Effects of Diaphragmatic Training on Posture and Stability in Asymptomatic Subjects: A Randomized Clinical Trial

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Abstract

Background: Diaphragm plays an important role in breathing and postural control and the potential factors are potentially involved with suboptimal respiration and suboptimal (faulty) posture and may be associated with musculoskeletal complaints. The zone of apposition is important because it is controlled by the abdominal muscles and directs diaphragmatic tension. The smaller the zone of apposition, there will be less inspiratory action of the diaphragm on the rib cage**.**

Objectives: To determine the efficacy of diaphragmatic training on posture and stability in asymptomatic subjects.

Study Design: A randomized clinical trial.

Method: 38 asymptomatic subjects were randomly assigned in the age group of between 20 to 55 years with poor posture and stability. All the participants were recruited on voluntary basis. The participants were divided into an experimental group (n=19) who were given Diaphragmatic training, Deep Cervical Flexor Strengthening, Thoracic Extensor strengthening and a control group (n=19) who were treated with Deep Cervical Flexor Strengthening, Thoracic extensor strengthening. To evaluate the subjects, two parameters were used photographic measurement to evaluate cranioveterbral angle and star excursion balance test to evaluate dynamic balance. All subjects were evaluated pre intervention and post intervention after the 4 weeks of treatment. Independent t test was used to compare the outcome between the groups and paired t test was used to compare the outcome with in group.

Result: Out of the (n=58) participants, 38 participants met with an inclusion criteria . This study concluded that there was a significant difference between the two groups in posture and dynamic balance at 4 weeks. In the experimental group, significant improvements were demonstrated for Star excursion balance test and Craniovertebral angle measurement ($P<0.01$), compared to the control group where craniovertebral angle was not statistically significant ($P>0.01$).

Conclusion: The effect of diaphragm training along with deep cervical flexor training and thoracic extensor strengthening improve the dynamic stability and balance significantly.

Keyword: *Dysfunctional breathing pattern, Craniovertebral angle, Forward head shoulder, Transabdominal pressure, Zone of apposition, strengthening.*

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Introduction

"Posture" refers to the alignment of body parts in relation to each other and is frequently cited risk factor leading to musculoskeletal disorders. Faulty posture leads to excess work load on the musculoskeletal system[1]. The prevalence of faulty posture was found in lean and normal individuals (26.4%), overweight (22.4%) and obese (20.2%) subjects[2]. Despite significant findings regarding adverse effects on measures of health and quality of life, posture is the only beginning to be recognised as a major health concern by clinician[3]. A combination of strengthening, stretching and behavioural/ biofeedback treatment strategies were used to correct the abnormal forward head posture in patients with cervical spondylitis and radiculopathy which included strengthening deep cervical flexors through chin tucks, strengthening of shoulder retractors in standing using a theraband, bilateral pectoralis stretches[4]. A combination of thoracic stretching, thoracic extension exercises and cervical and scapular muscles exercises were performed to improve thoracic kyphosis[5]. An electromyography biofeedback training technique was used to improve trunk stability[6]. A combination of lumbar stabilization exercises and thoracic mobilization was used to improve posture in back pain patients[7]. A core stability exercise was performed to improve trunk and pelvic stability[8]. Core stability is dependent on the strength, coordination and adaptability of core musculature is necessary for efficient biomechanical function, throughout the kinetic chain[9]. The existing treatment method such as thoracic muscle stretching and strengthening exercises, lumbar stabilization exercise, electromyography biofeedback training, showed good short term results. Long term remains questionable. Part of the reason for weak evidence on long term may be result of ignoring the role of diaphragm. The diaphragm has long been of interest to the medical profession, basic science literature states that the anatomical attachments of diaphragm plays an important role in breathing and stabilization of the trunk during postural activity [10]. Diaphragm has two parts, the costal part and crural part. Ideal diaphragm breathing exhibits a lateral costal expansion. The Zone of apposition expands both the lower ribcage and the abdominal wall during contraction[11]. The diaphragm has been found to contract prior to initiation of upper extremity movement, independently of the phase of respiration[1]. Postural stability is an active maintenance of body segments;stabilization is biomechanically interconnected and depends on coordinated activity controlled by CNS. The tonic phase coordinates with the breathing cycle and the phasic phase coordinates with the postural stabilization of the trunk followed by complete flattening of the diaphragm muscle hence provides good postural function[11]. Breathing biomechanics have been described with respect to expansion of the abdomino-thoracic region during inspiration at rest apical or upper costal breathing occurs when superior thoracic expansion exceeds the abdominal and lateral costal expansion[1]. If a greater muscle activity is needed the diaphragm flattens, however its excursion during breathing is smaller. In a situation like this individual usually hold their breath to increase postural stabilization and diaphragm is primarily activated for stabilization function[11]. Postural correction and stability and in the wake of potential effect of diaphragm. The aim of this study to find the much needed input on the possibility of integrating diaphragm in to the treatment protocols for postural correction and improving dynamic stability.

Materials and Method

This single blinded randomised clinical trial was conducted among asymptomatic subjects age ranging 20 to 55 years both males and females who were clinically diagnosed with poor posture of the spinal curvature was based on photographic measurements with the craniovertebral angle less than 50 degrees and thoracic curvature greater than 60 degrees[13]. Prior to the data collection ethical clearance was obtained and study is registered with Clinical trial registration India (Registration No: CTRI/2019/01/016935. The participants were explained about the study and an informed consent along with the photography consent was obtained from them on voluntarily basis. 38 participants out of 58 were recruited based on the inclusion and exclusion criteria. Inclusion criteria were: age ranging between 20 to 55, both male and female. Exclusion criteria were:Subjects with vestibular dysfunction, Subjects with respiratory disease, Subjects with previous history of lumbar fracture. The subjects were assessed for their suitability, including demographic information (age, height weight, Body mass index (BMI)) and baseline measurements like craniovertebral angle, dynamic balance. Further the participants were randomly allocated into experimental group(n=19) and control group (n=19) by using purposive random sampling method.

Phase I:

Photo Graphic Measurements for Assessing Posture: Body markers were placed over the the tragus of the ear, spinous process of C7 vertebrae, acromion process, upper thoracic, mid thoracic, lower thoracic. Participants were made to stand on a posture pad and the photographs were taken in lateral view. The data of the photographs were transferred to body style analyser software for the measurement of cervical, thoracic curvature[14].

Star Excursion Balance Test for Assessing Dynamic Posture (SEBT): Was performed in three directions (anterior, posterio medial, posterio lateral) 3 tape measures were labelled in 0.5 cm increments securing to the floor. In which one tape measure was oriented to the apex (anterior reach direction)[15]. Two additional tape measures were anchored at 135 degree to the apex (postero medial and postero lateral). Anterior border of the 2nd toe at the junction of three reach direction was the stance foot starting position and area immediately adjacent to the stance limb in a non-weight bearing position to reach foot starting position. Participantsplaced their hands on iliac crest to standardize starting position while standing. 4 practice trials were performed in all 3 directions on each limb prior to administration of test after showing the online video available at www.jospt.org[16]. The participants were given verbal feedback regarding movement and posture by giving 2 minute rest periods prior to formal testing[17]. Sum of the greatest reach direction for each of the 3 directions were divided by 100, to get the composite reach distance for each leg.

Phase II:

Diaphragm Training Techniques: Diaphragm weight training was performed by using sand bags by putting the participants in supine lying position. A small weight (3-5 lbs) was kept over the epigastric region and participants were asked to breathe in deeply raising the weight and breath out slowly, the protocol was given once a day in a set of five for 10 to 15 minutes

Proprioceptive neuromuscular facilitation for Diaphragm (Intercostal Stretch Technique): In supine lying with all the limbs in neutral position. The supra sternal notch was palpated downwards about 5cm the angle of Louis, traced laterally. The Intercostal stretch technique was applied over 2nd and 3rd rib bilaterally towards the next rib. The techniques were applied during expiration phase for three breaths with 1 minute rest and for three repetitions, twice in a day.

90/90 Bridge with Ball and Balloon: -Participants in supine with the feet flat on the wall and knees and hips bent at a 90-degree angle. A 4-6 inch ball was placed between the knees with right arm placed above the head and a balloon in left hand by putting pressure on the ball by back of the thighs and inner thighs. Participants were asked to inhale through the nose and slowly blow out into the balloon by maintaining the position constant with 3 second pause with tongue positioned on palate to prevent disruption of air from the ballon. The procedure was followed slowly stabilizing the balloon with the left hand and repeated for 4 weeks, 20 minutes/day. During exhalation pelvic tilt was observed off the mat and lower back flat on the mat.

Incentive Spirometry: The participants were asked to hold the mouth piece of the spirometer in mouth with lips tightly placed over it and were instructed to inspire slowly and deeply to raise the ball or the piston in the chamber to the set target. At maximum inhalation the mouth piece for 5-10 breaths/seconds followed by normal exhalation 10 sets, 5-10 seconds hold for 20 minutes

Deep Cervical Flexor Strengthening: The participant was asked to relax its neck muscles, an air filled visual pressure feedback device was placed under the cervical spine and to perform the flexion of the cervical spine to strengthen the deep flexor muscles of the upper neck and the flattening of cervical lordosis was confirmed using visual feedback from the sensor's dial at 20 mmHg. As the participant saw the dial and was instructed to press the bag slowly, the sternocleidomastoid muscle and the scaleneus anterior muscles were palpated by the investigator so that contraction did not occur. The pressure was increased slowly, by 2 mmHg each time until a value of 30 mmHg is reached. The contractions were maintained for 10 seconds and this was repeated 10 times, in three sets with a break of 2 seconds between contractions was done for 4 weeks for 20 minutes per day.

Thoracic Extension Exercise: -in a prone position on a bed a pillow was placed under the abdomen of the participant so that spine will be in a slightly flexed position. Participants were instructed to clasp both hands behind their neck and lift the upper trunk off the bed by holding neutral position for 30 seconds in set of five with ten seconds interval in between. The technique was administered for 4 weeks, for 20 minutes/day.

Statistical Analysis: The descriptive statistics was done to test the normality. Inferential analysis was carried out by non-parametric tests.

Findings: Out of the 38 participants, (n=19) were in experimental group and (n=19) were in control group with an average age of 39.02±9.1 and 37.2±7.6

respectively. The BMI for the both experimental group and control group was calculated as 24.5±3.0 and 23.6±2.7 respectively (Table 1). There were significant results in the pre and post comparison of experimental group of SEBT (left and right) and photo/cranio vertebral angle with the p value less than 0.05 and Mean±SD 85.3±2.9, 95.7±2.8 and 85.4±2.6, 95.7±2.3 and 44.5±1.9, 52.4±1.7 respectively (Table 2). In pre and post comparison of control group, there were insignificant results with P value > 0.05 in cranio vertebral angle with Mean±SDpre 46.1±2.2 and post 46.7±1.8 (Table 3). There were significant results experimental & control group comparison with p value <0.001 in all Pre post difference of SEBT (left, right) and craniovertebral angle.(Table 4)

Table 1: Demographic data

	Experimental Group	Control Group
N	19	19
Age	39.02±9.1	37.2±7.6
Weight	1.60±0.30	1.59±0.10
Height	61.5±3.6	60.0±2.6
BMI	24.5±3.0	23.6±2.7

Table 2: Pre post comparison of experimental group (Paired t-test)

Variables	Minimum	Maximum	Mean±SD	t- value	p- value
sebtleft Pre test Post test	80.3 90.7	88.7 98.7	85.3±2.9 95.7±2.8	68.2	<0.001*
sebtright Pre test Post test	80.3 90.3	88.7 98.7	85.4±2.6 95.7±2.3	77.3	<0.001*
Photo Pre test Post test	41.4 50	47.6 55	44.5±1.9 52.4±1.7	29.6	<0.001*

*p<0.001 statistically significant in both pre and post.

Table: 3 Pre post comparison of control group (Paired t-test)

Variables	Minimum	Maximum	Mean±SD	t- value	p- value
sebtleft Pre test Post test	80 85	87.3 92.3	83.5±2.3 88.2±1.9	20.7	<0.001*
sebtright Pre test Post test	77.5 85.3	85.7 90.6	81.8±2.2 87.4±1.6	23.9	<0.001*
Photo Pre test Post test	42 44	48.5 50	46.1±2.2 46.7±1.8	1.6	0.126

P value > 0.05 in cranio vertebral angle which is not statistically significant

Table 4: Experimental & Control group comparison (Independent t-test)

Variables	Experiment	Control	t- value	p- value
	Mean±SD	Mean±SD		
Pre post difference of sebtleft	10.5±0.7	4.8±1.0	20.5	<0.001*
Pre post difference of sebtright	10.3±0.6	5.6±1.02	17.5	<0.001*
Pre post difference of Photo	7.9±1.2	0.6±1.6	16.3	<0.001*

P<0.001 shows statistically significant in both experimental and control group

Discussion

We conclude that there is a significant improvement of SEBT (right & left) in both the groups,but there is no significant improvement of craniovetebral angle (CVA) in Control Group . In Between group analysis in the Experimental Group improved significantly better that Control Group in SEBT (left & right) and CVA .A proper diaphragmatic breathing style have increased the strength of the diaphragm and deep core musculature and this increase in strength and proprioception have positive effect to the increase in balance[1]. To evaluate the inspiratory muscle recruitment affects on proprioceptive use during postural control with low back pain (LBP), the author concluded that inspiratory muscle training facilitate the proprioceptive involvement of the trunk in postural control in individuals with LBP[14]. During extensive diaphragmatic training increase in the activation of abdominal musculature helps in maintaining the ideal zone of apposition whichhelps in relaxation of the trunk extensors by decreasing the lumbar lordosis and decrease in pain by reciprocal inhibition[1,12]. Diaphragmatic breathing style increases the strength of the diaphragm and deep core musculature and increase in strength leads to improvement in balance[1].

Conclusion

Correcting the faulty breathing pattern by proper diaphragmatic training reduces the load on the scalene and trapezius muscles and reduces upper chest breathing which leads to correction of posture and proper proprioceptive input helps in improving dynamic balance

Ethical Clearance: Ethical Board of the Faculty of physiotherapy, Srinivas University

Source of Funding: Self

Conflict of Interest: Nil

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