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The Buteyko Breathing Technique in Sports and Exercise: Physiological Mechanisms, Performance Outcomes, and Future Directions

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Abstract: Background: The Buteyko Breathing Technique (BBT) is a breathing-retraining method originally developed for respiratory disorders that has recently attracted interest as a complementary strategy in sports and exercise science.
Objective: This narrative review critically examined the physiological mechanisms underlying BBT and its effects on pulmonary, cardiovascular, and performance-related outcomes in physically active and athletic populations, and identified methodological limitations and future research priorities.
Methods: A critical narrative thematic review was undertaken by synthesizing evidence from PubMed, Scopus, Web of Science, SPORTDiscus, and Google Scholar, with emphasis placed on randomized controlled trials, systematic reviews, and experimental studies relevant to sports, exercise physiology, and respiratory physiology.
Results: BBT primarily improves functional aspects of breathing—breathing control, respiratory rate, breathing awareness, and perceived exercise tolerance—rather than conventional pulmonary function indices such as forced vital capacity, forced expiratory volume in one second, or the FEV_1/FVC ratio. Preliminary evidence suggests possible benefits for aerobic endurance, exercise tolerance, and recovery, but evidence for gains in maximal aerobic capacity, anaerobic performance, strength, or elite performance remains weak. The literature is limited by small samples, heterogeneous protocols, and a predominance of clinical rather than athletic cohorts.
Conclusion: BBT is a promising complementary breathing intervention for improving breathing behaviour and exercise tolerance, but current evidence does not support its use as a stand-alone performance-enhancing strategy. Well-designed randomized controlled trials in athletic populations, using standardized protocols and sport-specific outcomes, are required.
Keywords: Buteyko breathing technique; breathing retraining; sports science; exercise physiology; respiratory function; aerobic endurance; athletic performance.

I. INTRODUCTION

Respiration sustains aerobic metabolism by coupling oxygen uptake to carbon dioxide elimination, and the respiratory, cardiovascular, and neuromuscular systems act together to meet the rising metabolic demands of exercise (Welch et al., 2019). The respiratory system was long assumed to hold sufficient reserve to rarely limit performance in healthy individuals, so exercise-science research concentrated on cardiovascular and muscular adaptations. This view has since been revised: at moderate-to-high intensities, the work of breathing rises sharply, respiratory muscle fatigue can develop, and activation of the respiratory muscle metaboreflex diverts blood flow away from locomotor muscles, compromising performance (Welch et al., 2019; Harms et al., 2000; Romer & Polkey, 2008). Breathing is therefore increasingly regarded as a modifiable, trainable component of performance rather than a purely involuntary background process; voluntary manipulation of breathing frequency, tidal volume, and route has been shown to affect autonomic activity, gas exchange, and psychological responses to exercise (Migliaccio et al., 2023; Nicolò et al., 2023).

Several breathing strategies have been investigated in sport. Inspiratory muscle training (IMT) reliably improves inspiratory muscle strength and exercise tolerance (Cirino et al., 2023), although the magnitude of benefit depends on training status and loading protocol, and its underlying mechanistic basis has recently been questioned (Rodrigues & McConnell, 2024).

Diaphragmatic, paced, rhythmic, and nasal breathing have also drawn interest for their autonomic and psychological effects, although evidence quality remains heterogeneous. Nasal breathing in particular is proposed to aid humidification, endogenous nitric-oxide production, and carbon dioxide (CO_2) tolerance, though its benefits during high-intensity exercise—where ventilatory demand exceeds nasal airflow capacity—remain inconsistent (Migliaccio et al., 2023).

The Buteyko Breathing Technique (BBT), developed in the 1950s by Konstantin Buteyko (Buteyko, 1991), is grounded in the hypothesis that chronic hyperventilation lowers arterial and alveolar CO_2 below its optimal physiological range, impairing oxygen unloading to tissue via the Bohr effect (Bruton & Lewith, 2005; West, 2021). A typical programme combines nasal breathing, diaphragmatic breathing, reduced-volume breathing, breath-hold assessment (the Control Pause), relaxation, and breathing-awareness training. BBT has been most extensively studied in asthma, where reviews report improved symptom control and reduced bronchodilator use with little corresponding change in spirometric indices such as FEV_1 (Burgess et al., 2011; McHugh et al., 2003)—suggesting that its principal effect is on breathing behaviour rather than lung structure.

Despite growing interest among athletes and coaches, no thematic synthesis has integrated the mechanistic, physiological, and performance-related evidence on BBT specifically for healthy and athletic populations; existing reviews focus on clinical effectiveness, and sport-relevant findings remain scattered across respiratory physiology, exercise science, and sports medicine. This review therefore aimed to critically evaluate the physiological mechanisms underlying BBT and its effects on pulmonary, cardiovascular, and performance outcomes in physically active individuals and athletes, and to identify methodological limitations and priorities for future research.

II. METHODS

This study was conducted as a critical narrative thematic review, designed to critically synthesize and interpret the current evidence regarding the Buteyko Breathing Technique (BBT) within the context of sports and exercise science. Unlike a systematic review, which aims to comprehensively identify and quantitatively synthesize all eligible evidence using predefined protocols, a critical narrative thematic review allows the integration of findings across multiple disciplines to develop conceptual understanding, evaluate physiological mechanisms, identify methodological limitations, and highlight future research priorities (Grant & Booth, 2009). Accordingly, the present review emphasizes critical interpretation and thematic synthesis of the literature rather than exhaustive study identification or quantitative meta-analysis.

Evidence was identified through a targeted search of major biomedical, sports science, and health-related databases, including PubMed, Scopus, Web of Science, SPORTDiscus, and Google Scholar. Additional relevant publications were identified through manual screening of reference lists from key review articles and primary research studies to ensure comprehensive thematic coverage of the available evidence.

Studies were considered eligible if they were published in English in peer-reviewed journals and investigated the Buteyko Breathing Technique or standardized breathing retraining interventions relevant to sports, exercise physiology, respiratory physiology, or human performance. Clinical studies were included when they contributed to understanding physiological mechanisms or informed the interpretation of potential athletic applications. Conference abstracts, editorials, opinion articles, and non-peer-reviewed sources were excluded wherever possible.

Because this review was narrative rather than systematic, a formal risk-of-bias assessment was not undertaken. Nevertheless, methodological quality was considered throughout the evidence synthesis. Greater interpretative weight was assigned to randomized controlled trials, systematic reviews, meta-analyses, and well-designed experimental studies, whereas findings from observational studies, preliminary investigations, and mechanistic hypotheses were interpreted more cautiously. Particular consideration was given to study design, sample size, intervention standardization, participant characteristics, outcome relevance, and consistency of findings across studies when formulating conclusions.

III. PHYSIOLOGICAL MECHANISMS OF THE BUTEYKO BREATHING TECHNIQUE

BBT is theorized to act on breathing behaviour rather than lung structure, through several interrelated mechanisms. Central to its rationale is carbon dioxide tolerance: CO_2 regulates blood pH, respiratory drive, cerebral blood flow, and—via the Bohr effect—the unloading of oxygen from haemoglobin to active tissue (West, 2021). Habitual overbreathing is proposed to depress CO_2 below its optimal range, and BBT's reduced-volume, nasal-breathing exercises aim to restore CO_2 tolerance and slow ventilation. This hypothesis remains debated, but there is broader agreement that breathing pattern can influence ventilatory efficiency and respiratory comfort, particularly in individuals with dysfunctional breathing (Bruton & Lewith, 2005; West, 2021).

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Reduced respiratory muscle workload constitutes a second proposed mechanism. Unlike inspiratory muscle training, which strengthens the inspiratory muscles against external resistance, BBT imposes no such loading; instead, its emphasis on diaphragmatic breathing, nasal breathing, and reduced breathing frequency may lower unnecessary respiratory muscle activation. Evidence supporting this pathway remains largely inferential, drawn from IMT and respiratory-muscle-training literature rather than BBT-specific trials (Cirino et al., 2023; Rodrigues & McConnell, 2024).

Slow, nasal, diaphragmatic breathing is also linked to autonomic nervous system regulation, with increased vagal activity and reduced sympathetic outflow reported after slow-breathing interventions more broadly (Jerath et al., 2015; Noble & Hochman, 2019). In athletes, improved autonomic balance could plausibly support cardiovascular efficiency and post-exercise recovery, although direct BBT evidence in athletic samples is limited; most supporting data derive from slow diaphragmatic or yoga-based breathing rather than standardized BBT protocols.

Breathing economy—the ability to sustain adequate ventilation at minimal metabolic cost—provides a further plausible mechanism. Rapid, shallow breathing increases the mechanical and metabolic cost of ventilation without improving gas exchange, whereas slower, diaphragmatic breathing may reduce this cost and improve respiratory–locomotor synchrony during rhythmic exercise (Phillips & Stickland, 2019; Migliaccio et al., 2023). These adaptations are proposed to enhance exercise tolerance by reducing dyspnoea, respiratory discomfort, and perceived effort, allowing longer submaximal exercise duration even without measurable change in pulmonary function.

Overall, the strongest physiological rationale supports effects on breathing behaviour and economy, whereas evidence for respiratory-muscle and autonomic adaptations specific to BBT—as opposed to breathing retraining generally—remains preliminary, and several mechanistic claims, particularly around CO_2 regulation, are extrapolated from broader breathing research rather than confirmed in BBT-specific trials (Figure 1).

A critical distinction should be made between the Buteyko Breathing Technique and other commonly investigated breathing interventions. Inspiratory Muscle Training (IMT) primarily improves inspiratory muscle strength through external resistive loading, whereas BBT focuses on modifying breathing behaviour through reduced ventilation, nasal breathing, diaphragmatic control, and breathing awareness. Likewise, diaphragmatic breathing, paced breathing, yoga-based breathing, and isolated nasal breathing each target specific physiological pathways but do not constitute equivalent interventions. Consequently, physiological adaptations reported following these approaches should not be assumed to represent direct evidence for the effectiveness of BBT. Throughout the present review, evidence derived specifically from standardized BBT interventions was prioritized, while findings from other breathing modalities were used primarily to provide physiological context and support mechanistic interpretation.

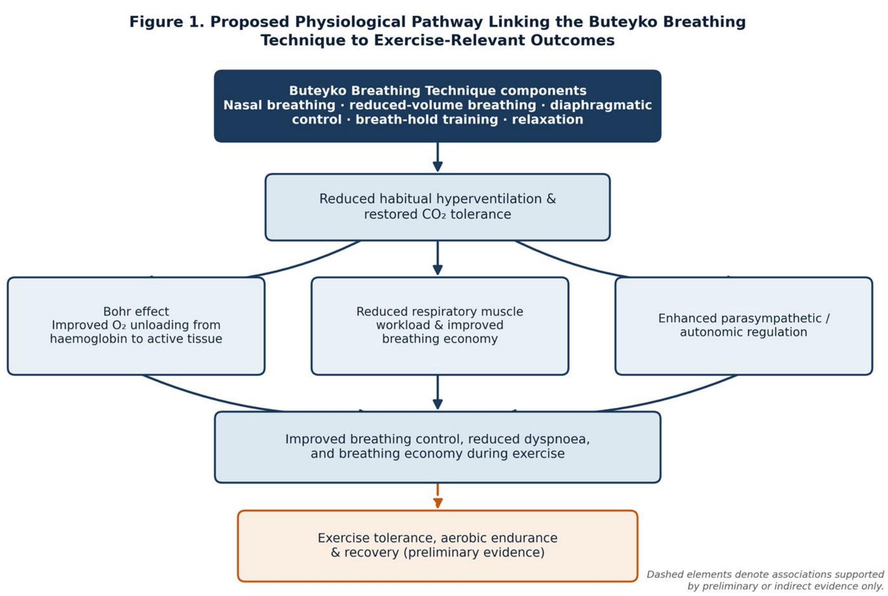

Figure 1. Conceptual model illustrating the proposed physiological pathways through which the Buteyko Breathing Technique may influence respiratory control, autonomic regulation, breathing economy, and exercise tolerance. Solid arrows represent mechanisms supported by direct evidence, whereas dashed arrows indicate pathways supported primarily by indirect or preliminary evidence.

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IV. EFFECTS ON PHYSIOLOGICAL AND PERFORMANCE PARAMETERS

Table 1 summarizes the available evidence across the physiological and performance domains investigated in relation to BBT.

A. *Pulmonary function*

Across both clinical and healthy populations, BBT produces minimal or non-significant change in forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio (Bruton & Lewith, 2005; Burgess et al., 2011; McHugh et al., 2003), consistent with a mechanism centred on breathing behaviour rather than lung structure. Because healthy individuals typically already show normal spirometry, there is limited physiological scope for further improvement. Peak expiratory flow rate appears somewhat more responsive, with modest but inconsistent gains reported in asthma cohorts and sparse data in healthy athletes (Burgess et al., 2011).

B. *Respiratory and cardiovascular parameters*

Reductions in resting respiratory rate are among the most consistently reported adaptations following BBT, plausibly reflecting reduced dead-space ventilation and improved tidal-volume utilization, although comparisons during standardized exercise in athletes remain scarce. Peripheral oxygen saturation shows little change, as expected given that healthy individuals already operate near-maximal resting saturation. Evidence for improved respiratory muscle endurance is inferential rather than direct, since BBT, unlike IMT, involves no resistive loading. Modest reductions in resting heart rate have been reported following slow-breathing interventions broadly, attributed to enhanced parasympathetic activity, though changes during maximal exercise are negligible and appear largely independent of breathing modality. Breathing-exercise meta-analyses report significant reductions in systolic and diastolic blood pressure, but evidence specific to BBT—rather than slow breathing generally—remains scarce, and healthy athletes with already-normal resting blood pressure have limited scope for improvement (Powers & Howley, 2021).

C. *Aerobic capacity and physical performance*

Small intervention studies report modest gains in VO_2max, aerobic endurance, or exercise tolerance following structured BBT programmes; a recent narrative review of 18 studies concluded that BBT shows promise for aerobic capacity but is limited by small samples and protocol heterogeneity (Patra et al., 2025). Because endurance performance can improve through reduced perceived exertion and better pacing even without a rise in VO_2max, aerobic capacity should not be treated as the sole performance indicator. In contrast, evidence for anaerobic performance, muscular endurance, and objective (as opposed to perceived) fatigue resistance remains sparse to absent, consistent with BBT's mechanistic emphasis on ventilatory rather than metabolic or neuromuscular pathways. Preliminary support exists for a role in post-exercise recovery via parasympathetic activation, though direct BBT trials are lacking, and no sport-specific evidence currently supports BBT as a routine performance-enhancing intervention in competitive athletes.

Table 1. Evidence synthesis of physiological and performance outcomes following Buteyko Breathing Technique interventions.

Domain	Parameter	Typical finding	Evidence strength
Pulmonary function	FVC	Minimal or non-significant change	Low
	FEV_1	Minimal or non-significant change	Low
	FEV_1/FVC ratio	Minimal or non-significant change	Low
	PEFR	Modest gains reported, inconsistent	Low–moderate
Respiratory function	Respiratory rate	Consistent reduction at rest	Moderate
	SpO_2	No meaningful change (ceiling effect)	Low
	Respiratory muscle endurance	Plausible; largely inferential	Low

Domain	Parameter	Typical finding	Evidence strength
Cardiovascular	Resting heart rate	Modest reduction (not BBT-specific)	Low–moderate
	Blood pressure	Reductions reported for breathing exercises generally; BBT-specific data scarce	Low
Performance	VO_2max / aerobic capacity	Modest gains in small studies	Moderate (preliminary)
	Aerobic endurance / exercise tolerance	Promising improvement	Moderate (preliminary)
	Anaerobic performance	Insufficient evidence	Very low
	Muscular endurance	Indirect effects only	Very low
	Fatigue resistance (perceived)	Possible benefit	Low
	Fatigue resistance (physiological)	No supporting evidence	Very low
	Post-exercise recovery	Plausible via autonomic regulation; direct evidence lacking	Low
	Competitive / sport-specific performance	No supportive evidence	Very low

V. PRACTICAL APPLICATIONS

Although evidence in athletic populations remains limited, several applications are supported by physiological rationale and preliminary data. BBT appears best suited to endurance disciplines (distance running, cycling, rowing, swimming, triathlon), where breathing efficiency contributes substantially to sustained performance, and to recovery contexts, where slow nasal/diaphragmatic breathing (5–10 minutes, seated or supine) may support the shift from sympathetic to parasympathetic dominance after training or competition. In intermittent team sports, BBT may assist breathing awareness and recovery between efforts rather than in-game performance, for which direct evidence is absent.

In strength and power sports, current evidence does not support using BBT to enhance maximal force, power, or sprint performance; breathing exercises are better positioned for cool-down and psychological regulation, and coaches should avoid imposing breath control during maximal lifts, where intra-abdominal bracing takes priority. In precision sports (e.g., shooting, archery, golf), a role in attentional and arousal regulation is plausible but currently speculative. Athletes with dysfunctional breathing patterns are likely to derive the greatest benefit, given the stronger evidence base in populations with baseline breathing impairment (Table 2). Across all contexts, BBT is best implemented as a long-term, adjunctive behavioural intervention integrated within—rather than substituting for—established endurance, strength, and psychological-skills programming, with pre-competition use limited to establishing breathing control rather than inducing fatigue. Figure 2 summarizes how these proposed mechanisms translate into practical domains, graded by current strength of evidence.

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Figure 2. Translation of Proposed BBT Mechanisms into Practical Application Domains

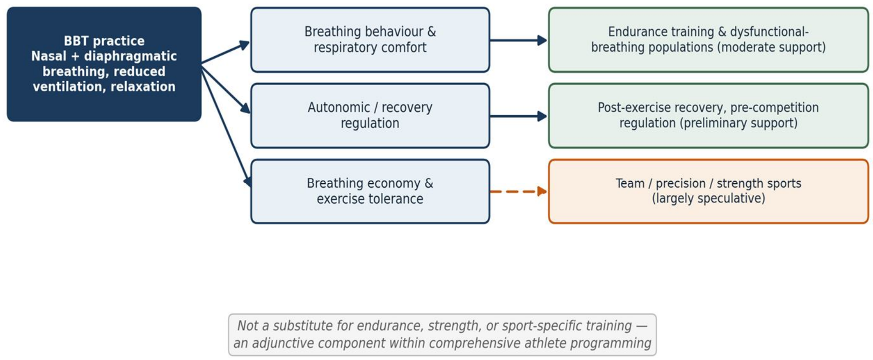

Figure 2. Translation of proposed BBT mechanisms into practical application domains, graded by current strength of evidence.

Table 2. Practical recommendations by athlete population

Population	Recommendation	Strength of evidence
Healthy recreationally active adults	May incorporate BBT as a complementary breathing strategy	Moderate
Endurance athletes	Potentially beneficial during low- and moderate-intensity training	Moderate
Team-sport athletes	May assist recovery and breathing awareness between efforts	Limited
Strength and power athletes	Primarily useful for recovery and relaxation, not performance	Limited
Athletes with dysfunctional breathing	Likely to derive the greatest benefit	Moderate to strong
Elite athletes	Individualized implementation recommended until stronger evidence is available	Limited

BBT should be introduced progressively and under qualified supervision in individuals with respiratory disease or cardiovascular instability, and should not replace established medical or sport-specific training interventions.

VI. DISCUSSION

The overall pattern of evidence indicates that the Buteyko Breathing Technique (BBT) is more likely to modify **breathing behaviour** than pulmonary or cardiovascular structure. Conventional spirometric indices, including FVC, FEV_1, and the FEV_1/FVC ratio, generally remain unchanged, whereas reductions in respiratory rate, improvements in breathing awareness, decreased dyspnoea, and enhanced exercise tolerance are reported more consistently (Bruton & Lewith, 2005; Burgess et al., 2011). This should not be interpreted as evidence against the effectiveness of BBT, as spirometric function and breathing efficiency represent distinct physiological constructs. Furthermore, healthy individuals typically exhibit normal pulmonary function, leaving limited physiological scope for measurable improvements in conventional spirometric outcomes (Powers & Howley, 2021).
A further consideration is that much of the available evidence originates from clinical populations, particularly individuals with asthma or dysfunctional breathing, where baseline respiratory impairment provides greater opportunity for improvement.

Consequently, extrapolating these findings directly to healthy or highly trained athletes may overestimate the practical benefits of BBT in competitive sport. Likewise, BBT should not be considered interchangeable with other breathing interventions. Inspiratory muscle training, diaphragmatic breathing, paced breathing, and yoga-based breathing employ distinct physiological stimuli and mechanisms of adaptation. Although these approaches are frequently discussed together, evidence derived from one intervention should not be assumed to support the effectiveness of another.

Methodological limitations further reduce confidence in the current evidence base. Existing studies are frequently characterized by small sample sizes, heterogeneous intervention protocols, variable intervention durations, inconsistent breathing instructions, and the co-administration of additional interventions such as relaxation training, education, or lifestyle modification. Furthermore, many investigations employ limited randomization procedures and inconsistently report allocation concealment, blinding, or intention-to-treat analyses, thereby restricting the strength of causal inference. The predominance of clinical rather than athletic populations, together with the reliance on spirometric outcomes that may be relatively insensitive to performance-related adaptations, further limits the applicability of current findings to competitive sport.

Taken together, the available evidence suggests that BBT should be regarded as an **evidence-informed complementary intervention** rather than an independent performance-enhancement strategy. Current evidence most strongly supports improvements in breathing control, respiratory comfort, and exercise tolerance, particularly among individuals with dysfunctional breathing patterns. By contrast, convincing evidence for meaningful improvements in maximal aerobic capacity, anaerobic performance, muscular strength, or elite sport performance remains insufficient.

Another important consideration is that several physiological mechanisms frequently attributed to BBT—including improved carbon dioxide tolerance, enhanced oxygen unloading through the Bohr effect, autonomic regulation, and improved breathing economy—remain biologically plausible but have not been conclusively demonstrated in healthy athletic populations. These mechanisms should therefore be interpreted as evidence-informed hypotheses rather than established physiological adaptations specific to BBT. Future mechanistic studies integrating cardiopulmonary exercise testing, respiratory electromyography, capnography, diaphragm ultrasonography, heart rate variability, and wearable respiratory monitoring technologies are required to clarify the physiological pathways through which BBT may influence exercise performance.

VII. LIMITATIONS OF THE REVIEW

This review has several limitations. First, as a narrative thematic review, it does not employ a formal systematic review methodology or quantitative meta-analysis. Second, much of the available evidence originates from clinical populations rather than healthy athletes, limiting the generalizability of findings to competitive sport. Third, considerable heterogeneity exists in intervention duration, breathing protocols, participant characteristics, and outcome measures, making direct comparison between studies difficult. Finally, several proposed physiological mechanisms remain based on indirect evidence derived from broader breathing-intervention literature rather than standardized BBT-specific investigations.

VIII. FUTURE DIRECTIONS

Progress in this field requires: (1) adequately powered, randomized controlled trials in healthy recreational and elite athletic populations, reported per CONSORT guidelines; (2) standardization of BBT protocols—duration, session frequency, breathing cadence, and progression criteria—to enable cross-study comparison (Bruton & Lewith, 2005); (3) research prioritizing athletic rather than clinical samples across endurance, team, and strength/power disciplines; (4) outcome measures that extend beyond spirometry to include exercise economy, time-to-exhaustion, repeated-sprint ability, recovery kinetics, and sport-specific performance; (5) mechanistic studies combining performance testing with diaphragmatic ultrasonography, respiratory electromyography, cardiopulmonary exercise testing, and autonomic measures to clarify the physiological pathways underlying any observed effects; and (6) head-to-head comparative trials against other breathing interventions (e.g., IMT, diaphragmatic or yoga-based breathing) to establish whether BBT confers unique benefit. Increasing integration of wearable respiratory monitoring and individualized training prescription is also likely to shape how breathing retraining, including BBT, is incorporated into future athlete-monitoring and performance programmes.

Future multicentre trials involving standardized BBT protocols and harmonized outcome measures would substantially improve the certainty and generalizability of the available evidence.

IX. CONCLUSION

This review indicates that the Buteyko Breathing Technique has greater potential to improve functional aspects of breathing—respiratory control, breathing rate, and perceived exercise tolerance—than to produce structural changes in pulmonary or cardiovascular physiology; conventional spirometric indices are generally unaffected, whereas breathing behaviour, respiratory comfort, and exercise tolerance improve more consistently (Bruton & Lewith, 2005; Burgess et al., 2011; Migliaccio et al., 2023). Evidence for sport-relevant performance gains is encouraging but preliminary: modest improvements in aerobic endurance and recovery have been reported, whereas convincing evidence for gains in VO_2max, anaerobic performance, strength, or elite performance is lacking, and existing studies are limited by small samples and heterogeneous methodology (Patra et al., 2025). BBT should therefore be regarded as a complementary strategy—rather than a substitute for evidence-based training—that may enhance breathing awareness, reduce unnecessary respiratory effort, and support recovery when integrated within comprehensive athletic programming (Powers & Howley, 2021). Larger, standardized, athlete-focused randomized controlled trials are required before its role in performance optimization can be firmly established.

Accordingly, BBT should presently be regarded as an evidence-informed adjunct rather than a stand-alone performance-enhancing intervention until stronger athlete-specific evidence becomes available.

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