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CLINICAL RESEARCH

Fascial release effects on patients with non-specific cervical or lumbar pain

Paolo Tozzi, Bsc (Hons) Ost, D.O., FT [a,*], Davide Bongiorno, M.D., D.O. [b], Claudio Vitturini [c]

[a] *Centro di Ricerche Olistiche per la Medicina Osteopatica e Naturale, C.R.O.M.O.N., Via Pasquale Fiore 18, Rome, Italy*[1]
[b] *Andrew Taylor Still Academy Italia, A.T.S.A.I., Bari, Naples, Milan, Italy*[2]
[c] *Università la Sapienza - Dipartimento di Psicologia, Rome, Italy*

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Osteopathy

Summary *Background:* Myofascial Release (MFR) and Fascial Unwinding (FU) are widely used manual fascial techniques (MFTs), generally incorporated in treatment protocols to release fascial restrictions and restore tissue mobility. However, the effects of MFT on pain perception, and the mobility of fascial layers, have not previously been investigated using dynamic ultrasound (US) in patients with neck pain (NP) and low back pain (LBP).
Objectives: a) To show that US screening can be a useful tool to assess dysfunctional alteration of organ mobility in relation to their fascial layers, in people with non-specific NP or LBP, in the absence of any organ disease; b) To assess, by dynamic US screening, the change of sliding movements between superficial and deep fascia layers in the neck, in people with non-specific NP, before and after application of MFTs c) To assess, by dynamic US screening, the variation of right reno-diaphragmatic (RD) distance and of neck bladder (NB) mobility, in patients with non-specific LBP, before and after application of MFTs d) To evaluate 'if' and 'at what degree' pain perception may vary in patients with NP or LBP, after MFTs are applied, over the short term.
Methods: An Experimental group of 60 subjects, 30 with non-specific NP and 30 with non-specific LBP, were assessed in the area of complaint, by Dynamic Ultrasound Topographic Anatomy Evaluation (D.US.T.A.-E.), before and after MFTs were applied *in situ*, in the corresponding painful region, for not more than 12 min. The results were compared with those from the respective Sham-Control group of 30 subjects. For the NP sub-groups, the pre- to post- US recorded videos of each subject were compared and assessed randomly and independently by two blinded experts in echographic screening. They were asked to rate the change observed in the cervical fascia sliding motions as 'none', 'discrete' or 'radical'. For the LBP sub-groups,

* Corresponding author. Via Festo Avieno 150, 00136, Rome, Italy. Tel.: +39 3486981064 (mobile); fax. +39 06 97749900.
E-mail address: pt_osteopathy@yahoo.it (P. Tozzi).
[1] www.cromon.it.
[2] www.atsai.it.

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a pre- to post- variation of the right RD distances and NB mobility were calculated on US imaging and compared. For all four sub-groups, a Short-Form McGill Pain Assessment Questionnaire (SF-MPQ) was administered on the day of recruitment as well as on the third day following treatment.
Results: The Chi square test has shown a significant correlation (0.915) with a *p-Value* < 0.0001 between the two examiners' results on US videos in NP sub-groups. The ANOVA test at repeated measures has shown a significant difference (*p-Value* < 0.0001) within Experimental and Control groups for the *a)* pre- to post- RD distances in LBP sub-groups, *b)* pre- to post- NB distances in LBP sub-groups; as well as between groups as for *c)* pre- to post- SF-MPQ results in NP and LBP sub-groups.
Conclusions: Dynamic US evaluation can be a valid and non-invasive instrument to assess and monitor effective sliding motion of fascial layers *in vivo*. MFTs are effective manual techniques to release area of impaired sliding fascial mobility, and to improve pain perception over a short term duration in people with non-specific NP or LBP.

Introduction

Fascia and MFTs

Fascia is a connective tissue organized in a three-dimensional network, that surrounds, supports, suspends, protects and connects muscular, skeletal and visceral components of the body. Studies suggest that fascia reorganizes along the lines of tension imposed or expressed in the body at both molecular (Dunn and Silver, 1983; Mosler et al., 1985) and macroscopic level (Sasaki and Odajima, 1996). Myers (2000) describes fascial meridians as tensile myofascial bands, that comprise a single continuous structure. From this perspective, the repercussion of a fascial restriction may be body-wide, and may potentially create stress on any structures enveloped by fascia (Greenman, 1989). The consequent distortion of the body's three-dimensional alignment may lead to biomechanically inefficient function (Rolf, 1977). It has been suggested that fascial strains can slowly increase, requiring progressive body adaptation at a local and global level (Levin, 1990). The pressure exerted with subsequent stress on the surrounding soft tissues may have mechanical and physiological effects. This is evident mechanically in the collagenous framework of the body, which is organized as a tensegritive structure (Levin, 1990), as well as at the cellular level (Ingber and Chen, 1999; Pischinger, 1991). The ground substance changes to a more 'sol'-like consistency (the fluid state of living colloids, reversible into a more solid, 'gel'-like state), while fibrous infiltration and cross links between collagen fibers may develop at the nodal points of fascial bands, together with a progressive loss of elastic properties (Chaitow, 1999). Fascial techniques aim to release such tensions, decrease pain and restore function. The proposed mechanism for fascial techniques is based on various studies that looked at the plastic, viscoelastic and piezoelectric properties of connective tissue (Fratzl, 2008). As the collagen fibers are released, they reorganize themselves in the underlying substance, whose viscosity changes so permitting tissue remodelling (Cantu and Grodin, 1992). This change in viscosity seems to involve an increase in the production of hyaluronic acid, together with the flow of as well as improved drainage of inflammatory mediators and metabolic wastes (Schultz and Feltis, 1996); together with reduced chemical irritation of the ANS endings and nociceptive stimuli to somatic endings (Lund et al., 2002; Mense, 1983).

To better understand the clinical implications of fascial restrictions in cases of acute and chronic NP or LBP, the quality of sliding motion between fascial layers *in vivo* appears to be of great importance (Langevin 2006).

FU is a commonly used, but seldom researched, technique in osteopathic practice (Ward, 2003), aimed to release fascia restrictions and to restore tissue mobility and function.

MFR is defined by Manheim (2001) as the facilitation of mechanical, neural, and psychophysiological adaptive potential as interfaced via the myofascial system. It represents a widely employed manual technique specific for fascial tissues, to reduce adhesions, restore and/or optimise fascia sliding mobility in both acute and chronic conditions (Barnes, 1996; Martin, 2009; Sucher, 1993; Walton, 2008). Some studies have shown the efficacy of MFR to decrease pain, improve posture, and quality of life (Barnes, 1990; Fernandez de las Penas et al., 2005; LeBauer et al., 2008; Lukban, 2001; Radjieski et al., 1998). However, according to Remvig (2008) "There are no published reliability studies documenting that the diagnostic method is reproducible and valid."

US screening

In many different studies and areas of practice, US is widely used to screen and diagnose for various:

a) Acute (Nelson et al., 1980) and chronic conditions (De Miguel et al., 2009; Falsetti et al., 2004): infective (Gandolfo et al., 1993; Harr et al., 1982; Simons et al., 1983), genetically transmitted (Heckmatt et al., 1982), inflammatory (Karabay et al., 2007; Kenney and Hafner, 1977), degenerative (Heers and Hedtmann, 2002) and neoplastic (Nishimura et al., 1992) diseases;
b) As well as to perform real-time investigation of dysfunctional syndromes, still not well-understood by other methods of screening (Cvitković-Kuzmić et al., 2002; Wong and Li, 2000).

US is also shown to be a reliable tool:

c) To assess the presence and the extent of surgery-related sequelae (Küllmer et al., 1997; Mann et al., 1989; Wiener et al., 1987), as well as the consequences of traumatic injuries (Bokhari et al., 2004; Murphy et al., 2005);
d) To monitor the procedure of invasive techniques of investigation and surgical intervention (Bassi et al., 1996; Gandolfo et al., 1993; Sinha and Chan, 2004);
e) To evaluate the follow up of patients under manual therapies in real-time (Hutzschenreuter et al., 1989; Park et al., 2007; Queré et al., 2009; Torstensen et al., 1994), or under specific therapeutic protocols (Wang et al., 2008);
f) To treat musculo-skeletal conditions when applied in a therapeutic form (Dogru et al., 2008; Downing and Weinstein, 1986; Esposito et al., 1984).

However, few studies have relied on US screening to investigate alterations of the mobility of organs on their fascial layers, and even fewer have related such impaired mobility with pain on the correspondent spinal level. No research has ever assessed, by real-time US screening, any possible change *in vivo* of the range of sliding movements between superficial and deep fascial layers, before and after MFTs are applied *in situ*, on patients with non-specific NP or LBP: as has been the scope of this study.

US screening of cervical organs mobility in patients with NP — Hypothesis 1 (H1)

Up to now, most of research has assessed thyroid mobility, esophageal motility and larynx mobility, by US screening, in people with NP in concomitance of a disease of the organ observed: thyroid mobility and shape have been evaluated in patient complaining of NP and suffering of subacute thyroiditis (Yamashita et al., 1993) and thyroglossal duct abscesses (Rohn and Rubio, 1980); additionally, esophageal sensory and motor function has been studied by US investigation, in dysfunctional (Hirano and Pandolfino, 2007), pathological (Takebayashi et al., 1991) as well as in normal conditions (Mittal, 2005); mobility and anatomy of the healthy larynx and perilaryngeal structure have been observed by US screening (Valente et al., 1996) mainly in the paediatric field (Friedman, 1997).

For the scope of this study, instead, the general mobility of cervical organs within the superficial and deep fascia complexes of the neck were investigated in relation to non-specific NP, in the absence of any cervical organ disease, before and after MFTs were applied *in situ*. Because the patient's discomfort or pain should be taken in account as clinically relevant phenomena, in addition, this study has questioned whether changes in fascial mobility, following manual therapy, might influence pain perception in symptomatic patients. Thus this study's first hypothesis:

H1: i) US screening can be used to assess a dysfunctional alteration of cervical organ mobility on their fascial layers, in people with non-specific NP and without cervical organ disease; ii) The application of MFTs to the symptomatic cervical region improves the quality and quantity of such fascial layers mobility, observable by US screening; iii) The application of MFTs decreases NP perception in the short term.

US screening of kidney and bladder mobility in people with LBP — Hypothesis 2 of this study (H2)

Research has shown the relation between lumbar pain and altered renal mobility and shape in patients with frank acute (Barbagelata López 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), by using US methods of screening. However, no study has established the criteria for "normal" kidney mobility. There is also no established neither if there is a correlation between renal mobility and lumbar pain in the absence of renal pathologies (although one study (Morgan and Dubbins, 1992) screened for pancreas and, partially, for renal mobility, using US, on patients with unrelated symptomatology).

With regard to US assessment of bladder mobility, research studies have investigated the degree of bladder descent in primiparae (Sartori et al., 2004), nulligravid and multiparae (Meyer et al., 1996), as well as in women with stress urinary incontinence (Pregazzi et al., 2002), the latter during both Valsalva manoeuvre and maximal pelvic floor contraction. However, only a few have questioned a relationship between bladder pathology and LBP, such as in a case of bladder prolapse (Heit et al., 2002), or general urological disease (Tilscher et al., 1977). There have been no such studies reported in the absence of bladder pathology.

Furthermore, no studies have investigated how back pain perception and kidney/bladder mobility varies after manual therapy is applied, in patients with no frank organic pathologies (the literature reports a preliminary study of chiropractic decompression (Browning, 1989) in six cases with pelvic dysfunction, although clinical signs were used as indicators for pre and post assessment). Therefore, this study has investigated the possible relationship between non-specific LBP and renal/bladder mobility, and their myofascial suspending and supporting structures, in patients with healthy kidneys and bladder, before and after MFTs were applied *in situ*. In addition, this study has questioned whether possible changes in fascial mobility, following manual therapy, may influence pain perception in symptomatic patients. Thus this study's second hypothesis:

H2: i) US screening can be used to assess dysfunctional changes in kidney and bladder mobility and their fascial layers, in people with non-specific LBP and without organ disease; ii) The application of MFTs to the symptomatic lumbo-pelvic region improves the quality and quantity of such organs mobility, measurable by US screening; iii) The application of MFTs decreases LBP perception over the short term.

Materials and methods

Population

During the one year period during which this study was conducted, out of the 356 subjects who came to the clinic presenting with NP or LBP, a total of 120 were recruited after examination and meeting the inclusion criteria. The inclusion criteria were an age between 18 and 60 years; a complaint of non-specific pain in the cervical or lumbar region, with or without associated neurological symptoms, with a duration of at least 3 weeks and of not more than 6 months; an MRI/US documented absence of inherited or acquired pathologies of the spine, or the neck, kidneys and bladder. Exclusion criteria were pregnancies, concomitant receipt of physical or manual therapy, the use of analgesics and/or anti-inflammatory drugs in the previous 72 h.

Out of the 120 people included in this study, 60 were suffering from non-specific NP, while the remainder reporting non-specific LBP. The subjects were randomly selected and assigned to Experimental and Sham-Control groups. A block randomization was applied at this phase: a block size of 6 was established and a random choice of the possible balanced combination in each block was made to determine the assignment of the two sub-groups (NP and LBP) into their respective main groups (Experimental and Control).

The male-female ratio as well as the age range and mean for each group are shown on Table 1.

Setting

This study was conducted over a period of 13 months, from September 2008 to October 2009 at the C.R.O.M.O.N. centre in Rome, Italy.

Real-time US screening

Each subject underwent a US scanning of the area of complaint, performed by a blinded, medical doctor with 15 years experience of specialised US screening. *ESAOTE My LAB 25 GOLD* device was used for this purpose. A *Dynamic Ultrasound Topographic Anatomy Evaluation* (D.US.T.A.-E.) was performed on each subject: This offered 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*.

Neck US screening

A D.US.T.A.-E. was performed on each subject of the NP Experimental and Sham-Control groups in supine position, with the head, in mild extension and right side-bending-rotation, rested on the couch, before and after MFTs or the sham treatment had been applied. A linear probe was used at 7.5–13 MHz. It was always positioned on the sagittal plane at the left antero-lateral region of the neck, between the sternocleido-mastoid muscle and the ipsilateral neurovascular bundle, as shown in Figure 1. The aim was to observe any quantitative and/or qualitative change in mobility between fascial layers of the neck region, such as pretracheal and retropharyngeal fascia, during quiet respiration, maximal inspiration-expiration, and swallowing, before and after treatment.

Two medical doctors, of 19 and 21 years experience in US screening and diagnosis, were asked to compare the results independently. They were blind to the groups (Experimental and Control) from which the images were obtained. After having randomly viewed and compared the pre- and post- US videos for every NP subject, they were asked to rate any possible change in quality and quantity of the cervical fascia sliding motions as ‘none’, ‘discrete’ or ‘radical’. The values obtained by the first examiner were called *Ultrasound Qualitative Scale 1* (US-QS1) results, whereas those collected from the second examiner were called *Ultrasound Qualitative Scale 2* (US-QS2) results.

Lumbar and pelvic US screening

A similar procedure was applied to LBP subjects: with patients supine, the probe was positioned in the lateral lumbar region, for a sagittal scan. A convex probe was used at 5 MHz and THI. The distance between the superior pole of the right kidney and the origin of the respective diaphragmatic crura (RD distance) was taken during both maximal inspiration (RdI) and maximal expiration (RdE), as shown on Figure 2, before and after treatment (see figure 2) was applied. The aim was to measure and compare

Table 1 A list of the number of subjects, male (M) and female (F), age range and age mean values for each main group (Experimental and Control) and the respective sub-groups (NP and LBP) is shown.

Study groups	Experimental group		Control group	
	NP	LBP	NP	LBP
Subjects	30	30	30	30
M	24	18	20	22
F	6	12	10	8
Age range	23–48	21–58	18–56	28–52
Age mean	37,3	39,1	39,6	39

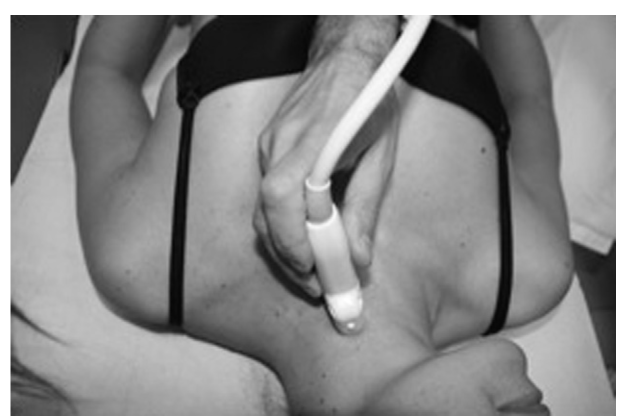

Figure 1 Standard procedure for the neck US screening in NP subjects. The standard procedure for US screening of the neck region for NP sub-groups is shown: the patient lies supine with the head resting on the couch, in a mild extension, and right side-bending-rotation. The probe is positioned on the left antero-lateral region of the neck, between the sternocleido-mastoid muscle and the ipsilateral neurovascular bundle, along the sagittal plane. A US recorded video was taken during swallowing, quiet and forced breathing, before and after treatment was applied.

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Figure 2 US RD distance measurement on LBP sub-groups. The distance between the superior pole of the right kidney and the origin of the respective diaphragmatic crura was taken during maximal inspiration and expiration in both LBP sub-groups, before and after treatment was applied.

pre- to post- range of kidney's supero-inferior sliding motion, during forced respiration.

Successively, the same subjects were also assessed at their pelvic region, in supine position, using the same type of probe. In this case, the probe was always positioned above the pubic symphysis, for transverse and sagittal scanning. The distance between the neck of the bladder and the anterior vesical wall on the perpendicular line (NB distances) was taken during maximal relaxation (NbR) and contraction (NbC) of the pelvic floor muscles, as shown in Figure 3 before and after treatment was applied. All patients were asked to urinate 2 h prior the session and then drink 500 cc. of water an hour before the same session. Bladder filling influences the position and mobility of the bladder neck and the proximal urethra, which are both more mobile when the bladder is nearly empty (Dietz and Wilson, 1999).

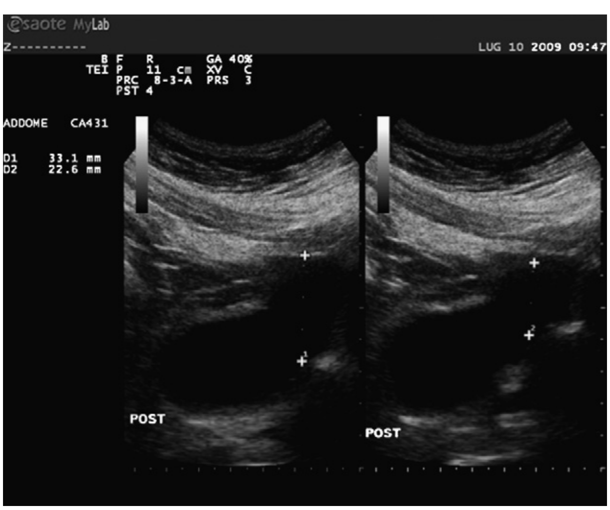

Figure 3 US NB distance measurement on LBP sub-groups. The distance between the neck of the bladder and the anterior vesical wall, on the perpendicular line, was taken during maximal relaxation and contraction of the pelvic floor muscles in both LBP sub-groups, before and after treatment was applied.

Pain assessment

Pain perception was measured using the *Short-Form McGill Pain Assessment Questionnaire (SF-MPQ)*, a responsive scale giving both reliable and valid data (Melzack, 1987). The SF-MPQ consists in a 15-point descriptor of average pain, articulated in 11 points of sensory experience and 4 of affective experiences. An intensity scale of 0—3 representing mild, moderate or severe pain, is given for each descriptor. The sensory and affective pain rating scores (ranging from 0 to 33 and from 0 to 12 respectively) are added together to give a value for total pain experience (ranging from 0 to 45). The total score has been used as the outcome of this study. The SF-MPQ was administered to every subject on the day of recruitment, as well as three days later.

Osteopathic assessment

An Osteopathic assessment was performed by an Osteopath, of 5 years experience, in the symptomatic region of the NP and LBP Experimental subjects, to locate the specific area of major fascial restriction of mobility, respectively in the neck and lumbar regions.

Treatment

The Experimental group received MFTs on the painful areas, by the same Osteopath who had previously assessed them. The treatment consisted of application of MFR and FU techniques:

MFR treatment

MFR consists in the application of a low load, long duration stretch along the lines of maximal fascial restrictions (Barnes, 1990). The latter are palpated by the practitioner and the pressure is applied directly to the skin, into the direction of restriction just until resistance (tissue barrier) is felt. Once found, the collagenous barrier is engaged for 90—120 s, without sliding over the skin or forcing the tissue (Manheim, 2001), until the fascia complex starts to yield and a sensation of softening is achieved.

a) *For the Experimental NP group*: MFR was applied in two stages, for not more then 2 min each. The aim was to release the deep and superficial cervical myofascial structures, having an effect on their reciprocal sliding motion, in both the anterior and the posterior neck region. The hold used with patient supine, was with the operator's caudal hand on the sternum and the cranial hand on the forehead, when MFR being applied to the anterior neck structures. The cranial hand was supporting the head at the suboccipit when MFR was applied to the posterior neck structures (Stanborough, 2004).

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b) *For the Experimental LBP group*: MFR was applied in two stages, for not more then 2 min each. The aim was to firstly release the right and then left psoas major and minor as well as the iliacus muscles and related lumbar organs, by using the cross-handed hold shown in Figure 4 (Stanborough, 2004). The kidneys are embedded and suspended by the renal fascia that is anatomically related to the diaphragm and psoas fascia, that is in turn a continuation of the thoraco-lumbar fascia (Bogduk, 2005). Secondly, the pelvic floor muscles and related pelvic organs were targeted to be released by the application of MFR through a global pelvic A/P hold. With the patient supine, one operator's hand on the sacrum, between patient legs, and one hand just above the pubic symphysis (Stanborough, 2004).

FU treatment

FU consists in 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 sensed and unwound until a release is felt (Ward, 2003).

a) *For the Experimental NP group*: MFR treatment was followed by FU of the neck, by using the same holds described above for the MFR technique. The overall FU treatment was applied for not more than 2 min.
b) *For the Experimental LBP group*: MFR treatment was followed by FU of the lumbar and lumbo-pelvic region. With regards to the lumbar region, the hold used is shown on Figure 5. This was applied on both sides. For the pelvic release, the same global A/P hold described above for the MFR technique was used. The overall FU treatment lasted not more than 6 min.

Figure 4 MFR hold for LBP Experimental group. The hold used for MFR technique applied to the Experimental LBP group is shown: a cross-handed hold along the psoas, with the cranial hand below the inferior costal margin and the caudal hand above the inguinal region. The aim is to release the psoas and iliacus muscles as well as related lumbar organs.

Figure 5 FU hold for LBP Experimental group. The hold used for FU technique applied to the Experimental LBP group is shown: the patient is side lying with the lower leg flexed; the operator behind, facing the patient. The caudal hand supports the upper patient leg with flexed knee. The cranial hand contacts the lateral lumbar region. By using the patient upper leg as a lever, and the cranial hand as a fulcrum, a tissue unwinding is performed aimed to release the psoas muscle, lumbar spine and kidney mobility.

Sham treatment

The Sham-Control group blindly received a sham treatment by someone who did not have any knowledge of anatomy or experience in manual therapy whatsoever.

a) *For the Sham-Control NP group*: The sham-osteopath rested his hands on the patient's neck, for 3 min, by using each of the two A/P holds described above for the MFR technique applied to the Experimental NP group. The sham treatment lasted 6 min in total, as was the case for the Experimental NP group (given by 4 min of MFR and 2 min of FU techniques application).
b) *For the Sham-Control LBP group*: The sham-osteopath rested his hands on the patient's lumbar and lumbo-pelvic region, for 4 min, using each of the following holds: left and right cross-hand hold, as shown in figure 4 the global A/P pelvic hold as described above for the MFR technique applied to the Experimental LBP group. The sham treatment lasted 12 min in total, as did the overall treatment for the Experimental LBP group (given by 6 min of MFR and 6 min of FU techniques application).

Ethic committee

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

Statistical analysis

All analyses were performed using the software "STATVIEW 5.0" (SAS Institute Inc.) and Microsoft EXCEL for some data graphic representations.

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a) With regards to H1 i) and ii): the results of the US-QS1 and US-QS2 were compared using the Chi square test, with a p value accepted at <0.05.
   With regards to H1 iii) as well as to H2 i), ii), iii), : the ANOVA test at repeated measures was used, with a p value accepted at <0.05, to calculate if between Experimental and Control groups there was a significant difference for the:
b) RD-T0 and RD-T1 distances in LBP sub-groups, by considering RD-T0 = RdI-T0 − RdE-T0 and RD-T1 = RdI-T1 − RdE-T1;
c) NB-T0 and NB-T1 distances in LBP sub-groups, considering NB-T0 = NbR-T0 − NbC-T0 and NB-T1 = NbR-T1 − NbC-T1;
d) pre- to post- SF-MPQ results.

Results

a) *US-QS*: The US-QS results (US-QS1 and US-QS2) for the NP study population are shown on Figure 6 with their respective frequency. A significant difference is shown with a *p-Value* < 0.0001. The Chi square test between US-QS1 and US-QS2 results, after they have been normalized in *z points*, has shown a significant correlation (0.915) with a *p-Value* < 0.0001 (confirming H1 i) and ii));
b) *US kidney values*: RD-T0 and RD-T1 distances in the LBP groups are shown on Figure 7 A significant difference is shown with an *F-Value* = 76.637 and a *p-Value* < 0.0001. In the Experimental group the mean value of RD-T0 was 10.33, St. Dev. 4.70, against the RD-T1 mean value of 21.60, St. Dev. 7.06. In the Control group the mean value of RD-TO was 8.93, St. Dev. 2.01, against the RD-T1 mean value of 10.10, St. Dev 4.49. The range of the all RD-T0 values was −3/+21 mm, mean 9.63, St. Dev. 3.65; the range of all RD-T1 values was −2/+32 mm, mean 15.85, St. Dev. 5.78 (confirming H2 i) and ii));
c) *US bladder values*: NB-T0 and NB-T1 distances in LBP sub-groups are shown on Figure 8. A significant difference is shown with an *F-Value* = 577.349 and a *p-Value* < 0.0001. In the Experimental group the mean values of NB-T0 was 12.70, St. Dev. 4.18, against the NB-T1 mean value of 22.73, St. Dev. 3.73. In the Control group the mean value of NB-TO was 12.20, St. Dev. 3.81, against the NB-T1 mean value of 12.90, St. Dev. 4.23. The range of NB-T0 values was +4/+21 mm, mean 12.45, St. Dev. 3.98; the range of NB-T1 values was +3/+30 mm, mean 17.82, St. Dev. 3.98 (confirming H2 i) and ii));
d) *SF-MPQ*: Pre- to post-differences between Experimental (NP + LBP) and Control (NP + LBP) groups are shown on Figure 9. A significant difference with an *F-Value* = 167.742 and a *p-Value* < 0.0001 is shown on Table 2. Means and St. Dev. values are shown on Table 3. The mean difference between groups was 4.883; the mean difference between pre- and post- was 4.483. No significant difference was found either between NP and LBP sub-groups (*p-Value* < 0.8582), or between genders (*p-Value* < 0.4866) or between age classes (*p-Value* < 0.5031), with respect to the study population (confirming H1 iii) and H2 iii)).

Discussion

This study shows that cervical and some lumbo-pelvic organs mobility, with respect to the surrounding myofascial structures, may be assessed by US screening; that such mobility changes are related with pain in the corresponding spinal area; that such mobility may be reduced or altered without frank organic pathology; that MFTs can improve

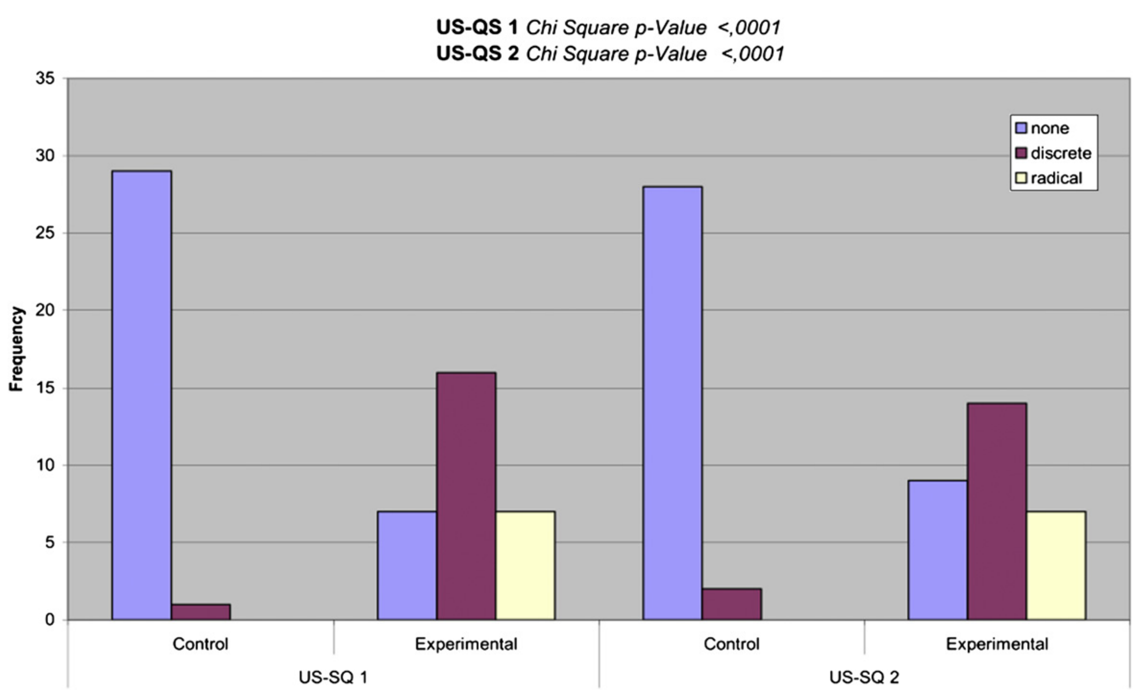

Figure 6 Chi square *p-Values* for US-SQ1 and US-SQ-2 results in NP sub-groups. The US-QS results (US-QS1 and US-QS2) for the NP sub-groups are shown with their respective observed frequency. A significant difference is shown with a *p-Value* < 0.0001.

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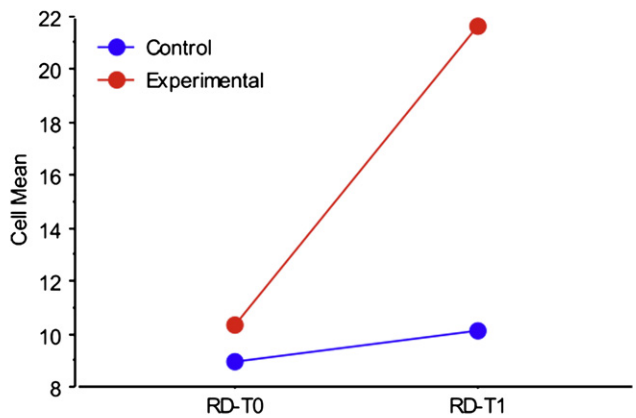

Figure 7 US kidney results in LBP sub-groups. The significant difference between RD-T0 and RD-T1 distances in LBP sub-groups are shown. In the Experimental group the mean values of RD-T0 was 10.33, St. Dev. 4.70, against the RD-T1 mean value of 21.60, St. Dev. 7.06. In the Control group the mean value of RD-TO was 8.93, St. Dev. 2.01, against the RD-T1 mean value of 10.10, St Dev 4.49.

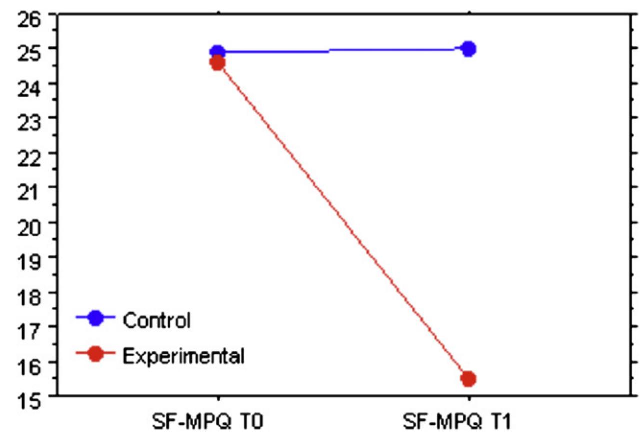

Figure 9 SF-MPQ results in the two study group. The significant difference between Experimental and Control groups for the pre- to post- SF-MPQ results is shown.

such fascia related organs mobility as well as reduce pain perception over a short term period.

H1 — neck pain, US screening of cervical fascia mobility and MFTs

Most research that has investigated the efficacy of manual therapies on subjects with neck pain have used US for sham treatment only, as de-tuned device (Koes et al., 1993; Schwerla et al., 2008), very few as a tool for measurement or monitoring (Licht et al., 1998). This study, instead, shows that US evaluation is a valid, non-invasive method to monitor and assess organs mobility in the cervical and abdomino-pelvic region, *in vivo* and real-time. Furthermore, intraluminal impedance and intramural or endoscopic US and ultrasonography have been mainly recruited in the last decades of research, because of advances in transducer technology, computerization, and graphic data presentation. This study also shows that release obtained by MFTs in the superficial and deep myofascial structures of the neck allowed a better motion of the organs related to those structures:

a) *Radical* findings: The two blinded examiners of US recorded videos have both separately indicated as 'radical' the change between the same pre and post images, in 7 subjects of the Experimental group, accounting for the 23.33% of the study group, whereas no 'radical' change was found in the Control group.
b) *Discrete* findings: a mean value of 15 of 'discrete' change was found in the Experimental group, versus a mean value of 1.5 in the Control group
c) *None* findings: With regards to the 'none' change, a mean value of 8 was found in the Experimental group, compared to a mean value of 28.5 for the Control group.

However, limitations of this part of the study were:

a) Method-related: the US property of scanning all planes reduces the chance of standardization (and often of quantification) of distance measurements;
b) Examiner-related: because of human margins of error, is extremely difficult to obtain and reproduce two images, 'pre' and 'post', in the same plane and angulation;
c) Patient-related: position, breathing, inter and intra tissue mobility, viscoelastic changes. The need for a mathematical model capable of comparing similar US images is paramount to analyse pre to post changes.

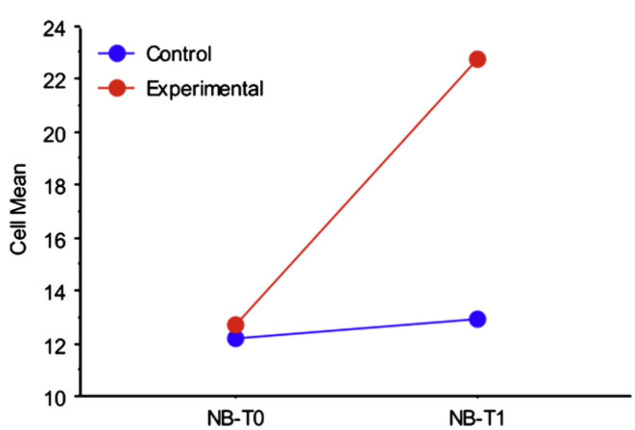

Figure 8 US bladder results in LBP sub-groups. The significant difference between NB-T0 and NB-T1 distances in LBP sub-groups are shown. In the Experimental group the mean values of NB-T0 was 12.70, St. Dev. 4.18, against the NB-T1 mean value of 22.73, St. Dev. 3.73. In the Control group the mean value of NB-TO was 12.20, St. Dev. 3.81, against the NB-T1 mean value of 12.90, St Dev 4.23.

H2 — lumbar pain, US screening of kidney mobility and MFTs

This study has also investigated the range of sliding motion of the right kidney in people with lumbar pain and absence of renal pathology, before and after specific MFTs were

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Table 2 ANOVA table for SF-MPQ values.

	DF	Sum of squares	Mean square	*F*-Value	*P*-Value	Lambda	Power
Gruppl	1	1430.817	1430.817	9.027	.0032	9.027	.863
Subject (Group)	118	18703.033	158.500				
Category for SF-MPQ	1	1206.017	1206.017	155.933	<.0001	155.933	1.000
Category for SF-MPQ × Gruppl	1	1297.350	1297.350	167.742	<.0001	167.742	1.000
Category for SF-MPQ × Subject (Group)	118	912.633	7.734				

applied on psoas muscles and lumbar region. The release followed by 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, re-established an optimal renal mobility, and via fascial continuation, have improved lumbar spine mobility. Although we could concluded that application of MFTs significantly improves kidney mobility and reduces pain perception, at this stage it is inappropriate to state that people with non-specific lumbar pain may present with a relative reduction of right kidney's mobility, due to the fact that no study has ever assessed "normal" kidney mobility during respiration and/or established an index of kidney mobility. Therefore, no comparison is possible between the values obtained (RD-T0 range values −3/+21 mm, mean 9.63, St. Dev. 3.65; RD-T1 range values −2/+32 mm, mean 15.85, St. Dev. 8.25) and those in "normal" conditions.

H2 — lumbar pain, US screening of bladder mobility and MFTs

This study has also investigated the range of neck bladder mobility in people with non-specific lumbar pain and a healthy bladder. The restriction identified may have contributed to or maintained LBP, via viscero-somatic reflex, and/or via venous and lymphatic drainage congestion, or more simply via mechanical tension through connective tissue connections (Ward, 2003). In fact, the bladder 'sits' on the pelvic floor and is partially supported and suspended by the endopelvic fascia via its extensions, such as the pubovesical ligaments, together with the pubosacral laminae from the levator ani muscle (Paoletti, 2003). MFTs have been shown to be effective at improving bladder mobility, and may have balanced pelvic floor tensions on the transverse and sagittal planes, restoring optimal bladder mobility and possibly general pelvic adaptive capacity. The latter meaning the potential ability of the pelvic girdle and its contents maintain a functional and mechanical balance against possible disrupting action of internal and external forces. This may have offered, in turn, a balanced and mobile support to the lumbar spine, possibly improving its mobility and reducing inflammation and pain. The range of neck bladder mobility found in this study was +4/+21 mm, mean 12.45, St. Dev. 3.98 at T0; and +3/+30 mm, mean 17.82, St. Dev. 6.35 at T1. Some studies have shown "normal" bladder mobility, although in women only and exclusively with regards to bladder descent during the Valsalva manouvre (Dietz et al., 2004). The degree of mobility was found to range from 1.2 to 40.2 mm (mean 17.4 mm). Other studies (Pregazzi et al., 2002) have, investigated bladder mobility during maximal pelvic floor contraction, using different electronic distance measurements, such as that between the bladder neck and the pubic symphysis, the bladder neck and the symphysis pubis line, the midline of the symphysis (alpha angle) and the angle between the proximal and distal urethra (beta angle). Most of these studies have used perineal ultrasonography that allows far more details and precision than the more traditional external US investigation method chosen for this study. Therefore, comparisons of the results of this study with those from previous ones are inappropriate at this stage. However, much research has relied on US investigations, especially perineal and introital, to assess for prolapses (cystoptosis, bladder neck and urethral mobility), confirming that US remains the first line examination for pelvic morphology and bladder function.

Table 3 Means table for SF-MPQ values.

	Count	Mean	Std. Dev.	Std. Err.
Control, SF-MPQ T0	60	24.883	9.151	1.181
Control, SF-MPQ T1	60	25.050	8.867	1.145
Experimental, SF-MPQ T0	60	24.650	8.582	1.105
Experimental, SF-MPQ T1	60	15.517	9.839	1.270

H1 and H2 — neck or lumbar pain and MFTs

In both NP and LBP sub-groups, MFTs have shown to be effective in reducing pain perception regardless of age, gender and pain location, with an SF-MPQ mean values of 24.65 at T0 and 15.51 at T1 in the Experimental group against the mean values ranging from 24.88 at T0 to 25.05 at T1 for the Control group. A significant difference was found (p-Value < 0.0001).

Suggestions for further research

In this study, pain assessment was performed over a short period of 3 days following treatment, on a relatively small study population (although the small p-values obtained support the statistical notion that the small study population doesn't minimise the validity of the study itself). Future studies should evaluate whether these findings are reproducible, in a larger population, and whether positive long-term outcomes can be achieved in both US findings and pain assessment. Future research should also consider investigating the effect of MFTs on specific NP or LBP, to evaluate their efficacy when a specific organ pathology is present at the corresponding spinal level. This may help to better

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understand the potential contribution of organ pathology to a viscero-somatic reflex in the symptomatic area, as well as the potential therapeutic contribution of MFTs to restore normal conditions. The results may also be compared with those collected from other types of physical, pharmacological or surgical interventions. The authors suggest that in further studies, an extra third variable: the subjective perception of the practitioner should be introduced. To date no study has compared simultaneously these three main perspectives: the subjective perception of the patient, the objective values from any sort of device-calculated measurements, and the subjective perception of the therapist on 'if' and 'to what degree' the tissues were perceived as restricted before treatment or released after. In addition, a real-time US screening may be used during manual technique applied to observe tissue change *in vivo* during treatment. The analysis of the relationship between these three diagnostic variables would be extremely useful in both clinical and research areas, due to the intrinsic relevance of diagnostic validity and reliability when a treatment effect has been shown.

Conclusions

Dynamic US evaluation can be a valid and non-invasive instrument to assess effective sliding motion of fascial layers *in vivo*. The association between change in fascial/organ movement and symptoms has been demonstrated, whereas a fascial involvement in both organ function and pain remains plausible at this stage. MFTs appear to be a useful method to improve or even restore normal tissue mobility and function as well as to decrease pain perception. Further studies should demonstrate whether these findings are reproducible, and whether positive long-term outcomes can be achieved.

Conflict of interest statement

We hereby assert that there are no actual or potential conflicts of interest including any financial, personal or other relationships with other people or organisations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, our work.

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