International Journal of Osteopathic Medicine (2013) 16, 68–80

ELSEVIER

International Journal of Osteopathic Medicine

www.elsevier.com/ijos

RESEARCH REPORT

Osteopathic intervention for chronic pain, remaining thoracic stiffness and breathing impairment after thoracoabdominal oesophagus resection: A single subject design study

Kristofer Bjerså [a,b,*], Catharina Sachs [c,d], Anders Hyltander [a,e], Monika Fagevik Olsén [a,b,f]

[a] *Department of Surgery, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden*
[b] *Department of Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden*
[c] *Scandinavian College of Osteopathy, Gothenburg, Sweden*
[d] *University of Wales, Cardiff, UK*
[e] *Department of Surgery, Östra Sjukhuset, Sahlgrenska University Hospital, Gothenburg, Sweden*
[f] *Institute of Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Sweden*

Received 14 May 2012; revised 12 October 2012; accepted 15 October 2012

KEYWORDS
Osteopathic manipulative treatment;
Thoracotomy;
Postoperative pain;
Range of motion;
Dyspnoea

Abstract *Background:* Thoracic surgery can cause negative effects such as chronic pain, impaired thorax movement and/or impaired breathing. There are indications that manual therapies, such as osteopathy, may be beneficial for these conditions.
Objective: To investigate effects of osteopathic intervention on chronic pain and remaining limitations to thoracic range of motion and breathing in patients who had undergone thoracoabdominal resection of the oesophagus.
Design: In a single-subject research design (Aa-B-Ab), 8 participants with chronic postoperative thoracic pain, stiffness and/or breathing impairment after standardized oesophagus resection were given 10 sessions of osteopathic treatment of 45 min. Expiratory vital capacity, thorax mobility, pain experience, and subjective perception of treatment were measured on three occasions during each phase. The

* Corresponding author. Department of Surgery, Sahlgrenska University Hospital, 41345 Gothenburg, Sweden. Tel.: +46 031 3428735; fax: +46 0 31 826475.
E-mail address: kristofer.bjersa@vgregion.se (K. Bjerså).

1746-0689/$ - see front matter
http://dx.doi.org/10.1016/j.ijosm.2012.10.003

two-standard deviation band method was used to indicate significant change.
Results: A significantly increased range of motion in the thorax was observed in thoracic excursion and in lateral flexion. A positive change in pain was also noted. The results in expiratory vital capacity were contradictory. The participants were generally positive toward the treatment given.
Conclusion: Osteopathic intervention may affect thoracic impairment and pain among people with chronic pain and impaired thoracic range of motion after thoracoabdominal resection of the oesophagus.

Implications for clinical practice

- Osteopathic treatment may be beneficial in managing post-thoracic stiffness and pain.
- Due to the lack of previous research of osteopathic manipulation in the surgical context, it is difficult to draw any further conclusion of clinical effectiveness.
- Before adopting these findings in clinical practice, future research is needed and should include larger populations of patients, be collaborative between international surgical centres and also evaluate the osteopathic treatment protocol used in this trial.

Introduction

A common surgical access in the treatment of oesophagus cancer is through incision between two ribs (costae), i.e. thoracotomy. The procedure is considered to be among the most painful surgical incisions.[1-3] Long-term follow-ups have reported postoperative chronic pain, breathing restriction, dyspnoea, decreased chest expansion and impaired physical performance.[4,5] There is currently no evidence of effective treatment to offer these patients. However, there are indications that manual medicine, i.e. "treatments given by hand", may be effective against pain associated with thoracotomy.[6]

One of the manual disciplines is osteopathic medicine, founded in the late 19th century and often seen as the origin of Western manual medicine. The basic concept in osteopathic philosophy is the self-healing and self-regulating capacity in the human body, which is thought to be dependent on the integrity and interrelatedness of structure and function at all levels in the body.[7] The model emphasizes the use of a variety of manual techniques to improve physiological function.[8] Little research has focused on effects of osteopathic interventions in the postoperative phase. However, smaller studies have shown positive results in patients undergoing gynaecological[9] or cardiac surgery,[10] or in patients with pancreatitis.[11] Osteopathic intervention guidelines have also been suggested for postoperative pain.[12] Two clinical studies have presented positive results of an osteopathic intervention for pneumonia.[13,14]

There is consequently an indication that osteopathic manual treatment can be beneficial for people suffering from pain, thoracic stiffness or breathing impairment after thoracotomy. Thus the aim of this study was to investigate the effects of osteopathic intervention on chronic pain and remaining limitations to thoracic range of motion and breathing in patients following thoracoabdominal resection of the oesophagus.

Methods

Study design and instrumentation

A single-subject research design, with Aa-B-Ab phases, was used.[15,16] "A" represents a nontreatment phase, where "a" is before the intervention and "b" is after the intervention. "B" refers to the ten weeks intervention phase. All three phases consisted of three measurement sessions: Aa once a week for 3 weeks, B every second to third week for 10 weeks, and Ab every second to third week for 8 weeks. Each measurement session consisted of physical measurements, a period of rest when the participants filled out questionnaires and, after 60 min, re-performance of the physical measurements.

The quantitative objective measurements (physical) were:

- Forced vital capacity (FVC)[17] measured with Easyone ultrasound spirometry[18,19](nnd Medical Technologies Inc, MA, USA)
- Thorax excursion.[20–22] Difference in chest circumference at level costae 4 and at xiphoid process during instruction of maximum inspiration and maximum expiration
- Respiratory thoracic and abdominal movement of rest and during maximum and minimum breathing movement, measured with Respiratory Movement Measuring Instrument (RMMI).[23,24]
- Lateral flexion measured at the thigh level of the tip of the index finger in a standing position and in maximal lateral bending position to the right and left.[25]
- Thoracic flexion assessed by measuring the distance between skin marks at the 7th cervical vertebrae spinous process and 30 cm caudal in a standing position, during maximal flexion of the back and the neck and in maximal extension.[21]
- Pain intensity assessed during lying, sitting and standing measured with Pain-o-meter.[26]
- Brief Pain Inventory short form (BPI-SF) Swedish version.[27,28] The BPI is scored in two measures — pain severity and pain interference — that range from 0 to 10, with higher scores indicating poorer functioning. Only pain severity is reported in this paper.
- Physical activity measured with the International Physical Activity Questionnaire short version (IPAQ-S) Swedish version[29–31] (Before (Aa) and after (Ab)).
- Intervention related questions for pain, stiffness, breathing, recommendation, intervention suitability, and sufficiency of the number of treatments evaluated at the final measurement session.

Participants

Clinical records for patients who had undergone resection of the oesophagus by thoracoabdominal surgery (by incision between right side costae five and six and abdominal middle incision) at one surgical centre in the southwest of Sweden between 2003 and 2010 were scanned for suitability of inclusion in the study. A total of 163 patients were identified. Of these, 78 were still alive at the start of the study. The exclusion criteria were: 1) known active malignity; 2) failing general condition; 3) psychiatric decease or cognitive dysfunction; 4) active alcoholism; 5) dermatological decease; 6) osteoporosis; 7) ongoing infection (except for cold or common virosis, or smaller wounds; 8) hemorrhagic disorder; 9) known neurological injury or disease affecting the thorax; 10) preoperative pain in the thorax; 11) previous treatment by an osteopath; and 12) living more than 50 km from the osteopathic intervention clinic. Of the 78 patients, 36 lived within 50 km of the osteopathic clinic, and after further exclusion due to other medical conditions, 19 patients were initially contacted and informed of the study by mail. These subjects were phoned one week after mail distribution, informed again about the study, checked for inclusion criteria and invited to participate. Inclusion criteria were: 1) perceived pain; 2) stiffness in the thorax and/or 3) dyspnoea commencing after the thoracotomy that did not resolve postoperatively. Of the 19 people invited, 9 accepted participation. Of those who declined to participate, 7 people had no symptoms in the thorax or breathing and 2 had pain and stiffness in the thorax but did not wish to participate. One of the subjects declined further participation after the first measurement session due to heavy reflux, not connected with the study. In total, 8 participants commenced the study protocol.

Ethical considerations

The Regional Ethics Review Board in Gothenburg, Sweden, approved the study (Dnr. 665-10). All participants received written and verbal information about the study before giving their written consent to participate.

Intervention

Participants were given osteopathic treatment once a week for 10 weeks. Each treatment was restricted to 45 min and limited to specified osteopathic techniques focussing on the thoracic region, see Fig. 1. It was also possible for the osteopath to give additional, individually adapted techniques within the consultation. All treatments in the study were delivered by two osteopaths, educated in Sweden and Great Britain, each with over 20 years of clinical experience.

Statistical analysis

Standard statistical measurements are not used in single-subject research design.[32] Instead, results are often presented graphically. The focus in this study was on graphically illustrating each subjects' values and the mean value of each phase, and using the two standard deviation band method. With this method, the mean and standard deviation (SD) of phase Aa are calculated and a band of

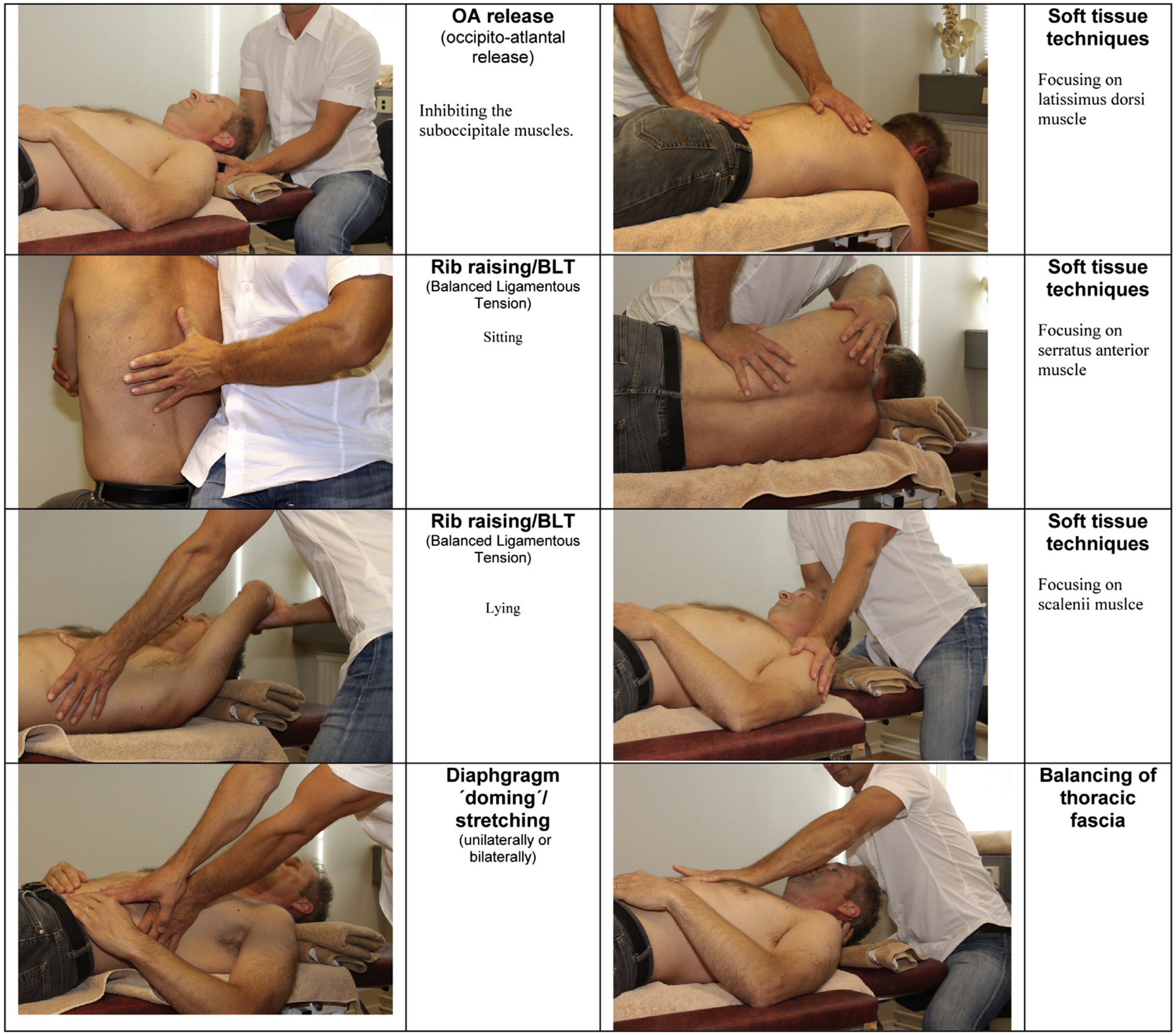


Figure 1 Standardized osteopathic techniques given at each treatment occasion.

+2SD/-2SD is graphically applied from the mean of phase Aa as a shaded area.[32] This shaded band is analogous to a 95% confidence interval (CI), and values outside this area are considered significant if two consecutive data points in the treatment or post-treatment phase fall outside the range of two standard deviations.[33] In this study, significance was accepted if two measurement points were observed on two consecutive different measuring dates.

Results

A total of 8 participants (n = 3 women, n = 5 men), mean age 61.9 years (range 67-51), with respiratory insufficiency or thoracic pain or stiffness were included in the study. Demographics are presented in Table 1. Four of the subjects were age pensioners, 2 disability pensioners, and 2 worked full time. Overall significant values for the parameters measured are presented in Table 2.

Vital capacity increased significantly during the treatment phase (B) in one subject but decreased in two (Fig. 2). Range of motion of the thorax in maximal inspiration-expiration breathing is shown in Fig. 3. Together with RMMI, an improvement in thoracic excursion was observed in three subjects in the upper thorax and four subjects in the lower thorax.

Lateral range of motion (ROM) in the thoracic spine is presented in Fig. 4 and shows increased ROM in six subjects for the right side and in three subjects for the left side. For thoracic flexion, a decrease in movement during the treatment phase (phase B) and the beginning of phase Ab was observed in one subject. No change in extension was measured for any subject.

Pain intensity estimation measured by Pain-O-Meter indicated an improvement in one subject with decreased pain during the treatment phase (B) and in the beginning of the Ab phase. However, the pain indication in BPI-SF shows a change in the experience of pain location and decreased area during the treatment and post-treatment phases, see Fig. 5.

The participants' experiences of treatment effect are presented in Fig. 6. One of the four subjects with a breathing limitation experienced a beneficial treatment effect, six of seven in stiffness and five of five in experienced pain. Four of the subjects perceived the number of treatments as sufficient, while two subjects perceived it to be too few, one subject too many, and one was unsure. Six of the subjects agreed completely

Table 1 Subject demographics and body mass index (BMI) and analgesic consumption at start and end of the study protocol.

Subject ID	Time since surgery (year)	Body mass index	Study start (1st measure in phase Aa)			Study end (last measure (9th) in phase Ab)		
			IPAQ-S (International physical activity questionnaire short form; Swedish version)		Analgesic usage	IPAQ-S (International physical activity questionnaire short form; Swedish version)		Analgesic usage
			Total MET	Time sitting (Minutes/day)		Total MET	Time sitting (Minutes/day)	
1	5	27.0	1665 (Low)	480	–	5023 (Moderate)	360	–
2	3	21.7	614 (Low)	600	–	211 (Low)	840	–
3	7	17.2	0 (Low)	600	Paracetamol pregabalin	0 (Low)	Unknown	Paracetamol pregabalin
4	7	20.7	0 (Low)	240	–	1952 (Low)	120	–
5	2	18.6	0 (Low)	Unknown	Paracetamol oxicodone	3379 (Moderate)	180	Paracetamol oxicodone
6	4	24.7	1139 (Moderate)	Unknown	Paracetamol	891 (Moderate)	Unknown	–
7	6	21.5	3100 (Moderate)	420	–	2197 (Moderate)	360	–
8	3	17.3	3939 (Moderate)	360	–	640 (Low)	240	–

Table 2 Number of participants with significant differences according to the two standard deviation manoeuvre during phase B and Ab; "+" indicates a significant increase in measured values, "−" indicates a significant decrease in measured values ($n = 8$).

Spirometry (Percentage of expiratory vital capacity (% FVC))	Thoracic excursion differential maximum inspiration and maximum expiration		RMMI				Lateral flexion		Thoracal flexion/extension measured from C7 and 30 cm caudalt		VAS measured with pain-o-meter		
	Upper thorax		Lower thorax										
	Level costae 4	Level xiphoideus	Left	Right	Left	Right	Left	Right	Flexion	Extension	Lying	Sitting	Standing
+1/−2[a]	+3	+4	+1	+3	+2	+4	+3	+6	−1	0	−1	0	−1

[a] Normalizing during phase Ab.

that they would recommend the osteopathic treatment to another who underwent the same operation and that the treatment is suitable after other surgical procedures in the thorax. No side effects of the treatment were reported. However, soreness, muscle pain and balance flux, similar to symptoms experienced after heavy exercise, was verbally reported by all 8 participants, but did not affect every day life and stabilized within a few days after treatment.

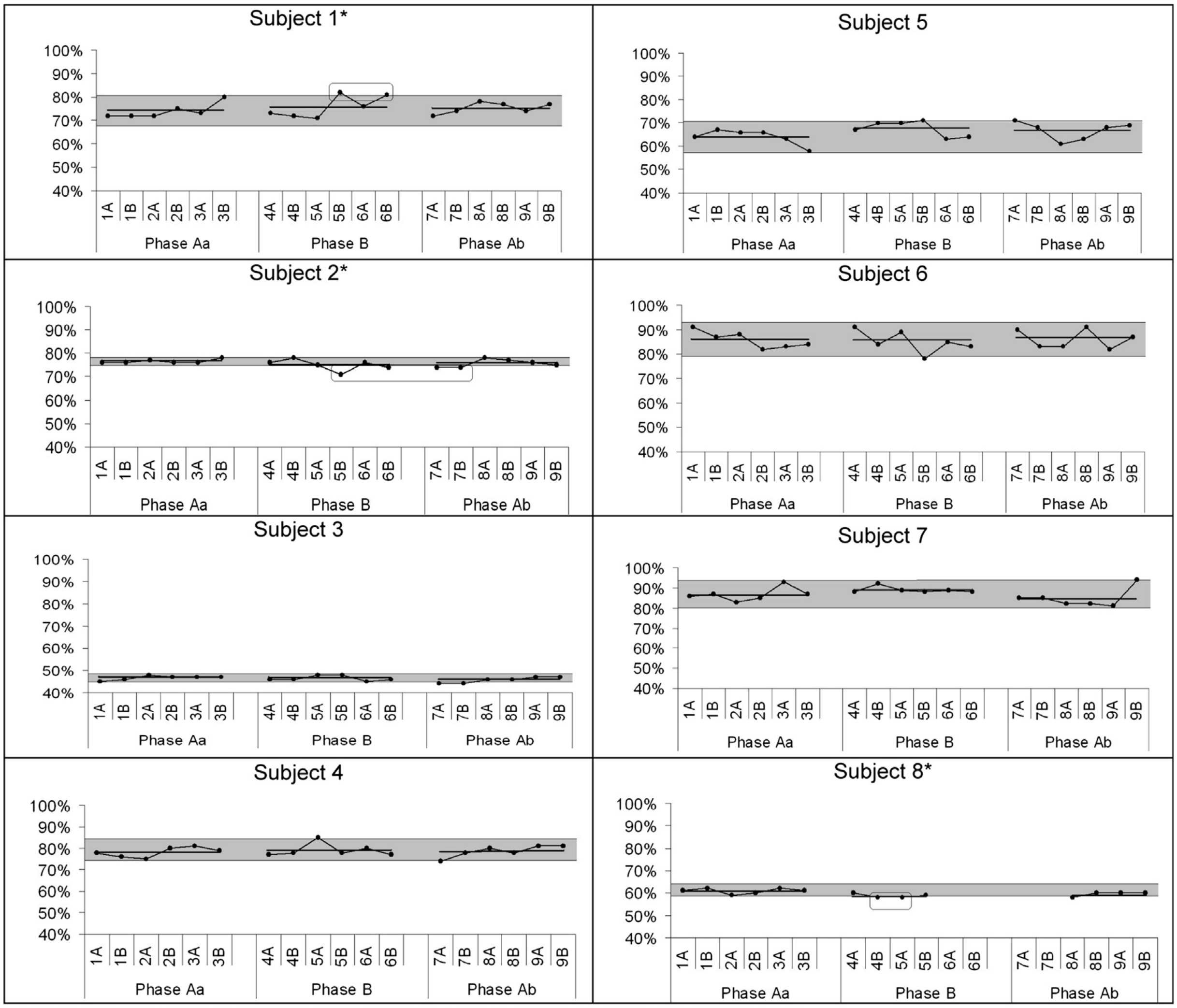
Discussion

The aim of this study was to investigate whether an osteopathic intervention might affect procedure related impaired breathing, thoracic ROM or thoracic pain in patients after thoracoabdominal surgery. The results show that there are tendencies that the osteopathic treatment may be favourable in affecting some of the variables measured. However, the results must be interpreted cautiously and in the context of the low number of participants and the limitations inherent in the study design.

Concerning breathing, vital capacity was minimally affected by the treatment. Previous studies of people with asthma or chronic obstructive pulmonary disease given manual therapies have shown decreased FVC or inconclusive results.[34,35] Despite asthma and postoperative breathing limitations after thoracotomy not being fully comparable, the absence of major treatment effects must be taken into consideration in future investigations.

Concerning the mobility of the thorax, all measures except thoracic spine flexion and extension showed significant improvement in three or more subjects. This is in accordance with Bockenhauer et al.,[36] who showed that, in a small study among people with asthma, range of motion increased significantly in the thorax after osteopathic treatment. Determining how this increased mobility affects each person in his or her life requires other research methodologies, but the participants in this study experienced feeling more mobility and less stiffness (Fig. 6).

A minor decrease in pain intensity was observed in the Pain-O-Meter measurement, but the results of the pain drawings in Fig. 5 indicate changes in perceived pain distribution among the subjects in the B and Ab phases of the study. The effect on neck pain in this study is promising, and improvement in neck symptoms have been suggested as an effect of osteopathic treatment and also of other forms of manual medicine.[37–39] Further research should however evaluate the difference in



* marks significant change in measuring values during the B and Ab phases. Marked in the figure with a sling.

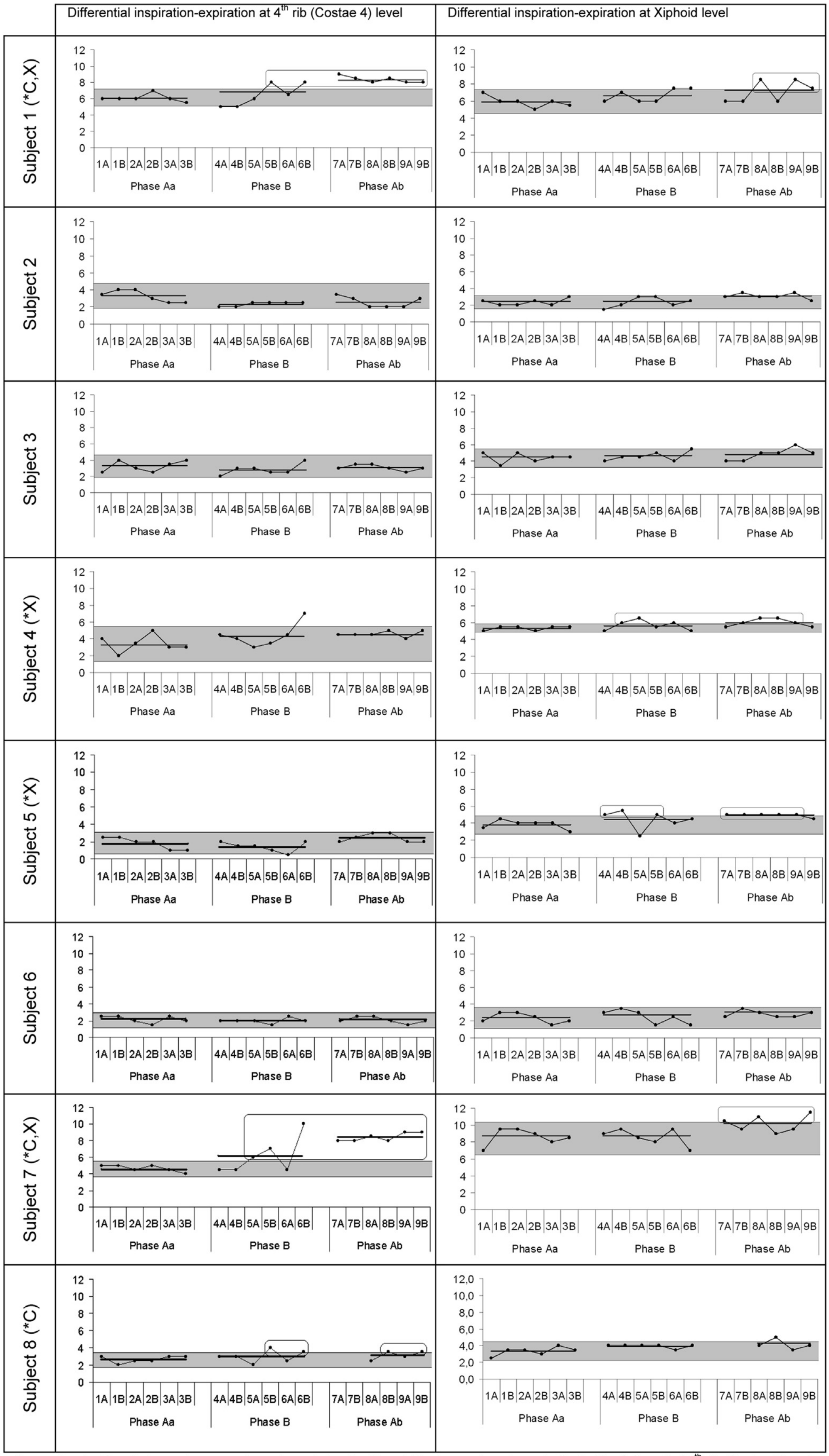
Figure 2 Expiratory vital capacity (percent predicted) during phases Aa, B and Ab ($n = 8$).

postoperative pain between patients receiving osteopathic treated and those without.

Seven of the 19 subjects contacted did not experience the symptoms investigated in this study. This proportion is comparable to a previous Swedish study.[4] Our intention was to investigate whether osteopathic intervention affects patients with remaining postoperative symptoms, and not whether the treatment was valuable for the whole population. Nothing is known about the effect of a preventive postoperative osteopathic intervention to shorten the recovery phase.

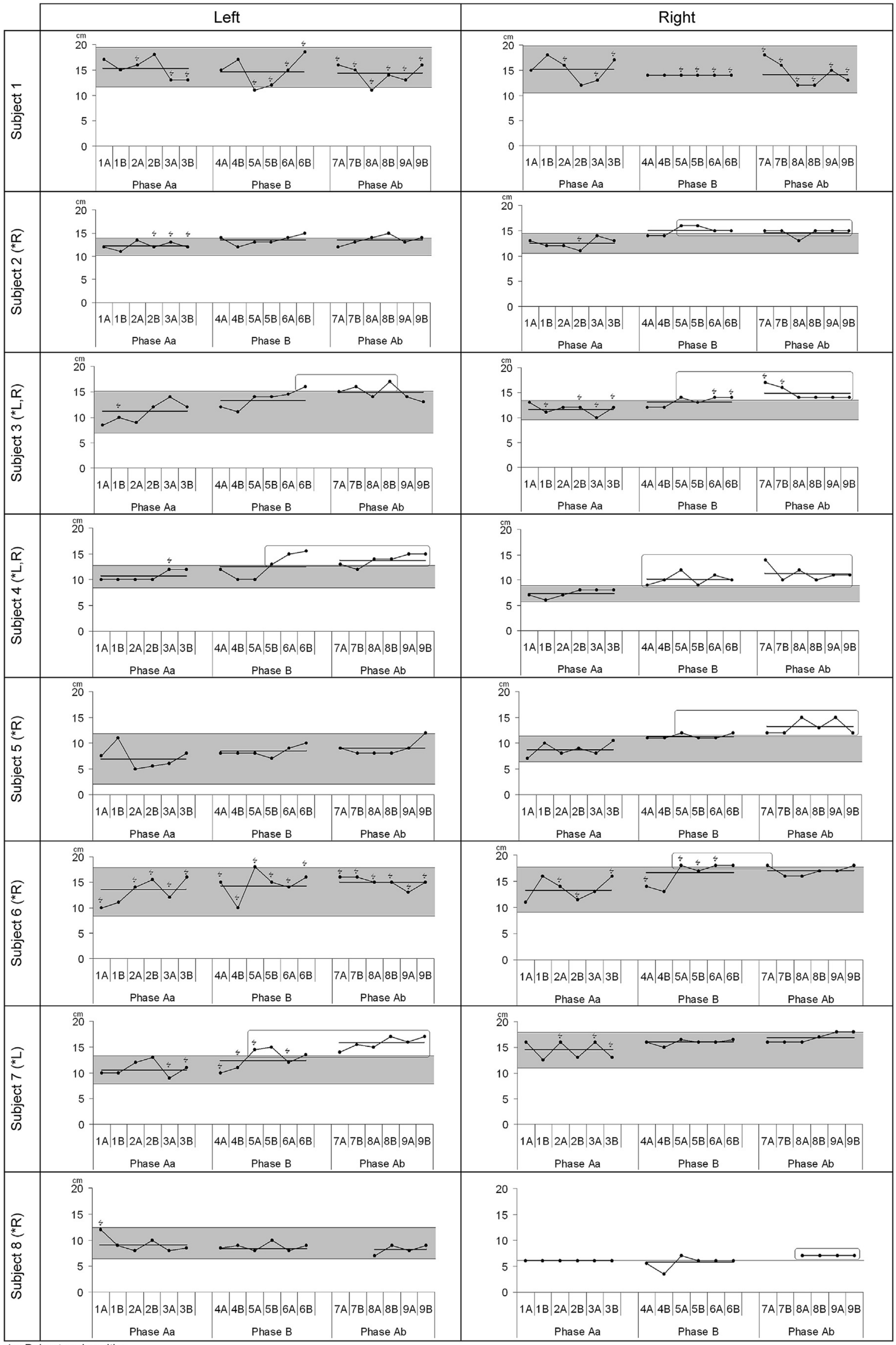
Previous studies indicate that an osteopathic intervention may increase lymphatic circulation.[40–42] However, in thoracoabdominal oesophagus resection, the thoracic duct is resected and ligated in the thoracic cavity to prevent chylothorax and resected together with the malign oesophagus section. Improvements in lymphatic circulation are therefore not a likely explanation for a positive treatment effect. Another anatomical effect of the surgery is vagotomy, which is a side effect of the resection of the oesophagus. Osteopaths sometimes discuss that vagus function is influenced by osteopathic intervention, but how this affects osteopathic treatment and treatment possibilities specifically after thoracoabdominal oesophagus resection remains unclear.

No side effects were reported, but reaction to treatment the day following one treatment, as muscle pain and sourness as well as balance flux, was verbally mentioned and stated by one participant in Fig. 6. Similar observations have been reported in a previous pilot study where the most common adverse effects of osteopathic treatment were local pain and stiffness.[43]



* = marks significant change in measuring values during the B and Ab phases. Levels are indicated by C (Level of 4th rib; Costae 4) and X (Xiphoid process). Marked in the figure with a sling.

Figure 3 Thorax excursion. Thorax circumference with maximum inspiration and maximum expiration at level of 4th rib and xiphoid process level. ($n = 8$).



ϟ = Pain at end position

* = marks significant change in measuring values during the B and Ab phases. Sides indicated by L (left) and R (right). Marked in the figure with a sling.

Figure 4 Lateral flexion ($n = 8$).

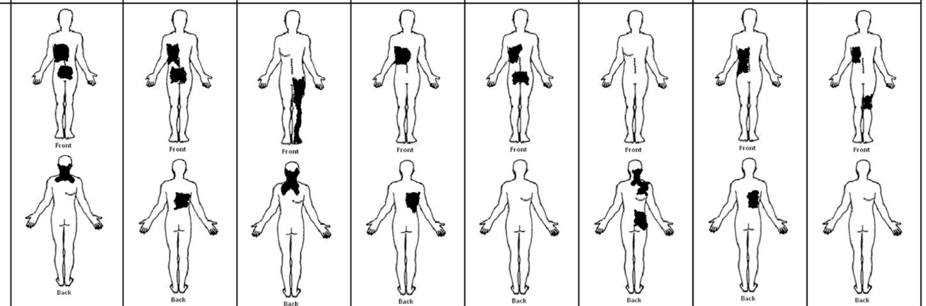
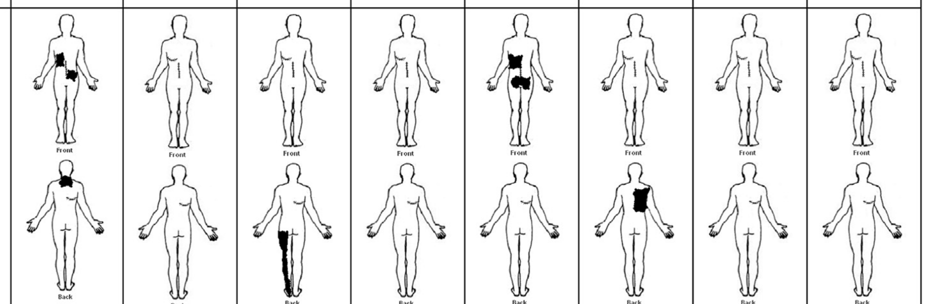
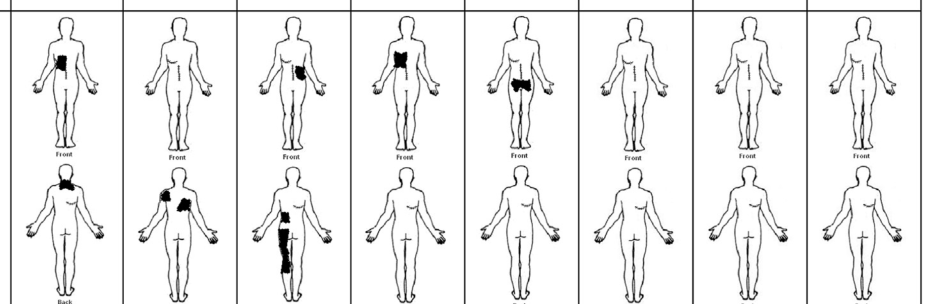
			Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8
BPI-SF (Brief Pain Inventory Short Form; Swedish version)	Period Aa (1st measuring)	Pain location								
		Pain Severity (Mean of question 3-6)	2.8	1.0	2.8	1.5	6.0	3.8	1.0	1.8
	Period B After 10 treatments (6th measuring)	Pain location								
		Pain Severity (Mean of question 3-6)	2.8	0	4.0	0	5.0	2.8	0	0
	Period Ab Final measurement (9th measure)	Pain location								
		Pain Severity (Mean of question 3-6)	3.5	1.5	4.0	2.0	4.0	0	0	0

Figure 5 Pain experience measured by the BPI-SF ($n = 8$).

	Experienced before osteopathic treatment	Effected by the osteopathic treatment
Breathing limitation	Yes: 4; No=4	Yes=1;No=6; Unknown=1
Comments "Easier to breath during treatment" "Hard to tell, but the body was feeling easier"		
Stiffness in the thorax	Yes=7; No=1	Yes=6; No=2
Comments "Have becomed looser and more mobile in the body" "The stiffness disappeared during treatment" "Stiffness relieved" "Less stiffness in the neck and columna" "I feel lighter, more mobile, and looser without any resistance"		
Pain in the thorax	Yes=5; No=3	Yes=5; No=2; Unknown=1
Comments "The day after treatment was bad, muscle pain, otherwise better" "Neck difficulties before, became better" "Neck much better" "There is no longer pain in the costae arcus" "Less pain"		

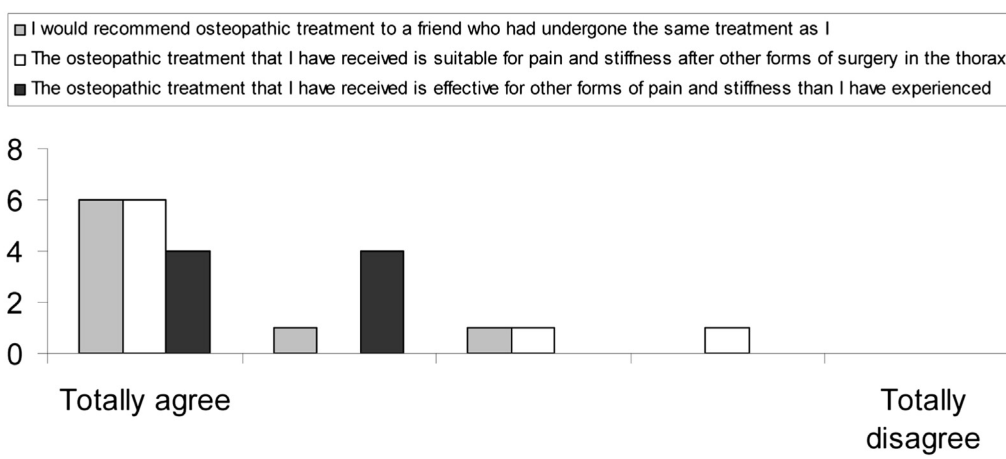


Figure 6 Participants' experiences of the osteopathic intervention ($n = 8$).

Methodological discussion

This study was conducted with a single-subject research design due to the low number of subjects. There are several well known limitations of this method including low generalisability of the results and inability to employ inferential statistical methods.[15] Before recommending an osteopathic intervention, it is therefore important to conduct further trials using group design with comparison groups and blinded assessors.

The utility of this type of single subject research design (Aa-B-Ab) may be debated. An Aa-B-Ab-C (placebo)-Ac process could have indicated the impact of the interaction between patient and therapist. Despite this unknown impact, our results indicate that there might be beneficial effects of manual treatment such as postoperative osteopathic intervention to thoracotomy in patients with pain and decreased range of motion of the thorax.

Osteopathic philosophy states that every treatment must be individualized. The treatment in this study was standardized, and it is not known whether an individualized intervention might have been more beneficial. It is also not known which postoperative phase is preferable for initiating treatment in terms of the optimal treatment effect.

From all points of view, it is important to minimize postoperative pain and address impaired range of motion in the thorax postoperatively. Future trials to evaluate osteopathic intervention closer to discharge are therefore needed.

Conclusion

Osteopathic intervention may affect thoracic impairment and pain among patients with chronic pain and impaired thoracic range of motion after thoracoabdominal resection of the oesophagus.

Author contribution

KB and MFO conceived the idea for the study. All authors contributed to the design and concept. CS contributed to the osteopathic treatment design together with AH, how was responsible for the surgical suitability. KB managed data collection. KB had main responsibility for the manuscript construction. All authors analysed and interpreted the data, revised the manuscript for logical content and approved the final version.

Competing interest

The authors declare that they have no competing interests and were free to interpret the data according to strict scientific rationale.

Acknowledgement

This study was supported by grants from the R&D council for Gothenburg and south Bohuslän, Sweden.

References

1. d'Amours RH, Riegler FX, Little AG. Pathogenesis and management of persistent postthoracotomy pain. *Chest Surg Clin N Am* 1998;**8**:703.
2. Kruger M, McRae K. Pain management in cardiothoracic practice. *Surg Clin North Am* 1999;**79**:387–400.
3. Peeters-Asdourian C, Gupta S. Choices in pain management following thoracotomy. *Chest* 1999;**115**:122S–4S.
4. Fagevik Olsén M, Grell M, Linde L, Lundell L. Procedure-related chronic pain after thoracoabdominal resection of the esophagus. *Physiother Theor Prac* 2009;**25**:489–94.
5. Fagevik Olsén M, Larsson M, Hammerlid E, Lundell L. Physical function and quality of life after thoracoabdominal oesophageal resection. *Dig Surg* 2005;**22**:63–8.
6. Hirayama F, Kageyama Y, Urabe N, Senjyu H. The effect of postoperative ataralgesia by manual therapy after pulmonary resection. *Man Ther* 2003;**8**:42–5.
7. Forum for Osteopathic Regulation in Europe (FORE). *European framework for standards of osteopathic education and training*. London, United Kingdom: Forum for Osteopathic Regulation in Europe; 2008.
8. WHO (World Health Organization). *Benchmarks for training in traditional/complementary and alternative medicine: benchmarks for training in osteopathy: WHO Library Cataloguing-in-Publication Data* 2010.
9. Goldstein FJ, Jeck S, Nicholas AS, Berman MJ, Lerario M. Preoperative intravenous morphine sulfate with post-operative osteopathic manipulative treatment reduces patient analgesic use after total abdominal hysterectomy. *J Am Osteopath Assoc* 2005;**105**:273–9.
10. O-Yurvati AH, Carnes MS, Clearfield MB, Stoll ST, McConathy WJ. Hemodynamic effects of osteopathic manipulative treatment immediately after coronary artery bypass graft surgery. *J Am Osteopath Assoc* 2005;**105**: 475–81.
11. Radjieski JM, Lumley MA, Cantieri MS. Effect of osteopathic manipulative treatment of length of stay for pancreatitis: a randomized pilot study. *J Am Osteopath Assoc* 1998;**98**: 264–72.
12. Nicholas AS, Oleski SL. Osteopathic manipulative treatment for postoperative pain. *J Am Osteopath Assoc* 2002;**102**:5S.
13. Noll D, Degenhardt B, Morley T, Blais F, Hortos K, Hensel K, et al. Efficacy of osteopathic manipulation as an adjunctive treatment for hospitalized patients with pneumonia: a randomized controlled trial. *Osteopath Med Prim Care* 2010;**4**:2.
14. Noll D, Shores J, Gamber R, Herron K, Swift Jr J. Benefits of osteopathic manipulative treatment for hospitalized elderly patients with pneumonia. *J Am Osteopath Assoc* 2000;**100**:776–82.
15. Backman CL, Harris SR, Chisholm JAM, Monette AD. Single-subject research in rehabilitation: a review of studies using AB, withdrawal, multiple baseline, and alternating treatments designs. *Arch Phys Med Rehabil* 1997;**78**:1145–53.
16. Zhan S, Ottenbacher KJ. Single subject research designs for disability research. *Disabil Rehabil* 2001;**23**:1.
17. Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault JC. Lung volumes and forced ventilatory flows. Report working party standardization of lung function tests, European Community for steel and coal. Official statement of the European Respiratory Society. *Eur Resp(Suppl)* 1993;**16**:5–40.
18. Barr RG, Stemple KJ, Mesia-Vela S, Basner RC, Derk SJ, Henneberger PK, et al. Reproducibility and validity of a handheld spirometer. *Respir Care* 2008;**53**:433–41.
19. Walters JAE, Wood-Baker R, Walls J, Johns DP. Stability of the EasyOne ultrasonic spirometer for use in general practice. *Respirol* 2006;**11**:306–10.
20. Fagevik Olsén M, Lindstrand H, Broberg JL, Westerdahl E. Measuring chest expansion; A study comparing two different instructions. *Adv Physiother* 2011;**13**:128–32.
21. Finsbäck C, Mannerkorpi K. Spinal and thoracic mobility — age-related reference values for healthy men and women. *Norsk Fysioterapi* 2005;**9**:136–43.
22. Moll JMH, Wright V. An objective clinical study of chest expansion. *Ann Rheum Dis* 1972;**31**:1–8.
23. Cahalin L, Ragnarsdóttir M. Reliability, validity and clinical utility of a novel respiratory movment measuring instrument. *Chest* 2002;**122**:207.
24. Ragnarsdóttir M, Kristinsdóttir EK. Breathing movements and breathing patterns among healthy men and women

20—69 years of age - reference values. *Respirat* 2006;**73**: 48—54.
25. Viitanen JV, Suni J, Kautiainen H, Liimatainen M, Takala H. Effect of physiotherapy on spinal mobility in ankylosing spondylitis. *Scand J Rheumatol* 1992;**21**:38—41.
26. Gaston-Johansson F. Measurement of pain: the psychometric properties of the Pain-O-Meter, a simple, inexpensive pain assessment tool that could change health care practices. *J Pain Symptom Manage* 1996;**12**:172—81.
27. Cleeland CS, Ryan KM. Pain assessment: global use of the Brief Pain Inventory. *Ann Acad Med Singapore* 1994;**23**: 129—38.
28. Idvall E. *Quality indicators in nursing (Swedish title: Kvalitetsindikatorer inom omvårdnad)*. 5th ed. Stockholm: Gothia; 2009.
29. Ekelund U, Sepp H, Brage S, Becker W, Jakes R, Hennings M, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Pub Health Nutrit* 2006;**9**:258—65.
30. Hallal PC, Victora CG. Reliability and validity of the international physical activity questionnaire (IPAQ). *Med Sci Sport Exerc* 2004;**36**:556.
31. The IPAQ group. *International physical activity questionnaire*. Available from. :, https://sites.google.com/site/theipaq/home; 2012.
32. Nourbakhsh MR, Ottenbacher KJ. The statistical analysis of single-subject data: a comparative examination. *Phys Ther* 1994;**74**:768—76.
33. Gottman JM, Leiblum SR. *How to do psychotherapy and how to evaluate it: a manual for beginners*. Holt, Rinehart & Winston; 1974.
34. Noll DR, Degenhardt BF, Johnson JC, Burt SA. Immediate effects of osteopathic manipulative treatment in elderly patients with chronic obstructive pulmonary disease. *J Am Osteopath Assoc* 2008;**108**:251—9.
35. Hondras MA, Linda K, Jones AP. Manual therapy for asthma. *Cochrane Database Syst Rev* 2005:CD001002.
36. Bockenhauer SE, Julliard KN, Lo KS, Huang E, Sheth AM. Quantifiable effects of osteopathic manipulative techniques on patients with chronic asthma. *J Am Osteopath Assoc* 2002;**102**:371—5.
37. Bischoff A, Nürnberger P, Voigt P, Schwerla F. Osteopathy alleviates pain in chronic non-specific neck pain: randomized controlled trial. *Int Osteopath Med* 2006;**9**: 27—46.
38. Cleland JA, Childs MJD, McRae M, Palmer JA, Stowell T. Immediate effects of thoracic manipulation in patients with neck pain: a randomized clinical trial. *Man Ther* 2005;**10**: 127—35.
39. Fryer G, Alvizatos J, Lamaro J. The effect of osteopathic treatment on people with chronic and sub-chronic neck pain: a pilot study. *Int J Osteopath Med* 2005;**8**:41—8.
40. Hodge LM, Downey HF. Lymphatic pump treatment enhances the lymphatic and immune systems. *Exp Biol Med* 2011;**236**:1109—15.
41. Schander A, Downey HF, Hodge LM. Lymphatic pump manipulation mobilizes inflammatory mediators into lymphatic circulation. *Exp Biol Med* 2012;**237**:58—63.
42. Huff J, Schander A, King H, Downey H, Hodge L. Lymphatic pump manipulation mobilizes inflammatory mediators into thoracic and intestinal duct lymph. *Int J Osteopath Med* 2010;**13**:109.
43. Froud R, Rajendran D, Fossum C, Collins P, Mullinger B. How do patients feel post-treatment? pilot study at a UK osteopathic teaching clinic of self-reported adverse events. *Int J Osteopath Med* 2008;**11**:151—2.

Available online at www.sciencedirect.com
SciVerse ScienceDirect