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ARTICLE *in* INTERNATIONAL JOURNAL OF OSTEOPATHIC MEDICINE · SEPTEMBER 2009

Impact Factor: 1.2 · DOI: 10.1016/j.ijosm.2008.10.002

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Contents lists available at ScienceDirect

International Journal of Osteopathic Medicine

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Research report

Comparison of the Manual Assessment of Respiratory Motion (MARM) and the Hi Lo Breathing Assessment in determining a simulated breathing pattern☆

Rosalba Courtney[a,*], Marc Cohen[b], John Reece[c]

[a] RMIT University, School Health Science, 11 Binburra Avenue, Avalon, NSW 2107, Australia
[b] School of Health Sciences, RMIT University, PO Box 71, Bundoora, VIC 3083, Australia
[c] Division of Psychology, School of Health Sciences, RMIT University, PO Box 71, Bundoora, VIC 3083, Australia

ARTICLE INFO

Article history:
Received 28 January 2008
Received in revised form
5 September 2008
Accepted 16 October 2008
Available online xxx

Keywords:
Dysfunctional breathing
Breathing pattern
Breathing assessment
MARM
Hi Lo

ABSTRACT

Aim: The aim of this study was to assess and compare the validity and potential utility of two manual breathing assessment procedures: the Manual Assessment of Respiratory Motion (MARM) and the Hi Lo Breathing Assessment. A secondary aim was to gauge the relationships between experience and the ability to perform these assessment techniques, by comparing the performance of students with practitioners.

Method: 56 osteopaths and osteopathic students were taught the MARM and the Hi Lo Breathing Assessment and trained to simulate breathing patterns. The participants, acting alternatively as breathers and examiners, then attempted to accurately determine whether the breathing patterns simulated by their partner were predominately abdominal, thoracic or, in the case of the Hi Lo, paradoxical. Participants were surveyed on their confidence in the use of each technique, their perceived ease in using each technique, and their intended future use of the techniques. Student and practitioner abilities to detect simulated breathing patterns were compared for the MARM and Hi Lo.

Results: Overall scores for correctly determining breathing patterns were not significantly different for the MARM or the Hi Lo, and there was no notable moderation of this effect according to experience, with both practitioners and students demonstrating a high level of performance on both techniques. There were some differences in accuracy of performance across different breathing styles, with Hi Lo assessment of paradoxical breathing being more difficult to identify correctly. Ease of learning was similar for MARM and Hi Lo but confidence in using the techniques, and intended future use was higher for the MARM. There were some significant relationships between these utility measures and performance, particularly on the MARM.

Conclusions: This study builds on our previous study to strengthen the evidence for the validity of the MARM and also supports the validity of the Hi Lo. Responses to the survey indicate that, overall, participants preferred the MARM to the Hi Lo. This study is a preliminary investigation of these techniques. Future studies to test the validity of these techniques should be performed in a clinical setting on individuals with actual rather than simulated breathing pattern disturbances.

1. Introduction

Breathing pattern disturbance and abnormal function of the respiratory muscles have been proposed to contribute to symptoms such as dyspnea,[1,2] neck and shoulder girdle pain,[3] and temporomandibular joint disorders.[4] It has also been argued that a person's habitual breathing patterns may influence posture and spinal stability, and it has been proposed that correct breathing is the foundation for the correction of dysfunctional movement and postural patterns.[5,6] It is difficult to evaluate the impact of breathing pattern on symptoms, movement and postural patterns on the basis of these previous studies because the characteristics of correct or dysfunctional breathing pattern were not clearly defined and the measurement techniques used to evaluate breathing pattern had not been standardized or validated.

Nevertheless in the clinical environment, breathing pattern is often assessed by observation and palpation and several palpatory

☆ Funding: This study was part of a PhD and supported by RMIT University. The Australian Osteopathic Association provided additional funds and administrative support.

* Corresponding author. Tel.: +61 2 99183460.
E-mail address: courtney2107@optusnet.com.au (R. Courtney).

1746-0689/$ – see front matter © 2008 Published by Elsevier Ltd.
doi:10.1016/j.ijosm.2008.10.002

techniques for assessment of breathing pattern have been described in manual therapy texts and other publications.[3,5,7–10] The techniques differ in the hand placement of the operator, and interpretation and recording of palpatory findings.

In a previous study one technique for evaluating and quantifying breathing pattern, the Manual Assessment of Respiratory Motion (MARM), was compared with measures performed with Respiratory Induction Plethysmography (RIP), an established standard for measuring breathing pattern.[11] This study tested inter-examiner agreement when two examiners used this technique to differentiate between diverse breathing and postural patterns. High levels of agreement between examiners were found with two MARM measures that reflected balance of thoracic to abdominal breathing, $r_{ic} = .85$, $p < .001$. Examiners' MARM measures also correlated with similar measures obtained from RIP, $r = .59$, $p < .01$. Both RIP and MARM methods were able to differentiate between abdominal and thoracic breathing patterns, but only MARM was able to differentiate between breathing changes occurring as an incidental result of postural change. It was concluded that the MARM was a reliable clinical tool for assessing breathing patterns and demonstrated better sensitivity to more dimensions of rib cage motion than RIP.[12]

The MARM procedure was first developed and applied in a follow-up study of breathing and relaxation therapy with cardiac patients in the 1980s. It appeared that two years after breathing therapy the MARM still showed differences between experimental and control patients.[13] The MARM is similar to other breathing assessment techniques that are based on the examiner's interpretation and estimation of the motion of their hands when placed at the posterior and lateral lower rib cage. However, the MARM is of particular interest as a clinical and research tool because it includes a system of notation that allows the examiner to derive numerical values for two variables related to relative distribution of breathing motion and another numerical variable for area of breathing involvement. The examiner can also gauge, rate and record their general impressions of breathing regularity, rib cage stiffness and symmetry of breathing.

In the previous validation study of the MARM high levels of inter-examiner agreement and agreement between MARM and RIP may have been due to the fact that the examiners were all experienced osteopaths.[12] It is unknown to what extent performance on various breathing assessments, such as the MARM and the Hi Lo, is moderated by the experience of the administrator; for example, do experienced practitioners and students differ in the accuracy of their assessments derived from these techniques?

The Hi Lo can be used to assess the motion of the upper rib cage and lower rib cage/abdomen and determine aspects of breathing such as rate, rhythm, relative motion and phase relation of upper and lower breathing compartments.[7] The Hi Lo assesses breathing from the motion observed at the front of the body while the MARM assessment is made with the examiner hands at the back on the mid thoracic and lateral lower rib cage and waist. The Hi Lo findings are reported as qualitative descriptions or as dichotomous variables in comparison with the MARM, which assigns numerical values. To our knowledge, no studies have compared these two assessment methods.

The main aim of this study was to examine the relationship between therapists' performance in the use of the MARM and Hi Lo by assessing the sensitivity and consistency of these techniques when used to assess simulated breathing patterns. Another aim was to gauge whether accurate performance in the use of these techniques was dependant on the examiners' general levels of experience in manual therapy. This was done by comparing results achieved by experienced osteopaths with those of osteopathic students. Finally, relationships between performance on the MARM and Hi Lo, and participants' views on their confidence in and perceived ease of use of each technique and their intention to use each technique in the future, were also considered.

2. Method

Volunteer examiners who were either osteopathic students ($n = 27$) or practicing osteopaths ($n = 29$) attended a two-hour training class that utilised a structured training format. In the training session, participants were taught how to do the simulated breathing techniques and the MARM and Hi Lo breathing assessment techniques.

Participants were paired, with one acting alternatively as 'examiner' and one as 'breather'. Pre-screening of breathing ability was used to exclude people who were clearly unable to correctly modify their breathing pattern.

The breather was instructed to alter their breathing pattern 3 times according to randomly selected written instructions, firstly while the examiner performed the MARM and subsequently the Hi Lo. In the case of the Hi Lo, breathing instructions were various random combinations of thoracic, abdominal or paradoxical breathing. In the case of the MARM the breathing instructions were various random combinations of thoracic or abdominal breathing but not paradoxical breathing. The examiner, who was blinded to the breathing instruction, performed the MARM procedure 3 times, followed by the Hi Lo breathing assessment 3 times, with the aim of accurately determining which breathing pattern was being performed.

Precautions were taken to exclude people who were clearly unable to comply with breathing instructions. People who identified themselves as unable to control their breathing were asked to inform the researcher and were either not involved in the study or excluded from the data set.

Of the 56 volunteers, 29 were practitioners and 27 were students. There were 36 females and 20 males. All performed the MARM and the Hi Lo, but due to errors in the numbering of recording sheets we were only able to analyse data on 55 MARM score sheets and 53 Hi Lo score sheets.

3. Description of breathing assessment techniques

3.1. Manual Assessment of Respiratory Motion (MARM)

The examiners were taught how to perform the MARM and how to record their findings (see Fig. 1) by drawing lines on a pie chart to indicate their estimation of thoracic/vertical or abdominal/lateral dominance, and by ticking a box to indicate either thoracic or abdominal breathing. Usually there are 3 MARM measurement variables that can be calculated from these lines. These variables were not used in this study but are included with Fig. 1 for the reader's interest. Courtney et al. (2008) gives a complete description of the MARM procedure and the full system of notation with calculation of variables in a previous publication.[12]

The following is the description given to examiners for how to perform the MARM. *The examiner sits behind the subject and places their hands on the lower lateral rib cage. The hands rest firmly but do not direct or restrict breathing motion. The hands are comfortably open with fingers spread so that the little finger approaches a horizontal orientation and the thumbs are approximately vertical. The examiner's lower fingers are below the lower ribs to feel abdominal expansion. The examiner makes an assessment of the overall vertical motion relative to the overall lateral motion. Simultaneously they evaluate to what extent the motion is predominantly upper rib cage, lower rib cage/abdomen, or in balance. The examiner then draws two lines. An upper line (A) represents the degree of vertical and upper thoracic motion and the lower line (B) represents the degree of lower*

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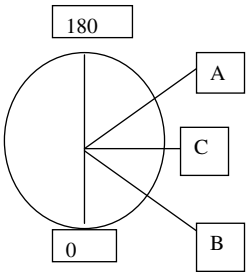

Variables Calculated From MARM Graphic Notation

Variable	Description	Calculation
Area of Breathing	Angle formed between upper line and lower line	Angle A B
Balance	Difference between angle made by horizontal axis (C) and upper line (A) and horizontal line (C) and lower line (B)	AC-CB
Percent rib cage motion	area above horizontal / total area between upper line and lower line x 100	AC/AB X 100

Fig. 1. The MARM graphic notation.

ribs and abdominal motion. The horizontal line (C) represents the thoraco-lumbar junction.

3.2. Hi Lo Breathing Assessment

The examiners received the following instructions for how to perform and record the Hi Lo:

"*Stand at the front and slightly to the side of the person. Place one hand on their sternum and one hand on their upper abdomen. Determine whether thoracic or abdominal motion is dominant during breathing and to what extent this is so. Also, check for paradoxical breathing by seeing if the abdomen moves in a direction opposite to the thorax during breathing; this is evident during inhalation if the abdomen moves toward the spine, and during exhalation if the abdomen moves in an outward direction*."

The extent of thoracic or abdominal breathing was rated using a score between 1 and 3. To avoid confusion and to allow direct comparison with MARM scores, examiners were also asked to tick a box indicating if they considered the breathing pattern to be predominantly abdominal or thoracic. Assessment of paradoxical breathing was also recorded by ticking a box.

3.3. Survey regarding utility of MARM and Hi Lo

Participants were given a questionnaire about their experience of learning and using the MARM and Hi Lo and their self-perceived ability to conduct the breathing techniques. The questions were as follows:

1. I found the (MARM or Hi Lo) easy to use.
2. I felt confident using the (MARM or Hi Lo).
3. I intend to use the (MARM or Hi Lo) in the future.
4. I was able to do the breathing techniques.

The responses to these questions were made using a five-point Likert scale where: 1 = strongly agree, 2 = agree, 3 = unsure, 4 = disagree, 5 = strongly disagree.

3.4. Data preparation and coding

All data were entered into SPSS spreadsheet for analysis. (SPSS Inc., Chicago, IL) Examiners' performance on both the MARM and Hi Lo was recorded dichotomously as either correct or incorrect for both thoracic and abdominal breathing, and, in the case of the Hi Lo only, for paradoxical breathing. Given the method of test administration, as outlined above, there were unequal numbers of tests of thoracic and abdominal breathing across the two methods. The scores for the three testing sessions were totaled to obtain an overall score out of three for both methods, although it should be noted that this total score of three could be made up of any combination of abdominal, thoracic, and, in the case of the Hi Lo, paradoxical breathing. The data relating to ease, confidence and intention toward future use of the two techniques were recorded in line with the five-point Likert scale described above. Because of the wording of the scale, a low score on these questions indicated a positive response.

4. Results

4.1. Comparison of accuracy between the MARM and Hi Lo

Descriptive results for the MARM and Hi Lo total scores and the utility measures are presented in Table 1. The mean total correct score on the MARM across both practitioners and students was slightly lower than the mean total correct score on the Hi Lo, but a Wilcoxon non-parametric signed ranks test found this difference non-significant. Further, a non-parametric correlation found no significant relationship between the two sets of scores. Non-parametric analyses were used for all significance testing because of the ordinal nature of the data.

These differences were not moderated by the experience of the administrator. Although the differences between the MARM and Hi Lo were slightly higher for the practitioners than the students, no significant differences were found between the scores of the two techniques for each group separately, and no significant correlations were found between performance on the two techniques for

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Table 1
Descriptive statistics for performance and utility measures.

Measure	Students ($n = 29$)		Practitioners ($n = 27$)		Total ($n = 56$)	
	M	SD	M	SD	M	SD
MARM – Total correct	2.46	0.64	2.54	0.99	2.48	0.82
Hi Lo – Total correct	2.61	0.50	2.77	0.51	2.69	0.51
MARM – Ease of use	1.36	0.73	1.41	0.97	1.38	0.85
MARM – Confidence in use	1.57	0.84	1.67	1.07	1.62	0.95
MARM – Intention toward future use	1.61	0.69	1.63	1.01	1.62	0.85
Hi Lo – Ease of use	1.46	0.64	1.52	0.70	1.49	0.66
Hi Lo – Confidence in use	2.04	0.79	2.19	0.88	2.11	0.83
Hi Lo – Intention toward future use	2.29	0.81	2.52	1.05	2.40	0.94

each group separately. These analyses used the same statistical methods as those outlined above. Further, a Mann–Whitney *U* test found no significant difference between practitioners and students in overall performance on either technique.

It is possible that these statistical outcomes were affected by a pronounced ceiling effect in the data. Given a maximum score of 3 for each technique, the mean values indicate nearly perfect performance for many participants. The data reflect this, with 50% (27/54) of participants scoring 3 on both measures. This proportion of perfect performance was higher for practitioners (16/26, 62%) than students, (11/28, 39%).

There was, however, some notable differences in accuracy across the different breathing styles (i.e., thoracic, abdominal, and paradoxical). Table 2 presents a detailed breakdown on performance for both practitioners and students on each technique for the different breathing styles. A Cochrane's *Q* test found no significant differences in performance across thoracic and abdominal breathing styles for the MARM for either the sample as a whole or for practitioners and students separately; however, a significant difference across the three breathing styles of the Hi Lo (thoracic, abdominal and paradoxical) was observed for the sample as a whole, $Q(2) = 10.36$, $p = .006$, with performance on paradoxical breathing (66% correct) inferior to both abdominal breathing (94% correct) and thoracic breathing (96% correct). This result was moderated by experience, with no significant difference found for practitioners, but a significant difference found for students, $Q(2) = 6.25$, $p = .044$; again, paradoxical breathing was found to be less easy to identify than either thoracic or abdominal breathing.

A more focused analysis of the relationships between the two techniques was conducted by considering the performance of participants in identifying abdominal and thoracic breathing patterns separately. A Cochrane's *Q* test found a significant difference between the MARM and Hi Lo on participants' ability to identify thoracic breathing, $Q(1) = 8.00$, $p = .005$, with superior performance shown using the Hi Lo technique. Interestingly, this difference was moderated by experience: no significant difference was found between the two methods in students' ability to identify thoracic breathing, but there was a significant difference with practitioners, $Q(1) = 5.00$, $p = .025$, with the Hi Lo demonstrating superior outcomes. Identical analyses found no significant differences in identifying abdominal breathing.

Consistency between the two methods was assessed using Cohen's κ; these analyses were conducted across the entire sample and for practitioners and students separately.

A modest level of agreement was found between the two techniques for identification of thoracic breathing, $\kappa = .29$, $p = .001$, but not with abdominal breathing. The agreement observed on the thoracic breathing scores was not moderated by experience, with moderate agreement being observed for students, $\kappa = .53$, $p = .001$, and practitioners (κ could not be calculated for this group because there were no incorrect assessments using the Hi Lo). Despite the lack of overall agreement between the two methods on their ability to correctly identify abdominal breathing, there was some moderation according to experience, with a substantial difference being observed for practitioners, $\kappa = .29$, $p = .037$, but not for students.

Table 2
Performance on specific MARM and Hi Lo measures.

Measure	Students	Practitioners	Total
	% Correct (ratio correct/total)	% Correct (ratio correct/total)	% Correct (ratio correct/total)
MARM			
Thoracic	82 (31/38)	88 (36/41)	85 (67/79)
Abdominal	87 (40/46)	78 (29/37)	83 (69/83)
Hi Lo			
Thoracic	94 (32/34)	97 (32/33)	96 (64/67)
Abdominal	93 (26/28)	96 (26/27)	95 (52/55)
Paradoxical	68 (13/19)	78 (14/18)	73 (27/37)

4.2. Simulated breathing

In response to the statement "I found the breathing techniques easy to do", only 3.8% of participants disagreed or strongly disagreed with this statement, although 14.8% of participants indicated that they were unsure. This figure most likely reflects uncertainty rather than an inability or true difficulty in performing the thoracic, abdominal and paradoxical breathing maneuvers.

4.3. Utility measures

Across both practitioner groups, there were no significant differences between the MARM and the Hi Lo with regard to perceived ease in using the technique. A Wilcoxon signed ranks test did, however, find significant overall differences between the two methods in terms of intended future use, $z = 4.73$, $p < .001$, and confidence in using, $z = 3.15$, $p = .002$. In both instances, the more positive impressions were in favour of the MARM. This difference was not notably moderated by experience, with a similar pattern of significant results emerging for both students and practitioners on both confidence and intention toward future use. Further, Mann–Whitney *U* tests revealed no significant overall differences between students and practitioners on any of these variables.

An interesting pattern of results emerged when ease, confidence and intention toward future use were related to performance on the two techniques. Non-parametric correlations revealed no significant relationships between any of the utility measures and performance on the Hi Lo; however, performance on the MARM was significantly correlated with its perceived ease of use, $r_\tau = .31$, $p = .018$, perceived confidence in use of the technique, $r_\tau = .28$, $p = .028$, and intention to use the technique in the future, $r_\tau = .43$, $p = .001$. In each instance, high scores on the utility measure

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(i.e., reflecting higher perceived ease, more confidence, and a more positive intention toward future use) were related to more accurate performance with the technique. Further, these relationships were clearly moderated by experience. For students, intention to use the MARM in the future revealed a strong positive relationship with performance on the method, $r_\tau = .49$, $p = .006$, which was not evident in the practitioners; however, significant positive relationships were found for the practitioners between perceived ease of using the MARM and performance on the MARM, $r_\tau = .51$, $p = .007$, and between confidence in using the MARM and performance, $r_\tau = .53$, $p = .004$.

Additional qualitative written comments and feedback from 6 participants suggested that the hand positioning of the MARM was more effective because it allowed improved sense of upper rib cage movement and the balance of upper rib cage to lower rib cage abdomen motion without intruding on the patients' breathing. Comments also indicated participants favored the system of notation used by the MARM and that hand placement on the front of the body with the Hi Lo tended to be more intrusive and was more likely to influence the patient to artificially alter their breathing pattern in response to the examiner's hands.

5. Discussion

This study indicates that less experienced practitioners with only a small amount of practice and training can use the MARM and Hi Lo with similar levels of accuracy to experienced practitioners. There were only minor differences observed between students and practitioner's performance, for examples students were better able to identify abdominal breathing using the MARM and in turn practitioners were better able to identify paradoxical breathing using the Hi Lo. More practitioners than students achieved a perfect score. Overall, however, both students and practitioners achieved similar levels of accuracy for most simulated breathing patterns.

Paradoxical breathing, performed by the 'breather' drawing in the abdomen during inhalation was found to be the most difficult simulated breathing pattern for examiners using the Hi Lo to determine. It is unlikely that simulation reproduced the actual muscle activity that occurs in real life paradoxical breathing. Inadequate relaxation and subsequent doming of the diaphragm during exhalation tend to accompany real life paradoxical breathing. The diaphragm then becomes inefficient in producing lateral expansion of the lower rib cage during inhalation.[4,14–16] Arguably the main clinical significance of paradoxical breathing is its effect on diaphragm function. The question of how well the Hi Lo measures true paradoxical breathing and more importantly diaphragm dysfunction has not been adequately answered by this study.

The common assumption that displacements of the ventral abdominal wall accurately indicate diaphragmatic activity is not always correct.[14,16,17] Therefore assessment of anterior displacement of the abdominal wall, as determined by techniques such as the Hi Lo, may not be the best way to assess the functionality of the diaphragm. In fact, excess forward displacement of the abdominal wall can compromise the ability of the diaphragm to lift and widen the lateral rib cage if this results in a large decrease of intra-abdominal pressure. Abdominal muscle tension assists the doming of the diaphragm and increases the zone of apposition by pushing abdominal contents up against the diaphragm. If intra-abdominal resistance is small because the abdomen is too compliant, the diaphragm descends too far into the abdominal cavity, reducing the zone of apposition; the diaphragm becomes shorter and flatter and fibers of the diaphragm become orientated in a more lateral rather than vertical direction. This impairs the diaphragm's ability to lift and widen the lower six ribs into their inspiratory position.[15]

The MARM evaluates expansion of the lower lateral rib cage and in some situations this may be a more reliable indicator of diaphragm efficiency than the Hi Lo observation of anterior abdominal displacement. With decreased force of diaphragm contraction, decreased lateral basal expansion is usually accompanied by a compensatory increase in accessory muscle use and, therefore, an increase in vertical and thoracic motion during inspiration. The fact that these two motions are simultaneously monitored by the MARM is strength of this technique.

MARM performance in both groups was related to how easy the examiner found this technique and their confidence in using it. Performance on the Hi Lo did not relate to any of the utility measures, i.e., ease, confidence, or future use. This indicates that individuals who found the MARM difficult and were not confident in using it did not perform as well. This suggests that some further training in MARM was needed by some individuals to improve ease and confidence and it is reasonable to speculate that this would have improved performance of the MARM in these individuals.

Preference for the MARM was shown in two ways, survey results showed that both students and practitioners were more confident with the MARM and more likely to use the MARM in the future. Invited comments showed that participants preferred the hand position and system of notation of the MARM. They found the hand position less intrusive, and felt that breathers were less likely to change their breathing in response to the examiner's hands when the examiner was sitting behind and placing their hands on the lower ribs only. However most examiners indicated an intention to use both techniques in the future. Students' intention to use the techniques in future was related to their performance on the MARM and Hi Lo. Interestingly practitioner's intention to use the techniques was not related to their individual performance but rather to their evaluation of the utility of the technique itself based on other factors.

There are other functions and ways of using the MARM and Hi Lo not tested in this study. For instance the MARM can be used to assess and note the examiner's impressions of the stiffness of rib cage and general freedom of breathing motion. MARM can also be used for assessing symmetry of breathing, which can be compromised by scoliosis and also by unilateral diaphragm dysfunction.[4] Non-uniform distribution of pressure distorts the rib cage and markedly stiffens it. In normal situations lung volume can increase up to 70% of maximum workload without stiffening the rib cage, however, when there is non-uniform distribution of breathing this distorts and stiffens the rib cage.[18] The Hi Lo and the MARM are best used in various body positions and with different breathing instructions to fully evaluate the flexibility, and thus functionality, of breathing.

There are several limitations to this study, some of which were self-imposed due to the need to maintain uniformity of teaching and testing. In designing the study we decided on a two-hour limit to teach both techniques and tried to maintain consistency across all four teaching sessions despite seeing that a longer training period with more individualized feedback could have been beneficial in some cases. While we did ask individuals to exclude themselves in the pre-test period if they felt they could not modify their breathing pattern as instructed, it was not possible with the current design to check that each breather was simulating each breathing technique correctly in each case. This makes interpretation of the accuracy scores more difficult because lack of accuracy could have been due to the breather rather than the examiner.

6. Conclusions

Both the MARM and the Hi Lo appear to accurately assess breathing patterns when used by both experienced clinicians and

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osteopathic students. Both practitioner and students have slightly more positive impressions of the MARM. As each technique has its own strengths and limitations the evaluation of dysfunctional breathing may best be performed using a combination of both techniques. Future studies to validate these techniques should be performed in a clinical setting on individuals with actual rather than simulated breathing pattern disturbances.

Acknowledgements

We would like to acknowledge the Australian Osteopathic Association for contributing funding assistance and administrative support for this project. Victoria University and RMIT University assisted by providing access to students, administrative support and teaching facilities. Also we would like to thank students and practitioners who kindly volunteered for this project.

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