Effects of Diaphragmatic Breathing Patterns on Balance: A Preliminary Clinical Trial

Rylee J. Stephens, DC,[a] Mitchell Haas, DC,[b] William L. Moore III, DC,[a] Jordan R. Emmil, DC,[a] Jayson A. Sipress, DC,[a] and Alex Williams, DC[a]

Abstract

Objective: The purpose of this study was to determine the feasibility of performing a larger study to determine if training in diaphragmatic breathing influences static and dynamic balance.

Methods: A group of 13 healthy persons (8 men, 5 women), who were staff, faculty, or students at the University of Western States participated in an 8-week breathing and balance study using an uncontrolled clinical trial design. Participants were given a series of breathing exercises to perform weekly in the clinic and at home. Balance and breathing were assessed at the weekly clinic sessions. Breathing was evaluated with Liebenson's breathing assessment, static balance with the Modified Balance Error Scoring System, and dynamic balance with OptoGait's March in Place protocol.

Results: Improvement was noted in mean diaphragmatic breathing scores (1.3 to 2.6, $P < .001$), number of single-leg stance balance errors (7.1 to 3.8, $P = .001$), and tandem stance balance errors (3.2 to 0.9, $P = .039$). A decreasing error rate in single-leg stance was associated with improvement in breathing score within participants over the 8 weeks of the study (–1.4 errors/unit breathing score change, $P < .001$). Tandem stance performance did not reach statistical significance (–0.5 error/unit change, $P = .118$). Dynamic balance was insensitive to balance change, being error free for all participants throughout the study.

Conclusion: This proof-of-concept study indicated that promotion of a costal-diaphragmatic breathing pattern may be associated with improvement in balance and suggests that a study of this phenomenon using an experimental design is feasible. (J Manipulative Physiol Ther 2017;xx:1-7)

Key Indexing Terms: *Diaphragm; Respiration; Postural Balance; Exercise; Breathing Exercises*

Introduction

Core strength and stability have become central topics in both injury prevention and physical performance. Core stability is dependent on the strength, coordination, and adaptability of the core musculature[1,2] and is necessary for efficient biomechanical function throughout the kinetic chain.[3] Increasing core stability has been reported to improve static and dynamic balance.[4-8] Poor scores on balance tests have been directly linked to increased injury rates in a healthy athletic population.[9,10]

The diaphragm has been hypothesized to be a respiratory muscle with postural function.[11] Its attachments to the lumbar spine help maintain intra-abdominal pressure.[12] The diaphragm has been found to contract prior to initiation of upper extremity movement,[12,13] independently of the phase of respiration.[14] Kolar et al used magnetic resonance imaging to demonstrate that the diaphragm may not function as one cohesive unit. Increased muscle firing was seen through the middle and posterior aspects of the diaphragm with isometric extremity loading.[12] Hodges et al reported that as respiratory demands increased, the postural function of the diaphragm decreased.[15]

Breathing biomechanics have been described with respect to expansion of the abdominothoracic region during inspiration at rest. Apical or upper costal breathing occurs when superior thoracic expansion exceeds the abdominal and lateral costal expansion. Costodiaphragmatic breathing is observed when the abdominal and lateral costal expansion is predominant over the superior thoracic expansion. Electromyography studies indicate that diaphragm firing patterns differ in apical (chest) breathers versus diaphragmatic breathers.[16] Although data are still limited, trends are emerging throughout clinical rehabilitation suggesting that a pattern of diaphragmatic breathing may be beneficial for core stability, posture, upper thoracic hypertonicity,[16] and decreasing incidence of low back pain.[17,18] However, a thorough literature review revealed no empirical link between diaphragmatic breathing and balance.

[a] Exercise and Sports Science Department, University of Western States, Portland, OR.
[b] Center for Outcomes Studies, University of Western States, Portland, OR.
Corresponding author: Rylee J. Stephens, DC, MSc, PO Box 683, Garibaldi Highlands, BC V0N1T0, Canada.
(e-mail: *ryleejstephens@gmail.com*).
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The purpose of this preliminary study is to explore the feasibility of performing a study to measure a potential link between breathing patterns and balance. We had 2 hypotheses: (1) breathing exercises that promote increased costodiaphragmatic movement and decrease upper thoracic movement alter breathing patterns to be more diaphragmatic in nature; and (2) as breathing biomechanics become more diaphragmatic in nature, balance will increase correspondingly.

Methods

Design

This study was a prospective clinical trial using 1 cohort without control. The study was conducted in Portland, Oregon, between April and June 2015.

Participants

Participants were recruited from the students, staff, and faculty at the University of Western States. The assessors in this study were four doctor of chiropractic students who were also enrolled in the Master of Sports Science program. Assessors were in their final year of both programs.

Participants were included if they were at least 21 years old, literate in English, ambulatory, and willing to attend 8 visits and complete the prescribed breathing exercises. Participants were excluded if they had a current or previous diagnosis of attention deficit disorder or attention deficit hyperactivity disorder, vascular disease, central nervous system disorder, benign paroxysmal positional vertigo, cancer, posttraumatic stress disorder, anxiety, depression, chronic pain, hypertension, congestive heart failure, or spinal stenosis. Participants who had had a concussion or brain injury in the previous year or a lower body injury or ear infection that required treatment in the past month or who were currently or trying to become pregnant were excluded. All participants had to confirm that they could perform the breathing assessment pain free and were not participating in any other balance-specific training. Participants' blood pressure and pulse were taken prior to initiating exercise to screen for any underlying cardiovascular risk factors.

This study was reviewed and approved by University of Western States institutional review board. Informed consent was given by all participants prior to participation in the study.

Outcome Measurements

Breathing and balance assessments were conducted before each breathing-exercise training session for 8 weeks. To improve the reliability of scoring, all assessments were scripted and performed by the same evaluator every week for each of the participants. The dynamic balance was measured by a computer, but the instructions to participants were read from a script by the same assessor every week. The following assessments were made:

Static Balance Assessment. The Modified Balance Error Scoring System (SCAT3: Sport Concussion Assessment Tool, 3rd ed) is a standardized, objective test used to assess balance and postural stability following head trauma.[19,20] The Balance Error Scoring System has been reported to have good to excellent interrater and test-retest reliability for the evaluation of healthy young adults[21] and some evidence of criterion validity in young healthy athletes.[22]

Subjects performed the test wearing shorts or pants rolled up and with shoes removed. Assessors provided scripted instructions as each subject performed a single trial of a double-leg stance (DLS), single-leg stance (SLS), and tandem stance (TS). For the SLS, participants stood on their nondominant foot. For the TS, the nondominant foot was in the front. Each trial was performed, with subjects' eyes closed, for 20 seconds while the examiner counted the number of errors. Types of errors included hands lifting off iliac crests; eyes opening; a step, stumble, or fall; moving the hip into more than 30° abduction; lifting forefoot or heel; and remaining out of the test position longer than 5 seconds. Scores for each test were calculated as the number of errors. If a participant committed multiple errors simultaneously, only 1 error was recorded.[23] Participants were told to reset and start again if they lost their balance. Scores were generated by the same assessor for all participants each week in an attempt to improve reliability.

Dynamic Balance Assessment. This was assessed using OptoGait's March in Place protocol (MicroGait Corp, Mahopac, NY).[24] By marching in place, the body is performing a dynamic movement in which balance is needed to provide a base of support. OptoGait's software measures flight and contact time on the left and right sides. OptoGait states that as balance improves, contact time and the percentage difference between right and left contact times will decrease.

Participants were asked to stand between the OptoGait's sensors with shoes off facing the assessor. They were read a script asking them to "march in place with a purpose, quickly, but comfortably, for 40 seconds." They were instructed to try and get their knees to 90° and that they would be doing this 2 times, the first time with their eyes open and the second time with their eyes closed. In the event that the participant marched out of the testing area, the test was redone immediately.[25] This protocol has not yet been reported to be a valid measurement of dynamic balance.

Breathing Assessment. This test was taken from a full-body assessment of functional movement by Leibenson.[17] It was used in this study as a marker to monitor response to training for conversion from apical to diaphragmatic breathing. Breathing assessment (BA) has not been assessed for reliability but has face validity in that the mechanics that distinguish breathing styles can be observed.

Participants were asked to lay on their backs in the 90/90/90 position (hips and knees 90° flexed with feet dorsiflexed). Their legs were supported by the assessor while their anterior

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