Mastering the Breath: A Guide to the Invisible Key to Athletic Success

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Abstract

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Introduction: During exercise, the respiratory system regulates gas exchange in the body to maintain physical function. Athletes can use proper breathing practice to optimize performance and recovery efficiency.

Literature Review: Proper practice of breathing techniques benefit the whole body by increasing the strength and flexibility of the respiratory system. This causes increased gas exchange efficiency and body control. Focused practice can prepare an athlete for sport performance, increase exercise tolerance and antioxidant function, and decrease impulsive reactions and metabolic stress.

Methods: The guide presents ways for the athlete to improve the respiratory system. Methods used in previously successful breathing interventions were drawn to create an educational tool to learn diaphragmatic breathing, basic breath control, and how to best use the breath for specific sport performance and recovery efficiency.
Conclusion: Consistent breath practice through yogic breathing techniques can increase internal awareness leading to better physical function and control, an important component for unlocking athletic success.
Introduction

The function of the respiratory system is to maintain appropriate gas levels in the body by exchanging oxygen and carbon dioxide. Failure to do this is detrimental for exercise performance and recovery. Proper breathing practice can significantly reduce internal damage produced from exercise and support athletic performance. (Harms, Babcock, McClaran, Pegelow, Nickele, et al., 1997; Harms, Wetter, Croix, Pegelow, & Dempsey, 2000: Babcock, Pegelow, Harms, & Dempsey, 2002). Modern and ancient breathing techniques can benefit sport through respiratory strengthening, parasympathetic reactivation, decreased perceived exertion rates, and better control and awareness of the body (Zope & Zope, 2013; Brown & Gerbar, 2005). Positive outcomes are seen before, during exercise, and after exercise, and apply to all types of athletic performance (Romer & Polkey, 2008; Raju, Madhavi, Prasad, Reedy, Reedy, et al., 1994; Aliverti, 2008; Dominelli & Sheel, 2012). Most of the respiratory system is not externally visible so proper education and awareness is necessary (DiMarco, Connors, & Kowalski, 2004). From simple diaphragmatic breathing to more complicated techniques, the athlete can learn to use proper breath in a variety of physical positions, and at different rates to train the respiratory system as one would the musculoskeletal system. The purpose of this paper is to discuss how breathing techniques can train the respiratory system to support athletic performance and recovery. The discussion will lead to the creation of an educational and practical breathing guide for athletes to optimize the use of the respiratory system.
Respiratory Anatomy & Function

The respiratory system consists of the lungs for gas exchange and muscles to create gas flow or tidal volume. The diaphragm is the primary muscle of inspiration. It is dome-shaped at rest, separating the chest and abdominal cavity. Fibers extend radially, originating on the inner surface of the lower 6 ribs, the xiphoid process, and the anterior surface of lumbar vertebrae 1-3, and centrally connect to a central tendon. Intercostal and abdominal muscles can assist respiratory efforts efficiently, while upper neck and back muscles can cause strain and inefficiency with respiratory action (Nelson & Beach, 2012; Courtney, 2009; Perry, Similowski, Klein, & Codd, 2010; Poole, Sexton, Farkas, Powers, & Reid, 1997). The muscles distort thoracic and abdominal dimensions, creating air flow through changing internal pressures. The greater the distortion and pressure change, the greater the airflow. Greater pressure changes also suggest greater diaphragm strength (Nelson & Beach, 2012). When the diaphragm contracts, it descends and assume a more transverse placement at the base of the ribs. This increases thoracic and lung volume, creates a negative pressure gradient to the external environment and oxygen flows into the lungs. Optimal use of the diaphragm involves using its full range of inspiratory and expiratory action. Stretching inspirations increase chest wall flexibility, tidal volume and respiratory efficiency (Perry et al., 2010; Poole et al., 1997). Exhalation involves passive recoil of the diaphragm. Abdominal and intercostal muscles can further decrease thoracic dimensions and stretch central tendon length storing elastic energy to produce greater inspiratory efforts (Nelson & Beach, 2012; Courtney, 2009; Perry et al., 2010; Poole et al., 1997).
The function of the respiratory system during exercise is to maintain an internal homeostasis during changing metabolic needs. Respiratory rate and work increase because of increased demand. Physical function under stress depends on the respiratory system’s ability to maintain appropriate gas proportions. If ventilation does not match metabolic need, performance will suffer from decreased motor control and focus and increased muscle tension, pain perception, sensitivity to fatigue, and rate of perceived exertion (Courtney, 2009; Dominelli & Sheel, 2012; Nelson, & Beach, 2012; Perry et al., 2010; Poole et al., 1997). The respiratory system can be strengthened so a given amount of work can be performed at the smallest oxygen cost allowing a greater proportion of cardiac output to be directed to other working muscles. Proper breathing also supports recovery from physical and psychological stress to maintain performance, prevent sensitivity to fatigue and promote recovery (Martarelli, Cocchioni, Scuri, & Pompei, 2011; Matsumoto, Masuda, Hotta, Shimizu, Ishii, et al., 2011).

The Importance and Benefits of Proper Breathing

Work of Breathing and Breathing Training

The diaphragm is the primary and most productive muscle of inhalation (DiMarco et al., 2004). Like other muscles, it is subject to training effects and fatigue (Harms et al., 2000; Guenette & Sheel, 2007; Wüthrich, Eberle, & Spengler, 2014). A stronger diaphragm puts less strain on the respiratory system (Hart, Nickol, Cramer, Ward, Lofaso, et al. 2002; Guenette & Sheel, 2007). As breathing rate increases to meet metabolic demand, so does respiratory load and work required. To exercise efficiently, respiratory work must be minimized while meeting demands (Guenette & Sheel, 2007;
Romer & Polkey, 2008). Respiratory load has significant effects on respiratory work, fatigue and exercise performance (Harms et al., 1997; Harms et al., 2000; Babcock et al., 2002). When healthy, trained, cyclists performed an exhaustive cycle test under mechanically created respiratory load or assistance, loaded conditions significantly increased respiratory work (732.9±52.0 vs 52.7±23.2 J/min; p<0.05). Assistance resulted in 2.5 times less work than a control group (194.1±26.3 J/min vs 527.2±23.2 J/min; p<0.05) (Harms et al., 1997). Similar interventions found up to 13% less diaphragm oxygen consumption during unloaded conditions compared to controlled suggesting less respiratory work (p<0.05) (Babcock et al., 2002; Harms et al., 2000).

When the diaphragm is strengthened, relative load on the respiratory system is decreased, less oxygen is needed at a given load, and exercise output at a given load can increase (Dominelli & Sheel, 2012; Romer & Polkey, 2008; Vogiatzis, Georgiadou, Koskolou, Athanasopoulos, Kostikas, et al., 2007).

If respiratory load is too great, the diaphragm can fatigue and maximum work production can be limited (Guenette & Sheel, 2007; Wüthrich, Eberle, & Spengler, 2014). Diaphragmatic fatigue at rest is typically not an issue because of low respiratory load, but it is during exercise from competition between the respiratory system and working muscles for a proportion of the body’s cardiac output for oxygen (Dominelli & Sheel, A., 2012; Romer & Polkey, 2008; Babcock et al., 2002). When the diaphragm works under relatively less load, a greater portion of blood flow can be directed toward working muscles to support exercise demonstrated by the strong inverse relationship found between the work of breathing and blood flow to the legs (r=−0.84) (Harms et al., 1997). When respiratory work is reduced 63%, blood flow to the legs significantly
increases $0.8 \pm 0.31$ l/min ($p=0.007$). The opposite happens when work increases ($p=0.002$) (Harms, Wetter, McClaran, Nickele… Pegelow et al., 1998). Less blood flow to working muscles means decreased oxygen delivery and increased sensitivity to fatigue, leading to decreased tolerance to whole body exercise. Under less respiratory load, cyclists are able to significantly extend exercise to exhaustion time $1.3\pm2.0$ min while loaded conditions can significantly reduce time by $1.0\pm0.8$ minutes ($p<0.05$). Unloading also results in significantly lower perceived exertion rates (RPE) and dyspnea at the beginning of exercise and at exhaustion ($p<0.05$). Strengthening diaphragm creates relatively unloaded conditions and results in decreased RPE, pain perception, dyspnea and fatigue, increasing exercise tolerance (Babcock et al., 2002; Romer & Polkey, 2008; DiMarco et al., 2004; Enright, Unnithan, Heward, Withnall, & Davies, 2006).

Inspiratory muscle training (IMT) increases pulmonary and whole-body function in healthy subjects, athletes and those with certain pathologies (Enright et al., 2006; Kapus & Usaj, 2012; Pal, Velkumary, & Madanmohan, 2004; Nield, Hoo, Roper, & Santiago, 2007; Ray, Pendergast, & Lundgren, 2010; Seo, Lee, & Kim, 2013). One method to measure diaphragm strength is through maximum inspiratory pressure (MIP). Eight weeks of breathing training 3 times a week can significantly increase MIP 41%, sustained MIP 36% ($p<0.01$), lung capacity 0.4L ($p<0.05$) and diaphragm thickness 0.5 mm ($p<0.05$). These results suggested greater diaphragm strength caused a 23% increase tolerance to exercise duration and intensity (Enright et al., 2006). A similar protocol performed 5 days a week for 4 weeks also increased MIP 40% and significantly decreased inspiratory ($p<0.001$) and expiratory work ($p<0.05$) (Ray et al., 2010). Six weeks of training twice a day also demonstrated significant increases in MIP ($p<0.01$),
tidal volume (p<0.01), O2 uptake (p<0.05) and time to exhaustion (p<0.01) during exercise (Kapus & Usaj, 2012). Many studies have similarly found significant improvements in diaphragm thickness, MIP, fatigue, oxygen saturation, lung diffusing capacity, exercise tolerance and respiratory efficiency but, however, have found contradictory conclusions on the effects of VO2 max (Edwards & Cooke, 2004; Driller & Paton, 2012; Downey, Chenoweth, Townsend, Ranum, Ferguson et al., 2007; Morgan, Kohrt, Bates, & Skinner, 2008; Wüthrich, et al., 2014). Studies using swimmers found that greater tidal volume and inspiratory strength through IMT, can improve respiratory efficiency and exercise tolerance when water constrains respirations (Ray et al., 2010; Kapus, & Usaj, 2012; Simpson, Ray, Lundgren, & Pendergast, 2012). It can be seen that training with mechanically induced respiratory resistance of at least 50% of MIP can produce significant, positive effects during exercise (Kapus & Usaj, 2012; Ray et al., 2010; Enright et al., 2006).

The previous studies saw significant results of IMT using mechanical devices to increase respiratory resistance. Manual breath techniques that create resistance show similar benefits in the respiratory system. Techniques to manually increase respiratory resistance include pursed lip, Ujjayi and Bhramari breathing (Nield et al., 2007; Bianchi et al., 2007; Matsumoto et al., 2011). Two months of pursed-lip breathing can produce significant increases in tidal volume, and inspiratory and expiratory time (p<0.001) suggesting a greater capacity for gas flow and optimal length-tension relationships for respiratory muscles to function (Han, Stegen, De Valck, Clément, & Van de Woestijne, 1996). Ujjayi practice can result in increased diaphragm strength, thoracic expansion and respiratory efficiency (Mooventhan & Khode, 2014). Bhramari breathing
can result in significant increases in functional respiratory measures including peak expiratory flow (PEF), forced expiratory flow (FEF) and similar to Ray et al. (2010), maximum voluntary ventilation (MVV) (Mooventhen & Khode, 2014).

Deep and controlled breathing techniques create practical benefits for the athlete. Athletes that practice a 48 minute per day, daily breathing protocol can attain significantly greater maximal work rates compared to baselines on a cycle test (172.22±22.16 vs 42.28±5.69 watt/min; p<0.01) and significant reductions in oxygen consumption per unit work during submaximal and maximal exercise (p<0.05). Practice can delay anaerobic threshold and allow increases in performance at less cost for a longer period of time (Raju et al., 1994). Another 3 month breathing protocol shows that 10 minutes of daily practice can cause increases in breath holding time (p<0.001) from decreased sensitivity to CO2 buildup and in turn, fatigue (Ravi & Swamy, 2013). Long-term daily breath practice in athletes, can cause a reduction in resting blood lactate and significantly greater oxygen saturation at rest (p<0.001) when incorporated into a training schedule (Sharma, Datta, Singh, Singh, Sen et al., 2008). Practicing breathing techniques at rest can prepare the body to operate efficiently during exercise.

Attention to respirations during exercise also has beneficial outcomes for the athlete. A 1:2 ratio of inhalation to exhalation at a rate of 10 breaths per minute shows to significantly delay anaerobic threshold and exhaustion compared to those practicing spontaneous breathing during an exhaustive exercise test (6 min. 12±32s/10 min. 2±13s vs 5 min 56±19s/9 min 42±24s; p<0.05). A 1:2 ratio also shows greater power output at anaerobic threshold and time of exhaustion versus spontaneously breathing (126.8±10.6/213.6±7.7 vs 109.6±10.5/204.8±6.8W; p<0.05). Respiratory strengthening
and control can increase respiratory function during exercise resulting in increased exercise tolerance.

**Oxidative Stress and Breathing for Recovery**

Exercise demands increase sympathetic activity, metabolic waste production and stress hormone levels. Reactive oxygen and nitrogen species (RONS) are waste products that cause oxidative stress, or internal cellular damage, when they are produced more quickly than the body’s antioxidant defense system can eliminate (Goldfarb & Bloomer, 2004; Bloomer, Goldfarb, Wideman, Mckenzie, & Consitt, 2005). Oxidative stress causes structural damage and disfunction of proteins, fats and DNA. (Goldfarb & Bloomer, 2004). Maintained oxidative stress can lead to a wide range of cardiopulmonary and psychologic pathologies that negatively affect physical performance (Zope & Zope, 2013). All types of exercise, from ultra-endurance to high intensity sprint events and from submaximal to exhaustive exercise, can induce significant oxidative stress up to 48 hours after the event making the balance between production and removal of waste important for all athletes to recover (Ilhan, Kamanli, & Ozmerdivenli, 2004; Martarelli et al. 2011; Skenderi et al. 2008; Watson et al., 2005).

Exercise induced oxidative stress is worsened with increased oxygen depletion from increased exercise intensity and duration. This causes greater sympathetic nervous system activation, metabolic waste and excess post-exercise oxygen consumption (EPOC), which strongly relates to longer recovery times (p<0.003)(Mann. Webster, Lamberts, & Lambert, 2014; McGrawley & Bishop, 2015) and performance decrements in repeated events (p<0.001) (Dunpont et al., 2010). Faster O2 replacement and
parasympathetic reactivation between exercise bouts strongly correlates with the smallest decreases in performance and better recovery (p<0.001; r=0.85) (Dupont et al., 2010). Efficient oxygen uptake, waste expulsion and parasympathetic activation will help balance the body and nervous system to bringing the body back to rest (Bloomer et al., 2005 Mann et al., 2014; McGawley, & Bishop, 2015; Dupont et al., 2010). Proper breath can facilitate this.

After a 24 hour cycle contest, where all participants showed increased oxidative stress markers (RONS) (P<0.01), 1 hour of deep diaphragmatic breathing (DB) had significant benefits. Five and 24 hours post exercise, participants who practiced DB showed significantly smaller RONS levels than controls only who rested in a quiet place (149.6/129.1% vs 159.9/154.0% of baselines) (p<0.01). Between hour 5 and 24 DB reduced RONS by 20.5% while the controls had a 5.9% decrease. This study also measured biological antioxidant potential (BAP) as the blood level of antioxidants. The greater the BAP, greater the defense against RONS. Compared to baselines, the DB group had significantly greater BAP than the control group (129.1 vs 114.2%; p<0.001). Specifically melatonin, a strong antioxidant, was significantly higher with DB after prolonged exercise (p<0.05) (Martarelli et al. 2011). Previous studies have found regular practitioners of Yogic breathing have increased levels of glutathione, glutathione peroxidase and superoxide dismutase, all of which are indicators of proper antioxidant function (Sharma et al., 2008; Chiplonkar & Agte, 2008). Cortisol is the body’s stress hormone. Sustained heightened levels can cause hormone dysfunction and oxidative stress. Deep breathing can decrease cortisol levels at rest and after metabolic stress (Dawson, Hamson-Utley, Hansen, & Olpin, 2014; Martarelli, 2010).
al. (2010) applied DB after exercise, cortisol levels were significantly less than in controls after breathing practice (p<0.05) and remained lower 24 hours post exercise. From increasing antioxidant function and decreasing stress hormones breath practice can increase recovery capability (Martarelli et al., 2011; Raju et al., 1994).

The respiratory sinus arrhythmia (RSA) is a natural occurrence that increases heart rate on inhalation and slows heart rate on exhalation. Chronic physical or mental stress can cause sympathetic dominance. Exercise stimulates the sympathetic nervous system (SNS) and impairs parasympathetic reactivation, measured by slowing the heart rate to a resting value (Buchheit Laursen, & Ahmaidi, 2007). Elongated exhalations through breath practice can balance parasympathetic activity and help restore homeostasis (Zope & Zope, 2013; Brown & Gerbar, 2005). After 15 days of slow, yogic breath practice twice a day for 30 minutes, resting heart rate can significantly decrease (p<0.05). Slow breathing increases parasympathetic activity to balance the autonomic nervous system and reduces the sympathetic response to stress (Pal et al., 2004) When breath control is applied to trained subjects during incremental exercise up to exhaustion, significantly increasing expiration time (p<0.01) increases parasympathetic activity and time to exhaustion (p<0.05) (Zope & Zope, 2013; Brown & Gerbar, 2005; Matsumoto et al., 2011). This implies the important of breathing practice to benefit the autonomic nervous system during performance and at rest. Antioxidant function and parasympathetic reactivation is important in athlete recovery to sustain long or short term performance. Athletes need be aware of their stress and develop a recovery technique to maintain high levels of performance.
Background of Breathing Techniques and Practice

The foundation of all breathing techniques is proper use of the diaphragm. Diaphragmatic breathing (DB) involves full inspirations with controlled exhalations causing a rise and fall of the abdomen and lateral expansion of the lower ribs. The use and practice of DB results in optimal respiratory function and benefits for dysfunctional breathing, athletic performance, stress, and recovery (Garza & Ford, 2009; DiMarco et al., 2004; Hagman, Janson, & Emtner, 2011; Dawson et al., 2014; Khalsa, Shorter, Cope, Wyshak, & Sklar, 2009). Education on breathing, awareness of breathing patterns and DB instruction in different postures, have long term benefits for the respiratory system, promote increased physical function, and lessen breathing problems with exercise and stress (Hagman et al., 2008; Hagman et al., 2011). Those unfamiliar with deep breathing instructed to sit upright and concentrate on 5 second inhale and 5 second exhale at a rate of 6 breaths per minute can significantly increase breath holding time (BHT) (48.3±4.92 vs 53.57±5.7; p<0.001) after 3 months of practice for 10 minutes a day. Breath holding time can suggest adapted tolerance to O2 depletion and CO2 buildup in brain chemoreceptors. Longer breath holding supports significantly greater thoracic expansion (p<0.001), stretching pulmonary tissue, causing increased lung compliance and volume. This results in greater air flow, increased respiratory efficiency and reduced work of breathing (Ravi & Swamy, 2013; Pal et al., 2004; DiMarco et al., 2004).

Prolonged and expanded respiratory efforts are important to optimally utilize the respiratory system. Normally, inspiration is active while exhalation is passive causing potential expiratory weakness and an imbalance between sympathetic and
parasympathetic activity. When expiratory muscles are recruited and expiration is prolonged, the diaphragm is lengthened and the lower ribs are pulled down and in by the abdominal and intercostal muscles. This decreases thoracic volume and end-expiratory lung volume (EELV). With reduced EELV, the diaphragm is lengthened, like a muscle put on stretch, and greater elastic recoil from stored energy can be used for maximum force production on inhalation. Maximum inspiratory pressure is dependent on the diaphragms fiber length preceding contraction and maximum expansion will contribute to increased lung compliance and airflow (Romer & Polkey, 2008; Aliverti, 2008; Dominelli & Sheel, 2012). Significant limitations in inhalation or expiration can decrease lung compliance and increase the work of breathing and sensitivity to fatigue (Dominelli & Sheel, 2012).

Prolonged respirations of 2 second inhales and 4 second exhales during exercise to exhaustion can result in greater performance. A 1:2 ratio can increase time to exhaustion and work output than spontaneous breathing (213.6 ±7.7 vs 204.8±6.7 W; p<0.05) (Matsumoto et al. 2011). When expiratory rate increases (faster exhale), capillaries may collapse in the lungs. Controlling and slowing the exhale maintains open capillaries increasing the availability for blood and oxygen (Dominelli & Sheel, 2012). Prolonged respirations lead to increased air flow and lung compliance by stretching chest capacity. Over time, cost and work of breathing is minimized and exercise tolerance can increase (Harms et al., 2000; Enright et al., 2006). Slow exhalations also influence the respiratory sinus arrhythmia (RSA) to find autonomic balance during activity preventing unnecessary sympathetic responses (Zope & Zope, 2013; Brown & Gerbar, 2005; Pal et al., 2004).
Ways to accomplish prolonged respirations include Ujjayi and pursed lip (PLB) breathing. Both techniques control and tone the diaphragm through resistance created by muscle contractions of lips or throat (Nield et al., 2007; Bianchi et al., 2007). Ujjayi breathing uses light contractions of laryngeal muscles to create expiratory resistance and slowed exhalation. Practice results in increased diaphragmatic strength (Mooventhan & Khode, 2014). PLB creates resistance by exhaling through pursed lips. Cues to teach PLB include blowing slowly through a straw or flickering a candle flame without blowing it out (Nelson & Beach, 2012). Four weeks of PLB, in participants with shortness of breath (SOB), can result in lower Borg ratings to describe SOB episodes (p=0.05), and increases in physical function (p=0.02) (Nield et al., 2007). In the short term, PLB breathing can decrease EELV and increase inspiratory volume (p<0.05) (Bianchi et al., 2007) which maximizes diaphragm function (Romer & Polkey 2008) and exercise tolerance (Carbral et al., 2015). During PLB, inspiratory muscles have longer rest intervals between respirations and a decreased work load (Cabral, D'Elia, Marins, Zin, & Guimarães, 2015).

One study of trained athletes found significantly increased tolerance to exhaustive exercise and power output when PLB was performed during exercise at a 1:2 inhale to exhale ratio (p<0.05). Despite a decreased breathing rate, PLB increased tidal volume and O2 and CO2 exchange efficiency (p<0.01) (Matsumoto et al., 2011).

Diaphragmatic breathing (DB) can significantly reduce the magnitude of exercised induced oxidative stress after prolonged exercise. Five and 24 hours post exercise, 1 hour of DB can result in a significantly faster expulsion of metabolic waste (20.5% vs 5.9% expulsion; p<0.01) and higher biological antioxidant potential (BAP) compared to just resting alone (129% vs 114.2%; p<0.01). Cortisol is also lowered with
DB post exercise (p<0.05). It was concluded that exercise increases metabolic stress, and cortisol decreases oxidative defense. DB can increase BAP and decrease cortisol levels and oxidative stress (Martarelli et al., 2011).

DB is also used a psychological technique used to decrease muscle tension, and performance anxiety (Dawson et al., 2014). Four weeks of daily, diaphragmatic breathing can decrease symptoms of and increase control over pre-competition anxiety in D1 collegiate athletes (Garza & Ford, 2009). Deep breathing reduces anxiety/tension (p=0.019) and anger/hostility (p=0.008) in performers and provides control techniques to efficiently manage pre-performance anxiety (Khalsa et al., 2009). These results suggest diaphragmatic breathing education and practice can help improve performance under high pressure situations as well as improve quality of life, decrease stress and promote recovery.

Ancient Yogic breathing techniques, or pranayamas, are rooted in the activation of the diaphragm and promotion of health and wellness (Kjellgren, Bood, Axelsson, Norlander, & Saatcioglu, 2007). Daily practitioners show lower resting heart rates and blood lactate, greater work output per unit oxygen during exercise (p<0.05) and delayed aerobic thresholds and times to exhaustion. Post-exercise pranayama contributes to significantly lower respiratory rates, oxidative stress, cortisol and lactate levels compared to controls (p<0.05) (Raju et al., 1994; Martarelli et al., 2011). Full diaphragmatic inhalations and controlled exhalations cause physiologic oscillations to balance stress. Oscillations are cyclic, rhythms of the body that maintain homeostasis, regulating cardiovascular, hormonal, lymphatic, digestive systems. Cycles include stimulation and rest periods allowing the body to practice going from activation
to rest. Multiple systems can be synchronized with breath practice to prevent unnecessary energy expenditure due to unorganization (Courtney, 2009).

A comprehensive yogic breathing practice called Sudarshan Kriya Yogic Breathing (SKY) involves Ujjayi, Bhaskrika and Sudarshan Kriya breathing techniques. Ujjayi, or Victorious breath, involves laryngeal contraction, creating a slight sound and vibration to increase airway resistance. Respiration is brought under control of the practitioner and is elongated to 2-4 breaths per minute (Zope & Zope, 2013; Brown & Gerbarg, 2005). Ujjayi breath can increase oxygen saturation and baroreflex sensitivity as well as decrease blood pressure and anxiety in healthy participants unfamiliar with breathing techniques (Mason, Vandoni, deBarbieri, Codrons, Ugargol, et al., 2013). Ujjayi breath can also create circulatory system oscillations to balance blood pressure and the respiratory sinus arrhythmia (Courtney, 2009). It is common for sympathetic activity to be maintained greater than parasympathetic and can cause inhibited recovery from stress. Slow, Ujjayi breathing can balance this through oscillations increasing parasympathetic activity (Brown & Gerbarg, 2005; Pal et al., 2004; Zope & Zope, 2013; Courtney, 2009; Moser, Penter, Fruehwirth, & Kenner, 2006). Similar to Ujjayi, Bhramari pranayama, or “humming bee breath”, creates increased resistance through slow exhalations and light laryngeal contractions. Subjects instructed to “inhale through both nostril and then exhale to produce the sound of a humming bee”, 10 minutes a day for 2 weeks, showed significant increases in lung functions similar to results of a mechanical pulmonary training. Results were attributed to prolonged respiratory efforts, increased diaphragm strength, expansion of the thoracic cavity, and stretching of respiratory muscles to create optimal force production (Mooventhyan & Khode, 2014).
Bhastrika, or Bellows Breath, involves rapid inhale and exhale at 30 breaths per minute (Brown & Gerbarg, 2005; Zope & Zope, 2013). Bhastrika breathing is also described as active inhalation and slow exhalation at a rate of 12 breaths per minute for three, five minute intervals separated by 1 minute of rest and slow breathing (Telles, Yadav, Gupta, & Balkrishna, 2013). Bhastrika causes increased sympathetic activation from quick rapid breathing. PNS activation follows from rest and slow breathing causing calmness and alertness. In the long term, fast-breathing techniques do not change resting heart rate or autonomic response to exercise (Pal et al., 2004).

However when slow breath follows fast breath as in Bkastrika, it trains the cardiovascular, respiratory and neural systems by temporarily raising heart rate requiring the body to return to rest like exercise. Bhaskrika helps the body practice recovering after stimulation. (Brown & Gerbarg, 2005; Zope & Zope, 2013). Eighteen minutes of Bhastrika can significantly reduce incorrect impulsive reactions in an anticipatory response task (p<0.04) (Telles et al., 2013). This can improve task focus when external stimuli is present as in an athletic event, preventing uncoordinated movement in high pressure situations.

Sudarsshan kriya breathing is a technique that involves modulating breathing rate between slow, medium and fast. Instead of having external stressors control your reactions, SKY teaches the practitioner to control the body through the breath. (Fokkema, 1999; Brown & Gerbarg 2005; Zope & Zope, 2013). A comprehensive breathing program can have positive effects on the endocrine system by creating oscillations in the hypothalmus-pituitary-adreal axis essential for the fight or flight response and balance autonomic activity (Zope & Zope, 2013). Six weeks of practice It can significantly
reduce anxiety, depression (p<0.001) and overall stress (P<0.005) through the release of oxytocin, a factor depleted in depressed subjects (Fokkema, 1999). Breathing practice increases resilience to acute and prolonged physical stress through a decrease in cortisol levels and blood lactate levels at rest and after exercise (Vedamurthachar, Janakiramaiah, Hegde, Shetty, Subbakrishna, et al., 2006; Janakiramaiah, Gangadhar, Murthy, Harish, Shetty, et al., 1998; Sharma et al., 2008). It can also increase superoxidedismotase (SOD), an indicator of proper antioxidative function and a decrease plasma malondialdehyde (MDA), an indicator of oxidative stress (Chiplonkar & Agte, 2008; Sharma et al., 2008). Breath practice is an important factor for any athlete to maintain performance (Dupont et al., 2010).

**Applications to the Athlete and Proposed Guide**

Proper breath practice has many positive outcomes in maximum and submaximal exercise, untrained and trained subjects, and healthy and pathologically affected populations. A more efficient diaphragm and respiratory system is less sensitive to fatigue and allows increased exercise tolerance. Training can strengthen the diaphragm to create greater chest wall compliance, airflow in the lungs and breathing efficiency during exercise to accomplish greater work rates at less of an oxygen cost. (DiMarco et al., 2004; Harms et al., 2000; Guenette & Sheel, 2007; Romer & Polkey, 2008; Babcock et al., 2002). Proper control of breathing can also alleviate oxidative stress from physical or mental disturbance. Elongated exhalations cause parasympathetic balance and allow inspiratory muscles to produce maximal efforts. Elongated inspirations expand the chest wall and increase chest wall compliance. This contributes to decreased work of breathing
and increased recovery efficiency. Breath practice is also supported to reduce performance anxiety, depression, stress, dysfunctional breathing and asthma symptoms. It can increase general physical function, antioxidant defense, focus and recovery from exercise (Enright et al., 2006; Kapus & Usaj, 2012; Pal et al., 2004; Nield et al., 2007; Ray, et al., 2010; Seo et al., 2013; Zope & Zope, 2013).

It is evident that proper breathing has numerous benefits not only contributing to better health, but increased physical performance. This is especially relevant in the athlete population, thus the purpose of this project is to form an educational guide specifically for athletes to improve their breathing patterns. Athletes training at any training level, in any sport type will be able to benefit from the project outcomes. The guide will begin with education on basic anatomy and physiology of the respiratory system providing understanding of an internal body system. The next part of the guide will suggest breathing practices. The first practice will introduce the basic technique of diaphragmatic breathing. Through tactile stimulation and awareness, the athlete will awaken the diaphragm, build a foundation for deeper practice and elongate respirations. The guide will provide assistance to learn this through cues, biofeedback, visualizations, and positions of support. Four breathing techniques influenced by Yogic practices will next be introduced.

The guide will then apply breathing techniques sport specifically. The focus for the endurance athlete, will be to increase exercise tolerance through control and proper technique, decreasing sensitivity to fatigue, lactate buildup, RPE and pain perception during long duration, whole body exercise (Martarelli et al., 2011; Skenderi, Tsironi, Lazaropoulou, Anastasiou, Matalas, et al., 2008; Babcock et al., 2002; Romer &
Polkey, 2008). Application to the anaerobic athlete will focus on how breathing techniques can be applied to attenuate metabolic waste build-up to prevent performance decrements in repeated events by inducing oxygen replacement and parasympathetic activity (McGrawley & Bishop, 2015; Dupont et al., 2010; Mann et al., 2014). Application to the intermittent athlete will focus on maintaining concentration during high pressure events decreasing incorrect anticipatory actions (Telles et al., 2013). This becomes important in any situation where the athlete has to react to external stimuli and, for example, block a goal, throw a ball to moving targets, intercept an unexpected pass, or change direction. Timing considerations will also be made for the athlete whose nature of sport constrains breathing (i.e. swimmers). Breathing interventions can increase tidal volume, chest wall compliance, and gas exchange efficiency when breathing must be controlled (Kapus & Usaj, 2012). Application will also be made for the aesthetic performer who may not want abdominal bulging. The guide will continue with steps to breathing for recovery after exercise. It will then conclude with an explanation of how interoception can be created through breath practice and how current elite performers use breath practice to benefit performance.

With education and practice, a proper breathing routine can be applied to the athlete with consideration for constraints of the situation, goal of routine, and characteristics of the activity and practitioner. The outcome of the project will educate the athlete on proper breath function and how practice can aid in performance. This is important because most of the respiratory system is internal and therefore invisible to the eye. With education, the athlete can become aware of their breathing and how they can improve it to maximize sport performance.
Methods

The breathing guide begins with an activity explained by Ungerleider (2005) to call attention to the respiratory system as follows: Take a deep breath in and hold it for 30 seconds. Create and notice tension in the shoulders, neck and upper back. Release and repeat this three times. How do you feel? Is this a state in which you want to remain? Is this a state in which you want to exercise? A goal of this guide is to teach athletes how to control this feeling and create a better internal environment for athletic performance. The first section explains basic respiratory function. It gives visuals to the main respiratory muscle, the diaphragm, as a sheet-like muscle, domed at rest, inserting on the inside of the ribs and lumbar vertebra from “nipple to navel” (Kaminoff, 2012, p.7). A diagram portrays respiration caused by diaphragm contraction as plunger-like, as it flattens and pulls down toward the abdominal cavity on the inhale and domes back to rest on the exhale. The lower ribs out from the midline of the body (Poole, Sexton, Farkas, Powers, Reid, 1997). Expiratory efforts form the intercostal and abdominal muscles are not pictured however, their function (Poole et al., 1997; Jerath, Edry, Barnes & Jerath, 2006), is detailed later in the guide.

The introduction section of the guide also provides reasoning behind practicing the breathing as well as key tips to remember to gain maximum benefits. Reasons to practice include, strengthening the respiratory system, increasing flexibility and capacity of lungs, maintaining control through stressful or pressured situations and supporting recovery efficiency. These are all goals appealing to athletes to improve athletic performance (Zope & Zope, 2013; Telles, Yadav, Gupta, Balkrishna, 2013; Martarelli,
Cocchioni, Scuri & Pompei, 2011; Enright, Unnithan, Heward, Withnall & Davies, 2006; Harms, Wetter, Croix, Pegelow & Dempsey, 2000; Romer & Polkey, 2008). Key tips for practice focus on, patience, awareness and consistency, not forcing anything and finding an individual practice is emphasized (Hagman, Janson & Emtner, 2011; Khan, Admed, Choi & Gutierrez-Osuna, 2013; Ungerleider, 2005). The remaining sections build on the introduction to educate athletes on basic breathing techniques, breath manipulation, best breath practice for specific exercise and breath for recovery.

Part 1: Diaphragmatic Breathing

The diaphragm is the foundation of deep breathing and respiratory strength. It can voluntarily control a habitual process caused by chemoreceptors in the brain. Because of this, it is important for the practitioner to remember that bringing the respiratory system under voluntary control may feel uncomfortable initially. Learning a new breathing pattern takes education and conscious practice before it becomes natural (Henderson, 2005). Breath training begins with simply noticing a smooth, consistent flow of air (Hourani, Kizakevich, Hubal, Spira, Strange et al., 2011; Ungerleider, 2005) creating awareness of the respiratory system. The practitioner should feel the belly, bellow the ribs and above the navel, and low ribs expand on the inhale. Visualize the diaphragm being reeled down and out toward the navel. On the exhale, the diaphragm relaxes, the belly retreats and air slowly releases.

Once comfortable with the basic pattern, the next step is to deepen inspirations, emphasize slow exhalations and retain the breath for a second at the end of each cycle (Hourani et al., 2005). Ungerleider (2005) provides a deepening technique collegiate DI
athletes have used to increases performance on and off the field (Ford & Garza, 2009):

Imagine the lungs and chest cavity in three sections: lower, middle and upper. First, imagine filling the bottom third of the lungs by pushing out on the diaphragm, stretching it to its max, opening the abdomen. Exhale. Next, fill the middle third through rib cage expansion in all directions. Exhale. Last, fill the top third by expanding the upper chest, shoulders and collarbone. Exhale. On each exhale emphasize pulling the abdominal muscles in and up to expel stale air. Visualize the airflow and release of tension throughout this practice. Repeat these steps and work up to 30-40 deep breaths a day (Ungerleider, 2005).

After stretching lung capacity, the next step is to elongate the breath. An equal, five second inhale to exhale ratio is best to begin with (Mason, Vandoni, deBarbieri, Codrons, Ugargol, et al., 2013). Ten minutes at this ratio can improve lung function and physiology (Ravi & Swamy, 2013). Take a deeper inhale into the abdomen and ribs then hold the breath for a second at the top. Begin to control the exhale by slightly pursing the lips or contracting the throat (this technique described later in detail). The abdominals and intercostal then maximally compress the lungs and chest cavity. Repeat this process with an equal inhale to exhale ratio or with a longer exhale.

The guide provides a page of tips to aid DB practice. Increasing time and frequency of DB practice increases the maximum benefits (Ungerleider, 2005; Sivakumar, Prabhu, Baliga, Pai, Manjunatha, 2011; Ravi & Swamy, 2013). However, the target audience of collegiate athletes may feel strained to add something else to the day. Cues can be set as reminders to check the breath a few times during the day. Five deliberate breaths allow technique, depth and pace awareness. This will incorporate
proper breath and practice into a busy daily life. Visualization and biofeedback can help those having difficulties with DB. Visualizations include “emphasize abdominal movement, keeping shoulders relaxed”, “see air filling the abdomen from the bottom up, like a glass of water or a balloon, then emptying” and “push out and flatten the diaphragm then allow it to retreat into the ribs” (Hourani et al., 2011; Henderson, 2005; Ungerleider, 2005). Resting the dominant hand over the diaphragm below the ribs, and the non-dominant hand on the upper chest adds biofeedback to differentiate between abdominal and chest movement. Both hands on the lower ribs with fingers facing in toward the midline sense lateral rib motion. A light object such as a tissue box resting on the abdomen also creates biofeedback (Henderson, 2005).

If difficulties arise during breathing, research suggests certain positions to support breath and diaphragm movement. Sitting or standing leaning forward with arms resting on a level surface or upright sitting with arms supported by a pillow, allow gravity to assist the diaphragm and prevent fatigue (Henderson, 2008). A semi-relined or supine position is also practiced.

**Part 2: Breath Manipulation**

The next section presents breath exercises to strengthen respiratory muscles, train the autonomic nervous system and increase control. Important considerations include pace, inhale to exhale ratio and resistance. Common yogic pranayama techniques are the primary source of exercises (Mooventhavan & Khode, 2014; Raju, Madhavi, Prasad, Reddy, Reddy, et al., 1994; Pal, Velkumary, Madanmohan, 2004; Zope & Zope, 2013).
Deeper inhalations increase the ability to expand the lungs under increasing amounts of CO2 buildup while elongating exhalation balances autonomic nervous stimulation and tones the diaphragm. Retaining the breath after inhalation or exhalation further slows the breath and accustoms the body to changing O2 and CO2. Purposeful control over these processes creates control of the whole body (Kapus Usaj, & Lomax, 2013). Begin with an equal 5-second inhale to exhale ratio, progressively elongating the exhale. Eventually, reach a 1:2 ratio to achieve greater gas exchange despite a lower breathing rate (Matsumoto, Masuda, Hotta, Shimzu Ishii et al., 2011).

Pursed lip, ujjayi, and Bharmari yogic breathing accomplish prolonged and resisted breathing (Raju et al., 1994; Zope& Zope, 2013; Neild, Hoo, Roper, Santiago, 2007). Pursed lip breathing involves exhaling slowly with contacted lips. Imagining exhaling through straw, pushing air out, or blowing a candle flame without putting it out (Nelson & Beach, 2012; Neild et al., 2007). Ujjayi and Bharmari breathing use laryngeal contraction and the sensation of the breath on the back of the throat to produce the sound of a humming bee or ocean waves during exhalation (Mooventhan & Khode, 2014; Zope & Zope, 2013). The practitioner should begin with an easy pace and then progressively increase exhale time as the technique becomes comfortable. Rates of 4-6 and 2-4 breaths per minute produce physiologic benefits (Mason e al., 2013; Courtney, 2009; Ungerleider, 2005; Ravi & Swamy, 2013).

Increasing breath pace does not change long-term autonomic function but produces benefits through sympathetic nervous system (SNS) control (Pal, et al., 2004). During bhastrika breathing, the practitioner increases breathing rate to 30 breaths per minute followed by a period of elongated exhales. The guide presents the technique as
done by Veerabhadrappa, Baljoshi, Khanapure, Herur, Patil, et al., (2011). SNS stimulation may cause mildly stressful feelings however, stable cortisol levels during practice concludes a stressful situation is not experienced. Mental steadiness and focus is felt instead (Zope & Zope, 2013). Three, 5 minute intervals of fast breathing separated by 1 minute of slow breathing causes less incorrect impulsive reactions to stimuli (Telles et al., 2013) better preparing athletes to make decisions in a rapidly changing environment. This techniques is presented last as it is considered a more advanced technique (Zope & Zope, 2013).

It is important to remember that the benefits of breathing practice increase progressively with time (Khan et al., 2013; Mason et al., 2013; Hagman et al., 2011). Many research protocols involve an intervention 3 weeks or longer to see significant results. However, studies investigating acute effects or shorter intervention protocols see consistently increasing benefits after a few minutes (Jerath et al., 2006; Pal et al., 2004; Telles et al., 2013; Martarelli, et al., 2011).

Part 3: Breathing During Sport Activity

Athletic performance benefits from respiratory efforts specifically by focusing on exhaling during activity (Matsumoto et al., 2011). As physical demand increases, O2 use and CO2 production increases. Carbon dioxide stimulates the brain’s breathing control center and the body feels “out of breath”. Instinct causes inhalation for more oxygen. Without exhalation, inhalation is limited and carbon dioxide continues to build. Exhaling motivates physiologic balance (Nelson & Beach, 2012). Allow the inhale to initiate and continue with proper technique (abdominal and rib expansion), then balance it out with
an equal or longer exhale (Kaminoff, 2012, p. 3). Breathing however will respond involuntarily to increased demands. Allowing the breath to flow and fluctuate as needed is important to match metabolism and exercise intensity (Haouzi, 2014).

It is important for athletes to recognize the position they are in most and practice breathing there. Cyclists sit with a flexed torso, runners maintain an erect but moving posture, batters and throwers may find themselves in a spinal twist, whereas swimmers’ breathing is restricted to the water. Spend conscious attention during sport practice to integrate a flow of breath with movement. This will help achieve positional efficiency of the breath and further increase internal body awareness, a factor seen in elite athletes (Nelson & Beach, 2012; Paulus, Flagan, Simmons, Gillis, Kotturi et al., 2012). Next, the guide provides strategies for athletes to best utilize the breath for their sport specific goal. This part focuses on goals of endurance, anaerobics, focus, timing and aesthetics.

Endurance athletes typically maintain a level of repetitive movement making it their homeostasis for an extended period. This allows the athlete to meditate on the breath to increase focus. A steady flow of activity calls for a steady flow of breath to meet metabolic needs. Allow the breath to fluctuate with exercise intensity (Haouzi, 2014). First, reach an equal ratio of breath to match activity. Allow inhaled to initiate, continue with proper form then balance with controlled exhales. After reaching a steady flow, elongate each exhale further. A 2 to 4 second inhale to exhale ratio increases exercise tolerance and avoids unnecessary rises in heart rate and blood pressure (Matsumoto et al., 2011). The athlete may try to deepen the inhale and elongate the exhale as much as possible or allow breathing rate to rise to practice bringing it back under control (Kaminoff, 2012, p. 3)
After an anaerobic event, oxygen is depleted and the PNS is impaired. This athlete must balance SNS and PNS to recover (Buchheit, Laursen & Ahmaidi, 2007). At the end of an event, notice, allow, deepen then lengthen the breath as in part one, keeping in mind that intense physiology of the body at this point may cause distress. The athlete should immediately focus on the breath to balance the inhale to exhale ratio. Gentle pursed lips or laryngeal contraction can help slowly equalize the breath. Do not expect rest after 1 inhale and exhale. Allow inhalation to initiate and continue with proper technique and maximal expansion. Balance it with an equal or longer exhale (Kaminoff, 2012, p. 3) over many cycles. Use a supported position if there is difficulty slowing the breath for gravity to help support the respiratory system (Henderson, 2008).

When a sport is intermittent, for example, short volleyball or tennis point sets, it may be easy to become distracted. Time preparing for a certain task can put an athlete under pressure and cause choking. Take at least 1-3 deep breaths focusing on a sport task during “off” time to keep calm and focus. Use Bhastrika breathing here, while steadying the mind on a task to find control, regain focus and prevent impulsive anticipatory actions (Telles et al., 2013; Zope & Zope, 2013; Veerabhadrappa et al., 2011). Find an appropriate timing to do this that works in the context of the sport. For example, a baseball player going up to bat may do this before leaving the dugout and continue slow controlled breathing as he steps to the plate.

Integrating timing of breath and movement becomes important when an athlete’s breathing is constrained by an external factor, for example, water. Time the exhale to be most complete right before emerging to inhale to support the most powerful and efficient inhale (Courtney, 2009). Practice timing outside the water to get a pattern to feel natural.
Breath timing for performing arts is important in that inhalation directly relates to upper body extension and exhalation with flexion (Kaminoff, 2102, p. 6, 25). Techniques for aesthetic performers follows.

Some athletes, like dancers or gymnasts have an added aesthetic expectation of their sport. Abdominal bulging during a routine may be unwanted. Here, rib expansion should be the focus. This type of breathing may increase the work of breathing at first but with time increased compliance and flexibility will cause a training effect to decrease load and intercostal breathing alone become efficient (DiMarco, 2004; Courtney, 2009).

Practice keeping the transverse and rectus abdominus contracted while expanding lateral ribs, still keeping in mind diaphragm movement (second step of the Ungerleider breathing technique). At the end of the exhale, contract the core in more relaxing the ribs down. Practice integrating breath flow with movement as it feels best for the individual. For example, spinal extension or expanding movements connect with inhalation and spinal flexion or contracting movements, with exhalation (Kaminoff, p 6, 25). The practitioner should send time practicing breath integration during a routine just as a musician practices breath timing with a wind instrument.

**Part 4: Recovery**

Breathing techniques aid in the recovery process by activating the parasympathetic nervous system, decreasing muscle tension, attenuating metabolic waste and increasing the body’s antioxidant defense potential.

Deep breathing can significantly increase pulmonary function and influence recovery after only two minutes (Sivakumar et al., 2011; Ravi & Swamy, 2013) with
positive effects consistently increasing with time. An extended period (1 hour) of conscious DB after exercise causing oxidative stress, will benefit an athlete 24 hours after recovery by removing more reactive oxidative metabolites (ROMs) and increasing antioxidant potential, more so than resting alone. It also significantly reduces cortisol and increases melatonin (a strong antioxidant) levels immediately and 24 hours after (Martarelli et al., 2011). The focus in this section is on basic DB. First, slow the breath to a natural pace. It may be beneficial to first practice Bhashrika breathing to contrast stimulation with relaxation, creating more awareness. After Bhashrika, continue with DB for as long as possible. Deepen inhales, mentally initiating relaxation. Elongate exhales, visualizing tension releasing (Ungerleider, 2005). The guide instructs athletes to DB for at least 2-10 minutes but for as long as possible after exercise for maximum benefits (Nelson & Beach, 2012). Forty breaths at 4-6 per minute is suggested for recovery (Hourani et al., 2011; Courtney, 2009). Use a supported position for increased respiratory support especially if an athlete experiences breathlessness after exercise. This section includes steps and tips from Hourani et al., (2011) to receive maximum recovery benefits.
Conclusion

The guide concludes with an explanation of interoception and examples from elite athletes using the breath, for real life integration of successful breathing practice. Along increased exercise capacity and resilience to physiologic stress (Zope & Zope, 2013; Enright et al., 2006; Mooventhen et al 2014), mastery of the respiratory system also creates interoception. Interoception is the ability to sense the internal physiology of the body and motivate actions to maintain an internal homeostasis. This is not “rest” necessarily but a dynamic balance between external demand and internal actions to remain functional even in extreme situations. It requires ongoing evaluation of the immediate situation. Breathing requires internal evaluation of the body’s needs to initiate the appropriate action for balance within the environment. If accomplished, the brain can adapt to perceive challenging situations as less challenging and better match anticipated expectations with physical actions. Elite performers including military SEALs show profound interoception through better control over extreme physical/mental challenges while continuing to perform (Paulus et al., 2012). Some advanced yoga practitioners can manipulate their metabolism from one, to more than 230 breaths per minute, increase carbon dioxide expulsion by over 300% and alter oxygen consumption by 60%. Advanced free divers can obtain the ability to dive up to 10 minutes using breath control (Tyagi & Cohen, 2013). Instead of allowing external stimuli to control the state of the body, breath control reverses this, allowing the practitioner to control the emotional and physical state of the body despite the external environment (Zope & Zope, 2013).
The guide presents tools for any athlete to use in and out of sport. However, it may be limited by the absence of live instruction. The target audience must rely on the individual reading and comprehension of the guide. This possible limitation was intended in order to provide an opportunity for self-efficacy in the athlete. A potential way to balance live instruction with self-learning would be to provide a workshop to initially explain and demonstrate the guide. This would provide opportunity for clarification and deeper explanation of techniques. Then the athletes would continue to practice independently. Further research will include testing for practitioner outcomes. Pre and post practice surveys using quality of life, stress, RPE, and exercise tolerance measures will give insight into subjective outcomes. Heart rate, breathing rate, hormones, metabolites, exercise tolerance and lung function measures may be used for pre and post objective outcomes. Future studies may measure outcomes in the short, as well as the long term to measure acute versus habitual effects. There is also opportunity to condense the presented information in to a “pocket guide” or poster presentation for display and quick reference.

Exercise, sport, physical activity or whatever its name, requires increased energy production and a sense of mind/body awareness especially when performed at an elite level. When the respiratory system strengthens and stretches, it functions optimally to create control and awareness for the invisible key to athletic success.


