean ± SD)

Statistical results obtained in the study are shown in table 2. Results are considered significant if p value is < 0.05.

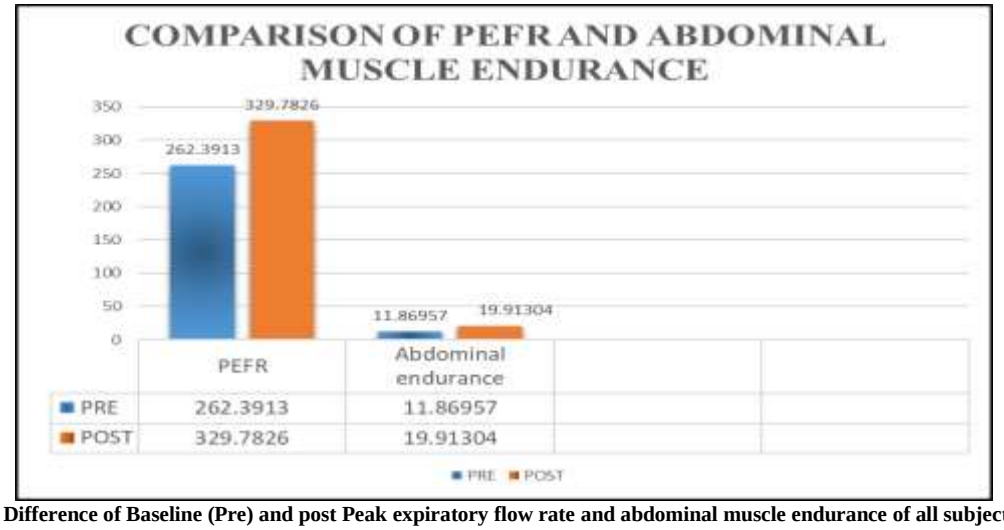
OUTCOME MEASURE	**PRE VALUE**	**POST VALUE**	**P VALUE**	**SIGNIFICANCE**
PEFR (Lit/min)	262.3913± 52.37407	329.7826 ± 74.07171	<0.001	SIGNIFICANT
Abdominal muscle endurance	11.86957± 1.820973	19.91304± 2.43958	<0.001	SIGNIFICANT

Table 2: Statistical result - P VALUES of PEFR and Abdominal muscle endurance of all subjects.

Pre PEFR Value was 262.3913 ± 52.37407 and post PEFR Value is 329.7826 ± 74.07171(Table 2, Graph 1). So, the mean difference of PRE and POST PEFR is 67.3913.

Pre abdominal muscle endurance value was 11.86957±1.820973 and post abdominal muscle endurance value was 19.91304 ± 2.43958. (Table 2, Graph 1). So, the mean difference of PRE and POST Abdominal muscle endurance is 8.04347.

Results by application of, Non-parametric Wilcoxon Signed Rank Test shows statistical significance having p<0.001 for PEFR and abdominal muscle endurance both. As the p values are <0.05 it is considered as statistical significant.



Graph: 1 Difference of Baseline (Pre) and post Peak expiratory flow rate and abdominal muscle endurance of all subjects (Mean).

DISCUSSION

The present study was conducted with the aim to find the effect of abdominal muscle exercises on Peak expiratory flow rate in normal healthy females.

The mean values of data from present study indicates that subjects showed improved peak expiratory flow rate and abdominal muscle endurance after 4 weeks of abdominal muscle exercises. Mean Difference (post –pre) of PEFR is 67.3913, p <0.001 after 4 weeks of abdominal muscle exercises. Which is statistically significant ($p<0.05$). As well as, mean Difference (post –pre) of Abdominal muscle endurance is 8.04347, p <0.001 after 4 weeks of abdominal muscle exercises. Which is also statistically significant ($p<0.05$).

The increase in peak expiratory flow rate is most likely due to, abdominal muscles' facilitator function, which improves the diaphragm's ability to produce pressure during respiration. During expiration, abdominal muscles contracts and increase in intra-abdominal pressure. Which push up diaphragm in cephalad position. In turn, there is raised pleural pressure and alveolar pressure which drives air out of the lungs.[12] Diaphragm strengthening achieved by abdominal exercises helps in maintaining an optimum length tension relationship of diaphragm, thereby increasing lung and chest wall compliance. [18]

The ADAPTIVE changes in the muscles determined by the exercise can account for the results of the study, since the metabolic capabilities of the muscles were continuously overloaded. The hypertrophy of the muscle fibers and the increase in the recruitment of its motor units causes the muscle, a contractile tissue, to strengthen. In addition, it profusely affects the metabolic demand associated with producing a given muscle force which leads to an increase in muscular endurance and power. [19]

Therapeutic exercises also activate both slow twitch (ST) and fast twitch (FT) fibers of the skeletal muscles, with increased fibre as the high content of FT fibers improves muscle strength [20]. However, during heavy breathing, expiration becomes a more active process and the elastic forces are insufficient to induce the requisite rapid expiration, so extra force is provided primarily by abdominal muscle contractions. [21]

In this study, all abdominal muscle exercises were included. Crunches engages all the abdominal muscle but primarily it works on rectus abdominis and oblique. Bicycle crunches lifts torso and contracts the oblique's muscle. Side planks are great exercises for strengthening the oblique's muscles. Heel taps activates most of the primary muscles thought out your midsection – including upper and lower abs, Transversus abdominis, Rectus Abdominis, But mostly targets oblique's muscle. When lowering legs, Focus on lower abdominals.

Hiroshi Ishida, Kenichi Kobara did study to correlate forced expiration with abdominal muscle thickness. Thicknesses of the right rectus abdominis, external oblique (EO), internal oblique, and transverse abdominis muscles were measured using B-mode ultrasonography. Result showed external oblique muscle displayed a significant correlation with PEF. EO causes a decrease in the transverse diameter of the rib cage. And During forced expiration, rib-cage deformation consisted of a rounding of the lower rib cage with the transverse dimension decreasing more rapidly than the lower anteroposterior dimension. [12]

The results of the present study is also consistent with a study by **Shweta Modi, Sweety Shah** where they included 15 middle aged women and found that 15 days of abdominal muscle strengthening exercise (curls up) enhanced Peak Expiratory Flow Rate. Here, Increase in peak expiratory flow rate is due to pressure on diaphragms that exert by number of abdominal wall muscles. Which in turn contracts thoracic cavity and causing forced exhalation. [22]

Deepali Hande , Bhavana Chhajed also supported this result by showing that , 3 weeks of Abdominal muscles exercises

improves Peak expiratory flow rate in normal individuals. Improvement in PEFR is due to, Abdominal muscles that pull rib cage downward during expiration, which have powerful effect of pulling downward on lower ribs and at the same time other abdominal contents push upward against diaphragm. Which assist in emptying lungs by forced expiration. [5]

Soheir M. El-Kosery, Akram Abd El-Aziz conducted study in postnatal women with diastasis recti as abdominal muscles play an important role in normal quiet inspiration and forced expiration. So, its affection causes real respiratory problems. That led to the importance of strengthening abdominal muscles in cases of diastasis recti to reach acceptable level of ventilatory functions. Result shows that, abdominal muscles exercise program improved pulmonary ventilation functions (MVV and FVC) and decreased intra-recti distance in women had diastasis recti postnatally. [23]

Khyati Shah, Anil Mishra further supported the result that, 6-weeks sit-up exercise training significantly improved abdominal muscle function, pulmonary functions & respiratory muscle function in female participants. As the Sit-up exercise that requires forceful contraction of abdominal muscles repeatedly, has been reported to significantly increase both abdominal muscle strength and endurance. [24]

Enhanced contraction of the expiratory muscles during fast manoeuvres was related to their preceding eccentric contraction during inspiration. Studies [25] have indicated that the concentric force output of a skeletal muscle is generally greater when it is immediately preceded by an eccentric muscle action than in a pure concentric action. This synergistic behaviour is known as "rebound or countermovement" effect and has been used in skeletal muscle training [26].

CONCLUSION

The present study concludes that, there is statistically improvement in PEFR and abdominal muscle endurance after four weeks of abdominal muscle exercises in healthy females. The Improvement was also clinically significant. Thus the present study accept the experimental hypothesis and reject the null hypothesis.

Hence, Upper and lower abdominal muscle exercises can be considered for increasing peak expiratory flow rate and abdominal muscle endurance in normal healthy females.

LIMITATION & FUTURE SCOPE OF THE STUDY

Only females were included in the study. Effect of Abdominal muscle exercise on Males can be added in future study.

CLINICAL IMPLICATIONS

This study suggests that individuals may benefit from performing non respiratory activities such as upper and lower abdominal muscle exercise that can be clinically implied to improve respiratory parameters, cough mechanism and in cardiovascular rehabilitation programme.

It helps to improve pulmonary functions even in normal females as pollution and sedentary life style affects pulmonary functions in normal individuals now a days.

It also improves abdominal muscle fitness in normal healthy females. Which can also help in stabilizing the spine well and reduce chances of low back pain.

A strengthening exercise programme will enable women to regain the pre-pregnant state of their abdominal muscles. This would in turn improve the peak expiratory flow rate and other forced expiratory indices (pulmonary health).

Declaration by Authors

Ethical Approval: Approved

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