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Andrew Hatchett
Exercise and Sports Science, University of South Carolina Aiken, Aiken, SC, USA

Janee McCarthy
Exercise and Sports Science, University of South Carolina Aiken, Aiken, SC, USA

Corresponding Author:
Andrew Hatchett
Exercise and Sports Science, University of South Carolina Aiken, Aiken, SC, USA

Breath training and pulmonary function and exercise performance

Andrew Hatchett and Janee McCarthy

Abstract
Purpose: To determine the relationship between a breath training protocol based on Yogic Breathing technique and pulmonary function, exercise performance and recovery from exercise performance.
Methods: Eight healthy recreationally trained participants completed anthropomorphic, cardiovascular fitness and pulmonary function assessments prior to a five-day breath training intervention. During the intervention length of time in which the participants could hold their breath was recorded. Upon completion of the intervention cardiovascular fitness and pulmonary function assessments were completed.
Results: All measures of pulmonary function trended in a positive direction with several resulting in statistically significant differences between pre- and post-intervention assessments. Cardiovascular fitness did improve, but not significantly. Breath holding time did improve significantly from pre- to post-intervention.
Conclusion: A five-day YB based breath training intervention can have positive effect on cardiovascular performance, pulmonary function and breath holding time.

Keywords: Breath training, pulmonary function, exercise performance

Introduction
The respiratory tract provides passageways for airflow between environmental air, rich in oxygen, and the gas exchange region within the pulmonary alveoli. Periodic pumping of gas in and out of the lungs is controlled by contractions of the respiratory muscles that rhythmically change the thoracic volume and produce the pressure gradients required for airflow [1]. Whole body maximal oxygen uptake (maximum aerobic power, aerobic capacity, VO2max) of human beings has interested researchers for many years and regular reviews have been published [2-4]. Its absolute magnitude and malleability with physical training has practical interest for elite soldiers, for the sports elite, and for anyone involved in physical exercise. Additionally, interesting research is being conducted linking breath training and mental health (anxiety, depression). Important for the interest in the topic is also that determination of oxygen uptake not only is a measure of aerobic energy turnover, but also offers precise measure of the capacity to transport and utilize oxygen, i.e., the functional capacities of the lungs, cardiovascular system and muscle mitochondria combined. In general aerobic power has been recognized as one of the fundamental components of physical performance and health [2, 5, 6].
Yogic Breathing (YB) is one of the several practices within the broad field of Yoga and is known to cause key changes within mind and body including blood pressure reduction, heart rate variability changes, and breathing frequency reductions [7, 8], predominant abdominal/diaphragmatic breathing [9-11], improved cognitive functions (e.g., mental alertness and reduced cognitive failure) [12, 13], increased bimanual dexterity and visuo-motor coordination [14], stress and symptom reduction in diseases such as cancer [15]. Little is known regarding the relationship between breath training, pulmonary function, exercise performance and recovery from exercise performance. Therefore, this research is designed to determine the relationship between a breath training protocol based on YB technique and pulmonary function, exercise performance and recovery from exercise performance.

Materials and Methods
Eight healthy recreationally trained participants met eight times during this research. The first session consisted of acquiring informed consent, the recording of anthropomorphic data and

the assessment of body composition. The second session was comprised of a Pulmonary Function Test (PFT) and a VO_{2max} test. Sessions 3 – 7 consisted of PFT assessment followed by a YB training session and ending with an additional PFT assessment. Session eight concluded the data collection portion of this research with a PFT assessment and a second VO_{2max} test.

Session 1 (30 minutes)

- Anthropomorphic assessment - Height (cm), Weight (km), Age (yrs) and Sex (F/M)
- Body composition assessment - The Bod Pod is the easiest and most accurate method of tracking body composition and body fat. Please do not eat, drink, or exercise for at least 3 hours prior to the test. Wear form fitting clothing (swim caps provided) men should wear spandex or lycra shorts without underwear and a swim cap. Women should wear either spandex or lycra shorts with a sports bra or a spandex/lycra swimsuit and a swim cap.
- Schedule Visit 2

Session 2 (45 minutes)

- Pulmonary Function Tests (PFTs) are noninvasive tests that show how well the lungs are working. Forced Expiratory Volume (FEV) – The volume that can be exhaled from a full inhalation by exhaling as forcefully and rapidly as possible for a timed period. Forced Vital Capacity (FVC) - The greatest total amount of air that can be forcefully exhaled after breathing in as deeply as possible. Forced expiratory flow (FEF) - is the average rate of flow during the middle half of the FVC test. Peak expiratory flow rate (PEFR) - is the fastest rate that you can force air out of your lungs.
- VO_{2max} assessment - Maximal oxygen uptake (VO2 max) specifically refers to the maximum amount of oxygen that an individual can take in and use during intense or maximal exercise. It is measured as milliliters of oxygen used in one minute per kilogram of body weight (ml/kg/min). The Bruce protocol is a maximal exercise test where the athlete works to complete exhaustion as the treadmill speed and incline is increased every three minutes. The length of time on the treadmill is the test score and can be used to estimate the VO2 max value.
- Heartrate and time to recover to a normal heartrate will be recorded.
- Schedule Visits 3-7

Session 3 – 7 (30 minutes)

- Pulmonary Function Tests (PFTs) are noninvasive tests that show how well the lungs are working. Forced Expiratory Volume (FEV) – The volume that can be exhaled from a full inhalation by exhaling as forcefully and rapidly as possible for a timed period. Forced Vital Capacity (FVC) - The greatest total amount of air that can be forcefully exhaled after breathing in as deeply as possible. Forced expiratory flow (FEF) - is the average rate of flow during the middle half of the FVC test. Peak expiratory flow rate (PEFR) - is the fastest rate that you can force air out of your lungs.
- Breathing Protocol

Warm-up protocol: 5 – 7 sets of nose only inhale

- Hold breath 3-4 times as long as it takes to inhale (3 second inhale = 9 – 12 second hold)
- Exhale 2 times the length of time it took to inhale (3 seconds inhale = 6 second exhale)
- 5 breaths finding the diaphragm – nose in, mouth out
- Inhale – fill up
- Exhale – empty

Cycle – 5 cycles of 5 rounds of the following

- One cycle = 3 second inhale - 2 second hold - 7 second exhale

After the 5th cycle, hold breath to the point of discomfort.
After the 5th cycle of the 5th round, hold as long as possible on the last round

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Session 8 (45 minutes)

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Descriptive statistics of the participants age, height and weight were analyzed. Results from the paired sample t-tests were reported with designation of statistical significance being indicated. All statistical analysis was conducted using SPSS Statistics v 25.0.0.0.

Results

There was not a statistically significant different between the participants in terms of mean age, mean height and mean weight. Table 1 reports the mean values for these variables in an effort to create a participant profile.

Table 1: Age, Height and Weight of participants

Variable (N=8)	
Age (y)	30.875
Height (cm)	170.213
Weight (kg)	70.963

Six of the eleven variables of interest showed a statistically significant difference between pre- and post-intervention scores. Participants recorded statistically significantly higher VO2max, Hold Time (min), FEV: FVC, FEF 50, FEF 75 and FET scores.

Table 2: Capacity, Performance and Pulmonary Function assessment scores pre- and post-intervention.

Variable	Pre-Intervention	Post-Intervention	p-value
VO2 max	39.15	39.965	0.026*
Hold Time (min)	1.276	2.808	0.017*
FEV 75	3.395	3.485	0.081
FVC	4.68	4.674	0.927
PEF	8.841	8.876	0.883
FEV:FVC	81.125	82.625	0.001*
FEF 25	6.831	7.018	0.385
FEF 50	4.105	4.743	0.001*
FEF 75	1.709	1.813	0.025*
MVV	141.625	144.625	0.098
FET	4.213	4.675	0.046*

* indicates statistical significance between the pre-intervention and post-intervention assessments.

Discussion

The aim of this study was designed to determine the relationship between a breath training protocol based on YB technique and pulmonary function, exercise performance and recovery from exercise performance.

Breath training yielded positive results in terms of breath holding time. A significant difference between the first and the last breath training session indicates participants increased the length of time in which they could hold their breath in the five days of treatment at a meaningful value.

VO2max or cardiovascular fitness results did not offer statistically significant changes as a result of this intervention. Although this was not a completely unexpected result based of previous research examining relatively intense exercise. Both Foster *et al*. [16] and Tabata [17] conducted short-term studies designed to influence cardiovascular performance. These studies were 6 and 8 weeks in duration, respectively. However, the mean score for this variable of interest did show a positive increase.

PFT results were mixed, in that a number of variables showed significant differences between the pre-intervention and post-intervention assessments. While other variables collected during the PFT did not show a significant difference. This may be an artifact of the length of the intervention or a result of the inability of this type of protocol not having an impact on those variables.

These results inspire a number of additional ideas and questions. Mainly, what would the impact of such a treatment program if the period of time in which the intervention were offered longer, six to eight weeks? Also, worth drawing attention to is the reporting of two subjects that ran for the purposes of training during the study. These two subjects significantly increased their individual VO2max performance as well as their Pulmonary Function Testing. This brings the idea of the ability to influence noted limiting factors of cardiovascular endurance as noted by Bassett and Howley [18].

Conclusion

The results of this research indicate that a five day breath training effort designed to encourage diaphragmatic engagement in the breathing mechanism can have positive effects on pulmonary function, breath holding time and cardiovascular performance. However, this influence was not seen in all variables of interest. Future research should include a longer intervention and cardiovascular training in conjunction with breath training. It would be interesting to assess the influence of YB based breath training interventions on pulmonary diffusion of athletes in various sports as well as its influence on recovery from short and long bouts of exercise at varying intensities. Additional variables to be assessed could including mood, depression, anxiety and cognitive function as these have all been shown to be influenced by YB, but have not been assessed in conjunction with cardiovascular performance.

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