# Title page

# Title

Assessing the impact of breathing retraining on asthma symptoms and dysfunctional breathing in children.

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Running head:IMPACT OFBUTEYKO ON ASTHMA CONTROL IN CHILDREN

# Abstract

**Objective:** To assess the impact of breathing retraining on asthma symptoms and dysfunctional breathing (DB) in children. DB contributes to poor asthma control and increased symptoms. Breathing retraining can improve DB but there is a lack of evidence in paediatrics. **Method:** Participants attended outpatient physiotherapy appointments and received individually tailored interventions, including Buteyko Breathing techniques. The primary outcome was the change in the Asthma Control Test (ACT) score or change in Childhood Asthma Control Test (CACT) score from first to final appointment. The ACT and CACT are validated in children ≥ 12 years (score range 0 – 25) and children aged 4-11 (score range 0 – 27) respectively. The secondary outcome measure was the change in Nijmegen Questionnaire (NQ) score from first to final appointment (score range 0 - 64). **Results:** One hundred and sixty nine patients attended and completed a mean of 6 physiotherapy sessions, over a mean of 15 weeks. Patients were aged 2 -18, mean 10 years. Fifty five patients were ≥12 years old and 114 were ≤11 years. One hundred and seven patients were on treatment step 1-3, and 62 patients on treatment step 4-5 of the British Thoracic Society guidelines. The mean ACT score improved by 4.4 (p<0.0001), the mean CACT score improved by 4.9 (p<0.0001), and the mean NQ score change improved by -9.3 points (p<0.0001). **Conclusion:** In addition to standard medical therapy, individually tailored physiotherapy interventions, consisting predominantly of Buteyko breathing techniques, improved asthma control and DB in children on all levels of asthma treatment.

## Introduction

Asthma affects approximately 19% of children, of which 11% have suboptimal asthma control 1. Asthma management is directed by national and international guidelines 2,3. The main goals of asthma management are to decrease asthma symptoms and prevent acute exacerbations 4. Acute asthma is a common cause of hospitalisation in children 4 and regional inequalities around this outcome still persist 5-7.

National asthma guidelines acknowledge that dysfunctional breathing (DB) can contribute to poor asthma control 3. However there is no consensus within the literature that clearly defines DB. Use of multiple terms such as breathing pattern disorder, hyperventilation and hyperventilation syndrome has led to ambiguity 8. DB is described as an alteration in the normal biomechanical breathing pattern which causes intermittent or chronic symptoms 8. A dysfunctional breathing pattern can be observed as upper chest breathing, as opposed to the normal diaphragmatic motion, irregularity of respiratory pattern, excessive sighing, mouth breathing and higher respiratory rates 8. DB symptoms can mimic or worsen those of asthma, frequently evident as exercise-induced dyspnoea 3 and chest tightness 9. The prevalence of DB in asthma may be as high as 25.8% 10. Methods to help evaluate DB in paediatrics include structured observation by a trained physiotherapist 8 in addition to the Nijmegen Questionnaire (NQ) symptom score 11.

Breathing retraining is the main intervention for improving DB 12. This can be established through a structured multidimensional approach such as the Buteyko Breathing technique 13, physiotherapy led breathing retraining 14 or a combination of approaches. Breathing retraining has been shown to improve quality of life, asthma symptoms 15 and NQ symptom scores 16 in paediatrics. Buteyko is a breathing retraining technique that utilises nasal and diaphragmatic breathing to establish a normal respiratory rate, volume, and pattern of breathing 3. Buteyko Breathing techniques improve asthma symptoms in adults 17-20 and children 21 and are recommended in national UK asthma guidelines 3. Despite these studies, evidence around breathing retraining and Buteyko techniques is lacking, particularly when used as part of routine physiotherapy interventions. This may be a reason why there is an inconsistent provision of physiotherapy services for asthma across the UK 22.

We evaluated the impact of Buteyko Breathing techniques, in combination with other physiotherapy interventions on decreasing asthma symptoms and decreasing DB in children. The primary objective was to assess the effectiveness of these interventions on decreasing asthma symptoms using the Asthma Control Test (ACT) or the Childhood Asthma Control Test (CACT), both validated measures of asthma control 3. The secondary objective was to assess the effectiveness of these interventions on decreasing DB symptoms using the NQ, in addition to decreasing dysfunctional breathing patterns using skilled physiotherapy observation. DB is classified as a dysfunctional breathing pattern that causes symptoms therefore both presence of a dysfunctional breathing pattern, in addition to symptoms is required to accurately detect this. There are no validated measures of DB in paediatrics; however the NQ has previously been used to detect and monitor DB symptoms in paediatric patients 10,11,16.

# Materials and Methods

This service evaluation was discussed with and registered with Alder Hey Children’s Hospital audit department (reference 5674). A service evaluation is a way to measure current practice within a service, utilising outcome measures that are already in use in current practice using only routinely collected data. All children who were referred to the physiotherapy clinic between December 2015 and January 2017 who had asthma or suspected asthma, in addition to suspected DB were included. Children <5 years that were referred into the physiotherapy clinic had a diagnosis of suspected asthma made by their respiratory paediatric consultant. Referrals were made from respiratory consultants and respiratory specialist nurses. Ethics approval was not required as data were collected as part of routine clinical practice; furthermore, treatments received were part of routine physiotherapy interventions. Nevertheless, written informed consent, in line with Trust policy, was taken from parents and recorded in the Trust physiotherapy notes. Any adverse event related to the intervention was recorded. Data were collected in accordance with good clinical practice 23.

At the first appointment, participants and their parents received the same education. The education included an explanation of what a normal breathing pattern was: nasal, diaphragmatic, quiet, slow and regular, in addition to education on how DB can affect asthma symptoms. For younger children education was focused on the parents. Furthermore, a diaphragmatic breathing inhaler technique was taught for all participants ≥ 5 years old who used a Pressurised Metered-Dose inhaler via the Volumatic® Spacer.

Subsequent physiotherapy treatments were tailored to the individual’s needs and focused around Buteyko Breathing techniques for children that were old enough to co-operate. Buteyko Breathing techniques included continual nose breathing at rest and during exercise with the use of mouth tape as required and more advanced techniques such as the control pause, extended pause, reduced breathing and the stop cough 13. The control pause involved pausing the breath after expiration until air hunger is felt, then controlling breathing afterwards. The extended pause is the same technique but encourages a longer breath hold using a distraction technique. Reduced breathing involved breathing less by extending the natural pause after expiration and by reducing the breath volume. The stop cough is a technique utilised for dry, irritated, excessive coughs and involves cough suppression techniques such as a breath hold and swallow. For a physiotherapist to be proficient in Buyteko Breathing techniques by the Buteyko breathing Association, completion of a 3 day practical course with pre and post coursework is required 13. Patients were advised to practice Buteyko breathing techniques twice daily for 10 minutes each time at home between physiotherapy sessions. Other physiotherapy interventions were utilised as indicated, as part of an individualised structured treatment plan. These included saline nasal irrigation for allergic rhinitis and inspiratory muscle training with a diaphragmatic breathing technique for athletic children. Additionally a positive expiratory pressure adjunct, percussion, expiratory vibrations and 0.9% saline nebulisers were used for participants with repeated respiratory infections, alongside their asthma. For participants with high levels of anxiety, progressive muscular relaxation was taught.

Exercise symptoms were assessed through observation, auscultation and spirometry. Physiotherapy sessions were 1 hour in duration, and continued every 2-4 weeks until the patient plateaued or improved. Participants were also discharged from clinic for non-attendance at two consecutive appointments. Participants were included in the analysis if they had attended 2 or more physiotherapy sessions.

# Outcome measures and statistical analysis

Data were routinely collected on the first and final physiotherapy appointment and sporadically during other physiotherapy appointments. Data were recorded in an anonymous database by a blinded physiotherapist. The primary data collected was the validated Asthma Control Test (ACT) for children aged ≥12 years 24,254 and the validated Childhood Asthma Control Test (CACT) for 4 to 11-year olds 26,27. The ACT has a score range of 0-25 and the CACT of 0-27. A 3-point change in the ACT 28 and 2-point change in the CACT 29 are accepted as the minimal clinically important difference, with a score of ≤ 19 in the ACT and CACT signifying poor control.

The secondary outcome measure was the NQ, with a score range of 0-64 and a recall period of 4 weeks was used. This was completed by participants ≥12 years independently and with parental guidance aged ≤11 years. A score of ≥23 indicated symptoms of DB 10,11,16. In addition participant’s breathing patterns were observed and classified as a dysfunctional breathing pattern if it was from the upper chest (rather than diaphragmatic) and also if there was presence of a high respiratory rate for their age, mouth breathing or excessive sighing. A normal breathing pattern was classified as diaphragmatic and nasal, and in a slow, quiet, regular pattern.

We analysed differences in the ACT, CACT, and NQ scores obtained at the first and final physiotherapy appointment using the Wilcoxon matched pairs signed rank test with statistical significance set at P<0.0001. Sub analysis on ACT, CACT and NQ score changes was also conducted using Mann-Whitney U test with statistical significance set at P<0.0001 comparing children on treatment step 1-3 to treatment step 4-5 of national asthma guidelines 30. Sub analysis of NQ score change comparing children with a baseline score of <23 with a baseline score of ≥23 was conducted using Mann-Whitney U test. Statistical analysis for the difference between number of participants that had an observed dysfunctional breathing pattern on the first and final appointment was conducted using Chi-square test with statistical significance set at p<0.0001.

# Results

# Participants

Two hundred and twelve participants were referred into the service, and 169 of these attended 2 or more appointments (79.7%). Participant baseline characteristics and outcome measure completion are summarised in Table 1. Sixty-three percent (n=107) of participants had asthma on treatment step 1-3 and 37% (n=62) on treatment step 4-5. During the evaluation 28/169 (17%) participants increased and 3 (1.8%) reduced their level of asthma medication.

**Breathing retraining interventions**

The mean number of physiotherapy sessions attended was 6 (range 2-20) with 2-4 weeks between each appointment. Each appointment was 1 hour in duration and the mean time from first to final session was 15 weeks. Participants received one or more physiotherapy treatments as demonstrated in Table 2. Ninety-seven percent of participants received breathing retraining intervention through Buteyko techniques: the remaining 5/169 (3%) of participants were too young to comply with these techniques and received other interventions accordingly.

# ACT in participants aged ≥12 years

Within our patient cohort, 51/55 (93%) completed an ACT on the first and final appointment (Table 1). Only 3/55 (5.5%) had incomplete data, and 1/55 (1.8%) did not understand the questionnaire. Overall, the mean change in score was +4.4, which was clinically and statistically significant (p<0.0001, Figure 1). Clinically significant improvements in ACT score (≥+3) were noted in 35/51 (69%) participants, while 14/51 (27%) had clinically insignificant score changes (<+3 and <-3) and 2/51 (4%) had a significant deterioration in score change (≥-3).

Of the participants who completed the ACT, 30/51 (58.8%) were on treatment step 1-3, while 21/51 (41.2%) were on treatment step 4-5. Poor asthma control (ACT ≤ 19) was identified in 20/30 (66.7%) children on treatment step 1-3, and 19/21 (90.5%) of those on step 4-5 on the first appointment. This decreased to 8/30 (27%) and 8/21 (38.1%) respectively at their final appointment. The mean ACT score change was +3.5 in children on treatment step 1-3, and +5.7 in treatment step 4-5. There was no significant difference between score changes in children on treatment steps 1-3 compared to 4-5.

# CACT in participants aged 4-11 years

Within our patient cohort, 94/114 (82%) completed a CACT on the first and final appointment (Table 1). Only 11/114 (10%) had incomplete data, and 9/114 (8%) were too young or did not understand the questionnaire. Overall the mean change in score was +4.9, which was clinically and statistically significant (p<0.0001, Figure 1). Clinical significant improvements in CACT score (≥+2) were noted in 71/94 (76%) participants, while 17/94 (18%) had clinically insignificant score changes (<+2 and <-2) and 6/94 (6%) had a significant deterioration in score change (≥-2).

Of the participants who completed the CACT, 64/94 (68%) were on treatment step 1-3, while 30/94 (32%) were on treatment step 4-5. Poor asthma control (CACT ≤ 19) was identified in 53/64 (83%) children on treatment step 1-3, and 24/30 (80%) of those on step 4-5 on the first appointment. This decreased to 29/64 (45%) and 14/30 (47%) respectively at their final appointment. The mean CACT score change was +4.7 in children on treatment step 1-3, and +5.5 in treatment step 4-5. There was no significant difference between score changes in children on treatment steps 1-3 compared to 4-5.

# Dysfunctional Breathing

Within our patient cohort, 114/169 (67%) completed a NQ on the first and final appointment (Table 1). Only 17/169 (10%) had incomplete data, however 38/169 (22%) were too young or did not understand the questionnaire. Overall the mean change in score was -9 points, which was a statistically significant improvement (p<0.0001, Figure 2). Improvements in dysfunctional breathing symptoms (NQ score ≥-1) were noted in 100/114 (88%) participants, 3/114 (3%) stayed the same, and 11/114 (10%) had a deterioration in score change (≥+1). 91% (153/169) of participants had an observed dysfunctional breathing pattern on the first appointment and 16% (27/169) on the final appointment (p<0.0001).

Of the participants who completed the NQ 40/114 (35%) had a baseline score of ≥23, and 74/114 (65%) had a baseline score of <23. One hundred percent (40/40) of participants that had a baseline NQ score of ≥ 23 also had an observed dysfunctional breathing pattern. On the final appointment, 6/40 (15%) still had a NQ score of ≥ 23 an 2/6 (33%) had an observed dysfunctional breathing pattern. Overall the mean NQ score improvement was -7 points for participants with a baseline NQ score of <23 and -13.5 points for those with a baseline NQ score of ≥23 on the final appointment, which was a statistically significant difference between the two groups (p<0.0001).

Of those who completed the NQ, 69/114 (61%) were on treatment step 1-3, whilst 45/114 (39%) were on treatment step 4-5. DB symptoms (NQ score ≥ 23) was identified in 20/69 (29%) children on treatment step 1-3, and 20/45 (44%) of those on step 4-5 on the first appointment. This decreased to 6/69 (9%) and 9% (4/45) respectively at their final appointment. The mean NQ score change was -9.0 in children on treatment step 1-3, and -9.8 in treatment step 4-5. There was no significant difference between score changes in children on treatment steps 1-3 compared to 4-5.

**Adverse events:** There were no adverse events related to the intervention.

# Discussion

This is the largest service evaluation of physiotherapy and breathing retraining in childhood asthma that we are aware of. We found that our individualised physiotherapy interventions, which comprised predominately of Buteyko Breathing techniques, in addition to standard medical management, significantly improved asthma symptom scores and significantly decreased DB.

Evidence for the impact of physiotherapy interventions on asthma symptoms in children is somewhat lacking 31. Although a double blinded randomised study in 16 children found that breathing and endurance exercises at home improved asthma symptoms 15, the details of the breathing exercises used, the number of drop outs and the control group were not described. Additionally, a randomised controlled study in 25 children demonstrated that inspiratory muscle training combined with breathing exercises, compared to a control group, improved symptoms in poorly controlled asthma 32. To our knowledge no previous full publications have used a validated asthma control measure to assess the effectiveness of physiotherapy interventions in children, or included as many participants.

In this service evaluation, the prevalence of DB symptoms (NQ score ≥23) was 35%, which is higher than the 25.8% prevalence previous research has found 10. This may be due to our targeted cohort that was referred to physiotherapy based on a suspicion of DB. Nevertheless, our findings support previous work 10,11 that DB may be a clinically relevant co-morbidity in paediatric asthma. High NQ scores (≥23) can be associated with non DB symptoms e.g. anxiety or stress 33 however in this service evaluation it predominately correlated with an observed dysfunctional breathing pattern. An observational study in 62 adults with medically unexplained dyspnoea demonstrated a poor correlation between a dysfunctional breathing pattern and total NQ symptom scores 34. Our data demonstrated a high level of observed dysfunctional breathing patterns at baseline, however the prevalence and significance of this is unknown as there is no data on the prevalence of dysfunctional breathing patterns in the general paediatric population. Furthermore without a validated dysfunctional breathing symptom questionnaire in paediatrics, the correlation between an observed dysfunctional breathing and DB symptoms is also unknown.

A randomised controlled trial in 94 adults with asthma demonstrated an equal response to breathing retaining in participants with a baseline NQ score of <23 (suggesting no DB symptoms) and ≥23 (suggesting DB symptoms) 35. In this service evaluation, DB symptoms (NQ scores) significantly improved in children with both a baseline score of <23 and ≥23, however participants with a baseline score of ≥23 had a significantly greater response. These data suggest that although a baseline NQ score ≥23 strongly correlated with DB, it was not sensitive enough to identify children who would benefit from breathing retraining therefore should not be used in isolation in clinical practice.

Service evaluations are at risk of bias, and prospective studies will be needed to confirm these findings. We attempted to maximise the quality of these data by ensuring all patients referred into the physiotherapy service were captured in these data and by the use of validated asthma scoring systems. Although medications were documented at the beginning and end of physiotherapy intervention, we were not able establish the changes in medical treatment during the period of physiotherapy intervention, so effects of increased (or decreased) medication are not captured in these data. An additional limitation is that the secondary outcome of DB is difficult to quantify as there is no standardised approach to assess for the presence of DB symptoms in paediatrics. We measured DB symptoms using the NQ, which is only validated for supporting a diagnosis of hyperventilation syndrome in adults 36 however has been also used previously as a measure for DB symptoms11. Twenty two percent of participants were unable to complete a NQ due to their age or comprehension, suggesting that validation studies should be conducted in this age group. We also acknowledge that the process of filling in pre and post intervention questionnaires can contribute to perceived improvements in symptoms therefore we cannot be sure that improvements in our data were due to the physiotherapy intervention. Additionally, long-term follow-up studies are required to assess whether the improvements we observed are sustained.

A prospective randomised controlled trial (RCT) is required to assess both the clinical and cost effectiveness of patient centred physiotherapy interventions in children with asthma. We propose that such a study should be powered to detect improvements in asthma control, symptoms, exacerbations, and quality of life as these outcomes have been found to be of particular importance to children and families 37. We have undertaken a post-hoc analysis of these data to estimate the sample size for a future RCT. To detect a change in ACT/CACT with a power of 90% and 5% significance, 30 children would be required per group. This RCT is therefore achievable in terms of numbers of children who would need to be recruited. It is possible of course that change in other parameters such as quality of life will be smaller and would require a larger number to show significance. There is also a need for an outcome measure that is validated for identifying DB symptoms in paediatrics, that is sensitive to change, and has a minimally important difference. This questionnaire should be used in conjunction with skilled physiotherapy observation of breathing patterns to diagnose DB accurately.

# Conclusion

In addition to standard medical therapy, individually tailored physiotherapy interventions, comprising predominately of Buteyko Breathing techniques, improved asthma control and DB in children on all levels of asthma treatment.

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