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Low back pain and kidney mobility: local osteopathic fascial manipulation decreases pain perception and improves renal mobility

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Fascial techniques/Manipulation;
Fascial/Osteopathic treatment;
Still technique;
Fascial unwinding

Summary *Objectives:* a) To calculate and compare a Kidney Mobility Score (KMS) in asymptomatic and Low Back Pain (LBP) individuals through real-time Ultrasound (US) investigation. b) To assess the effect of Osteopathic Fascial Manipulation (OFM), consisting of Still Technique (ST) and Fascial Unwinding (FU), on renal mobility in people with non-specific LBP. c) To evaluate 'if' and 'to what degree' pain perception may vary in patients with LBP, after OFM is applied.
Methods: 101 asymptomatic people (F 30; M 71; mean age 38.9 ± 8) were evaluated by abdominal US screening. The distance between the superior renal pole of the right kidney and the ipsilateral diaphragmatic pillar was calculated in both maximal expiration (RdE) and maximal inspiration (RdI). The mean of the RdE–RdI ratios provided a Kidney Mobility Score (KMS) in the cohort of asymptomatic people. The same procedure was applied to 140 participants (F 66; M 74; mean age 39.3 ± 8) complaining of non-specific LBP: 109 of whom were randomly assigned to the Experimental group and 31 to the Control group. For both groups, a difference of RdE and RdI values was calculated (RD = RdE–RdI), before (RD-T0) and after (RD-T1) treatment was delivered, to assess the effective range of right kidney mobility.
Evaluation: A blind assessment of each patient was carried using US screening. Both groups completed a Short-Form McGill Pain Assessment Questionnaire (SF-MPQ) on the day of recruitment (SF-MPQ T0) as well as on the third day following treatment (SF-MPQ T1). An Osteopathic assessment of the thoraco-lumbo-pelvic region to all the Experimental participants was performed, in order to identify specific areas of major myofascial tension.

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Intervention: Each individual of the Experimental group received OFM by the same Osteopath who had previously assessed them. A sham-treatment was applied to the Control group for the equivalent amount of time.
Results: a) The factorial ANOVA test showed a significant difference (p-value < 0.05) between KMS in asymptomatic individuals (1.92 mm, Std. Dev. 1.14) compared with the findings in patients with LBP (1.52 mm, Std. Dev. 0.79). b) The ANOVA test at repeated measures showed a significant difference (p-value < 0.0001) between pre- to post-RD values of the Experimental group compared with those found in the Control. c) A significant difference (p-value < 0.0001) between pre- to post-SF-MPQ results was found in the Experimental cohort compared with those obtained in the Control.
Conclusions: People with non-specific LBP present with a reduced range of kidney mobility compared to the findings in asymptomatic individuals. Osteopathic manipulation is shown to be an effective manual approach towards improvement of kidney mobility and reduction of pain perception over the short-term, in individuals with non-specific LBP.

Introduction

Disability and health care costs related to LBP are of worldwide interest (Williams et al., 1998). In particular, non-specific LBP constitutes about three-quarters of the back pain for which family physicians are consulted, whereas it represents just a minority of the back pain that requires surgical intervention (Deyo and Phillips, 1996). Only recently have fascia and the non-specialized connective tissues of the back been taken into consideration in relation to the pathophysiology of LBP (Corey et al., 2011; Langevin and Sherman, 2007).

The perirenal fascia is a collagenous connective tissue sheath, which encloses the perirenal space and contains the kidney and adrenal gland. It develops as an anterior thin layer, also referred to as Gerota Fascia, and a posterior thicker layer, known as Zuckerkandl Fascia (Chesbrough et al., 1989). In the coronal plane, the anterior and posterior perirenal fasciae ascend to the diaphragm, fusing in the midline to attach to the crus of their respective hemidiaphragms, before descending to the level of the iliac fossa, merging laterally into the iliac fascia and medially with the periureteric connective tissue (Meyers, 1976; Standring, 2004). The posterior renal fascia inserts cranially onto the inferior phrenic fascia, medially onto the quadratus lumborum fascia (Lim et al., 1990), laterally with the fascia of psoas major. This continues with the anterior layer of the thoracolumbar fascia (TLF) that in turn is attached medially to the anterior surfaces of the lumbar transverse processes (Bogduk, 2005). The iliac fascia itself blends with the anterior layer of the TLF over quadratus lumborum in the upper retroperitoneum as well as with the endopelvic fascia inferiorly (Standring, 2004). An anterior view of these anatomical features is shown in Fig. 1A and 1B.

In view of these fascial connections between kidneys and surrounding dorso-lumbo-pelvic structures, one of this study's aims is to investigate any possible alteration of renal mobility in individuals suffering with non-specific LBP, compared to healthy individuals. To date, only a few studies have investigated the alteration of kidney mobility on their fascial layers, while also relating such mobility alteration to pain at the corresponding spinal level. Evidence is available to support the relationship between lumbar pain and altered renal mobility and shape, in patients with frank acute (Barbagelata et al., 2008) and chronic (Rivera et al., 2008) kidney pathology, as well as in cases of inherited (Bajwa et al., 2004) and acquired conditions (Watkins et al., 2009). However, only one previous study has investigated a possible correlation between renal mobility and lumbar pain in the absence of renal pathologies (Tozzi et al., 2011). Nevertheless, "normal" kidney mobility remains uncertain, poorly investigated and mostly based on small population samples. The average cranio-caudal displacement of the right kidney during forced respiration in healthy individuals has been measured in only two studies, and reported as 40 mm, ranging from 20 mm to 70 mm (Suramo et al., 1984), and 39 mm on average (Schwartz et al., 1994). Organ displacement following a deep breath can be three times greater than that during quiet breathing (Davies et al., 1994). In fact, with regards to the kidney, the average movement during quiet breathing has been shown to be as little as 19 mm (range 10—40 mm) (Suramo et al., 1984), and 11 mm (range 5—16 mm) (Davies et al., 1994). However a complex renal movement in some individuals was observed in terms of velocity and acceleration (Davies et al., 1994). This leads to the first hypothesis of this study: H1: *People suffering from non-specific LBP have reduced kidney mobility compared to that found in pain-free people*.

Osteopathic medicine incorporates manipulative approaches aimed at localizing and resolving body unity issues by enhancing homeostatic mechanisms as well as structure—function interrelationships (Kuchera, 2007). The aim of osteopathic diagnostic palpation is to identify and resolve somatic dysfunctions, defined as any "impaired or altered skeletal, arthrodial, and/or myofascial function", related to neural and/or vascular elements, that might underlie pathophysiological conditions (Allen, 1993). The observational and palpatory features of a somatic dysfunction include sensitivity to palpation, tissue texture changes, positional (DiGiovanna et al., 2004) and/or functional (Greenman, 1989) asymmetry and restricted motion (Ward, 2003). Osteopathic Manipulative Treatment (OMT) seems to be generally effective for LBP (Licciardone et al., 2005; Seffinger et al., 2010); generally requiring less medication than standard medical therapies (Andersson et al., 1999); with positive physical and psychological

outcomes in primary care at little extra cost (Williams et al., 2003). Only one previous preliminary study of these by the authors of this paper, has investigated whether pain patterns in patients suffering with non-specific LBP might improve together with kidney range of mobility, following osteopathic techniques applied *in situ* (Tozzi et al., 2011). However, results remained inconclusive because no comparison was possible with a definitive "normal" kidney mobility during respiration. For the scope of this study, ST and FU have been selected within a wide-ranging armamentarium of fascial manual techniques.

Thus this study's second hypothesis: H2: i) *The application of OFM to the symptomatic region in people with non-specific LBP improves the range of kidney mobility*; ii) *The application of OFM decreases LBP perception over a short term duration.*

Materials and methods

Population

During the period in which this study was conducted, 101 asymptomatic volunteers (F 30; M 71; mean age 38.9 $\pm$ 8) were recruited. The inclusion criteria were the absence of a history of LBP, any other chronic pain that had limited activities of daily living or work, plus a current pain index of less than 1 (on a 10 point Visual Analogue Scale).

In addition, out of the 256 people who came to the clinic presenting with LBP, 140 participants were recruited (F 66; M 74; mean age 39.3 $\pm$ 8), after being assessed and having met the inclusion criteria: an age between 18 and 60 years; a complaint of non-specific pain in the lumbar region, with or without associated mild neurological symptoms, with a duration of at least 3 weeks and of not more than 3 months; an MRI/US documented absence of inherited or acquired pathologies to the spine and kidneys.

Exclusion criteria for both groups (asymptomatic and with LBP) were: previous severe back, renal or low extremity injury, surgery or pathology; major structural spinal deformity (scoliosis, kyphosis, stenosis), ankylosing spondylitis or rheumatoid arthritis; spinal fracture, tumor or infection; bleeding, neurological or major psychiatric disorder; acute systemic infection; pregnancy, kidney ptosis; litigation for LBP; concomitant physical or manual therapy, the use of analgesic and/or anti-inflammatory drugs in the last 72 h.

Out of the 140 participants with LBP, 109 were randomly selected and assigned to the Experimental group and 31 to the Control group, by using a simple randomization method. The male—female ratio as well as the age range and mean for each group are shown in Table 1. No significant difference of means age between the two groups (p-value > 0.1) was found.

Setting

This study was conducted over a period of 14 months, from September 2009 to October 2010 at the C.R.O.M.O.N. clinic centre in Rome, Italy; and at the Alliance Medical, CRL Lissone, Italy.

Real-time US screening

US investigation is a non-invasive method that provides accurate information about form, size and mobility of the kidney, together with pathological changes (Judmaier, 1986). An *ESAOTE My LAB 25 GOLD* device was used for the scope of this study. Each participant received a blinded *Dynamic Ultrasound Topographic Anatomy Evaluation* (D.US.T.A.-E.) carried out by a medical doctor with 16-years of experience who specialised in US screening, in the right lumbar region: a method of US screening that included recordings of real-time US videos, with a specific focus on anatomical margins and morphologies of the organs assessed, together with their effective sliding motion on surrounding connective tissue structures *in vivo* (Tozzi et al., 2011). Considering the evidence of a common alteration of right renal mobility, particularly in women, when a patient moves from a supine position to a side lying position (Morgan and Dubbins, 1992), each participant of this study was assessed in the supine position with extended lower limbs, head resting directly on the couch, and the right arm slightly abducted, with elbow flexed and the hand resting on the right breast region. The probe was positioned in the right lateral thoraco-lumbar region, along the intercostal space between the 10th and 11th rib, in the parasagittal line running from the axillary space to the lateral border of the greater trochanter, as shown in Fig. 2. A convex probe was used at 5 MHz and enhanced THI (Tissue Harmonic Imaging, that improves the resolution of contrast between hyper and hypocogenicity of the tissues being screened). In an MRI-based study, kidney motion appeared to be in a tilted coronal and sagittal plane, showing a vertical displacement of 39 mm on average between the end range of forced respiration, together with a minimal mean deviation (less than 4 mm) in all three dimensions (Schwartz et al., 1994). Such minimal range of A/P and lateral renal deviation, has been confirmed by the demonstration of no appreciable A/P and lateral displacement (less than 2 mm) of the diaphragm during respiration (Davies et al., 1994). Based on these findings, this study measured the renal cranio-caudal displacement only. A parasagittal image was acquired: the distance between the superior pole of the right kidney and the origin of the respective diaphragmatic crura was taken during both maximal inspiration (RdI) and maximal expiration (RdE), as shown in Fig. 3, in both asymptomatic and LBP groups. The aim was firstly to measure and compare the average range of right renal mobility during forced respiration between healthy individuals and people suffering of LBP. Secondly, the identical procedure was repeated on the LBP group after treatment was applied, in order to measure and compare supero-inferior range of kidney mobility before and after intervention.

Pain assessment

Pain perception in the LBP group was measured using the SF-MPQ. The SF-MPQ represents a responsive scale giving both reliable and valid data (Melzack, 1987), through a 15-point descriptor of average pain, articulated in 11 points of sensory experience and 4 of affective experiences. Each

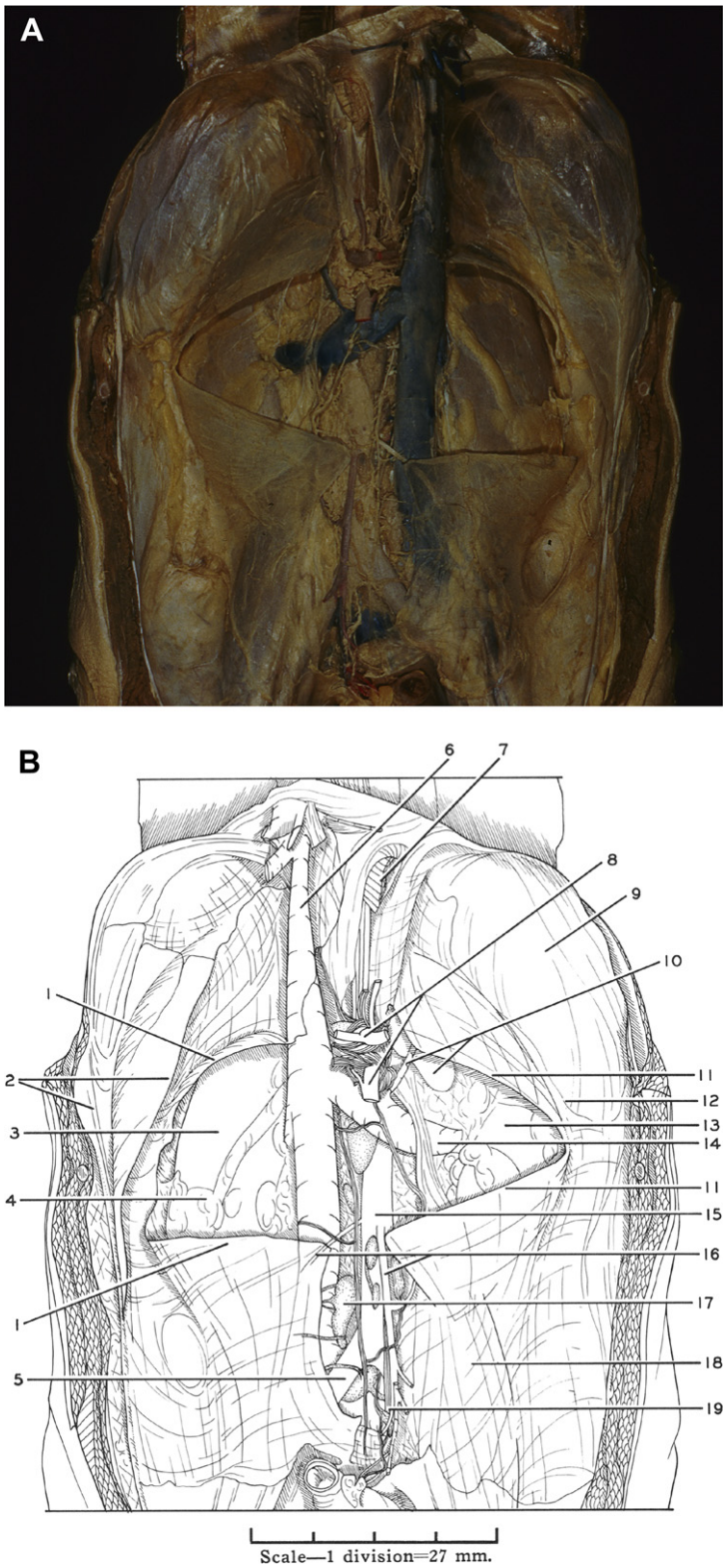

Figure 1 (A and B) Renal fascia, general anterior view. With the kind permission of the Lane Medical Library of the Stanford University School of Medicine. 1. Renal fascia (anterior layer, cut and elevated) 2. Peritoneum (partially elevated) 3. Ren (covered by renal capsule) 4. Capsula adiposa 5. A. iliaca communis 6. Vena cava inferior 7. Oesophagus 8. Upper pointer: Truncus coeliacus Lower Pointer: A. mesenterica superior 9. Diaphragma 10. Left pointer: V. suprarenalis sinistra Right pointer: Glandula suprarenalis sinistra (covered by fascia) 11. Anterior layer of renal fascia (opened and elevated) 12. Line of reflection of phrenicolienal ligament 13. Ren sinister (covered by adipose capsule) 14. V. renalis sinistra 15. Aorta abdominalis 16. Lefr pointer: A. testicularis dextra Right pointer: A. mesenterica inferior 17. Nodus lymphaticus lumbalis 18. M. psoas major (covered by fascia) 19. Filament of plesus hypogastricus superior.

Table 1 Study groups. A list of the number of participants, male (M) and female (F), age range and age mean values for each LBP group (Experimental and Control) is shown. No significant difference of means age between the two groups (p-value > 0.1) was found.

	Experimental group	Control group
Participants	109	31
M	54	20
F	55	11
Age range	20–59	23–55
Age mean	39.8 ± 7	37.6 ± 1

descriptor is defined on an intensity scale of 0–3 representing mild, moderate or severe pain. Therefore, the value for total pain experience (ranging from 0 to 45) is given by the addition of the sensory (ranging from 0 to 33) and affective pain (ranging from 0 to 12) rating scores. The total score was used as the outcome of this study. The SF-MPQ has been administered to every LBP participant on the day of recruitment, as well as three days later.

Osteopathic assessment

A standard osteopathic assessment of the thoraco-lumbo-pelvic region in the Experimental group only was performed by an Osteopath with 6 years experience in order to locate the specific areas of major fascial and bony dysfunction. The assessment was based on the detection of the classical osteopathic features of a somatic dysfunction (DiGiovanna et al., 2004), firstly through common 'fascial listening posts' (thighs, pelvis, lower rib cage, upper thoracic cage) with patients in the supine position. Secondly, where indicated by fascial listening, minor mobility testing of the spine and pelvis were applied through induction of movement, to define the restricted planes of motion (Greenman, 1989). However, no deep tissue palpation of the abdomen was performed.

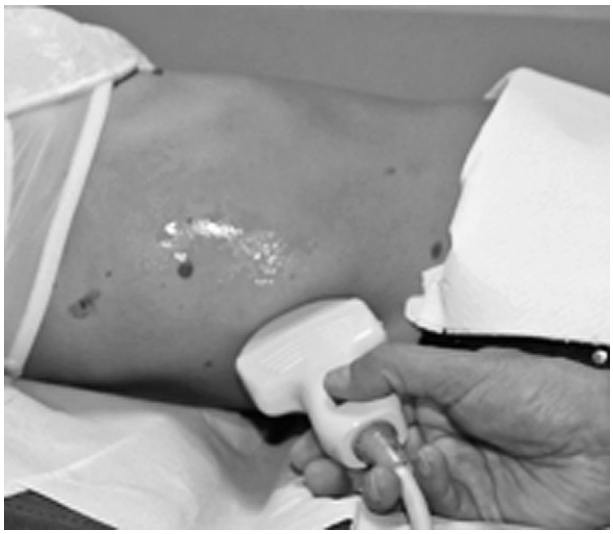

Figure 2 Standard procedure for the US screening. The standard procedure for US measurement of the right kidney is shown: the patient lies supine with extended lower limbs, the head resting on the couch and the right arm slightly abducted, with flexed elbow and the hand resting on the right breast. The probe is positioned in the right lateral lumbar region for a parasagittal scan, along the intercostal space between the 10th and the 11th rib, in the parasagittal line running from the axillary space to the lateral border of the greater trochanter. A US recorded video was taken during quiet and forced breathing in every participant of this study, as well as before and after treatment was applied in the LBP group.

Treatment

The Experimental group received OFM to the lumbar region lasting not more than 3½ min in total by the same Osteopath who performed the assessment. OFM consisted of application of not more than 2 min of ST and of not more than 90 s of FU. The objective was to firstly improve the lumbar spine mobility by freeing the restricted segments using the ST. Then to gain a bilateral release of the back wall and deep muscles of the lumbar region, together with their surrounding fascial structures by application of FU. The tissue changes were aimed to result in an indirect effect on kidney mobility via the myofascial continuity, as well as in improving lumbar spine mobility.

ST

ST is a method of manipulation that was first developed and used by Andrew Taylor Still MD, founder of Osteopathic Medicine. The principle consists of manipulating the dysfunctional tissues to further increase their malposition, and then applying pressure to them in such a direction as to force them back towards normal position (Hazzard, 1905). When applied to fascia, the ST requires firstly to determine the position of ease (movement in a preferred direction rather than towards restriction barriers) for the fascial element that is restricted; secondly to introduce and maintain a compressive force into the tissue; finally to use the hand applying the force to follow the tissue to unwind along a wandering pathway towards and through the position of initial restriction (Van Buskirk, 2006). ST was applied to the Experimental participants on the lumbar spine using the lower limb as leverage, in both side lying positions, for not more than 60 s per side, as shown in Fig. 4.

FU

FU is a commonly used technique in osteopathic practice (Johnson and Kurtz, 2003), aimed to release fascial restrictions in order to restore tissue mobility and function. It consists of a functional indirect technique: the operator engages the restricted tissues by unfolding the whole pattern of dysfunctional vectors enclosed in the inherent fascial motion. A shearing, torsional or rotational component may arise in a complex three-dimensional pattern that needs to be supported, amplified and unwound until a release is felt (Ward, 2003). For the Experimental group, the ST was followed by FU of the lumbar region using the hold shown in Fig. 5. The overall FU treatment lasted for not more than 90 s.

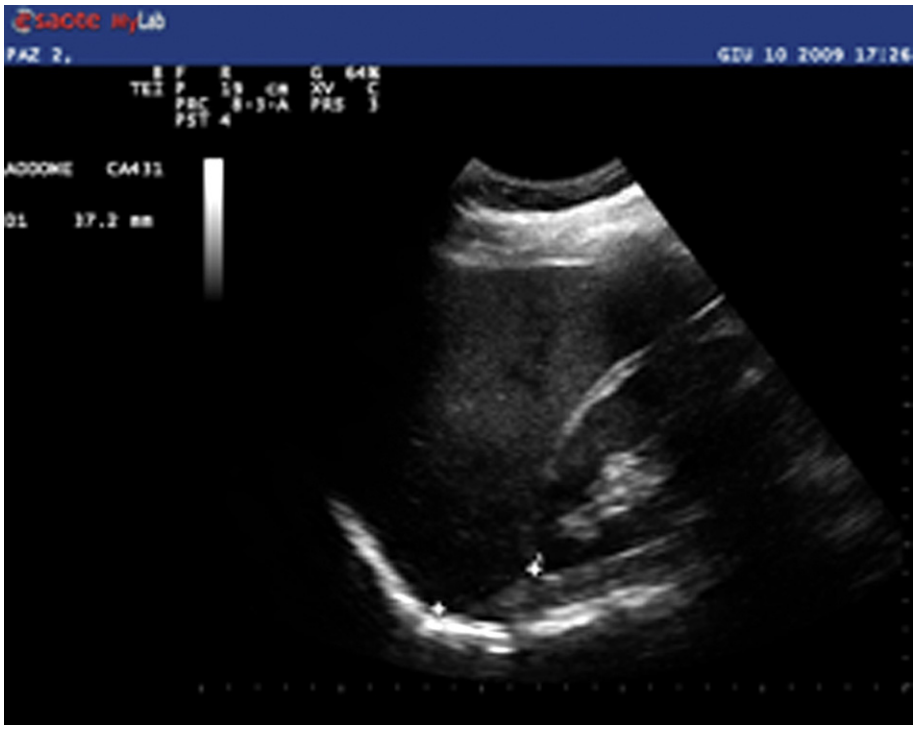

Figure 3 US measurement. The distance between the superior pole of the right kidney and the origin of the respective diaphragmatic crura was taken and calculated during maximal inspiration (RdI) and expiration (RdE). The mean of the RdE—RdI ratios has provided a KMS in the pain-free group and LBP groups. In addition, a difference of RdE and RdI values was calculated (RD = RdE—RdI), before (RD-T0) and after (RD-T1) treatment was delivered in the LBP group, to assess the effective range of right kidney mobility.

Sham-treatment

The Control group blindly received a sham-treatment by someone who did not have any knowledge of anatomy or experience in manual therapy whatsoever. The sham-osteopath just rested his hands on the patient's lumbar region for 60 s, using exactly the same left and right lumbar spine-hip hold behind the patient, as used for the Experimental group; and also for the same 90 s period with the patient in sitting position, as shown in Figure 5. The sham-treatment lasted 3½ min in total, as did the overall intervention for the Experimental group.

Ethic Committee

The research study has been approved by the L.U.Me.N.-Oli.S ethical committees, related to the institution in which it was performed. All the participants who took part in the project gave informed consent.

Statistical analysis

All analyses were performed using the software "STATVIEW 5.0" (SAS Institute Inc.). With regards to the H1:

a) The mean of the ratios between Renal-diaphragmatic distances in Exhalation (RdE) and those in Inhalation (RdI) phases has provided a Kidney Mobility Score (KMS) in the cohorts of asymptomatic and LBP individuals;
b) The factorial ANOVA test was used with a *p*-value accepted at <0.05, to calculate if there was a significant difference between the KMS obtained in the 2 groups.

With regards to the H2i) and H2ii): the ANOVA test at repeated measures was used, with a *p*-value accepted at <0.05, to calculate if there was a significant difference between Experimental and Control groups respectively for

i) RD-T0 and RD-T1 distances, by considering RD-T0 = RdE-T0—RdI-T0 and RD-T1 = RdE-T1—RdI-T1;
ii) pre- to post-SF-MPQ results.

Results

a) *KMS:* In the pain-free group RdE range values were 6.3/60 mm, mean 26.80, Std. Dev. 13.13; whereas the RdI range values were 4/63 mm, mean 18.76, Std. Dev. 14.18. The mean of the RdE—RdI ratios has provided a KMS of 1.92 mm, Std. Dev. 1.14 for the cohort of asymptomatic individuals. In the LBP group, RdE range values were 10/98.8 mm, mean 29.00, Std. Dev. 18.36; whereas the RdI range values were 4/100.5 mm, mean 23.30, Std. Dev. 19.18. The mean of the RdE—RdI ratios has provided a KMS of 1.52 mm, Std. Dev. 0.79 for the LBP group;

Figure 4 ST hold. The hold used for ST applied to the Experimental LBP group is shown: the patient is side lying with the head resting on a pillow, and the lower leg flexed. The operator stands behind, facing the patient, with the caudal hand supporting the upper patient leg at the flexed knee, and with the cranial hand contacting the lateral lumbar region. By using the patient's upper leg as a lever, and the cranial hand as a fulcrum, a tissue release is achieved through the different steps involved in ST execution.

b) A significant difference (F-value = 5.372; p-value < 0.05) was found between the KMS value in asymptomatic people (KMS 1.92 mm, Std. Dev. 1.14) and that found in patients with LBP (KMS 1.52 mm, Std. Dev. 0.79);

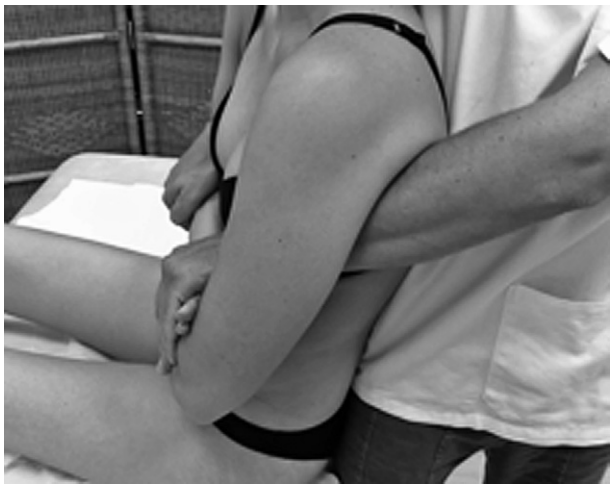

Figure 5 FU hold. The hold used for FU technique applied to the Experimental LBP group is shown: the patient is sitting on the couch with their arms crossed, while the operator stands behind. The practitioner places his hands underneath and through patient's arms, contacting the patient's lumbo-pelvic region with the lateral part of his hip region. By using the patient trunk as leverage and the lumbo-pelvic region as fulcrum, lumbar tissues tensions are unwounded up to when a release is felt.

i) *US kidney values*: RD-T0 and RD-T1 distances in the LBP groups are shown in Fig. 6. A significant difference is shown with an F-value = 117.106 and a p-value < 0.0001. In the Experimental group the mean value of RD-T0 was 5.79 mm, St. Dev. 8.55, against the RD-T1 mean value of 11.34 mm, St. Dev. 8.96. In the Control group the mean value of RD-T0 was 4.98 mm, St. Dev. 8.43, against the RD-T1 mean value of 4.90 mm, St. Dev 8.15;

ii) *SF-MPQ:* pre- to post-differences between Experimental and Control groups are shown in Fig. 7. A significant difference with an F-value = 206.068 and a p-value < 0.0001 is shown on Table 2. In the Experimental group the mean values of SF-MPQ at T0 was 16.10, St. Dev. 5.99, against the SF-MPQ at T1 mean value of 9.30, St. Dev. 5.55. In the Control group the mean value of SF-MPQ at T0 was 14.03, St. Dev. 4.90, against the SF-MPQ at T1 mean value of 15.41, St. Dev 5.24. The mean difference between groups was 2.024; the mean difference between pre- and post-values was 4.986.

Discussion

This study shows that the right kidney mobility, with respect to the surrounding myofascial structures, may be assessed by US screening *in vivo* in real time; that such mobility is significantly greater in asymptomatic individuals than in people with non-specific LBP; that such mobility may be reduced or altered without a frank organic spinal or renal pathology in people with non-specific LBP; that OFM applied to superficial and deep lumbar myofascial structures in people with non-specific LBP can improve renal mobility as well as reducing LBP perception over a short-term period.

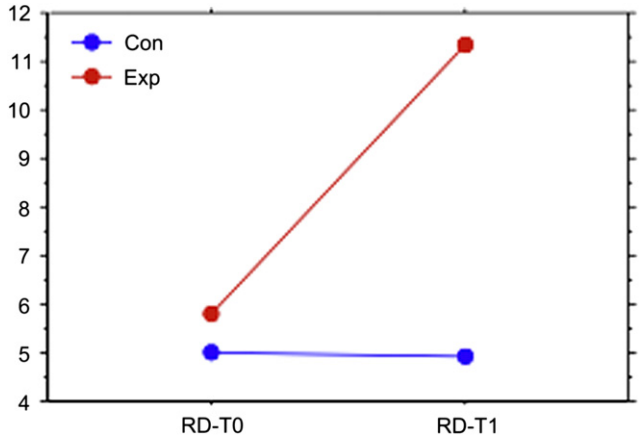

Figure 6 US kidney results in the LBP group. The significant difference between RD-T0 and RD-T1 distances in LBP groups are shown: in the Experimental group the mean value of RD-T0 was 5.79 mm, St. Dev. 8.55, against the RD-T1 mean value of 11.34 mm, St. Dev. 8.96. In the Control group the mean value of RD-T0 was 4.98 mm, St. Dev. 8.43, against the RD-T1 mean value of 4.90 mm, St. Dev 8.15.

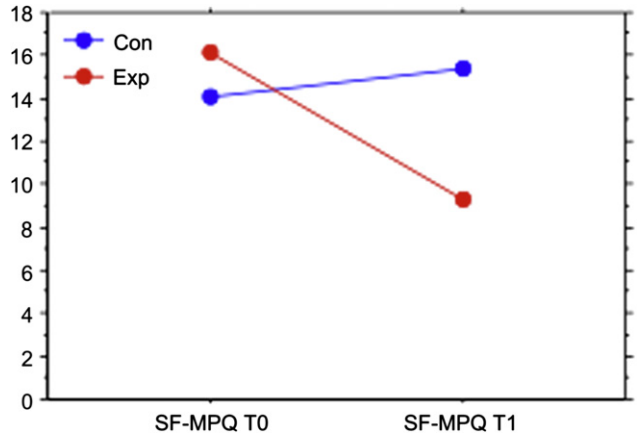

Figure 7 SF-MPQ results in LBP group. The significant difference between Experimental and Control groups for the pre- to post-SF-MPQ results is shown. In the Experimental group the mean values of SF-MPQ at T0 was 16.10, St. Dev. 5.99, against the SF-MPQ at T1 mean value of 9.30, St. Dev. 5.55. In the Control group the mean value of SF-MPQ at T0 was 14.03, St. Dev. 4.90, against the SF-MPQ at T1 mean value of 15.41, St. Dev 5.24.

General limitations of this study were possibly related to the US method of screening, whose property of scanning all planes reduces the chance of absolute standardization (and often of quantification) of distance measurements. The exact reproducibility of the US scanning at a pre- and post-treatment phase may also have been reduced by operator-related factors such as difference in the pressure used to apply the probe to the skin. Patient-related factors may have also had an influence such as position, inter- and intra-tissue mobility, viscoelastic changes, breathing pattern. Kidney displacement has been shown to be generally greatest for abdominal breathers and less than average for thoracic breathers (Davies et al., 1994), although this has been demonstrated in quiet respiration only. In addition, all of the results obtained in this study with regards to the range of right kidney mobility cannot account for the general renal mobility in both asymptomatic and LBP groups, because of the obvious absence of information about the contralateral organ mobility. At this stage, the assumption that the left kidney would behave as the right one either in asymptomatic and LBP individuals, either before and after OFM, represents speculation, even if plausible.

This study has also unexpectedly revealed 3 different types of right kidney mobility during forced breathing in the population observed. Such typologies of kidney mobility have been noticed, defined and described by the authors, who have compared the recorded videos obtained by D.US.T.A.-E., as follows:

1. *Type A or 'free kidney'*: the right kidney shows a supero-inferior slide relatively free with respect to the diaphragm and the liver mobility, independent of liver motion in particular. This type of renal mobility was evident in the 76% of the pain-free people and in the 52% of the individuals with LBP;
2. *Type B or 'fixed kidney'*: an independent movement of the diaphragm and liver can be appreciated, but with the right kidney seeming relatively fixed to the liver. The two organs show a reduction or an absence of inter-independent sliding motion, appearing to move as a unit. 8% of the asymptomatic individuals showed such renal mobility, compared to the 40% of the LBP group;
3. *Type C or 'paradoxical kidney'*: the right kidney shows a paradoxical sliding motion, being greater than that visible in the liver and of that observed in type A. In fact, because of its retroperitoneal location, the kidney is supposed to show a US-scanned lesser mobility than the liver, being mainly intraperitoneal. However in type C, the diaphragmatic descent in inspiration is

Table 2 ANOVA table for SF-MPQ values.

	DF	Sum of squares	Mean square	*F*-value	*P*-value	Lambda	Power
Groups	1	197.742	197.742	3.321	0.0705	3.321	0.424
Subject (Group)	138	8215.958	59.536				
Category for SF-MPQ	1	353.343	353.343	90.056	<0.0001	90.056	1.000
Category for SF-MPQ × Groups	1	808.528	808.528	206.068	<0.0001	206.068	1.000
Category for SF-MPQ × Subject (Group)	138	541.457	3.924				

associated with an abnormal kidney motion, greater than that observed in the liver. Type C kidney mobility was present in 16% of the pain-free individuals, compared to the 8% found in people with LBP.

The means table of the RdE and RdI for the Type A, B and C mobility in the pain-free as well as in the LBP groups are shown in Table 3. The different range of inter-individual patterns of kidney displacement during respiration may reflect the wide variability in renal mobility observed and measured by previous studies (Davies et al. 1994; Schwartz et al., 1994; Suramo et al., 1984; Tozzi et al., 2011).

H1. People suffering from non-specific LBP have reduced kidney mobility compared to that found in pain-free people.

A significant difference (p-value < 0.05) was found between the KMS in asymptomatic people (1.92 mm, Std. Dev. 1.14) comparing with that found in patients with LBP (1.52 mm, Std. Dev. 0.79). Therefore, the H1 is confirmed.

Since abdominal organs mobility is strictly related to diaghragmatic excursion, people with LBP may presumably present different renal displacement because of a different breathing pattern compared to pain-free individuals. However, evidence shows that no difference in breathing patterns occurs at rest between people with LBP and healthy individuals, although it does occur during motor control tests, due to motor control dysfunction rather than pain severity (Roussel et al., 2009).

The authors speculate that a reduction of kidney mobility in people with non-specific LBP compared to pain-free individuals may be caused by or associated with a viscero-somatic and/or a somato-visceral interplay between the kidney and the lumbar spine, possibly via aberrant neurological reflexes (Korr, 1947; Van Buskirk, 1990), and/or via venous and lymphatic drainage congestion (Ward, 2003), and/or mechanical tension through connective tissue continuity. Known physiological connective tissue responses, following specific load and mechanical stress through its collagen bundles, involve remodelling of the collagenous matrix (Grinnell, 2008; Swartz et al., 2001). In this fashion, resultant changes in tissue viscoelastic properties may occur together with a change of the colloidal consistency of the ground substance in the fascia to a more solid state (Cummings and Tillman, 1992). A US-based comparison of subcutaneous and perimuscular connective tissues forming the superficial and deep TLF, showed a 25% greater perimuscular connective tissue thickness and echogenicity in people with LBP, who expressed less relative tissue motion between the deep and superficial connective tissue of the back than the pain-free control group (Langevin et al., 2009). Therefore, the authors speculate that in the LBP individuals, pain-related fear may have lead to decreased range of lumbar mobility, resulting in connective tissue remodelling, in particular at the lumbar myofascial structures, possibly causing a reduction of kidney mobility via fascial connections.

Table 3 Means table for the Type A, B and C of right kidney mobility in the Control (Con), Experimental (Exp) and pain-free (Norm) groups.

	Count	Mean	Std. Dev.	Std. Err.
Con. A. RdE-T0	16	30.244	16.071	4.243
Con. A. RdI-T0	16	19.712	15.569	3.892
Con. B. RdE-T0	13	28.577	23.015	6.383
Con. B. RdI-T0	13	26.346	23.311	6.465
Con. C. RdE-T0	2	10.950	1.344	.950
Con. C. RdI-T0	2	19.450	1.768	1.250
Exp. A. RdE-T0	58	28.802	14.277	1.875
Exp. A. RdI-T0	58	17.488	13.561	1.781
Exp. B. RdE-T0	41	32.563	24.287	3.793
Exp. B. RdI-T0	41	31.615	25.581	3.995
Exp. C. RdE-T0	10	25.430	14.381	4.548
Exp. C. RdI-T0	10	31.790	15.228	4.815
Norm. A. RdE-T0	77	29.277	11.589	1.321
Norm. A. RdI-T0	77	15.088	9.288	1.058
Norm. B. RdE-T0	8	8.025	1.293	.457
Norm. B. RdI-T0	8	10.650	3.543	1.253
Norm. C. RdE-T0	16	24.300	15.559	3.890
Norm. C. RdI-T0	16	40.525	17.001	4.250

H2i. The application of OFM to the symptomatic region in people with non-specific LBP improves the range of kidney mobility.

This study has also investigated the range of sliding motion of the right kidney in people with lumbar pain and absence of spinal and renal pathology, before and after specific OFM were applied *in situ*. In the Experimental group the mean value of RD-T0 was 5.79, St. Dev. 8.55, against the RD-T1 mean value of 11.34, St. Dev. 8.96. In the Control group the mean value of RD-T0 was 4.98, St. Dev. 8.43, against the RD-T1 mean value of 4.90, St. Dev 8.15. A significant difference was found (p-value < 0.0001).

The Control group has shown a 2 to 1 female/male ratio, compared to the 1 to 1 ratio in the Experimental group. Such differences may have partly influenced the results. Given the same waist and pelvis sizes, a female and a male may have different organ displacement values due to the variation in body characteristics, although the little evidence available at the moment does not support this hypothesis (Davies et al. 1994). In addition, some of the female participants may have been through a recent pregnancy when included in this study, although a current pregnancy was an exclusion factor. Possible post-partum complications may have affected organ mobility, although no evidence is available to support this hypothesis. The Osteopathic assessment delivered to the Experimental group only may have also skewed the results, although this assessment procedure was kept to a minimum of fascial listening and induction mobility testing.

Manual loading of fascia as in various manual treatments may lead to correction of fascial hypertonicity via activation of fibroblasts response (Eagan et al., 2007) and different receptors present in the fascial tissue (Lundon, 2007). The authors speculate that the unwinding of the fascial restrictions may have restored the optimal tissue elasticity of the surrounding myofascial structures, rebalanced the intra- and inter-visceral pressure, improve the diaphragm and lumbar spine mobility, and via the fascial continuation re-established an optimal renal mobility.

The forced respiration requested during the US screening may have also contributed to lumbar myofascial structures relaxation and played a role in improving range of kidney mobility, although the control group did not show the same degree of change. Cummings and Howell (1990) have demonstrated the effects of respiration on myofascial tension whereas Kisselkova and Georgiev (1976) reported that resting EMG activity of non-respiratory muscles were cycled with respiration, suggesting that they receive input from the respiratory centres. The influence of respiration on the muscoloskeletal system seems to be plausible.

H2ii. The application of OFM decreases LBP perception over a short-term duration.

OFM has shown to be effective on decreasing pain perception in the LBP group with an SF-MPQ mean values of 16.10 (St. Dev. 5.99) at T0 and 9.30 (St. Dev. 5.55) at T1 in the Experimental group, against the mean values ranging from 14.03 (St. Dev. 4.90) at T0 to 5.41 (St. Dev 5.24) at T1 for the Control group. A significant difference was found (p-value < 0.0001). The authors speculate that following the application of OFM, the reduced pain patterns in the Experimental group may be related to the OFM-related anandamide effect of the endocannabinoid (eCB) system (McPartland et al., 2005): an endorphin-like system constituted of cell membrane receptors, endogenous ligands and ligand-metabolizing enzymes. It is proposed that activation of the eCB system through myofascial manipulation diminishes nociception and pain, reduces inflammation in myofascial tissues and plays a role in fascial reorganization (McPartland et al., 2005). This has been shown to occur in people with chronic LBP following OMT (Degenhardt et al., 2007). Pain reduction has been also linked to modulation of hypersympathotonia by applied OMT, with an improvement in a variety of visceral and somatic aspects (Kuchera and Kuchera, 1994; Van Buskirk, 1990). Parasympathetic tone may also have an influence as its upregulation following manual therapy has been reported to evoke an increase in heart rate variability (Vagedes et al., 2009), together with an influence on blood shear rate and blood flow turbulence in particular (Querè et al., 2009). However, apart from the possible physiological effects that OFM may have beneficially caused in the tissue, in clinical trials such as the one being presented, OMT may be perceived by participants as a more credible treatment than many control procedures (Licciardone and Russo, 2006): treatment credibility may have interacted with subject expectations. This may be particularly relevant in a study such as this, in which self-reported data was a feature.

Suggestions for further research

Future research should evaluate a KMS for the contralateral kidney in order to establish a more definitive and complete score of renal mobility. In this study, pain assessment was performed over a short period of only 3 days after treatment. Future research should consider whether findings are reproducible, whether they are similar in a larger population, and whether positive long-term outcomes can be achieved in both US findings and pain assessment.

Conclusions

The traditional kidney mobility pattern needs to be revisited and incorporated into a more complex picture. Three different patterns of kidney mobility were found in asymptomatic as well as in individuals with LBP, although they were present in different percentages. It has been demonstrated that people with non-specific LBP presents a significant reduced range of right kidney mobility, compared with that measured in asymptomatic people. In addition, OFM was shown to be an effective manual approach to improve or possibly restore kidney mobility and reduce pain perception over the short-term in individuals with non-specific LBP. The association between changes in fascial/organ movement and symptoms has been demonstrated; whereas a fascial involvement in both organ function and pain remains plausible at this stage.

Conflict of interest statement

None declared.

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