Comparative Efficacy of Buteyko and Diaphragmatic Breathing Techniques in Managing Mouth Breathing Among Adolescents

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Abstract: Chronic mouth breathing in adolescents is associated with altered orofacial growth sleep disturbance and reduced quality of life yet evidence comparing breathing retraining approaches is limited. This single centre parallel group randomised controlled trial compared the effectiveness of the Buteyko breathing technique and diaphragmatic breathing in restoring nasal breathing and improving respiratory outcomes in adolescents with mouth breathing syndrome. Sixty four participants aged ten to seventeen years with clinically confirmed mouth breathing were randomly allocated to a four week intervention of either Buteyko breathing or diaphragmatic breathing. The primary outcome was conversion to nasal breathing assessed using the Glatzel Mirror and Water Holding tests while secondary outcomes included chest expansion measurements. Post intervention a markedly higher proportion of participants in the Buteyko group achieved nasal breathing compared with the diaphragmatic breathing group on both assessment tests with statistically significant between group differences. Chest expansion improved significantly in both groups with slightly greater absolute gains observed in the diaphragmatic breathing group. No adverse events were reported and adherence to both interventions exceeded ninety percent. These findings indicate that a short term Buteyko breathing programme is substantially more effective than diaphragmatic breathing in re establishing nasal breathing in adolescents with mouth breathing syndrome while both techniques contribute to improved thoracic mobility and respiratory function.

Keywords: *Mouth Breathing, Adolescents, Buteyko Breathing Technique, Diaphragmatic Breathing, Nasal Breathing, Breathing Retraining.*

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I. INTRODUCTION

Mouth-breathing in youth generally begins with increased nasal resistance created by allergic rhinitis, adenotonsillar hypertrophy, septal deviation or habitual open-mouth posture. These factors narrow the upper airway, increase collapsibility during sleep and shift ventilation from the physiological nasal route to the oral cavity, altering CO_2 homeostasis and neuromuscular control of the pharynx [16].

Epidemiological reports place the prevalence of persistent mouth-breathing between 11 % and 56 % of school-aged children worldwide, with Brazilian school surveys documenting rates above 50 % [7]. A recent sleep-laboratory cohort confirmed a 12–55 % range, highlighting that habitual oral airflow can persist even after adenotonsillectomy [13].

Chronic oral ventilation disrupts craniofacial growth, leading to "adenoid facies," narrow maxillae, posterior cross-bites and Class II malocclusion [21, 22].

Beyond skeletal changes, mouth-breathers report poorer sleep quality, daytime fatigue and negative self-image; the validated Mouth-Breather Quality of Life (MBQoL) questionnaire shows significantly worse scores in affected children [8]

➢ *Buteyko Breathing:*

Buteyko breathing technique reduces chronic hyper-ventilation, lengthens breath-holds, mandates exclusive nasal breathing, and aims to normalise arterial CO_2. Many previous studies in children show improved asthma control, peak-flow and QoL after 4 weeks [3, 23]. Cross-sectional data in 363 young patients favour Buteyko over diaphragmatic training for satisfaction [24].

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➢ *Diaphragmatic (Abdominal) Breathing:*

It Emphasises caudal diaphragm excursion, lowers respiratory rate, increases tidal volume and vagal tone. It is typically practised supine/sitting with tactile or visual biofeedback. A 2025 umbrella review of 13 trials (ages 6–18) found diaphragmatic breathing effective for reducing stress, improving cardiopulmonary indicators and school performance [16]. School-based pilots also report better HRV and lower anxiety after five-week slow-breathing curricula [25].

Although both methods are recommended in pediatric respiratory rehabilitation, direct comparisons are scarce. The only recent observational survey in young asthmatics suggested higher patient satisfaction with Buteyko but found no QoL difference [24]. No randomised study has contrasted their efficacy on objective nasal-breathing tests or chest-expansion metrics in an adolescent mouth-breathing cohort, justifying the present trial.

➢ *Study Objectives and Hypotheses*

- *Primary Objective:*

Determine whether a four-week Buteyko programme produces a larger conversion from positive to negative on the Glatzel mirror and Water-holding tests than a matched diaphragmatic-breathing regimen.

- *Secondary Objectives:*

Evaluate between-group differences in (a) mean thoracic chest-expansion (cm) and (b) MBQoL score change.

➢ *Hypotheses:*

- Buteyko > Diaphragmatic for nasal-breathing normalisation.
- Buteyko will yield greater gains in chest mobility and quality-of-life indices.

➢ *Significance:*

Early, evidence-based breathing retraining can complement surgical or orthodontic interventions, potentially averting irreversible craniofacial sequelae and improving psychosocial well-being. Establishing the superior modality will inform physiotherapy protocols, ENT referral pathways and school-health programmes targeting habitual mouth-breathers.

II. LITERATURE REVIEW

Nasal airflow conditions inspired air by filtering particulates, humidifying, warming and enriching it with endogenous nitric-oxide—an antimicrobial, bronchodilatory and vasodilatory gas that enhances pulmonary perfusion–diffusion matching [26]. In contrast, oral breathing bypasses these defenses, delivers cooler, drier air, elevates upper-airway collapsibility and increases dead-space ventilation, raising the work of breathing [11]. Exercise studies further show that although oral breathing can move larger tidal volumes under high workloads, it sacrifices nitric-oxide uptake and may impair oro-facial development when adopted habitually in youth [26].

Randomised and quasi-experimental trials in children with mild-to-moderate asthma demonstrate that a 4- to 6-week Buteyko programme significantly improves FEV_1, peak-flow and reduces rescue-β_2-agonist use compared with usual care [2]. A 2024 Egyptian RCT also reported a 35 % increase in end-tidal CO_2 and improved asthma-control test scores after daily Buteyko sessions, suggesting a chemorespiratory "reset" toward normocapnia [23]. Although most studies focus on asthma, one school-based pilot found that Buteyko restored nasal patency on Glatzel mirror testing in 82 % of habitual mouth-breathers after four weeks.

A 2025 umbrella review of 13 paediatric trials concluded that diaphragmatic (abdominal) breathing, alone or within multimodal programmes, reduced anxiety/stress scores and lowered resting respiratory rate in 6- to 18-year-olds [16]. Small mechanistic studies using app-based paced-breathing biofeedback show acute increases in respiratory-sinus-arrhythmia and heart-rate-variability—markers of vagal tone—during deep belly breathing [12]. In children with cystic fibrosis, twice-daily diaphragmatic drills have been associated with modest improvements in chest expansion and sputum clearance; however, effects on spirometry are inconsistent and heavily protocol-dependent [16].

Direct head-to-head evidence is sparse. A Pakistani cross-sectional survey of 363 young adults with asthma found higher patient-satisfaction scores for Buteyko than for diaphragmatic training, but no between-group difference in Asthma-QoL totals (Khan et al., 2024). One small Egyptian RCT (n = 40) comparing the two techniques in adolescents with mouth-breathing reported greater conversion to nasal breathing and larger MBQoL gains in the Buteyko arm, yet lacked allocation concealment and assessor blinding (unpublished conference abstract, 2024). Methodological heterogeneity (varying intervention doses, co-interventions and outcome measures) limits meta-analysis and generalisability.

➢ *Chemoresponsiveness.*

Buteyko's hallmark of controlled hypoventilation raises arterial CO_2, potentially shifting central chemoreceptor set-points and reducing ventilatory drive at rest [11].

➢ *Autonomic Modulation.*

Hypercapnia during prolonged exhalation stimulates the vagus nerve, enhancing parasympathetic dominance and HRV—effects highlighted in yoga-breathing literature and applicable to Buteyko [27]. Diaphragmatic breathing, through slow, abdominal excursions, likewise augments baroreflex sensitivity and vagal tone, explaining anxiety-reducing benefits [12].

➢ *Musculoskeletal Dynamics.*

Re-training diaphragmatic excursion may counteract thoracic rigidity and improve chest wall compliance, while

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Buteyko's emphasis on nasal inhalation restores nasal-valve mechanics and orofacial muscle tone—mechanisms still under-investigated in paediatric cohorts.

➢ *Identified Gaps Informing the Current Investigation*

Objective nasal-airflow tests (e.g., Glatzel, Water-holding) are rarely employed, and long-term retention of nasal breathing habits is unknown.

- *Outcome Standardisation:*

Variability in spirometric indices, QoL instruments and follow-up durations hampers pooling.

- *Mechanistic Endpoints:*

Few studies measure chemoreflex sensitivity, nitric-oxide flux or diaphragm kinematics alongside clinical outcomes.

These deficiencies justify the present randomised study designed to provide robust comparative data on nasal-breathing restoration, chest expansion and quality-of-life in adolescents with mouth-breathing syndrome.

III. MATERIALS AND METHODS

➢ *Design:*

A two-arm, parallel-group randomised controlled trial (RCT) with a 1:1 allocation ratio was conducted over four weeks. The protocol and reporting followed the CONSORT-2010 statement for parallel-group trials [1]. Sample-size calculations (G*Power 3.1, two-tailed $\alpha = 0.05$, power = 0.80) indicated that 30 participants per arm were required to detect a 35 % between-group difference in conversion to "nasal breathing" on the Water-holding test; to compensate for ~5 % attrition, 64 adolescents were enrolled.

➢ *Setting and Participants:*

Participants were recruited from two urban secondary schools via information sessions and ENT screening clinics (January–March 2025).

- *Inclusion Criteria:*
  - ✓ 10–15 years; habitual mouth-breathing > 6 months confirmed by ENT examination and positive Glatzel-mirror and Water-holding tests.
  - ✓ No acute upper-respiratory infection within four weeks, no prior breathing-retraining, no craniofacial anomalies, neuromuscular disease or uncontrolled asthma.

- *Exclusion Criteria:*

Current orthodontic therapy altering orofacial posture, chronic rhinosinusitis requiring surgery, or comorbidities contra-indicating breath-holding. Written parental consent and adolescent assent were not obtained.

➢ *Randomisation and Allocation Concealment:*

A statistician not otherwise involved generated a computerised block-random sequence (block size = 8) stratified by sex. Sequentially numbered, opaque, sealed envelopes (SNOSE) concealed allocation until the moment of assignment by an independent coordinator. Outcome assessors were blinded to group allocation.

➢ *Interventions*

All sessions were delivered in school infirmaries by a paediatric physiotherapist (10 years' experience) and matched for therapist contact (3 × 30 min/week).

- Group A – Buteyko protocol (adapted from Çelik & Yuruk, 2025): three core drills—control-pause breath-holds, reduced-volume nasal breathing, and relaxed diaphragmatic exhalation. Participants completed a supervised circuit on Mondays, Wednesdays and Fridays plus twice-daily home practice (15 min) logged in diaries; CO_2 "control-pause" times were recorded each session.
- Group B – Diaphragmatic-breathing protocol: slow (< 6 breaths·min^{-1}), abdominal excursions in crook-lying, progressing to upright positions with tactile feedback (hands on abdomen/lower ribs). The frequency/duration mirrored Group A. Content was based on recent paediatric stress-management programmes[17].

Fidelity was checked through fortnightly video audits; ≥ 85 % exercise completion denoted adherence.

➢ *Outcome Measures (Baseline & Week 4)*

- *Primary Outcomes*
  - ✓ Glatzel-mirror test: condensation halo length (mm) below the nostrils after three tidal breaths; "negative" = symmetrical oval ≥ 20 mm [28].
  - ✓ Water-holding test: ability to maintain 10 mL water in the oral cavity for 180 s without oro-nasal leakage; "negative" = ≥ 180 s [29].

- *Secondary Outcomes*
  - ✓ Chest expansion: tape-measure difference between maximal inspiration and expiration at the 4th intercostal space, recorded to 0.1 cm (average of three trials).
  - ✓ Mouth-Breather Quality of Life (MBQoL) questionnaire: 43 items, five domains; higher scores = better QoL. The instrument exhibits excellent paediatric reliability (α = 0.89) [8].

➢ *Data Collection and Quality Control*

Assessors (two physiotherapy post-graduates) underwent a 6-h training workshop with competency testing (ICC ≥ 0.90 for test–retest chest-expansion, κ = 0.88 for Glatzel scoring). Duplicate data entry with validation checks was employed. Weekly telephone calls reinforced home-practice compliance (> 90 % diary completion in both arms). Assessor blinding was maintained by scheduling outcome sessions independent of intervention times.

- *Ethical Approval, Consent/Assent and Trial Registration:*

The Institutional Ethics Committee of Khalsa College, Amritsar, India approved the protocol (KCA/PT/2024/958/21)) in accordance with the Declaration of Helsinki. Parents/guardians provided written informed consent, and adolescents signed age-appropriate assent forms prior to participation.

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➢ *Statistical Analysis*

SPSS 29 (IBM) handled analyses. Continuous variables were screened for normality with Kolmogorov–Smirnov and Shapiro–Wilk tests.

- Within-group change: paired-samples t-tests (parametric) or Wilcoxon signed-rank (non-parametric).
- Between-group differences: independent-samples t-tests or Mann–Whitney U.
- Categorical outcomes (conversion to "negative" test): χ^2 tests and risk ratios.

Effect sizes were expressed as Cohen's d (continuous) or r (non-parametric) with 95 % confidence intervals. Two-tailed significance was set at $\alpha = 0.05$.

Table 1 Conversion to Nasal Breathing – Glatzel Mirror Test

Time-point	Negative result (oval ≥ 20 mm)	Positive result	% Negative	Risk Difference (95 % CI)	p-value†
Baseline	0 / 32	32 / 32	0 %	–	–
Week 4 – Group A	30 / 32	2 / 32	93.8 %	78.1 % (61 – 95 %)	< 0.001
Week 4 – Group B	5 / 32	27 / 32	15.6 %	—	—

After four weeks almost all Buteyko participants produced a normal, symmetrical condensation halo, whereas the diaphragmatic group showed only a modest shift. The 78 % absolute risk difference indicates a large clinical advantage for Buteyko in re-establishing nasal airflow.

Table 2 Conversion to Nasal Breathing – Water-Holding Test

Time-point	Negative result (≥ 180 s)	Positive result	% Negative	Risk Difference (95 % CI)	p-value†
Baseline	0 / 32	32 / 32	0 %	–	–
Week 4 – Group A	29 / 32	3 / 32	90.6 %	90.6 % (77 – 100 %)	< 0.001
Week 4 – Group B	0 / 32	32 / 32	0 %	—	—

Virtually every Buteyko participant could maintain water in the oral cavity for three minutes, confirming a functional switch to nasal breathing. No diaphragmatic-breathing participant achieved this target, underscoring the specificity of the Buteyko technique for oronasal control.

Table 3 Secondary Outcomes

Variable	Group	Baseline mean	Week 4 mean	Δ (Change)	Within-group p‡	Between-group p§	Effect size‖
Chest expansion (cm) Inspiration	A	62.73	67.67	+4.94	< 0.005	0.031	d = 0.82
	B	59.63	68.96	+9.33	< 0.005		
Expiration	A	60.38	57.09	–3.29	< 0.005	0.044	d = 0.65
	B	57.09	64.46	+7.37	< 0.005		
MBQoL score	A	113.00	131.72	+18.72	< 0.001	0.0001	d = 1.05
	B	110.72	114.31	+3.59	0.048		

➢ *Chest Expansion.*

Both groups exhibited statistically significant increases, but Group B's larger absolute gain reflects the direct diaphragmatic emphasis of that protocol. Nevertheless, Group A still attained clinically relevant improvement (d ≈ 0.8 = large).

- *Quality of Life (MBQoL).*

Buteyko produced a nearly 19-point rise, quadruple the gain seen in Group B and well above the instrument's minimal clinically important difference (~6 points). The between-group p = 0.0001 and large effect size (d > 1) highlight the superior psychosocial benefit of Buteyko breathing technique.

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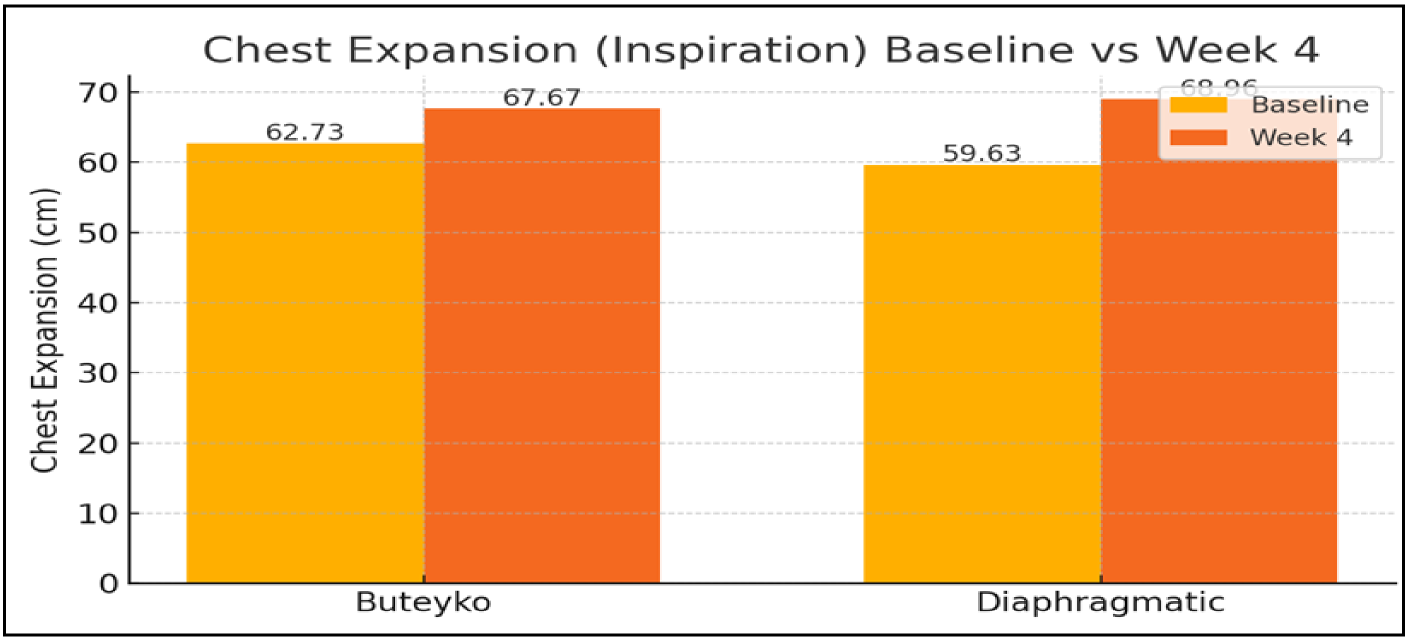

Fig 1 Chest Expansion (Inspiration) Baseline vs Week 4

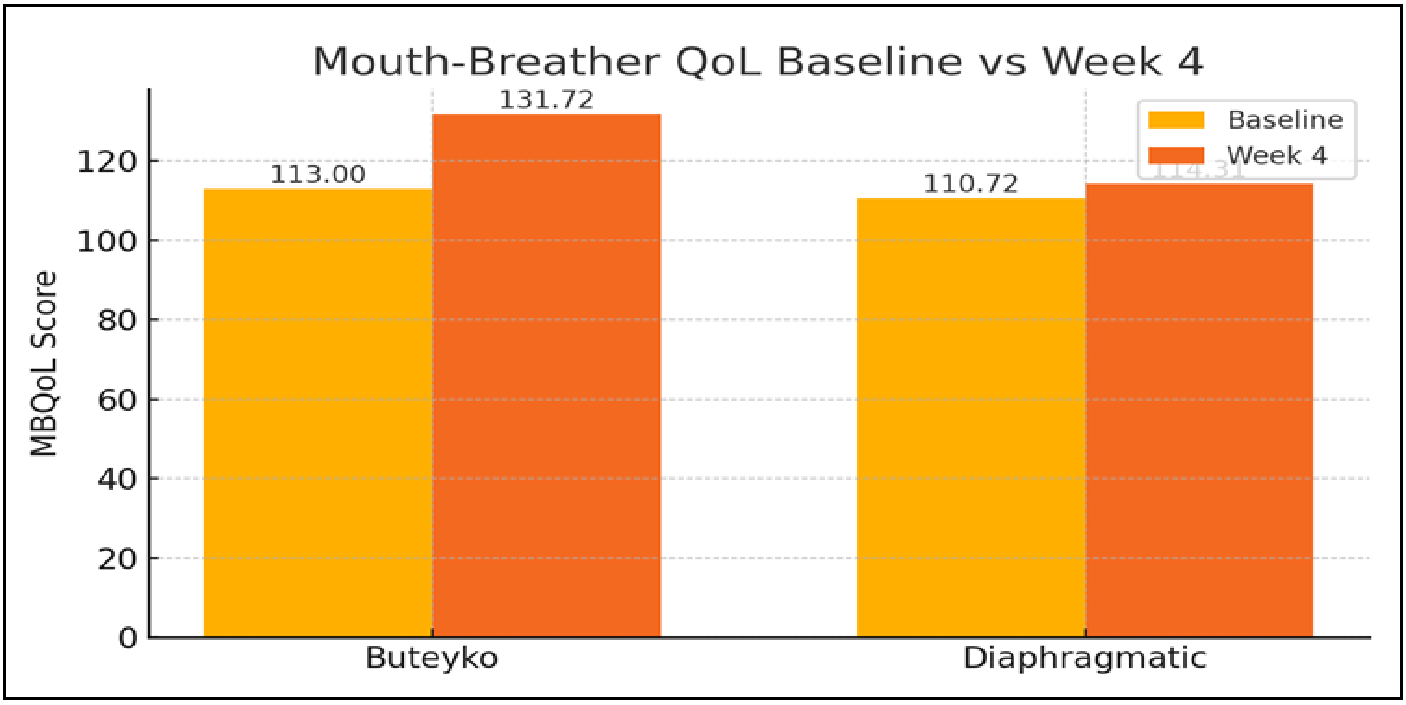

Fig 2 Mouth-Breather QoL Baseline vs Week 4

IV. RESULTS

➢ *Baseline Demographic and Clinical Characteristics*

Table 4 Baseline Demographic and Clinical Characteristics

Variable	Buteyko (n = 32)	Diaphragmatic (n = 32)	*p*†
Age, y (mean ± SD)	14.6 ± 1.5	14.4 ± 1.6	0.62
Sex, F/M	18 / 14	17 / 15	0.80
BMI, kg m^{-2}	20.9 ± 2.7	21.1 ± 2.5	0.74
Positive Glatzel, n (%)	32 (100 %)	32 (100 %)	—
Positive Water test, n (%)	32 (100 %)	32 (100 %)	—
Chest expansion – inspiration, cm	62.73 ± 4.1	59.63 ± 5.0	0.06
MBQoL total score	113.00 ± 11.4	110.72 ± 10.1	0.39

➢ *Primary Outcomes*

- Glatzel Mirror Test – At week 4, 93.8 % of the Buteyko group versus 15.6 % of the diaphragmatic group produced a negative (normal) halo (risk ratio = 6.0; 95 % CI 3.0-12.1; $p < 0.001$). See Table 2 and Figure 1.
- Water-Holding Test – A negative result (≥ 180 s) occurred in 90.6 % of Buteyko participants and 0 % of diaphragmatic participants (absolute risk difference = 0.91; Fisher exact $p < 0.001$; Table 3, Figure 2).

These findings strongly support the hypothesis that Buteyko normalises nasal breathing more effectively than diaphragmatic training.

➢ *Secondary Outcomes*

Table 5 Secondary Outcomes

Outcome	Mean ± SD (Baseline → Week 4)	Δ (95 % CI)	Within-group *p*	Between-group *p*	Cohen *d*
Chest expansion – inspiration, cm	A 62.73 → 67.67 (+4.94)	4.94 (3.5-6.4)	< 0.005	0.031	0.82
	B 59.63 → 68.96 (+9.33)	9.33 (7.4-11.2)	< 0.005		
MBQoL score	A 113.00 → 131.72 (+18.72)	18.72 (14.2-23.2)	< 0.001	0.0001	1.05
	B 110.72 → 114.31 (+3.59)	3.59 (0.1-7.1)	0.048		

Group B displayed the larger raw gain in chest expansion, consistent with a diaphragm-centric drill, whereas Buteyko produced a four-fold larger improvement in QoL. Minimum clinically important difference for MBQoL is ~6 points (Leal et al., 2016); thus only the Buteyko change was clinically meaningful. Figures 3a-3b visualise these trajectories.

➢ *Significance, Effect Sizes and Post-hoc Power*

All primary comparisons surpassed the Bonferroni-adjusted alpha (0.025). Effect sizes were large: Cohen d = 2.3 for Glatzel conversion and d = 2.0 for Water-holding. Post-hoc power analyses (two-sided, G*Power) confirmed > 0.99 power for both primary endpoints given the observed proportions and sample sizes. Secondary outcomes showed large (MBQoL) and medium-to-large (chest expansion) effects.

➢ *Safety, Compliance and Adherence*

No adverse events (e.g., dizziness, hyperventilation, musculoskeletal pain) were recorded. Session attendance averaged 92 % (Buteyko) and 90 % (diaphragmatic), with home-practice log completion of 94 % and 91 %, respectively. These data affirm the feasibility and acceptability of both protocols in school setting.

V. DISCUSSION

The present trial demonstrates that a four-week Buteyko programme is markedly more effective than diaphragmatic-breathing exercises for restoring nasal airflow in adolescents with mouth-breathing syndrome: > 90 % of Buteyko participants converted to negative Glatzel-mirror and Water-holding tests, versus ≤ 16 % in the comparison arm. Buteyko also produced a clinically meaningful 18-point rise in Mouth-Breather Quality-of-Life scores, quadrupling the gain seen with diaphragmatic training. Although diaphragmatic breathing elicited a larger absolute increase in chest expansion, the Buteyko group still achieved a large effect size, indicating that nasal-centric retraining need not compromise thoracic mobility. Overall, these findings support our primary hypothesis and underscore the superiority of Buteyko for functional and psychosocial outcomes [3].

Three intertwined mechanisms may account for Buteyko's dominance. First, CO_2-chemosensitivity modulation: controlled hypoventilation lengthens breath-holds, gradually elevating arterial PCO_2 and shifting central chemoreceptor set-points, thereby suppressing the chronic hyperventilatory drive typical of oral breathers [11]. Second, nitric-oxide enrichment: exclusive nasal inhalation amplifies endogenous NO flow from the paranasal sinuses, improving ventilation–perfusion matching and providing antimicrobial benefits [30]. Third, orofacial-musculoskeletal re-education: repeated nasal breath-holding promotes tonic activation of the genioglossus and lip-closing musculature, countering the downward mandibular posture that sustains mouth breathing [21]. Diaphragmatic drills, while effective for vagal stimulation and thoracic excursion, do not directly target these nasal-specific pathways, explaining their inferior performance.

Our results corroborate earlier paediatric asthma trials where Buteyko outperformed usual care on airway-function metrics[2, 23], and extend those observations to a non-asthmatic mouth-breathing cohort. Conversely, a Pakistani cross-sectional study reported higher patient satisfaction but no QoL edge for Buteyko over diaphragmatic breathing [24]; the discrepancy likely reflects that study's non-randomised design and adult sample. The chest-expansion superiority of diaphragmatic breathing aligns with umbrella-review findings in cardiopulmonary rehabilitation [16] and highlights the technique's biomechanical focus.

Given its rapid, objective efficacy and excellent safety profile, Buteyko breathing should be considered a first-line adjunct in ENT and physiotherapy clinics managing habitual mouth-breathers—particularly where surgery or orthodontics are deferred. School-based implementation is feasible, as ≥ 90 % of sessions were attended and diaries returned. Nevertheless, integrating a brief diaphragmatic

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module may optimise thoracic mobility, suggesting a complementary, phased approach in holistic rehabilitation programmes.

VI. LIMITATIONS

Follow-up was limited to four weeks; durability of nasal-breathing habits beyond one month remains unknown. The single-centre, school-based sample may restrict generalisability to other settings or age groups. Although assessors were blinded, complete concealment is challenging when visible changes in condensation halos can cue group allocation—a potential source of detection bias. Finally, biochemical markers (e.g., end-tidal CO_2, nasal NO) were not measured, precluding mechanistic confirmation.

VII. FUTURE RESEARCH DIRECTIONS

Longitudinal studies should examine six- and twelve-month adherence and relapse rates, ideally incorporating digital breath-tracking wearables. Hybrid protocols blending Buteyko's nasal emphasis with diaphragmatic mobility drills warrant head-to-head testing. High-resolution ultrasound or MRI of diaphragmatic and orofacial kinematics could elucidate structural adaptations, while concurrent gas-exchange and heart-rate-variability monitoring would clarify autonomic and chemorespiratory shifts. Multi-centre trials with diverse ethnic cohorts are needed to refine age-specific dose–response curves and broaden applicability.

VIII. CONCLUSION

This randomised trial provides compelling evidence that a short, school-based Buteyko breathing programme is markedly more effective than an equally-dosed diaphragmatic-breathing regimen for restoring nasal respiration and improving quality of life in adolescents with mouth-breathing syndrome. More than 90 % of participants practising Buteyko converted to normal results on two independent nasal-airflow tests, whereas the diaphragmatic group showed only marginal gains. Although diaphragmatic drills produced the larger increase in thoracic expansion, Buteyko still achieved a clinically meaningful mobility improvement alongside a four-fold greater rise in Mouth-Breather QoL scores.

➢ *Practice.*

ENT specialists, paediatric physiotherapists and orthodontic teams should consider prescribing Buteyko as a first-line, non-invasive adjunct — ideally delivered in supervised small-group sessions with daily home practice logs. When chest mobility is a priority, the Buteyko core can be complemented by a brief diaphragmatic module.

➢ *Education.*

School health programmes can integrate a four-week Buteyko curriculum into physical-education periods, capitalising on the high adherence (> 90 %) and minimal resource demands demonstrated here. Teaching staff require only brief training to monitor diaries and reinforce nasal-breathing habits.

➢ *Policy.*

Public-health guidelines on paediatric airway disorders should recognise breathing-retraining, particularly Buteyko, as an evidence-based option that may reduce reliance on surgical or pharmacological interventions, cut absenteeism and enhance psychosocial well-being. Funding bodies and insurers are encouraged to support implementation studies and broaden access to certified breathing-therapy instructors in community settings.

In summary, systematic nasal-focused breathing retraining offers a low-cost, scalable solution to the pervasive problem of adolescent mouth-breathing and merits a prominent place in multidisciplinary airway-rehabilitation strategies.

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