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Improvements in multi-dimensional measures of dysfunctional breathing in asthma patients after a combined manual therapy and breathing retraining protocol: a case series report

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ABSTRACT

Background: Dysfunctional breathing (DB), which is present in 30–65% of asthmatics, can contribute to increased levels of dyspnea and non-respiratory symptoms which respond poorly to usual pharmacological treatment and impact on asthma control and quality of life. Treatments that target DB in asthmatics have been shown to improve symptoms, asthma control, and quality of life and, in some cases, to improve lung function.

Case presentation: This case series reports on outcomes of a standardised breathing retraining and manual therapy package in 1 male and 5 females with physician-diagnosed asthma, who were also assessed using biochemical, biomechanical and symptomatic measures of DB. After 6 weeks of treatment most participants showed normalisation of all objective DB measures and reduction in respiratory and non-respiratory symptoms. This was associated with improved perceived control of asthma, despite improvements in lung function parameters occurring in only one participant. Participants without signs of DB at the initial evaluation did not show reduced symptoms or improved perceived control of asthma.

Conclusions: These observations suggest that there may be an important role for manual therapy and breathing retraining packages as adjunctive treatments to improve management of patients with asthma and other chronic respiratory disease whose condition is aggravated by DB. The substantial number of individuals with chronic respiratory disease who have poor disease control, disproportionate dyspnea and unexplained symptoms due to DB may be more likely to benefit from non-pharmacological treatments like manual therapy and breathing retraining than those with normal or functional breathing.

Introduction

Background

Asthma is a chronic condition that has been shown to be poorly controlled with medication in 50% of people, despite advancements in pharmacological interventions [1]. A number of co-morbidities contribute to poor asthma control and one of these is dysfunctional breathing (DB) [2]. DB is complex and multi-dimensional and can include various combinations of chronic or intermittent hyperventilation, neuromuscular breathing pattern disorders and stress related and psychophysiologically-driven breathing disturbances [3–5].

DB is thought to affect 30–65% of asthmatics [6,7] and can lead to poor asthma control, poor medication response, reduced quality of life and increased respiratory and non-respiratory symptoms [3,8,9]. Therapies that target DB in asthma sufferers have been shown to reduce medication needs and improve asthma control and quality of life (QoL) in patients [10–12]. While breathing and relaxation exercises are the most commonly used approach for correcting dysfunctional breathing, manual therapy can also be included as part of the therapy package [13].

While there is little evidence that manual therapy is effective in improving spirometric measures of lung function and substituting for medical treatment in individuals with asthma [14–16], it has the potential to reduce symptoms [17,18] and might be particularly helpful as an adjunctive treatment [15] in asthmatics with DB [7,19].

Presence of DB in asthma patients increases subjective respiratory and non-respiratory symptoms independent of disease severity [6,9,20], increases medication usage and adversely impacts on asthma control [21]. DB symptoms, asthma control, medication usage and quality of life can be improved when the relevant biochemical, biomechanical and/or psychophysiological dimensions of dysfunctional breathing are appropriately targeted and successfully corrected [22].

Changes in subjective dyspnea symptoms associated with improved neuromuscular aspects of breathing have been described in previous research on manual therapy for asthma patients [17,18] and neuromechanical factors are known to play an important role in the severity and quality of dyspnea symptoms [23]. Therefore, asthma sufferers with DB of a biomechanical nature would presumably be the ones most

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likely to demonstrate clear improvement from the addition of manual therapy to breathing retraining. Given the overlap between biomechanical dimensions of DB with biochemical and psychophysiological aspects of DB [24], these are also likely to respond, particularly if the manual therapy is combined with breathing retraining.

No previous studies have reported on the impact of breathing retaining combined with manual therapy on biomechanical or other dysfunctional breathing measures in asthma sufferers. This case series describes the changes in DB (thoracic dominant) pattern and other DB measures, including DB symptoms and end tidal CO2 (ETCO2), lung function and some quality of life measures in six individuals with asthma after a combined breathing retraining and manual therapy protocol.

Case presentations

The participants in this case series study were all patients of the Southern Cross University Osteopathic Student Clinic in Lismore, Australia. Flyers were displayed in the reception area of the clinics inviting potential participants. Of the people who responded to the advertisement and met the inclusion/exclusion criteria six agreed to participate in the evaluation and 6 week treatment program. Inclusion criteria were medically diagnosed asthma and age greater than 18 years. Exclusion criteria were inability to understand English, cancer, osteoporosis or restrictive lung disease. Participants ages ranged from 26 to 74 years. Five participants were female and one was male. Following is brief demographic and background information on each participant. While all patients reported that their asthma was diagnosed by a physician, we did not verify the exact details of the date of diagnosis.

Participant 1 is a 48 year old Caucasian female with asthma since childhood. Her symptoms include wheezing and anterior chest tightness, exacerbated by dust. She currently uses Symbicort 1-2x/day, and has previously trained in Buteyko breathing to manage asthma symptoms.

Participant 2 is a 27 year old Caucasian female, student and massage therapist. She presents with unproductive dry cough, worse in the evening and in cold weather, restricted breathing, despondency in relation to her asthma and depression which she manages with anti-depressants. She does not currently use any medication to manage asthma symptoms, however she used ventolin, intermittently during the previous 12 months.

Participant 3 is a 68 year old Caucasian female retiree who has a diagnosis of COPD and asthma. She is currently using Spiriva, Seretide and Lukast to manage symptoms. She has experienced several bouts of bronchitis in the previous year.

Participant 4 is a 25 year old Caucasian male, student, presenting with asthma, exacerbated by exercise and seasonal weather changes. He is currently using ventolin to manage asthma symptoms. He previously used a serrotide preventer. He has been hospitalized three times for asthma in the last 3 years.

Participant 5 is a 46 year old Caucasian female, presenting with asthma, exacerbated by allergens. She is currently using Seretide 25 1x/day to manage her asthma symptoms.

Participant 6 is a 20 year old Caucasian female, student, presenting with asthma, exacerbated by exercise and allergens. Currently using ventolin to manage her asthma symptoms.

Consent and ethics

All participants gave informed consent to participate in this study and for their data to be used anonymously. This study was approved by Southern Cross University Human Research Ethics Committee (Approval number: ECN-16-005).

Outcome measures

Participants were assessed on all outcome measures before and after completion of the treatment program. Questionnaires were also re-administered at a 4 week telephone follow-up with the interviewer reading the questions to the participant, noting the score for each answer, adding the individual scores and finally recording the total score for each questionnaire. One person was not available for follow-up questionnaires. Outcome measures included: (1) dysfunctional breathing and rib cage expansion measures, (2) lung function measures, and (3) quality of life and psychometric questionnaires.

1. Dysfunctional Breathing and Rib Cage Expansion Measures
   - **Manual Assessment of Respiratory Motion (MARM)** assesses extent and balance of vertical to lateral direction of motion perceived by their practitioner's hands at the posterior and lateral lower rib cage [25]. The MARM was used to assess relative contribution of upper and lower rib cage motion during five breathing and postural instructions: (1) sit naturally and breathe normally, (2) sit upright, (3) take a deep slow breath, (4) breathe sideways into the practitioner's hands, (5) sit naturally and breathe normally again. In this study, a simple notation system was use, with 0 indicating balanced upper rib cage to lower rib cage movement and 3 indicating maximal thoracic/upper rib cage dominant movement. Scores were added for all five breathing and posture instructions. A minimum score of 0 indicates balanced breathing for all postures; a maximum score of 15 indicates maximal thoracic breathing for all manoeuvres. Minimal Clinically Important Difference (MCID) has not yet been established for the MARM. Previous studies that have used the MARM with a more complex notation system but the same hand placement and patient instructions regarding posture and breathing behaviours have shown good interexaminer reliability and clinical utility [26,27]. Changes in MARM values have been shown to correlate with reductions in dyspnea after breathing retraining [19,28].
   - **Chest expansion** comparing difference between full inhalation and full exhalation at both xiphoid and axilla levels were measured in centimetres using a cloth tape measure. Although MCID has not been established for chest expansion there is some research on normal distribution of values according to gender. In one study of 428 adults, expansion of the upper thoracic region was measured at 2.6 + 1.4cm for males and 2.2 + 1.2cm for females; expansion of the lower thoracic region at 2.3 + 1.2cm for males and 1.7 + 1.1cm for females ($p < 0.05$). In this same study values for males and females combined that are less than the 25th percentile, between the 25-75th percentiles and greater than the 75th percentile are considered to be poor, moderate, and good expansion respectively. For the upper expansion the values are 1.4 cm (poor), 3.1 cm (moderate), 5.1 cm (good) and for the lower expansion 1.0 cm (poor), 2.7 cm (moderate) and 4.3 cm (good) [29].
   - Self-Evaluation of Breathing Questionnaire (SEBQ) was used as a measure of DB symptoms [30]. Test retest reliability has been shown to be high for the SEBQ [31].A minimum score of 0 indicates no self-reported impairment; a maximum score of 75 indicates maximal respiratory discomfort and self-perception of disordered breathing. There are no established cut-scores but expert opinion suggest a score of 25 can be used as an appropriate cut-score to differentiate normal from dysfunctional breathers [32]. MCID has not been established for the SEBQ.
   - Nijmegen Questionnaire (NQ) is a screening tool used to detect patients with hyperventilation complaints and DB patterns [33]. Scores > 20 are used as the cut-score to identify DB in patients with various conditions [34]. MCID has not been established for the NQ, however NQ values in healthy individuals range from 10 to 12 ± 7 and values do tend to decrease towards these levels

after breathing retraining [34].
- o End-Tidal CO2 capnometry: Using a capnometer, carbon dioxide (CO2) levels are measured in expired air and provide a non-invasive measure of ventilation [35]. While PaCO2 less than 37 mmHg is indicated by older texts to indicate physiological hyperventilation [36]. More recent research by Gardner suggest that levels below 35 indicate mild hyperventilation, below 32 mmHg indicate moderate hyperventilation and below 30 mm HG indicate severe hyperventilation [37].

2. Lung Function Measures
   - o Forced vital capacity (FVC) is the amount of air which can be forcibly exhaled from the lungs after taking the deepest breath possible [38]. Forced expiratory volume in 1 s (FEV1) is the volume, exhaled in the first second of forced expiration [38]. The average minimal patient perceivable improvement for FEV1 is reported as 0.23 L [39].
3. Quality of Life and Psychometric Questionnaires
   - o The Asthma Quality of Life Questionnaire (AQLQ) contains 32 questions in four domains (symptoms, activity limitations, emotional function and environmental stimuli). Patients are asked to recall their experiences during the last two weeks and to respond to each question on a 7- point scale. A score of 7 indicates no impairment; a score of 1 indicates severe impairment. The MCID in the AQLQ is 0.5. A change of 1.0 represents a large improvement [40].
   - o Perceived Control of Asthma Questionnaire (PCAQ) is an 11 item questionnaire evaluating perceived control of asthma symptoms. A minimum score of 0 indicates very poor perceived control of asthma; a maximum score of 55 indicates high perceived control of asthma [41]. The PCAQ has demonstrated internal consistency (Cronbach's alpha = 0.74) and excellent construct validity, correlating strongly with asthma severity, Quality of Life, and Medical Outcomes Study Short Form (SF-36) measures of health status ($p < 0.05$) [42]. MCID has not been established for the PCAQ.
   - o Hospital and Anxiety Depression Scale (HADS) assesses the level of anxiety and depression experienced by patients in a hospital outpatients' clinic. Scores of between 0 and 7 indicate normal; scores between 8 and 10 indicate borderline abnormal; scores between 11 and 21 indicate abnormal [43]. A change of 1.5 units or greater in magnitude is required for MCID [44].

Treatment

The treatment, which occurred over 6 weeks, combined a 2-h breathing instructional and practice session during which participants were taught the Breathing Basics (see below) protocol and four sessions of manual therapy using the Breathing Muscle Reset protocol.

Breathing retraining: The Breathing Basics protocol

All participants attended a 2-h Breathing Basics group instruction and practice session and were asked to practise the prescribed sequence of breathing techniques daily in formal practice sessions of 15 minutes and informally during activities of daily life. The Breathing Basics protocol was developed by one of the authors (RC) in the course of clinical practice and refined over several years. Participants were instructed on the following topics: (1) how mouth breathing and poor breathing patterns aggravate asthma symptoms, (2) how tension affects breathing pattern, (3) how to improve their ability to breathe through their nose, (4) how tension, posture, breathlessness and changes in the speed and depth of breathing affect breathing muscles and rib cage motion, and (5) how to breathe when they feel breathless. Next, participants were taught a sequence of breathing exercises called the Breathing Basics routine. This routine involved learning techniques for rehabilitating nasal breathing and improving diaphragm and respiratory muscle function and breathing pattern. Participants were taught alternate nostril breathing, humming and breath -holding techniques to improve nasal airflow. They were also trained to breathe slowly and softly into the area of the lower rib cage and abdomen, in a range of postures including supine lying, prone lying, kneeling, sitting and standing.

Manual therapy: the Breathing Muscle Reset protocol

Participants received four osteopathic manual therapy sessions using the Breathing Muscle Reset protocol (detailed below). The same manual therapy protocol and treatment sequence was used for each participant. This protocol was developed by one of the authors (RC). She has used it in her osteopathic clinical practice for a number of years. The techniques were applied by authors GB, AS and RG in the osteopathic student clinic at Southern Cross University. Participants received 4 separate treatments, lasting 30–40 minutes each.

Techniques used in the Breathing Muscle Reset protocol are described below. The same sequence was used in each patient. Muscles targeted in this protocol included primary and secondary muscles of respiration (i.e., the diaphragm, upper trapezius, scalenes, intercostal muscles, rectus abdominis and abdominal obliques).

The treatment sequence and procedure was as follows:

Patient prone

- Prone Muscle Energy Technique for lower rib cage with resistance post inhalation and stretch on exhalation
  - o Operator places hands on anterior surface of the lower rib cage, lifting the rib cage as the patient inhales. The patient holds their breath for 5 seconds after inhalation and attempts to pull their rib cage back to the table with a light force while operator resists. Patient relaxes and operator stretches the muscles of the rib cage by pushing in an anterior and lateral direction for 5 seconds (Fig. 1).
- Diaphragm proprioceptive training
  - o Operator places their hands at various locations on the lower rib cage and abdomen, including: a) on both sides of the lateral aspects of the lower rib cage (Fig. 2), and b) on the abdomen and lower back (Fig. 3). Operator applies slight resistance with both hands while the patient breathes into the operator's hands for 3–5 breath cycles.

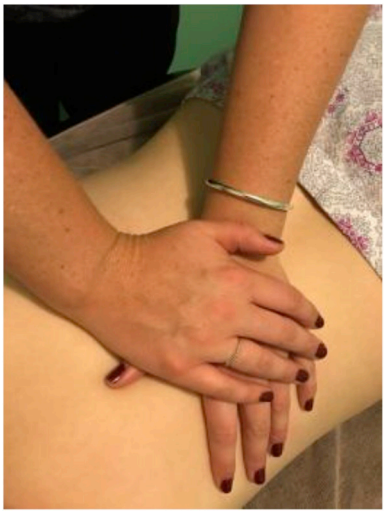

Fig. 1. Prone post isometric relaxation and stretch for lower rib cage with resistance post inhalation and lateral stretch on exhalation.

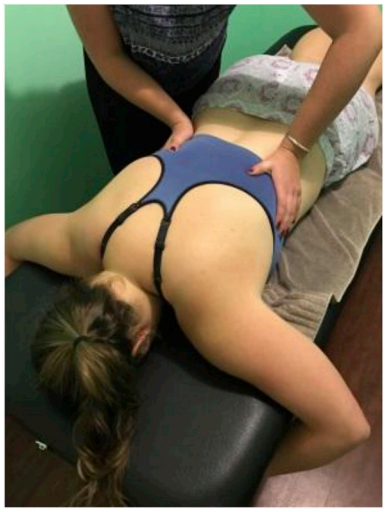

Fig. 2. Diaphragm proprioceptive training with operators hands on lateral aspects of the ribs.

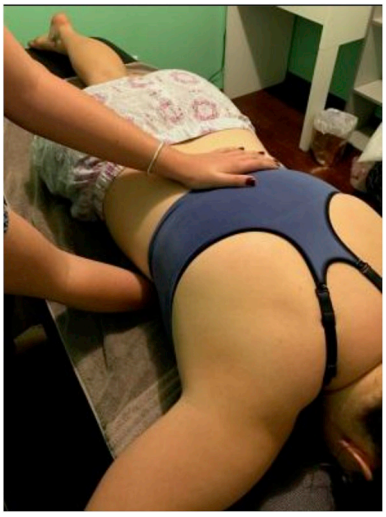

Fig. 3. Diaphragm proprioceptive training with operators hands on the abdomen and back.

Patient side-lying

- Side-lying post-isometric relaxation and stretch for lower rib cage region
  - o Patient lies on their side with the upper arm overhead. Operator places one hand on the lateral rib cage and the other on the patient's upper arm. After an inhalation the patient holds their breath and pushes their arm against the operator's hand. The operator resists the motion of the arm and also the expansion of the rib cage for 5 seconds. The patient relaxes on the exhale while the operator stretches the muscles of the rib cage by applying gentle pressure inferiorly (Fig. 4).
- Soft tissue massage and myofascial release of abdominal muscles (rectus abdominis, abdominal obliques and transverse abdominis) and sub-costal area using cross fibre manipulation for 4–5 seconds on each location (Fig. 5).
- Facilitation of diaphragm doming using upward pressure from the abdomen and downward pressure on the lower six ribs during inhalation and exhalation, The operator applies sustained gentle pressure over 3–5 breath cycles (Fig. 6).
- Myofascial release on lateral neck fascia and scalene muscles. The operator applies direct gentle pressure over scalene muscles,

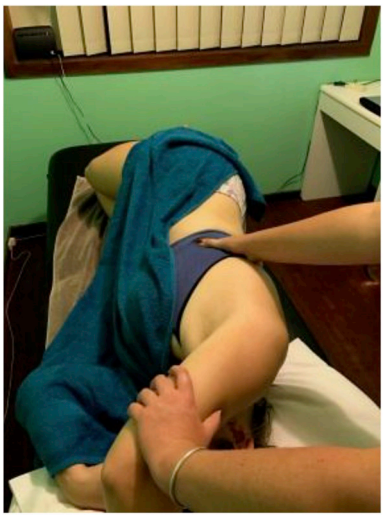

Fig. 4. Side-lying post isometric relaxation and stretch for lower rib cage with resistance post inhalation and stretch on exhalation.

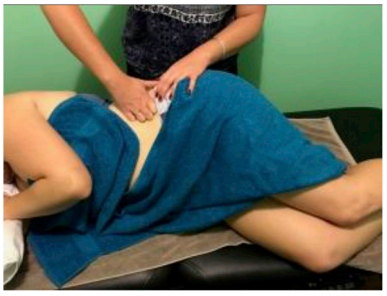

Fig. 5. Soft tissue massage and myofascial release of abdominal muscles and sub-costal region.

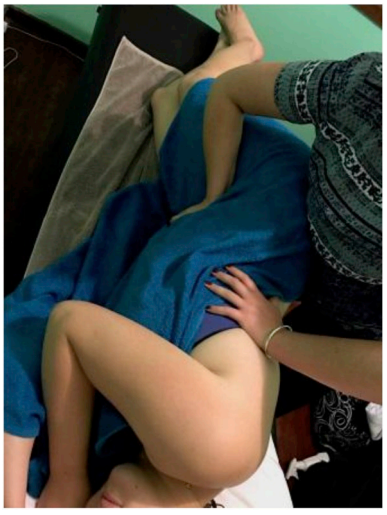

Fig. 6. Facilitation of diaphragm doming using upward pressure from the abdomen and downward pressure on lower ribs.

anchoring the muscle belly while the patient actively rotates their head towards the table (Fig. 7). This action is repeated 3 times.

Patient supine

- Supine post-isometric relaxation and stretch for lower rib cage with post-inhalation and stretch on exhalation

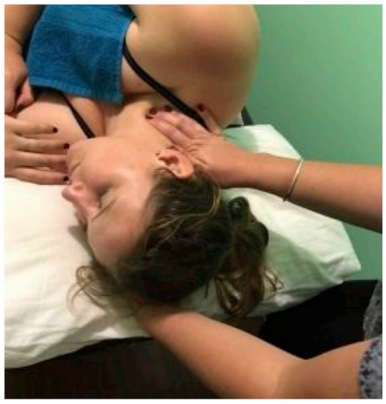

Fig. 7. Myofascial release on lateral neck fascia and scalene muscles.

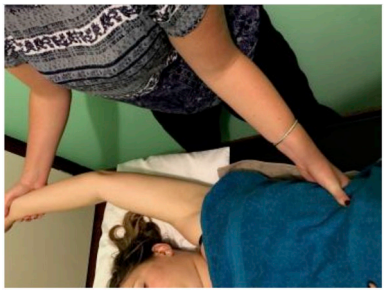

Fig. 8. Supine post-isometric relaxation and stretch for lower rib cage with resistance post inhalation and stretch on exhalation.

- The patient lies supine with the upper arm overhead. The operator places one hand on the lower rib cage and the other on the patient's upper arm. After an inhalation the patient holds their breath and pushes their arm against the operators hand with a light upward force. The operator resists the motion of the arm and also the expansion of the rib cage for 5 seconds. The patient relaxes on the exhalation while the operator applies gentle pressure on the rib cage in an inferior direction (Fig. 8).

Post-isometric relaxation and stretch of upper ribs and anterior neck region

- Operator stands at the head of the table and places their hands on the patient's shoulders. After an inhalation the patient holds their breath and lifts their shoulders towards their head against the operator's hands with a light force. The operator resists the motion of the shoulders for 5 seconds. The patient relaxes on the exhalation while the operator pushes the shoulders towards the patient's feet (Fig. 9).
- Operator places one hand on the patient's upper rib cage and the other hand under the patient's head. After an inhalation the patient holds their breath and pushes their head backwards into the operator's hand with a light force. The operator resists the motion of the head for 5 seconds. The patient relaxes on the exhalation while the operator pushes the upper ribs towards the patient's feet (Fig. 10).

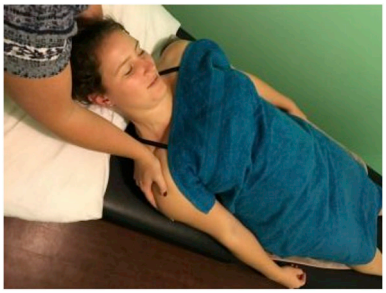

Fig. 9. Post-isometric relaxation and stretch of upper ribs and anterior neck region.

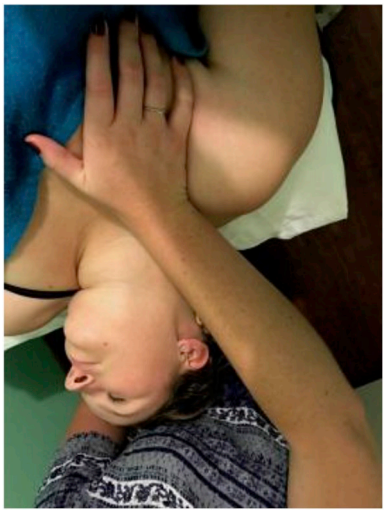

Fig. 10. Post-isometric relaxation and stretch of upper ribs and anterior neck region.

Data collection

Data collected from all outcome measures were collected at initial intake. At completion of the 6 week treatment period all outcome measures were repeated. All questionnaires were readministered at 1 month follow-up.

Data analysis

All participant data were recorded on an Excel spreadsheet. Data from outcome measures were initially tabulated for each patient and then collated by outcome measure and analysed visually using tables and graphs where possible either in the context of MCID or according to cut-off scores differentiating normal from dysfunctional.

Results

Dysfunctional breathing measures

MARM values indicating balance of upper thoracic to lower thoracic/abdominal breathing are represented by lower scores, with a score of 0 indicating that breathing motion was evenly and optimally distributed between upper thoracic and lower thoracic/abdominal compartments. MARM scores improved (i.e. reduced) in all six participants and became optimal (i.e. with score of 0) in three participants post treatment (Table 1).

There was no clear trend in chest expansion measures at the levels of the xiphoid or axilla. Three of the six participants had improved

Table 1
Simplified manual assessment of respiratory motion (MARM).

Case no.	Pre-treatment MARM Total	Post-treatment MARM Total
P1	0	0
P2	2	0
P3	12	3
P4	4	3
P5	8	1
P6	7	0

Table 2
Chest Expansion Measures (in centimetres) at Xiphoid and Axillary Region[a].

Case no.	Pre Tape Xiphoid Difference	Post Tape Xiphoid Difference	Pre Tape Axillary Difference	Post Tape Axillary Difference
P1	3	5	3	2.8
P2	3.5	5.7	4	3.8
P3	1.8	5.5	3.3	5.5
P4	5.5	5.3	5	4.2
P5	5.8	4.8	4.3	2
P6	3.8	3.2	2.3	3

[a] Chest Expansion measures in centimetres report difference between maximal exhalation and maximal inhalation, measured at xiphoid and axilla.

xiphoid expansion, while the other three were either unchanged or had a small reduction in xiphoid expansion; two of the six improved axilla expansion while 4 were either unchanged or reduced (Table 2).

On the DB questionnaires (SEBQ and NQ) all five participants who attended for follow up had lower SEBQ scores at the 4 week follow-up than at the initial intake. In four of the five participants who attended for follow up, SEBQ scores had reduced further at the 4 week follow up. All six participants had reduced symptoms scores for respiratory discomfort symptoms as measured by the SEBQ at the end of the treatment period (Table 3). Five of the six participants had improved their DB symptoms as reflected in NQ scores at the end of treatment, and four of the five had a further reduction of NQ scores at the 4 week follow up. All participants had lower NQ scores at follow up than at the start of treatment (Table 4).

Capnometry assessment found that four participants (P2, P3, P5, P6) had CO2 levels diagnostic of hyperventilation (ETCO2 $<$ 35 mm Hg) at initial capnometry assessment [45]. Three participants had moved into the normal range, when capnometry was repeated at the end of the treatment (P2, P5 and P6). Only one participant (P3) remained in the hyperventilation range (Table 5).

Lung function

Only one participant (P3) had improved lung function. In this participant FEV1 increased from 29% of the predicted value for age, gender and height to 39% of predicted. FVC also increased from 54% of predicted to 70%. Participant 3 had a reduction of FVC from 159% of predicted to 88% of predicted despite no change in FEV1 [46] (Table 6).

Quality of life and psychometric questionnaires

On the Asthma Quality of Life Questionnaire only one participant (P2) achieved a minimally significant clinical change or MCID of 0.5 for this score (Table 7). Five of the six participants reported an increase in perceived control of asthma symptoms (Table 8). Four participants were in the reference range for depression (score $>$ 7) at the beginning of their treatment and three remained in this range post treatment. Three participants were in the reference range for anxiety (score $>$ 7) at the beginning of treatment and three remained in the reference range for anxiety at the end of treatment (Table 9).

Table 3
Dysfunctional breathing symptoms questionnaires: Self evaluation of breathing questionnaire (SEBQ)[a].

Case no.	Pre SEBQ	Post SEBQ	Follow-up SEBQ
P1	19	18	NA
P2	42	18	24
P3	49	40	9
P4	28	16	12
P5	36	27	9
P6	22	20	2

[a] SEBQ total scores at pre and post treatment and at 6 week follow-up.

Table 4
Dysfunctional breathing symptoms questionnaires: Nijmegen questionnaire (NQ)[a].

Case no.	Pre NQ	Post NQ	Follow-Up NQ
P1	10	20	NA
P2	33	10	23
P3	32	30	2
P4	7	3	4
P5	16	13	3
P6	23	12	11

[a] NQ total scores at pre and post treatment and at 6 week follow-up.

Table 5
Capnometry – end tidal (ET) CO2 measures (mmHg).

Case no.	Pre ET CO2	Post ET CO2
P1	40	38
P2	27	41
P3	29	30
P4	42	41
P5	31	37
P6	26	36

Discussion

The most significant findings in this case series were that most participants showed normalisation of objective DB measures, improvement in respiratory and non-respiratory DB symptoms, and increases in their perceived control of asthma. While there were some improvements in lung function parameters (FEV1 and FVC), depression and anxiety symptoms (HADS) and quality of life measures (AQOL) for different individuals, changes were not consistent across the group. The improvements in DB measures and DB symptoms despite lack of improvements in lung function are consistent with findings in other research that utilised more intensive breathing therapy without the addition of manual therapy [47–49].

Normalisation of dysfunctional breathing measures

In this case series a general trend towards normalisation of all DB measures was observed in the majority of participants. Five of six participants showed improvements in breathing pattern. The one participant who did not improve (P1) showed optimal breathing pattern in all challenge situations from the start therefore improvement was not possible. Four participants with chronic hyperventilation were hypocapnic (ETCO2 in the hypocapnic range $<$ 32 mmHg) at the start of treatment; only three were hypocapnic at the end of treatment.

Reduction of dysfunctional breathing symptoms

Five of the six participants had improved DB symptoms as measured by the NQ scores at the end of treatment and all participants showed improvements in the SEBQ, although the changes were minimal (1–2 points) in two participants. The participant who had completely optimal balanced breathing pattern at rest and during postural and respiratory challenge at the start of treatment (P1) did not have any improvement in NQ scores and the least improvement in SEBQ scores by the end of the treatment period.

The findings above showing a link between improved breathing pattern and dysfunctional breathing symptoms is consistent with research showing that hypertonicity and poor responsiveness of respiratory muscles to central ventilatory drive is an important

Table 6
Lung function measures[a].

Case No.	Pre FEV1	Pre FEV1% Predicted	Post FEV1	Post FEV1% Predicted	Pre FVC	Pre FVC % Predicted	Post FVC	Post FVC % Predicted
P1	2.45	77	2.07	70	3.54	88	3.25	86
P2	3.81	101	3.7	99	4.19	95	4.38	99
P3	0.7	29	1.01	39	1.76	54	2.38	70
P4	2.95	68	2.82	64	4.22	78	4.61	86
P5	2.41	80	2.49	82	4.55	159	3.21	88
P6	3.58	90	3.66	92	4.25	93	4.8	104

[a] Forced Expiratory Volume at 1 second (FEV1) in Litres, pre and post treatment. Forced vital capacity (FVC) in Litres, pre and post treatment.

Table 7
Asthma related quality of life questionnaire (AQLQ)[a].

Case no.	Pre AQLQ	Post AQLQ	Follow Up AQLQ
P1	5.63	5.88	5.88
P2	5.88	6.59	6.66
P3	3.84	3.97	3.75
P4	6.06	6.4	6.5
P5	5.72	5.81	5.88
P6	5.9	6.28	5.88

[a] AQLQ pre treatment, post treatment and at one month follow up.

Table 8
Perceived control of asthma questionnaire (PCAQ)[a].

Case no.	Pre PCAQ	Post PCAQ	1 Month Follow Up PCAQ
P1	36	44	39
P2	43	53	51
P3	38	31	31
P4	41	51	52
P5	32	39	38
P6	41	44	44

[a] Perceived Control of Asthma Questionnaire pre treatment, post treatment and at one month follow up.

Table 9
Hospital anxiety and depression scale (HADS)[a].

Case No.	Pre HADS (D)	Post HADS (D)	Follow Up HADS (D)	Pre HADS (A)	Post HADS (A)	Follow Up HADS (A)
P 1	3	3	4	6	6	8
P 2	15	2	10	10	6	9
P 3	9	11	8	6	12	9
P 4	3	0	0	1	1	1
P 5	9	9	8	9	11	10
P6	8	8	7	11	13	13

[a] Hospital anxiety and depression scale scores pre-treatment, post treatment and at one month follow up.

contributor to perceived respiratory symptoms in people with asthma [23].

Psychometric and quality of life measures

Perceived control of asthma improved in the majority of participants (5 of 6 participants), despite the fact that only one participant achieved minimally clinical significant change in asthma specific quality of life scores as measured by the AQOl. Asthmatics with DB have been found to have a decrease in subjective sense of control as measured by the perceived control of asthma questionnaire (PCAQ) [50]. Reduced sense of control has been shown to increase anxiety, fear and emotional distress and adversely affect a range of health outcomes [51]. Lack of perceived control associated with anticipation of not being able to satisfy one's ventilatory needs has been shown to play a part in conditioning inappropriate and excessive increase in ventilation and sensitization to bodily symptoms [52]. This suggests that the PCAQ might be useful for evaluating positive outcomes in asthma patients with DB in a dimension of quality of life not evaluated by the AQOL. Apart from one participant (P3) who had an improvement in depression symptoms it did not seem that the treatment produced noticeable changes in mood.

Lung function changes

One participant (P3) had a simultaneous increase in both FEV1 and FVC at post treatment measurement. As ratios between these measures did not change in this patient, it suggests that the improvements may have been due to the observed improvement in breathing mechanics (chest expansion measures and breathing pattern as measured by the MARM) rather than to improvements in actual lung function. No improvement in lung function was observed in other participants.

This lack of improvement in objective lung function measures such as FEV1 and FVC is consistent with much research on manual therapy [14,15] and breathing retraining [47] although some recent studies have shown improvement in lung function parameters in patients undergoing targeted and intensive breathing retraining for periods in excess of 3 months [53].

Limitations

Given that this study reports on patients treated in the context of normal clinical environment examiners were not blinded when assessing outcome measures. Medication usage on testing days was not recorded, therefore any possible effect of medications on lung function or breathing pattern on testing days is not known. While improvements in the MARM were observed this is a somewhat subjective measure for which MCID has not been established.

Conclusion and recommendations for future research

Manual therapy combined with breathing retraining resulted in improvements in most DB measures in most of the participants in this case series. It did not lead to improvements in spirometric measures of lung function. Consequently, manual therapy and breathing retraining in these patients can reduce symptoms and complications even if the do not produce measurable change in lung pathology or lung function, particularly in asthma patients with DB.

The trends observed in this case series suggest that formal research utilising treatment packages that combine manual therapy with breathing retraining are warranted. Recent reports that DB is more prevalent in COPD patients than in asthma patients with similar effects on symptom escalation [54] suggest that this type of treatment package could be tested on patients with COPD as well as patients with asthma.

Competing interests

None of the authors have any competing interests in the manuscript.

Ethical approval and consent to participate

Ethics approval was received from Southern Cross University Human Research Ethics committee (Approval number: ECN-16-005). All participants gave their informed consent to participate.

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Consent for publication

All participants gave consent for their data to be used anonymously.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijosm.2019.01.003.

References

[1] Demoley P, et al. Update of asthma control in 5 European countries. Eur Respir Rev 2010;19:150–7.
[2] Porsbjerg C, Menzies-Gow A. Co-morbidities in severe asthma: clinical impact and management. Respirology; 2017.
[3] Barker N, Everard ML. Getting to grips with 'dysfunctional breathing'. Paediatr Respir Rev 2015;16(1):53–61.
[4] Courtney R. Multi-dimensional model of dysfunctional breathing and integrative breathing therapy - commentary on the functions of breathing and ItsDysfunctions and their relationship to breathing therapy. J Yoga Phys Ther 2016;6(4).
[5] Courtney R. Breathing training for dysfunctional breathing in asthma: taking a multidimensional approach. ERJ Open Research 2017;0(00065–217).
[6] Thomas M, et al. Prevalence of dysfunctional breathing in patients treated for asthma in primary care: cross sectional survey. BMJ 2001;322:1098–100.
[7] Stanton AE, et al. An observational investigation of dysfunctional breathing and breathing control therapy in a problem asthma clinic. J Asthma 2008;45(9):758–65.
[8] Hagman C, Janson C, Emtner M. A comparison between patients with dysfunctional breathing and patients with asthma. Clin Res J 2008;2(2):86–91.
[9] Agache I, et al. Dysfunctional breathing phenotype in adults with asthma-incidence and risk factors. Clin Transl Allergy 2012;2(18).
[10] Thomas M, McKinley RK, Freeman E, Foy C, Prodger P, Price D. Breathing retraining for dysfunctional breathing in asthma; a randomised controlled trial. Thorax 2003;58:110–5.
[11] Holloway E, West RJ. Integrated breathing and relaxation training (Papworth Method) for adults with asthma in primary care: a randomised controlled trial. Thorax 2007;62(12):1039–42.
[12] Burgess J, et al. Systematic review of the effectiveness of breathing retraining in asthma management. Expert Rev Respir Med 2011;5(6):789–807.
[13] Jones M, et al. Does manual therapy provide additional benefit to breathing retraining in the management of dysfunctional breathing? A randomised controlled trial. Disabil Rehabil 2015;37(9):763–70.
[14] Hondras MA, Linde K, Jones AP. Manual therapy for asthma. Cochrane Database Syst Rev 2005(2). Cd001002.
[15] Kaminskyj A, et al. Chiropractic care for patients with asthma: a systematic review of the literature. J Can Chiropr Assoc 2010;54(1):24–32.
[16] Guiney PA, et al. Effects of osteopathic manipulative treatment on pediatric patients with asthma: a randomized controlled trial. J Am Osteopath Assoc 2005;105(1):7–12.
[17] Bockenhauer SE, et al. Quantifiable effects of osteopathic manipulative techniques on patients with chronic asthma. J Am Osteopath Assoc 2002;102(7):371–5. discussion 375.
[18] Lowhagen O, Bergqvist P. Physiotherapy in asthma using the new Lotorp method. Complement Ther Clin Pract 2014;20(4):276–9.
[19] Courtney R, et al. Medically unexplained dyspnea: partly moderated by dysfunctional (thoracic dominant) breathing pattern. J Asthma 2011;48(3). 259-165.
[20] Grammatopoulou EP, et al. Hyperventilation in asthma: a validation study of the NijmegenQuestionnaire – NQ. J Asthma 2014;51(8):839–46.
[21] Veidal S, et al. The impact of dysfunctional breathing on the assessment of asthma control. Respir Med 2017;123:42–7.
[22] Courtney R. Breathing training for dysfunctional breathing in asthma: taking a multidimensional approach. European Respiratory Journal Open Research 2017;3(4). 00065-2017.
[23] Lougheed MD. Variability in asthma: symptom perception, care and outcomes. Can J Physiol Pharmacol 2007;85(1):149–54.
[24] Courtney R, Greenwood K, Cohen M. Relationships between measures of dysfunctional breathing in a population with concerns about their breathing. J Bodyw Mov Ther 2011;15(1):24–34.
[25] Courtney R, van Dixhoorn J, Cohen M. Evaluation of Breathing Pattern: comparison of a manual assessment of respiratory motion (MARM) and respiratory induction plethysmography. Appl Psychophysiol Biofeedback 2008;33:91–100.
[26] Courtney R, Reece J. Comparison of the manual assessment of respiratory motion (MARM) and the Hi Lo breathing assessment in determining a simulated breathing pattern. Int J Osteopath Med 2009;12:86–91.
[27] Courtney R, van Dixhoorn J, Cohen M. Comparison of manual assessment of respiratory motion (marm) and respiratory induction plethysmograph (the lifeshirt) in measurement of breathing pattern. (abstract). International society for the advancement of respiratory psychophysiology.*(ISARP)*. 2006. Newport, Rhode Island.: Journal of Biological Psychology (in press).
[28] Bockenhauer SE, et al. Measuring thoracic excursion: reliability of the cloth tape measure technique. J Am Osteopath Assoc 2007;107(5):191–6.
[29] Adedoyin RA, et al. Reference values for chest expansion among adult residents in ile-ife, Nigeria-a cross-sectional study. J Phys Ther 2013;6(2):54–8.
[30] Courtney R, Greenwood KM. Preliminary investigation of a measure of dysfunctional breathing symptoms: the self evaluation of breathing questionnaire (SEBQ). Int J Osteopath Med 2009;12:121–7.
[31] Mitchell A. Test retest reliability and determinants of the self evaluation of breathing questionnaire. Osteopathy. Auckland: Unitec Institiute of Technology; 2011.
[32] Kiesel K, et al. Development of a screening protocol to identify individuals with dysfunctional breathing. International Journal of Sports Physical Therapy 2017;12(5):774–86.
[33] Dixhoorn J, Duivenvoorden HJ. Efficacy of the Nijmegen Questionnaire in recognition of the hyperventilation syndrome. Journal of Psychomatic Research 1985;29(2):199–206.
[34] van Dixhoorn J, Folgering H. The Nijmegen Questionnaire and dysfunctional breathing. ERJ Open Research 2015;1(1).
[35] Razi E, et al. Correlation of end-tidal carbon dioxide with arterial carbon dioxide in mechanically ventilated patients. Arch Trauma Res 2012;1(2):58–62.
[36] Comroe JH. Physiology of respiration. Chicago: Year Book Medical Publishers; 1974.
[37] Gardner W, Meah MS, Bass C. Controlled study of respiratory responses during prolonged measurement in patients with chronic hyperventilation. Lancet 1986;2:826–30.
[38] West J. Respiratory physiology. third ed. London: Williams and Wilkins; 1985.
[39] Santanello N, et al. What are minimal important changes for asthma measures in a clinical trial? Eur Respir J 1999;14(1):23–7.
[40] Juniper EF, et al. Validation of a standardized version of the asthma quality of life questionnaire. Chest 1999;115(5):1265–70.
[41] Katz PP, et al. Perceived control of asthma and quality of life among adults with asthma. Ann Allergy Asthma Immunol 2002;89(3):251–8.
[42] Katz PP, et al. Perceived control of asthma: development and validation of a questionnaire. Am J Respir Crit Care Med 1997;155(2):577–82.
[43] Zigmond A, Snaith. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67:361–70.
[44] Bhandari NJ, et al. Comprehensive pulmonary rehabilitation results in clinically meaningful improvements in anxiety and depression in patients with chronic obstructive pulmonary disease. J Cardiopulm Rehabil Prev 2013;33(2):123–7.
[45] Gardner W. Hyperventilation syndromes. Respir Med 1992;86:273–5.
[46] Morris JF, Koski A, Johnson LC. Spirometric standards for healthy nonsmoking adults. Am Rev Respir Dis 1971;103(1):57–67.
[47] Thomas M, et al. Breathing exercises for asthma: a randomised controlled trial. Thorax 2009;64(1):55–61.
[48] Bowler SD, Green A, Mitchell A. Buteyko breathing technique in asthma: a blinded randomised controlled trial. Med J Aust 1998;169(7):575–8.
[49] Cowie R, Underwood MF, Reader PG. A randomised controlled trial of the Buteyko technique as an adjunct to conventional management of asthma. Respir Med 2008;102(5):726–32.
[50] Ritz T, et al. Hyperventilation symptoms are linked to a lower perceived health in asthma patients. Ann Behav Med 2008;35(1):97–104.
[51] Seeman M, Seeman TE. Health behavior and personal autonomy: a longitudinal study of the sense of control in illness. J Health Soc Behav 1983:144–60.
[52] Han J, et al. Medically unexplained dyspnea, psychological characteristics and role of breathing therapy. Chinese Med J 2004;117(1):6–13.
[53] Grammatopoulou EP, et al. The effect of physiotherapy-based breathing retraining on asthma control. J Asthma 2011;48(6):593–601.
[54] Law N, et al. Dysfunctional breathing is more frequent in chronic obstructive pulmonary disease than in asthma and in health. Respir Physiol Neurobiol 2018;247:20–3.