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Effects Of Different Abdominal Exercises On Abdominal Strength And Endurance

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ABSTRACT

Purpose: This study determined the effects of a new modality of core stabilisation exercises based on diaphragmatic breathing on abdominal fitness.

Subjects: 60 physically inactive, healthy males and females were randomly assigned to an experimental group (n = 30) and a control group (n = 30).

Methods: The experimental group combined diaphragmatic breathing exercises with global stretching postures and common abdominal exercises, and the control group performed only common abdominal exercises both for 20 minutes 4 times weekly for 4 weeks. Abdominal fitness (measured with the American College of Sports Medicine curl-up [cadence] test, Double leg lowering test (DLLT) and Isometric Trunk flexor endurance test (ITFET).

Results: Significant changes in curl-up (cadence) test, Double leg lowering test and Isometric trunk flexor endurance test were recorded in the experimental group at the post training assessment, whereas in the control group, no significant differences over baseline were observed in Isometric trunk flexor endurance test and ACSM curls up test.

Conclusion: Compared with traditional abdominal exercises, core stabilisation exercises based on breathing and global stretching postures are more effective in improving abdominal fitness.

KEYWORDS: Abdominal strength, Abdominal endurance, Diaphragmatic breathing

INTRODUCTION

In recent years, abdominal muscle training has gained increasing popularity, and exercises like “crunches” or “planks” have become an integral part of both fitness and rehabilitation programs.

The abdominal muscles are the muscles forming the abdominal walls, the abdomen being the portion of the trunk connecting the thorax and pelvis. An abdominal wall is formed of skin, fascia, and muscle and encases the abdominal cavity and viscera.

It consists of four main muscles:

1)Transversus abdominis

2)Rectus abdominis

3)External oblique muscles

4)Internal oblique muscles

All the abdominal muscles have different muscle fibres orientation and act in all three planes during movements and are linked together by having a common site of connection or by fascia. Actions associated with abdominal muscle control can be complex. A single muscle does not usually work in isolation but in harmony with others. The abdominal muscles support the trunk, allow movement, hold organs in place, and are distensible (being able accommodate dynamic changes in the volume of abdominal contents).

The deep abdominal muscles, together with the intrinsic back muscles, make up the core muscles and help keep the body stable and balanced, and protects the spine. The most common traditional exercises) and training methods to enhance abdominal strength and stability employ body weight exercises consisting of static or dynamic contractions in various body positions (e.g., supine, lateral), starting with isolated movements and then continuing through with more complex sequences such as crunches, sit-ups, and planks (prone or lateral).

Correct breathing (especially as it involves the respiratory muscles) is vital to abdominal training because respiratory muscles are directly involved during common core stability exercises. DePalo et al. found that the diaphragm is actively recruited in many resistant training exercises, including sit-ups. Other studies demonstrated that the respiratory muscles are involved in a variety of activities in which respiration is not primarily involved. Because breathing is one of the most basic patterns directly related to human movement, as seen in neonates, inefficient breathing may result in muscular imbalance and motor control alterations that can affect general motor quality.

The aim of this study was to evaluate whether, as compared with a training protocol of common exercises, abdominal training plus breathing exercises would more greatly enhance abdominal strength and endurance.

SUBJECTS AND INCLUSION CRITERIA

All participants gave their consent via an online form after having been informed about the objectives and scope, procedures, risks, and benefits of the study. Participation was voluntary, and withdrawal from the study was permitted at any time.

Total number of subjects: 60 [Experimental group or group 1 = 30],[Control group or group 2 = 30]

Inclusion criteria:

- Nonsmokers without pulmonary disease or a history of low back pain
- Gender – Female and Male both
- People willing to participate in the study

Exclusion criteria:

- People with history of any recent fracture/pathology or abdominal/spine surgery
- People involved with a high intensity exercise regime
- People having frequent episodes on low back pain
- Acute or chronic smokers
- Any cardiopulmonary disease

PROCEDURE AND TOOLS

Before the start of the study, all subjects did not engage in any physical activity. The subjects were matched and randomly assigned to two groups. Each group performed the assigned exercise protocol for 20 minutes, 4 times per week. Data were collected before and after 4 weeks of training. No other physical exercise, aside from that specified for the purposes of this study, was performed during the study period.

Study design: An experimental study

Sampling method: Simple random sampling

Sample size: Total 60

Group 1 [EG]: 30 individuals, mean age 21 ± 3 years, height 1.65 ± 8 m, weight 57 ± 9 kg (Female:male=15:15)

Group 2 [CG]: 30individuals, mean age 21 ± 3 years, height 1.61 ± 12 m, weight 51 ± 9 kg (Female:male=15:15)

Study setting: Government physiotherapy college, Jamnagar.

Study duration: 4 weeks

The American College of Sports Medicine (ACSM) curl-up (cadence) test, Double Leg Lowering test (DLLT), and Isometric Trunk Flexor Endurance test (ITFET), were used to assess abdominal muscle fitness.

1) Timed Partial Curl Up Test: The timed partial curl up test is a standard in the fitness industry and is included here, even though it uses the hook lying position and thus encourages hip flexor activation.

Purpose: Strength test for abdominals.

Position of Patient: Supine in hook lying position on a mat with arms at sides, palms facing down, and the middle fingers touching a piece of tape affixed to the surface parallel to the hand. A second piece of tape is affixed 12 cm (4.7 in) further than the initial tape for those younger than 45 years and 8 cm (3.1 in) further for those 45 years and older

Stand to the side of the patient. Ask the patient to perform a slow, controlled sit up in time, lifting head and scapulae off the mat, while the middle finger reaches to the second tape. If successful, use a metronome set to 40 beats/min to time repetitions. Ask the patient to curl up as many times as possible keeping time with the metronome. The low back should be flattened before curl up. Test: The individual does as many curl ups as possible without pausing, to a maximum of 75.

Scoring: ACSM Norms for partial curl up

AGE										
	20–29		30–39		40–49		50–59		60–69	
Sex	Male	Female	Male	Female	Male	Female	Male	F Female	Male	F Female
90th percentile	75	70	75	55	75	55	74	48	53	50
80	56	45	69	43	75	42	60	30	33	30
70	41	37	46	34	67	33	45	23	26	24
60	31	32	36	28	51	28	35	16	19	19
50	27	27	31	21	39	25	27	9	16	13
40	24	21	26	15	31	20	23	2	9	9
30	20	17	19	12	26	14	19	0	6	3
20	13	12	13	0	21	5	13	0	0	0
10	4	5	0	0	13	0	0	0	0	0

2) Isometric Trunk Flexor Endurance Test (ITFET):

Purpose: Measure isometric core endurance.

Position of Patient: Sitting on table with wedge supporting the back at angle of 60° to the table. Hips and knees flexed to 90°, with feet stabilised with a strap. Arms are folded across the chest.

Ask the patient to hold the test position when the wedge is pulled back 10 cm. Time effort as soon as the wedge is pulled back. Terminate test when the patient can no longer maintain the 60° angle independently.

Scoring: Ages 18 to 55 years (mean, 30 years), mean hold time = 178 seconds.

Exercisers held the test 3 times as long as nonexercisers (186 s vs. 68.25 s)

3) The Double Leg Lowering test (DLLT):

Purpose: To assess abdominal muscles and the ability of muscles to maintain the posterior pelvic tilting position against the load (lowering both lower limbs from the vertical position)

Position of Patient: Subject lying in supine, the arms are held across the chest and the head rested on the floor.

The tester places their finger tips underneath the subject's lower back. The subject may bend their knees first to move to the starting position, before straightening the knee joint. The subject aims to sustain the pressure on the tester's fingers under the lower back by contracting the abdominals as the legs are lowered. During the test, if the pressure on your hand is decreased, stop the test and the angle is measured.

The score is the angle of the legs in degrees from the floor. Below is a guide to scoring for this test :

Angle	Rating
90	very poor, starting position
75	poor
60	below average
45	average
30	above average
15	good
0	excellent, legs horizontal

The two training protocols were administered for 20 minutes 4 times per week for 4 weeks in both groups; all exercises were performed after a standardised 10-minute warm-up.

The EG exercises were focused on achieving and maintaining a proper diaphragmatic breathing pattern for 2–3 seconds during inspiration and 8–10 seconds during expiration, with a vocal sound emitted to induce active deep internal abdominals. To do this, the subject inhales, expanding the lower abdominal region, the side and back of the abdomen, and the lower ribs. The chest is kept relaxed without pushing out the stomach, and the head is aligned with the spine to avoid excessive bending of the spine or body compensations. The exercise sequence is as follows:

EXERCISES FOR EXPERIMENTAL GROUP [EG]:

1) GLOBAL MUSCLES STRETCHING POSTURES

2) CRUNCHES: 15 repetitions, 2 sets

3) CRUNCHES WITH ROTATION: 15 repetitions on both sides, 2 sets

4) QUADRUPED-ALTERNATE ARM AND LEG RAISE: 15 second hold, 2 series

5) PLANK ON ELBOWS: 15 second hold, 2 series

EXERCISES FOR CONTROL GROUP [CG]:

1) CRUNCHES: 15 repetitions, 2 sets

2) CRUNCHES WITH ROTATION: 15 repetitions on both sides, 2 sets

3) QUADRUPED-ALTERNATE ARM AND LEG RAISE: 15 second hold, 2 series

4) PLANK ON ELBOWS: 15 second hold, 2 series

For statistical analysis, data were obtained before the treatment and after the end of treatment from both the groups. Sit and reach test was scored before and after the intervention.

Mean and standard deviation of Pre and Post-test values of ITFET, DLLT and ACSM Curls up test of Group 1 [EG] and group 2 [CG] was calculated. Data was entered into a personal computer, and all statistical analyses were performed using the Statistical Package for the Social Sciences IBM™ SPSS™ version 25.0. Descriptive statistics such a mean and standard deviation were calculated to describe all the variables. For normal distribution of data, normality test "Shapiro-wilk test" was done.

Normality test

If $p < 0.05$: then the null Ho hypothesis can be rejected (i.e. the variable is not normally distributed).

If $p > 0.05$: then the null H1 hypothesis can be accepted (i.e. the variable is not normally distributed).

1. **Results were tested for normal distribution using a Shapiro-Wilk test.**

	Experimental group (EG)	**Control Group (CG)**
ITFET	**p=0.003 (P<0.05)**	**p=0.075 (P>0.05)**
DLLT	**p=0.000 (P<0.05)**	**p=0.00 (P<0.05)**
ACSM Curls up test	**p=0.465 (P>0.05)**	**p=0.123 (P>0.05)**

In our data for Group 1[EG] the data for ITFET and DLLT is not normally distributed, data for ACSM Curls up test is normally distributed. For Group 2 [CG] the data for IFET and ACSM Curls up test is normally distributed, data for DLLT is not normally distributed.

2. **For within group analysis Wilcoxon test and Paired t test respectively.**

Paired t test

Group	Outcome measure	N	Mean	SD	t value	df	p value
Experimental group	ACSM Curls up test	30	-7.23	6.41	-6.17	29	0.000
Control group	DLLT	30	-14.70	45.81	-1.75	29	0.089
	ACSM Curls up test	1.46	30	9.13	0.879	29	0.387

Wilcoxon test

Group	Outcome measure	Z	p value
Experimental group	ITFET	-4.78	0.000
	DLLT	-4.58	0.000
Control group	DLLT	-2.81	0.005

3. **We compared the outcome of the above analysis using Mann Whitney test and Independent t test respectively.**

Mann Whitney test

Outcome measure	Mann-Whitney U diff	Wilcoxon W diff	Z diff	p value diff
ITFET	266.5	731.5	-2.713	0.007
ACSM Curls up test	392.5	857.5	-0.852	0.394

Independent t test

Outcome measure	N	Mean diff	Std. Error Difference	t value	df	p value
DLLT	30	-8.83	2.82	-3.12	58	0.003

RESULTS

The above analysis suggests -

- Comparison of the pre and post intervention values (Wilcoxon signed rank test and Paired t test) of the outcome measure showed there was statistically significant difference in all test values in the Experimental group. For the control group significant difference is only seen in the ACSM Curls up test.

- On comparing both group values (Mann Whitney test and Independent test) showed that there was no statistical difference between the two groups in terms of ACSM Curls up test, but there is statistical difference seen in ITFET and DLLT.

DISCUSSION

The main finding of this study is that, compared with traditional exercises, a program including core exercises performed with a focus on muscular chain stretching and breathing techniques can lead to greater improvement in abdominal muscle endurance and muscle strength to some extent. Furthermore, the results suggest that a series of exercises performed with a vocal sound emission can be a valid strategy to enhance proper diaphragmatic breathing patterns and deep internal abdominal activation much more than in traditional abdominal routines in which people tend to hold their breath or use chest wall respiration.

Our results show that, while traditional core exercises can improve muscular strength and endurance, improvements are greater with muscular chain stretching in combination with breathing techniques.

As reported in previous studies, proper diaphragmatic breathing is directly linked to better functional movement, but combining proper breathing with global stretching postures can produce a greater effect. Regarding the biomechanical aspects of breathing, the expiration phase promotes active recruitment of the abdominal muscles, contrasting the natural elevation of the rib cage (induced by raising the arms overhead); to the contrary, elevating the arms raises the anterior chest wall, makes the thoracolumbar column hyperlordotic, and puts the diaphragm in an oblique position that inhibits its proper function. During exhalation, the thoracolumbar spine returns to a more neutral position (opposing the previous hyperlordosis), and the diaphragm is more horizontal without posterior pelvic tilt. The subject should inhale to expand the lower portion of the abdominal region, the side and back parts of the abdomen and lower ribs, keeping the spine aligned and the chest relaxed. Using a correct diaphragmatic breathing pattern promotes co-contraction of the abdominal muscles in the so-called bracing technique, which provides trunk stiffness and stability.

When focusing on diaphragmatic breathing, it is important not only to reestablish a correct respiratory pattern but also to ensure lumbar spine stabilisation by increasing intra-abdominal pressure and activation of the core structures to transfer forces from the centre of the body to the lower extremities. To produce an economic breathing pattern, all joints must be centred in a stable position to involve all muscular chains. The head, eyes, and spinal curves should all be aligned with the pelvis and the hips down to the knees and feet. This can be achieved with proper diaphragmatic breathing and adequate muscle tone distribution (as can be trained with EG exercises).

LIMITATIONS

The present study has several limitations. The sample size was small, and the subjects did not belong to a specific population. Electromyographic assessment of the abdominal muscles was not performed.

In addition, the control group exercise protocol was home based, the experimental group performed the exercises under observation.

CONCLUSION

In conclusion, EG exercises that incorporate correct breathing patterns and body flexibility offer an alternative to traditional abdominal exercises. As such, they may be useful for coaches or physical therapists when selecting core exercises to improve overall abdominal fitness and to retrain correct diaphragmatic breathing. Further research is needed to compare abdominal breathing with other core exercises in order to clarify the combination of breath and abdominal exercises in treating painful disorders (low back pain, neck pain) and improving motor control in fitness and rehabilitation programs which was not possible for this research due to limited time limit.

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