International Journal of
EXERCISE SCIENCE

Original Research

Effects of 3 Weeks Yogic Breathing Techniques on Sub-maximal Running Responses

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ABSTRACT

International Journal of Exercise Science 16(4): 1066-1076, 2023. This study investigated the influence of yoga breathing techniques (YBT) on physiological and perceptual responses during sub-maximal treadmill running. Runners (n = 21) of various fitness (VO2max 48.4 ± 9.5 ml/kg/min) were assigned to Yoga (YG) or control (CT) group before completing pre/post treadmill trials where velocity was self-selected to produce an RPE 4 and RPE 7 (10 min each). YG (n =11) practiced three styles of YBT (30 min/day, 6 days/wk) for 3 consecutive wks. Self-selected running velocity for YG improved significantly at both prescribed RPE 4 (pre 157.63 ± 26.20 M/min, post 181.02 ± 24.22 M/min, p = 0.01) and prescribed RPE 7 (pre 201.97 ± 31.28 M/min, post 222.68± 35.32 M/min, p = 0.01). VO2 at RPE 7 increased significantly (pre 42.6 ± 6.9 ml/kg/min, post 47.3 ± 6.2 ml/kg/min, p = 0.02), TV at RPE 7 (pre 1.81 ± 0.30, post 2.04 ± 0.41, p = 0.01), and MV at RPE 7 (pre 77.25 ± 12.42, post 91.23 ± 20.05, p = 0.01). The CT group showed no significant changes except for TV at RPE 7 (pre 1.9 ± 0.3, post 2.0 ± 0.3, p = 0.04). Current results suggest YBT positively influences running velocity regulation during self-selected running.

KEY WORDS: Ventilation, perceived exertion, pranayama, self-selected pace

INTRODUCTION

Perception of exercise and understanding of psychophysiological responses may be useful for intensity regulation for athletes and general exercising populations. Exercise induced fatigue may persuade pacing during running, which may be influenced by physiological capacity, motivation, and experience (10) among other factors. Fatigue during exercise may be reflected in part by Ratings of Perceived Exertion (RPE), which allows a runner to subjectively assert feelings of effort using a numerical scale that has been used in both clinical and research settings as a standard indicator of physical strain (6). Running performance is typically hindered by muscle soreness/fatigue (7), poor mechanics (8, 9, 22), shortness of breath/inefficient breathing patterns (5), or deficient available energy (3). Among the most overlooked in traditional athletic training programs is breathing. Higher ventilatory stress has been shown to negatively impact running economy for male and female athletes (16). However, respiratory apparatus fatigue shows a delayed onset after 8 weeks of practicing pranayama, otherwise known as yoga breathing techniques (YBT) (27). Yadav (29) also showed increased power of respiratory muscles across 12 weeks of YBT and suggested a withdrawal of the brancho-restrictor effect, meaning that there was less tightness in the smooth muscle and surrounding tissue in the lungs.

Resting ventilation after YBT shows significant improvement in several previous studies that evaluated pre and post forced vital capacity (FVC), peak expiratory flow rate (PEFR), breath holding time (BHT), tidal volume (TV), minute ventilation (MV) also referred to in previous literature as pulmonary ventilation (PV), and maximal voluntary ventilation (MVV) (2, 11-12, 27- 28). YBT have been studied extensively in terms of respiratory regulation and blood pressure (2, 5, 11, 27), oxygen consumption and blood lactate levels immediately following exercise (21), as well as body composition and anerobic power (4), yet there has been little evaluation of how YBT may affect exercise responses such as self-selected running velocity particularly when linked with a perceptually prescribed intensity. Interestingly, previous research suggests the practice of yoga pranayama may decrease pain response, wherein the perception of pain (intensity and unpleasantness) experienced during testing (via painful thermal heat stimuli, 11-point pain scale) decreased in the healthy control subjects (vs. participants with fibromyalgia) while breathing slowly (one-half their normal breathing rate) over the course of 10 min (29). That study attributed reduced pain intensity and unpleasantness to the role of affect regulation of emotion ("positive effect" or parasympathetic activity, was reported to be strongly associated with those who had decreased pain response). As for the fibromyalgia group, it is suggested they were unable to maintain the positive effect gains from pranayama as well as the healthy control group. Therefore, it may be concluded that pranayama facilitates pain response during demanding situations through regulation of emotion (30), which could plausibly relate to exercise in the current study. The present study supports the contention that regular practice of YBT alters the intensity-RPE relationship as evidenced by the YG group selecting a higher velocity to achieve the same prescribed RPE after YBT.

Although yoga training is not considered to be as physically intense/forceful as endurance or strength training programs, cardiorespiratory benefits can be achieved within 6 days/week for 2 months (~48 hours) of pranayama practice, as previously found (27). As a complimentary practice, the benefits of yoga may contribute to exercise performance via improved body composition, aerobic endurance, and anaerobic power (4), whereas the benefits of YBT compliment the vasculature in terms of improved blood flow, which may be attributed to harmony between the body and mind (2). This study investigated 3 weeks of YBT on resting ventilation as well as acute exercise response in runners with no previous exposure to any form of YBT. It is our hypothesis that 3 weeks of YBT will augment respiratory function and exercise ventilation, thus translating cardiopulmonary benefits to various running adaptations.

METHODS

While YBT have shown benefits towards resting lung functions, there is a lack of research on effects of YBT on self-selected running velocity. To evaluate the impact of YBT on running velocity, participants completed two running sessions (pre and post) in which they ran on a treadmill for 5 mins at a prescribed RPE 4, which was increased during the same running bout to a prescribed RPE 7 for an additional 5 minutes. In addition to running velocities, FVC, FEV1, and PEFR values were assessed with each treadmill trial (pre and post). Prior to data collection participants were randomly assigned to either a yoga (YG) or control (CT) group. YG completed 3 consecutive weeks of 30 minutes/day 6 days/week of pranayama. There was no intervention for CT. All participants were instructed to continue their normal training routines. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (17).

Participants

Runners of various fitness volunteered for this study (n = 21), including males (n = 9) and females (n = 12), ages 18-40 yrs (Table 1). Though gender differences were not analyzed, gender per group was as follows: (n = 5) males and (n = 6) females in YG group, and (n = 4) males and (n = 6) females in CT group. Participants completed a questionnaire that indicated a range of 5-100 miles/week and a history of 23:33 min ± 5:02 min average 5k finishing time. A power analysis using alpha of 0.05, beta of 0.8 and an effect size of 3 ml/kg/min; with sigma (SD) of 5 suggested 20 participants were needed. All participants were new to yoga, and denoted minimal risk for exercise participation based on current ACSM (1) health and fitness facility preparticipation questionnaire pre-screening recommendations and the PAR-Q+ (28). Exclusion criteria included the use of chronic medication, with the exception of oral contraceptives. Participants provided written consent prior to data collection, and affirmed they were non-smokers. All procedures were approved by the local Institutional Review Board for protection of Human Subjects prior to data collection.

Table 1. Descriptive data for participants (n = 21) Mean ± SD.

Variable	YG (n = 11)	CT (n = 10)	Overall (n= 21)
Age (yrs)	21 ± 2	23 ± 6	22 ± 5
Height (cm)	169 ± 9	173 ± 8	170 ± 9
Weight (kg)	65 ± 10	71 ± 9	68 ± 10
Body Fat (%)	15 ± 7	18 ± 9	17 ± 8
VO_2 Max (ml/kg/min)	52.1 ± 11.1	44.4 ± 5.3	48.4 ± 9.5
Basal Heart Rate (bpm)	56 ± 9	59 ± 11	58 ± 10
Systolic Blood Pressure (mmHg)	120 ± 14	119 ± 5	119 ± 10
Diastolic Blood Pressure (mmHg)	77 ± 6	80 ± 8	78.4 ± 7
Miles per week	33 ± 35	14 ± 11	24 ± 28
Estimated 5k pace (min)	22 ± 5	25 ± 4	23 ± 5

Protocol
All descriptive characteristics for participants are reported in Table 1. During trial 1, participants were assessed for resting blood pressure using a manual sphygmomanometer and stethoscope (Safety-Lok™, Becton, Dickinson and Company, Franklin Lakes, NJ). FVC, FEV1, and PEFR were tested with a spirometer (Vacumed, Ventura, CA, USA) in which the best of 3 attempts was recorded. Skinfold measurements were taken at 3 sites (male; chest, abdomen, thigh, female: triceps, iliac, thigh) using skin fold calipers (Lange Calipers, Cambridge, MA, USA) to estimate body fat percentage (20), which were measured by the same investigator to avoid interindividual variability. Height (cm) was measured using a stadiometer (Invicta Plastics Limited, Leicester, England) and body mass (kg) was assessed using a digital scale (BWB-800, Tanita Inc. Tokyo, Japan).

Following anthropometric measures, participants were fitted with a HR monitor (T31 Transmitter, Polar Electro, Kempele, Finland) and completed a graded exercise test to volitional exhaustion on a motor-driven treadmill (TrackMaster TMX425C, Fullvision Inc., Newton, KS, USA). Metabolic data (VO_2, RR, TV, and MV) were assessed via indirect calorimetry (Parvo Medics TrueOne 2400, Sandy, UT, USA) which was calibrated prior to each test in accordance with manufacturer guidelines using calibration gases and a 3-liter syringe. The treadmill protocol began at a speed reflecting the participants self-reported comfortable 5-k race pace (1 ½ miles/hr slower than finishing pace). The treadmill remained at a 1% incline and speed was increased 0.5 mph (13.4 meters/min) every 2-min until the runner reached volitional exhaustion. VO_2max was recorded as the highest 60-sec average near test completion.

Participants returned to the lab at least 48 hours after max trial, well rested (>24 hrs with no strenuous physical activity) and instructions to be well hydrated. FVC/FEV1/PEFR were assessed (as above) immediately prior to both pre and post running trials. Trials 2 (pre-intervention of YBT) and 3 (post-intervention of YBT) were repeated trials, which consisted of a 10-minute treadmill trial in which participants followed a protocol of submaximal running at individualized self-selected, blinded treadmill velocities prescribed to elicit an RPE of 4 (moderate intensity) and then an RPE of 7 (moderate-high intensity). The RPE scale was explained to participants prior to the start of the running trials. After a 3-5-min warm-up, participant's velocity was adjusted by the project investigator until the participant notified it "felt like" an RPE of 4 with a simple hand gesture. At that time, velocity was clamped for 5 min. The project investigator made participant aware when treadmill speed would slowly increase, and when the participant notified the project investigator their RPE was at a 7, velocity was clamped for another 5 min. Treadmill trials at prescribed RPE 4 and RPE 7 were completed sequentially with no recovery between the two intensities. Subjective intensity was used for this study to analyze self-selected/perceived running pace before and after intervention of YBT. HR, VO_2, RR, MV, and TV were recorded throughout using the Parvo system as described above. Oxygen cost at a selected velocity was measured from the end of minute 4 to the end of minute 5 min via indirect calorimetry steady metabolic rate. Pre and post trials were completed at a similar time of day for each participant. Participants were randomly assigned to (YG) or (CT) group following the pre-running trial.

Following trial 1, YG participants met with a certified yoga instructor to learn three different YBT: Dirgha (breath awareness BAW), Kapalabhati and Bhastrika (high frequency yoga breathing HFYB).

Training procedure for each breath:

1. *Dirgha*: diaphragmic breathing; 3-part breath for filling 3 parts of the lung: belly (lower lung), rib cage (mid lung), and chest (upper lung). For in-depth description see (2, 29).
2. *Kapalabhati*: Forceful exhalation (quickly contracting abdominals) and passive inhalation. For in-depth description see (15, 24-25).
3. *Bhastrika:* Rapid yet complete inhalation and exhalation, both forceful and equal in length. For in-depth description see (26).

Once participants showed an understanding (subjectively evaluated by the instructor) of performing each breath properly through verbal guidelines, they were given written instructions as well as a practice log to take home. YG were to complete the techniques at their residence, in the morning 6 days/week (1 session/day), 30 min per session. Breath types were practiced for 10 min each in the above order. YG were instructed to start the Pranayama practice at home the day following trial 2 and continue for 3 weeks (18 total sessions) or until trial 3 was completed. Practice was prescribed to occur in the morning, to reduce physical or mental activity beforehand and be pre-prandial (26). Dismissal criteria for low adherence was < 5 full practices per week (15 total sessions).

Statistical Analysis

Means and standard deviations were calculated for descriptive data (Table 1). Self-reported running volumes are also presented in Table 1 as means, standard deviations and ranges by group (CT vs. YG). There were no significant differences between groups (Table 1). Pre vs. post measurements for resting ventilation and treadmill (RPE 4, RPE 7) trials were compared using a 2 (group) x 2 (time point) repeated measures ANOVA each prescribed RPE. When appropriate, follow up paired t tests were used to assess pre vs. post means within groups. Results were considered significant at $p \leq 0.05$. Effect sizes are reported in the results section.

RESULTS

For FVC there was no significant main effect for trial ($p = 0.14$, $n_p^2 = .110$), group ($p = 0.83$, $n_p^2 = .002$), or for the interaction between trial and group ($p = 0.23$, $n_p^2 = .074$). For FEV1 the main effect trial approached significance ($p = 0.10$, $n_p^2 = .138$) but was not significant ($p = 0.64$, $n_p^2 = .012$) for group or for the interaction of trial and group ($p = 0.26$, $n_p^2 = .065$). For PEFR main effects were not significant for trial ($p = 0.19$, $n_p^2 = .088$) or ($p = 0.79$, $n_p^2 = .004$) for group or for the interaction of trial and group ($p = 0.35$, $n_p^2 = .046$). Follow up t tests were conducted for paired samples (pre vs. post) within each group are included in Table 2. Velocity (M/min) at both RPE 4 and RPE 7 had a main effect for trial ($p \leq 0.01$, $n_p^2 = .374$ and $p \leq 0.01$, $n_p^2 = .344$) and for group ($p \leq 0.01$, $n_p^2 = .330$ and $p = 0.02$, $n_p^2 = .255$) respectively. The interactions for trial and group were significantly different for RPE 4 and RPE 7 ($p = 0.04$, $n_p^2 = .198$ and $p = 0.04$, $n_p^2 = .210$). Additionally, main effects for trial and group were significantly increased ($p \leq 0.01$, $n_p^2 = .311$, $n_p^2 = .242$) for VO_2 at

RPE 7. Follow up t test revealed VO_2 was not significantly increased for RPE 4 (p = 0.20), however it was significantly higher for RPE 7 (p = 0.02) for YG (Table 3). HR was significantly lower at RPE 4 for the main effect of trial ($p \leq 0.01$, n_p^2 = .354) and approached significance at RPE 7 (p = 0.06, n_p^2 = .181); for group HR was only significantly lower at RPE 4 ($p \leq 0.01$, n_p^2 = .027) (Table 3). Interactions for trial and group for HR were significantly different for RPE 4 (p = 0.02, n_p^2 = .242) and RPE 7 ($p \leq 0.01$, n_p^2 = .319). RR main effects of trial and group were not significantly different for RPE 4 (p = 0.68, n_p^2 = .017; p = 0.46, n_p^2 = .029) or RPE 7 (p = 0.51, n_p^2 = .023; p = 0.81, n_p^2 = .003). Additionally, the interaction of trial and group was not significantly different for RR in regards to RPE 4 nor RPE 7 (p = 0.78, n_p^2 = .005; p = 0.30, n_p^2 = .057). TV was significantly increased at an RPE 4 and RPE 7 for the main effect of trial (p = 0.04, n_p^2 = .200 and $p \leq 0.01$, n_p^2 = .415) but was not significantly different for the main effect of group (p = 1.00, n_p^2 = .000 and p = 0.68, n_p^2 = .009) nor for the interaction of trial and group (p = 0.42, n_p^2 = .034; p = 0.17, n_p^2 = .096). TV was significantly increased for YG at RPE 7 (p = 0.01) and approached significance for RPE 4 (p = 0.08) with t test (Table 3). However, TV for CT had an effect at RPE 7 (p = 0.04) but no effect for RPE 4. MV main effect of trial approached significance (p = 0.07, n_p^2 = .163) at RPE 4, but significant ($p \leq 0.01$, n_p^2 = .320) at an RPE 7. The main effect of group and the interaction of trial and group were not significantly different for RPE 4 (p = 0.97, n_p^2 = .000; p = 0.59, n_p^2 = .015) or RPE 7 (p = 0.66 n_p^2 = .011; p = 0.10, n_p^2 = .136). T test revealed MV was significant at RPE 7 (p = 0.01) while there was no effect for RPE 4 in YG. CT had no main effect for any other measure. RR had no effect for either CT or YG. Follow up t tests were conducted with results in P values for paired samples follow up t tests (pre vs. post) within each group are included in Table 3.

Table 2. Spirometry pre vs. post between yoga (YG) and control (CT).

Group	FVC Pre	FVC Post	FEV1 Pre	FEV1 Post	PEFR Pre	PEFR Post
Yoga (YG)	5.7 ± 1.8	4.7 ± 1.3**	4.9 ± 1.6	4.0 ± 1.0*	9.3 ± 3.0	8.0 ± 2.1*
Control (CT)	5.1 ± 1.6	5.1 ± 0.9	4.3 ± 1.3	4.2 ± 0.9	9.0 ± 2.4	8.8 ± 2.3

Values are as mean ± 1SD, ** significant at p = 0.12, * significant at p = 0.10, as compared to levels in similar conditions (at rest, before exercise) before Pranayama training. FVC forced vital capacity (L), FEV1 forced expiratory flow rate in one second (L), PEFR peak expiratory flow rate (L/sec).

Table 3. Pre vs. post self-selected running velocity. (n = 21). Mean ± SD.

Trial	Group	M/MIN	VO_2	HR	TV	RR	MV
RPE 4	Pre YG	158 ± 26	35.0 ± 6.0	165 ± 19	1.6 ± 0.3	36.7 ± 4.1	60.1 ± 10.9
	Post YG	181 ± 24*	37.9 ± 4.5	175 ± 14*	1.8 ± 0.4**	37.1 ± 7.3	65.1 ± 18.2
RPE 7	Pre YG	202 ± 31	42.6 ± 6.9	183 ± 15	1.8 ± 0.3	42.9 ± 4.1	77.3 ± 12.4
	Post YG	223 ± 36*	47.3 ± 6.2*	190 ± 12*	2.0 ± 0.4*	45.1 ± 5.7	91.2 ± 20.1*

RPE 4	Pre CT	142 ± 14	32.5 ± 3.5	165 ± 13	1.7 ± 0.3	38.5 ± 9.7	62.6 ± 9.1
	Post CT	147 ± 14	33.4 ± 3.3	166 ± 15	1.7 ± 0.3	39.7 ± 7.6	67.9 ± 10.1†
RPE 7	Pre CT	180 ± 22	38.9 ± 3.4	182 ± 8	1.9 ± 0.3	44.9 ± 7.7	85.1 ± 10.3
	Post CT	183 ± 24	40.1 ± 4.6	180 ± 12	2.0 ± 0.3*	4.4 ± 8.4	88.8 ± 16.0

Pre-yoga (YG) (n = 12). Pre-control (CT) (n = 10). Values are as mean ± 1SD P*<0.05 and approached significance at P**=0.08 and P†=0.09 as compared to levels in similar conditions before YBT. M/MIN meters per minute, VO2 oxygen consumption (ml/kg/min), HR heart rate (beats per minute), TV tidal volume (L), RR respiratory rate (breath per minute), MV minute ventilation (mL/min).

DISCUSSION

This study investigated effects of 3 weeks YBT on self-selected velocities at perceptually prescribed running intensities (RPE 4, RPE 7). Physiological measurements investigated were MV, RR, TV, and HR during exercise as well as measures of resting ventilation (FVC, FEV1, PEFR) (Table 2). Although resting respiratory values trend with a slight decline (Table 2), the most critical findings of this study were that YBT improved self-selected running pace at both intensities, indicating that the velocity required to achieve an RPE of 4 or 7 was increased after YG (Table 3), indicating that habitual practice of YBT may help running "feel easier." In another study, 6 weeks of YBT resulted in a decreased sweat response as well as an increase in respiratory pressures (14). Sengupta et al. (23) suggested that an increase in respiratory pressures, both inspiratory and expiratory, indicates improved strength of respiratory muscles, thus leading to less discomfort with heavy breathing. This may explain why running "felt easier" to the participants in the YG in the current study.

The lack of improvement in the current spirometry values (Table 2) with 3 weeks of YBT could potentially be explained by the overall length of the treatment period as well as the amount of time practiced per session (30 minutes). Yadav et al. (29) implemented yoga and pranayama (1 hr/day) over 12 weeks and observed significant improvements in FVC, FEV1, and PEFR at the 12 week completion point. Therefore, it could be suggested that a yoga training period of greater than 3 weeks is needed to elicit significant respiratory function improvements (29). Previous findings show that 6 weeks of YBT 20 min per day (twice a day on weekdays and once on Saturdays) was adequate treatment volume to result in a new rhythm of breathing in the bulbopontine complex (11). This training of the bulbopontine complex is relevant for breathing patterns during exercise, in that during YBT the complex is taught to prolong both the inspiration and expiration, which enables the respiratory system to function in its fullest capacity (11).

An alternative approach for reasoning an advancement in respiration has been identified in several other studies as the broncho-constrictor effect (constriction of the lungs due to tightening of smooth muscle and surrounding tissue) (29). In that study, yoga was associated with a withdrawal of the broncho-constrictor effect, and in another study (27), it was suggested that due to muscular advantage gained with YG training, there is a delayed onset of fatigue. A different study also mentions YBT has an impact on fatigue, partially due to reshaping breathing habits as mentioned above, and furthermore is explained that the aveoli are trained to withstand higher CO_2 (2). A separate study showed YBT to improve RE with no significant rise in blood lactate, suggesting YBT to be beneficial without potentiating muscle soreness when implemented into an athletes training program (21). Current results showed YBT to improve ventilation while exercising (Table 3), which agrees with previous studies appraisal of reshaping breathing habits and cardiopulmonary fatigue with YBT.

One study (10) explains the effort given during exercise (self-selected pace) to be a response of a feedforward system, that can be altered from continuous afferent feedback. The afferent feedback from the muscle (level of muscle recruitment and muscle pH) is proposed to help regulate pacing strategy (10). If this mechanism is an explanation for preventing premature fatigue, then YBT may be represented as input to the brain's mathematical algorithm to monitor the "cost" of running, based off perceived ability of the lungs and breath to sufficiently sustain the physical task of running. Perhaps, in the present study, the task of running was perceived as more attainable at each prescribed intensity (RPE 4, RPE 7) after YBT due to the afferent feedback from the respiratory control center to the brain (10). Nicolo et al. (18) also correlates respiratory effort to perceived exertion/self-selected pace. In a previous study, trained cyclists performed 3-time trials (10 min, 20 min, 30 min) in which self-selected pace was to reflect a maximal power output that could be maintained per trial duration. That study found a significant relationship between respiratory frequency and RPE, and also relating perceived exertion to central command of the brain as stated in former studies (6, 10, 18).

Parameters of the lung during rest after YBT seems understood physiologically, however, the connection to psychological changes from yoga in relation to perceived exertion is less well understood. Yoga has been utilized as a method of stress reduction and treatment for anxiety (23) in which there is a respective translation to a reduction in blood pressure and heart rate at rest. Because yoga does produce these psychological/physiological effects, it seems plausible that the present study of YBT may have produced a relief of mental stress that aided in the readiness for running. These patterns indicate the physical task to feel easier, thus enabling higher workloads to be achieved at the same RPE pre/post trial. No direct measures of mental stress were taken, and more work is warranted for a definitive answer.

Limitations: The current study implemented 3 types of YBT (Dirgha, Khapalabati, and Bhastrika) for the analysis of effects towards perceived exertion and function of the lungs. Understanding and adequate performance of the YBT prescribed was subjectively evaluated and approved by the instructor, with no formal criteria, which may have been a limitation to this study as it relates to the participants collective ability and proper practice of each breath. Participants in the current study could practice pranayama on their own and record their practice for compliance. Although this flexibility optimized ecologically validity, scheduled sessions with the yoga teacher may have been beneficial to the participants understanding of precise timing and performance of the breathing techniques. However, the current study chose ecological validity over tight control of the yoga practice to represent a realistic approach for implementing YBT alongside a running program. Participants also had various levels of conditioning and experience, which may be a limiting factor for assessing additional benefits towards running economy or respiratory improvements afforded via YBT.

Practical Applications: Current results suggest YBT may serve as an effective and accessible training method for athletes to improve respiratory control/ventilation and achieve higher running velocities with a similar numerical perceptual rating as compared to lesser velocities before YBT. The current study found of significant improvement in self-selected velocity associated with RPE, along with lowering HR and various measures of ventilation, indicating YBT may help physical tasks feel easier. The YBT volume in the present study seems to have met minimum requirements of training adaptations at a physiological level that produce a favorable outcome. Further work in the area of pranayama and endurance training should be explored to verify these propositions including studies investigating a potential dose-response relationship.

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