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Società Italiana
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CONTENTS

Prevention and treatment of functional decline in older adults: the S.I.F. guessed the theme of its 1st International Congress

R. GATTI

School of Physiotherapy, Fondazione Centro San Raffaele del Monte Tabor, Milan, Italy

In October the S.I.F is going to realize its 1st International Congress about recovery and conservation of wellness and autonomy in the geriatric population. The title of the Congress is "Physiotherapy: prevention and treatment of functional decline in older adults"; its aim is to spread updated evidence-based knowledge about the Physiotherapy of the elderly with co-morbid conditions. Several experts from European and American countries have been invited as speakers.

The first Scientific Congress of a new Scientific Society is the occasion to underline the cultural setting of the Society and its ability to debate about internationally considered themes. Moreover, the Congress also has to involve a great number of colleagues. During the months before the Congress two criteria can be used in order to assess the quality of the initiative: the number of Congress registrations and the consideration of the Congress' theme in the international scientific Community.

With my great pleasure I have to note that almost 200 physiotherapists have already signed up for the Congress and it is reasonable to look forward to a high participation at the Congress considering other four months of time to sign up.

Regarding the second point it is interesting to underline the interest that the just concluded 16 International WCPT Congress has dedicated to the theme of physiotherapy in the older adult.

Of the whole, 135 presentations, shared in oral communications and posters discussion and presentation were dedicated to the older adult. These have been divided in two sessions: balance and falls and general aspect. The scientific communications' level were high and they focused on physiopathology, prevention and treatment of older adults.

The theme of physiotherapy in older adults has been studied from different points of view. In order to give some examples I am going to cite some of the presentations that I found particularly interesting.

About the physiopathology a group of Japanese colleagues presented a poster about the brain activation pattern during gait of healthy elderly measured by positron emission tomography (PET),[1] showing differences of the brain activation between subjects with stable or unstable gait. Another group of United Kingdom colleagues presented data about the prevalence of vestibular system disorders in elderly fallers who did not report dizziness.[2] Using the Head thrust test and the Dynamic visual acuity test this research showed that a prevalence of vestibular disorders in asymptomatic elderly fallers is present. Hence, it is probable that a high proportion of these patients are undiagnosed and untreated. The authors concluded their communication emphasising the importance of vestibular screening and rehabilitation to achieve effective falls prevention in elderly fallers. The international

WCPT Congress is the occasion to gather colleagues from all the world, in order to share in the physiotherapists' community the different scientific activities. Some Indian colleagues presented the impact of aging on anthropometry, architecture and function of quadriceps [3] and a group of Brazilian colleagues analyzed the correlation between lower extremity muscle strength, calf circumference, handgrip strength, functional mobility and physical activity level in a group of active older people.[4]

Interesting news regarded which are the best characteristics of the exercise. A group of Australian colleagues presented an update of their previous systematic review on the effect of exercise on falls rates in older people.[5] The analysis confirmed that exercise addressed to challenging balance training and high dose of exercise can prevent falls. On the contrary a walking training does not seem to have impact on the number of falls. A challenging balance training resulted useful in order to prevent falls also in older people with cognitive impairment.[6] Much attention has been dedicated to falls originated by co-morbidity conditions. For example a group of Swedish colleagues presented a communication on balance in elderly after hip fracture and showed data about this particular co-morbidity condition. In the oldest group of the studied subjects the balance problem after hip surgery was more severe.[7] Also some drugs can induce balance impairment. A group of Australian colleagues studied 150 people attending outpatients epilepsy clinics and taking anti-epileptic drugs and 76 healthy control participants.[8] Antiepileptic drugs are frequently used by older adults for common health problems including epilepsy, migraine, trigeminal neuralgia, neuropathic pain syndrome and psychiatric disorders. The result of this study underlined the increased problem of balance impairment, falls and fractures for people taking anti-epileptic drugs, especially those on polytherapy, a frequent condition in older people.

Finally a lot of other exercises have been proposed as the Tai chi, the yoga, the core stabilization exercises, exercises performed in groups of people or directly executed in the patient's home.

The general idea that arises from the WCPT Congress is that the physiotherapy of older adults is an actual scientific, social and economical aspect of the rehabilitation field. The co-morbidity present in older people forces the physiotherapists to observe and to treat the motor function pathology, that cannot be considered as the addition of the single diseases' outcomes. Moreover in older adults physiotherapy, it is evident that the improvement of the normal daily activities and the participation in a normal social life is the goal of the physiotherapy intervention.

After the 16th international WCPT Congress I am glad to say that the S.I.F. guessed the theme of its first international annual Congress.

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ORIGINAL ARTICLE

Pain location reliability of the median neurodynamic Test 1 in healthy subjects

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ABSTRACT

Aim. Neurodynamic tests have been introduced to assess the neural tissue mobility and sensitivity to mechanical stress. Therefore it is important for clinicians to understand neurodynamic tests' normal and abnormal responses, in order to consider a diagnosis of neurogenic disorders. The purpose of this study was to investigate the reliability of the submaximal pain location induced by Median Neurodynamic Test 1 (MNT1) in healthy subjects.

Methods. Three physical therapists (R, M, E) were involved in the study as examiners. Fifteen healthy volunteers were randomly allocated to one of five sessions. The examiners performed the MNT1 twice (t1, t2) on both sides on all the subjects. Examiners and side order were randomized and subjects waited fifteen minutes before receiving a second test on the same side. Subjects were instructed to stop the test at submaximal pain and to record the response on a body chart. In order to analyze the pain location the body charts were split in twenty-eight anatomical areas. Intraexaminer and interexaminer reliability of the painful response were investigated using the Jaccard index (JI). Additionally in each subject left and right painful responses similarity were analyzed.

Results. The mean JI for intraexaminer reliability was 0.67 (SD 0.21) for R, 0.65 (SD 0.26) for M and 0.52 (SD 0.31) for E. The mean JI for inter-examiner reliability was 0.58 (SD 0.25) for M *versus* R, 0.51 (SD 0.28) for R *versus* E and 0.49 (SD 0.29) for M *versus* E. The mean JI for left and right comparison was 0.61 (SD 0.27).

Conclusion. The reliability of submaximal pain location response during MNT1 in healthy subjects seems to be moderate. *(It J Physiother 2011;1:41-7)*

Key words: Stress, mechanical - Pain - Physical therapy modalities.

An important aspect of the examination procedure in physical therapy is to identify any possible cause of patient's pain.[1] Minor lesions in the peripheral nervous system can be the cause of persistent pain and other sensory symptoms.[2] There is evidence that increased neural tissue mechanosensitivity occurs in many patients who experience these kinds of disorders.[3] Increased mechanosensitivity of peripheral nerves consists in an increased sensitivity to mechanical loading.[4, 5]

Currently, tests that can readily identify neural tissue pain disorders are not available, and the detection of increased neural tissues mechanosensitivity relies on subjective and clinical examination.[6] Part of this examination consists in neurodynamic tests. The first provocative maneuver for peripheral nerve was the "straight leg raise test".[7] Over the last three decades, after Elvey introduced a similar test for the upper limb (the "brachial plexus tension test", 1979),[8] examination techniques known as "neurodynamic test" have been developed.[9, 10] The median neudodynamic test 1 (MNT1) is one of the most investigated neurodynamic test for the upper limb.

Like the other neurodynamic tests, this technique is based on the assumption that upper limb movements require neural tissue to move, adapt, and extend in length.[11] Consequently, the use of a precise and sequential positioning of the limb in order to apply tension of the neural components is described. It is theorized that the MNT1 moves and exerts longitudinal stress on the median nerve, its proximal nerve roots and on the cervico-brachial plexus, provoking sensory and motor responses.[12] Finally, *in vitro* studies have shown the anatomical relationship between stress and strain on the median nerve during MNT1.[13-15]

MNT1 can be used with a diagnostic purpose, as for example to detect radiculopathy,[16] but it is most valuable when symptoms are consistent with a minor peripheral nerve or a nerve root injury [6] and the neurological exam is inconclusive. MNT1 is suggested in all patients with symptoms in the arm, head, neck and thoracic spine.[17]

Neurodynamic tests are considered positive when three conditions are satisfied: 1) provocation of symptoms complained by the patient; 2) different response between the involved and uninvolved side; 3) symptoms change, decrease or increase, in response to structural differentiation.[17, 18] Resistance to passive movement, onset, quality and location are other aspects commonly observed while performing neurodynamic tests.[18]

With respect to intra and inter-examiners reliability of MNT1, most studies investigated whether sub-maximal pain occurs at a consistent point of the range of movement. Good to excellent reliability coefficients values were observed for MNT1, both in clinical and laboratory setting.[19-23] Although these results support the use of MNT1 as a reliable clinical outcome measure,[20] it is necessary to better investigate the normal neurogenic responses, in order to enhance its application in clinical practice.[9] Because pain reports are critical for the diagnosis and treatment of pain disorders, it could be relevant to determine how reliable is the submaximal painful response to MNT1, and how consistently asymptomatic subjects report location and quality of their symptoms. Low values of reliability or inconsistency in pain reporting may be misleading and may obscure real changes in pain.[24]

Assuming that performing MNT1 sub-maximal pain occurs at a consistent point in range,[19, 20, 22] the aim of this study was to investigate the reliability of the submaximal pain location induced by MNT1 in healthy subjects.

Materials and methods

Participants

A total of 15 healthy students, 11 female and 4 male (age 22.1±0.7), have been enrolled from the School of Physiotherapy of the Vita Salute University. Students did not have any previous experience with the concept of neurodynamic testing. Subjects were excluded if they had any history of neck pain, upper limb muscular or joint injury, and neurological or vascular conditions.

Procedure

Full explanation of the procedures without disclosure of the study's hypothesis was given and subjects provided written informed consent before beginning of the study. All the experiments were conducted at the laboratory of movement analysis of the San Raffaele Hospital, Milan.

Prior to the experimental phase, a novice physiotherapist (E) and two experienced physiotherapists (M, R) underwent a 5 hours of training to ensure a proper execution of the MNT1.

Subjects were randomly allocated to one of 5 daily sessions. During each session examiners performed the MNT1 twice (t1, t2) on left and right upper limbs. Examiners and sides order were randomized and subjects had a 15 minutes break mid-testing to ensure that they did not feel a sensitization of the upper limbs.

Subjects were positioned supine on a plinth, without a pillow and with their cervical spine in neutral position. All tests were carried out slowly and following standardized stages (Figure 1). While the MNT1 was applied one of

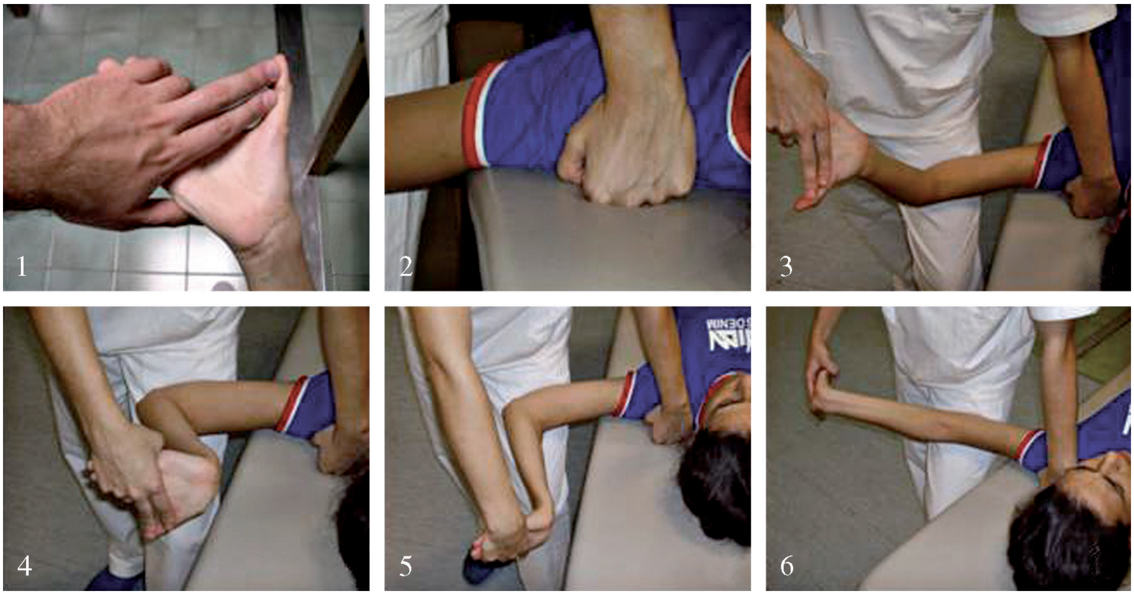


Figure 1.—The different stages during the MNT1: handgrip with fingers fixation (1), scapular fixation (2), glenohumeral abduction (3), Forearm supination and wrist and extension (4), glenohumeral external rotation (5), elbow extension (6).

the three examiners verified and confirmed the proper execution of the test. Subjects were instructed to stop the test at the submaximal pain as defined by Coppieters:[22] " a substantial discomfort, which corresponded with the greatest level of pain which the subject was prepared to tolerate, knowing that the test had to be performed repeatedly". The test was slowly executed and no other details were given to the examiners about its execution. Once achieved the position of submaximal pain it was maintained for three seconds.

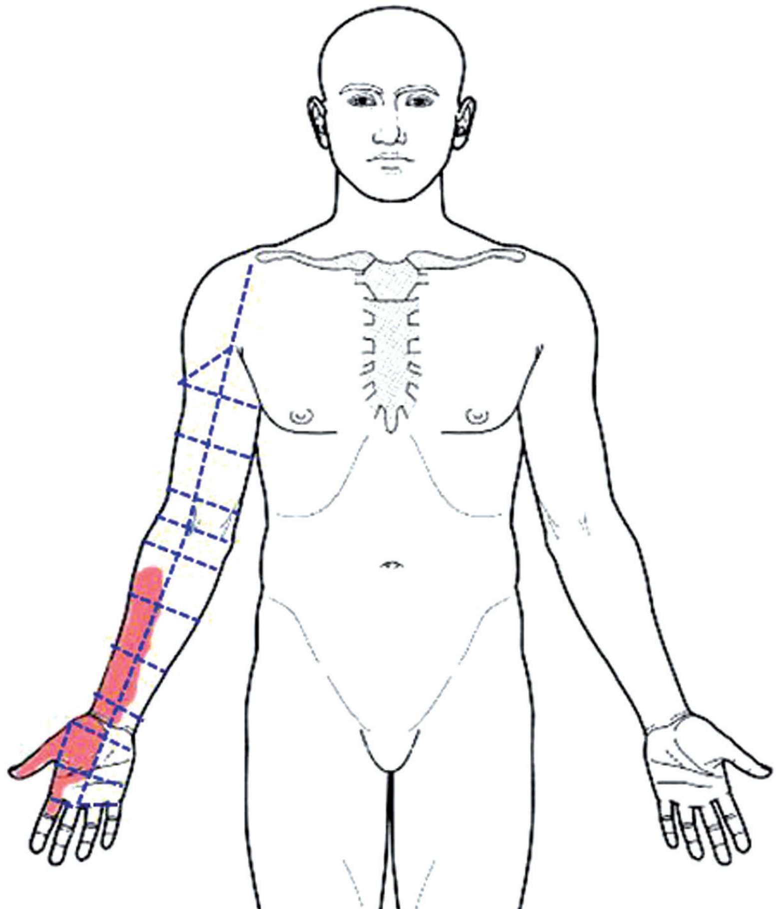
Once the test was released subjects was instructed to draw pain location (pain drawing) using a upper quadrant body chart (Figure 2). Additionally the sensory response was described using one the following terms: sharp, stretch, pins and needles, burning, prickling, tingling.

Statistical analysis

In order to analyze the pain drawing on the body charts two upper limb grids (left and right) with 28 anatomical areas (1 to 7 for the arm, 8 to 11 for the elbow, 12 to 17 for the forearm, 18 to 19 for the wrist, 20 to 23 for the hand, 24 to 28 for the fingers) were printed on a transparent film.

For each test the same examiner (M) overlapped the transparent film on the body charts in order to fill the pain location among the anatomical areas described by the subjects. The results were reported on a column matrix and, on the whole, 180 column matrixes (3 examiner x 2 left MNT1s x 2 right MNT1s x 15 subjects) were scored. Two values were defined for each matrix's element, 0 if no pain drawing was present in the anatomical area and 1 if at least 50% of the area was filled with the pain drawing. Doubts concerning the score were discussed among the three examiners. The frequency of the anatomical areas pain locations and the percentage of sensory response description during MNT1s has been described.

In order to establish the reliability of pain response, the degree of similarity among column matrixes has been analyzed by Jaccard Index [25] (1 complete similarity, 0 no similarity). Intra-examiner reliability has been defined comparing the pain drawings from the same subject on t1 and t2 on both sides. Inter-examiner reliability has been defined comparing pain drawings from the same subject on t1 on both sides among the examiners (M vs. R, R vs. E and M vs. E). Additionally the similarity of the pain response be-



				Arm							Elbow				Forearm						Wrist		Hand				Fingers				
Exam.	Rip.	Side	Subj.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
M	t1	r	xxx	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	1	0	0	1	0	0	0	0

Figure 2.—An example of pain drawing after MNT1. The blue dashed lines show the anatomical grid used to score the pain response location. Below a column matrix that described the pain response reported on the body chart.

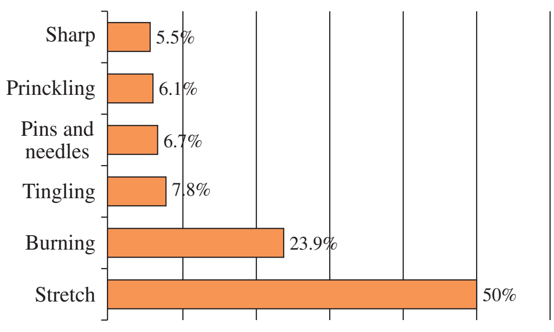


Figure 3.—Nature of the sensory response considering all the MNT1s performed during experimental study.

tween left and right has been analyzed using pain drawings on t1 for all the examiners.

Results

All subjects reported a painful response and filled the upper quadrant body charts, according with the given descriptors. The most frequent sensory responses were stretch (50%) and burning (23.9%). All the other descriptors accounted for less than 10% (tingling 7.8%, pins and needles 6.7%, prickling 6.1%, sharp 5.5%) (Figure 3).

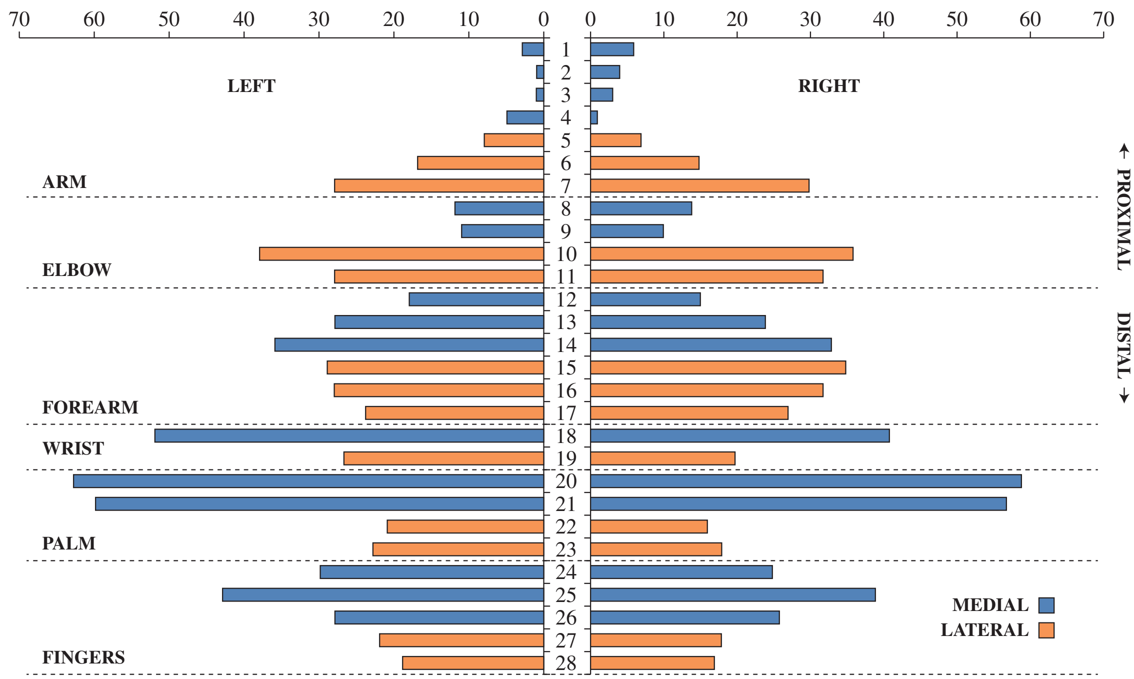


Figure 4.—Left and right pain frequency for each anatomical area (1 to 28). Orange histograms are for the medial anatomical areas and blue histograms are for lateral anatomical areas.

Considering the 180 column matrixes (90 for the left side, and 90 for the right side) reporting the 28 anatomical areas: the anatomical areas of the arm was scored 129 times, the anatomical areas of the elbow was scored 181 times, the anatomical areas of the forearm was scored 329 times, the anatomical areas of the wrist was scored 140 times, the anatomical areas of the hand was scored 317 times, and the anatomical areas of the fingers was scored 267 times. Data of frequency for each single anatomical area are shown in Figure 4.

The mean JI for intra-examiner reliability was 0.67 (SD 0.21) for R, 0.65 (SD 0.26) for M and 0.52 (SD 0.31) for E. The mean JI for inter-examiner reliability was 0.58 (SD 0.25) for M *versus* R, 0.51 (SD 0.28) for R *versus* E and 0.49 (SD 0.29) for M *versus* E. The mean JI for left and right comparison was 0.61 (SD 0.27).

Jaccard index data for intra-examiner, inter–examiner and left-right similarity are shown in Figure 5.

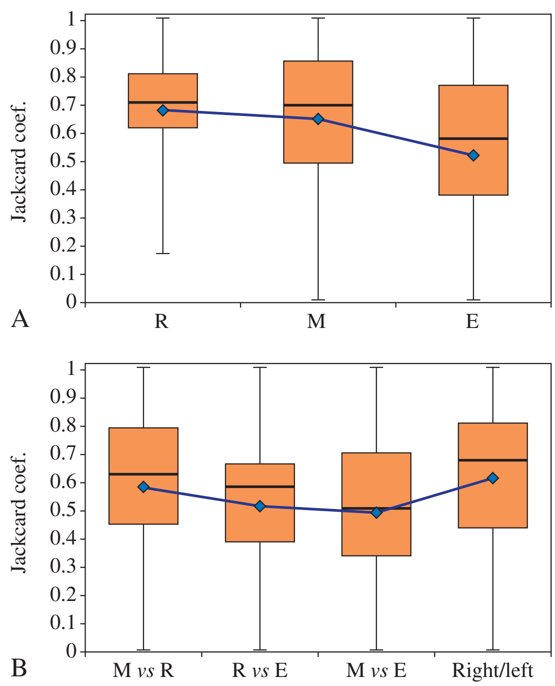


Figure 5.—Box-plots showing the values of JI for intra-examiner reliability (A) , inter-examiner reliability and right/left similarity (B). The blue dots represent the mean JI values.

Discussion

As previously reported [10, 26, 27] the present study showed that stretch is the most frequent sensation during the MNT1 execution in healthy subjects. Nevertheless other descriptors like burning, tingling and pins and needles were also used (Figure 3). This suggests caution for any interpretation on the nature of painful response in both healthy and pathological subjects.

The frequencies of the painful response on the considered anatomical areas (Figure 4) confirm that the distal and medial part of the upper limb are the typical pain locations during MNT1 in healthy subjects. A similar pattern has already been described by Kenneally [28] in 1985 and also reported in a recent study.[27] Nevertheless in our study the occurrence of pain response in other areas of the arm has been observed so, from our results, it is not possible to define a specific pattern for the submaximal painful response during MNT1, also assuming that it occurs at a consistent angle of the elbow extension.[19, 20, 22] We cannot exclude that, by increasing the number of the observations a more specific painful pattern will be revealed. Again, the higher frequencies for pain location have been scored at specific areas like the medial aspect of the wrist and the medial aspect of hand palm (Figure 4). These findings are consistent with biomechanical studies that report a great strain of the median nerve at distal joints during the MNT1.[29-31]

This is the first study exploring the reliability of the painful response location induces by MNT1 using pain drawings. Theoretically, the reliability of a painful response using a body charts should be as a perfect overlapping of two pain drawings. In that case the JI will be scored as 1. The mean JI for the intra-examiner reliability showed quite good values close to 0.7, except for the novice physiotherapist (E). The pain drawings performed after the two consecutive MNT1 by experienced physiotherapists (M, R) involved mainly the same anatomical areas. Unfortunately the interquartile ranges for the JI (Figure 5) are wide for all the examiners.

The same trends were also observed for the inter-examiner as well as for the left and right similarity. Although in these cases mean values of the JI are less interesting and approximate the 0.50. The same measurements error was also reported in two similar reliability studies focusing on the pain response related to range of motion at the elbow joint;[23, 32] as in our study the MNT1 was performed in a pure clinical setting.

Two possible explanations should be considered in order to discuss the large interquartile ranges: an inappropriate MNT1 handling among examiners and the instability of painful response. The MNT1 is described as a complex multi joints test,[22] several stages should be executed in a proper order, with a constant velocity and limited amount of force.[10, 18] For the MNT1 execution good manual skills are required as well as clinical experience in musculoskeletal assessment. This seems to be confirmed in our study where the novice physiotherapist showed the lowest IJ values. We did not apply any customized device to control the MNT1 execution as it was out intent to study the MNT1 in pure clinical setting. An examiner was present during the experimental phase only to verify correct sequence of MNT1 stages. The submaximal pain was not a well defined on/off response and when subjects stopped the elbow extension (the last MNT1 stages) and waited a few seconds to figure out the pain they also commented it as "expanding" or "moving". Even the examiners noticed that also little variations in the MNT1 stages resulted in a variation of the painful response. Again it is important to underline that the pain drawing validity has been confirmed only in patients with low back pain[33,34] and no evidences are available for other conditions like neurogenic pain.

Future research on painful response location induced by MNT1 should include a proper control of the test and subjects with neurogenic pain.

Conclusions

The reliability of submaximal pain location response during MNT1 in healthy subjects seems to be moderate and its application to test neurogenic disorder needs to be further investigated.

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ORIGINAL ARTICLE

The effects of manual hyperinflation with or without rib-cage compression in mechanically ventilated patients

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ABSTRACT

Aim. Manual hyperinflation and expiratory rib-cage compression are physiotherapeutic techniques used to remove airway secretions in intensive care patients. This study was performed to investigate the effects of manual hyperinflation with or without expiratory rib-cage compression on lung compliance, gas exchange, and secretion clearance in mechanically ventilated patients.

Methods. Twenty-two intubated, mechanically ventilated, and hemodynamically stable intensive care unit patients were studied in a controlled, randomized, case-crossover trial. The patients received manual hyperinflation, with or without expiratory rib-cage compression, with a minimum 3-h interval between the two interventions. Manual hyperinflation with or without expiratory rib-cage compression was performed for 5 min before endotracheal suctioning. Respiratory mechanics and hemodynamic variables were measured 5 min before (baseline) and then 5 and 20 min after the interventions. Arterial blood gases were determined 5 min before (baseline) and 20 min after the interventions. Secretion clearance was measured as sputum weight. The two measurements were obtained on the same day.

Results. No significant differences were observed in gas exchange and secretion clearance between the two interventions. In each case, static lung compliance and tidal volume improved significantly at 5 min post-intervention ($p<0.01$), whereas at 20 min post-intervention, only static lung compliance had improved significantly above baseline ($p<0.01$).

Conclusions. Our results suggest that the addition of expiratory rib-cage compression to manual hyperinflation does not improve lung compliance, gas exchange, or secretion clearance in mechanically ventilated critically ill patients.
(It J Physiother 2011;1:48-54)

Key words: Physical therapy modalities - Lung compliance - Respiration, artificial.

Patients who are intubated and mechanically ventilated are at increased risk of secretion retention, atelectasis, and pneumonia as a result of significantly impaired bronchial mucociliary transport velocity.[1] Several physiotherapeutic techniques reduce the incidence of ventilator-associated pneumonia in intensive care patients such that secretion removal is major aim of physiotherapy in intensive care.[2, 3] One such technique, manual hyperinflation, provides a tidal volume to the lungs that is greater than baseline. It is effective in secretion clearance and is frequently used, with or without a head-down tilt position, in the care of intubated mechanically ventilated patients to increase alveolar oxygenation, recruit atelectatic segments, and mobilize pulmonary secretions.[3-5] Another technique could be effective in secretion management of mechanically ventilated patients: expiratory rib-cage compression, which consists of manual compression of the rib cage during the expiratory phase and release from compression at the end of expiration.[6, 7] In animal models, rib-cage compression alone worsened oxygenation, ventilation, and secretion clearance.[8, 9] Only one publication addressed the effects of combining rib-cage compression and suctioning on oxygenation, ventilation, and airway-secretion removal in mechanically ventilated patients.[10] The present study focused on the unexamined effects of manual hyperinflation with or without rib-cage compression and on lung compliance, gas exchange, and secretion clearance in mechanically ventilated critically ill patients.[5]

Materıals and methods

The study was carried out in the 13-bed general intensive care unit of our instution. Informed consent was obtained from each patient's next of kin and the study was approved by the institutional Ethics and Human Research Committee.

Twenty-two patients who met the following inclusion criteria were recruited. Subjects had to be intubated and ventilated (via an oral endotracheal tube) on pressure-controlled (PC) or pressure-regulated volume-controlled (PRVC) ventilation. Adequate sedation and neuromuscular blockage were performed and routine manual hyperinflation as physiotherapy was applied.

Patients were excluded from the trial if they required a fraction of inspired oxygen (FiO_2) >0.6 or met any of the following criteria: positive end expiratory pressure (PEEP) >10 cmH_2O; pulmonary pathology contraindicating lung hyperinflation (e.g., acute respiratory distress syndrome); arterial oxygen saturation (SaO_2) <90%; an unstable hemodynamic condition, as defined by a mean arterial pressure <65 mmHg and acute cardiac dysrhythmias; presence of rib fracture; presence of a chest tube; and peak airway pressure >40 cmH_2O (as read from the ventilator). In addition, patients were withdrawn from the study if they suffered hemodynamic compromise during treatment, as defined by the above variables, and if the ventilator settings needed to be changed during the study period.

Study Design

The efficacy of manual hyperinflation combined with expiratory rib-cage compression was investigated in a prospective, controlled, randomized, and case-crossover study. Patients were allocated randomly using cards in unmarked envelopes to receive either manual hyperinflation with expiratory rib-cage compression prior to suctioning in the first period, followed by manual hyperinflation without expiratory rib-cage compression prior to suctioning in the second period; or manual hyperinflation without expiratory rib-cage compression prior to suctioning in the first period, followed by manual hyperinflation with expiratory rib-cage compression prior to suctioning in the second period.

Measurements

Total static lung compliance (C_{rs}) and tidal volume (V_T) were recorded directly from the mechanical ventilator (Galileo; Hamilton Medical AG, Bonaduz, Switzerland). Gas exchange was measured as PaO_2/FiO_2 and PCO_2 with a blood-gas analyzer (Stat Profile M; Nova Biomedical, Waltham, MA, USA). Airway secretions were collected by endotracheal suctioning in a preweighed sputum trap attached to the suction catheter of the closed-suction system (Trach-Care; Kimberly-Clark/Ballard Medical Products, Draper, UT, USA). Suctioning was followed by flushing 4 mL of sterile saline through the suction tubing into the trap to clear any secretions remaining in the catheter. To measure the wet weight of sputum, the sputum trap was weighed before and after suctioning on an electronic weighing scale (Tefal, Ecully Cedex, France). The weight of the aspirated secretions was calculated by subtracting the sum of the trap weight and the 4 mL of sterile saline from the weight of the trap containing the secretions. Mean arterial pressure (MAP) and heart rate (HR) were read directly from the patient-monitoring equipment (Draeger Medical Systems, Inc., Telford, PA, USA).

Protocol

The patients were positioned such that the most affected lung region was uppermost. The appropriate side-lying position for treatment was decided based on the morning chest radiograph and in consultation with the intensivist. Both interventions were performed with the patients lying on the same side. The two treatments were carried out on the same day and separated by at least 3 hours.

Baseline measurements of respiratory mechanics, arterial blood gases, and hemodynamic variables were recorded 5 min before each of the interventions and with the patient in the supine position. Both interventions were applied for 5 min between baseline measurement and endotracheal suctioning. During the measurement periods, collected airway secretions were weighed as described above. Post-intervention measurements of respiratory mechanics and hemodynamic variables were recorded 5 and 20 min after endotracheal suctioning; arterial blood gases were analyzed 20 min after endotracheal suctioning. One researcher, blinded to all outcome measures, administered manual hyperinflation to all of the study patients. An assistant physiotherapist collected the sputum and recorded the data.

Endotracheal suctioning

Endotracheal suctioning was carried out at the end of manual hyperinflation using a 16 French in-line closed-suction catheter. Hyperoxygenation was not performed before or after suctioning. A negative pressure of –48 kPa was applied for 10 s, during which the catheter was rotated and withdrawn. Patients did not receive endotracheal suctioning within the 30 min prior to either intervention.

Manual hyperinflation

Manual hyperinflation breaths were delivered via a Mapleson F circuit, with an oxygen gas flow of 15 L/min. A manometer (Siemens AG, Erlangen, Germany) was incorporated into the manual hyperinflation circuitry to ensure that peak airway pressure during the intervention did not exceed 40 cmH_2O. Manual hyperinflation was always performed by the same intensivist. The inspiratory pause lasted approximately 2-3 s, with six breaths per minute for 5 min.

Rib-cage compression

Expiratory rib-cage compression was always performed by the same physiotherapist, who applied the same technique and amount of force. In this maneuver, both hands are used to gradually squeeze the rib cage in conjunction with chest-wall vibration during expiration. From the end of inspiration to the end of expiration, an attempt is made to compress the rib cage over the part that includes the most effected lung region. Every rib-cage compression is interrupted at the end of each expiratory phase to allow free inspiration by manual hyperinflation.

Statistical analysis

The data were analyzed with the Statistical Package for the Social Sciences for Windows, version 11.0 (SPSS Inc, Chicago, IL, USA). Sputum wet weight and gas exchange were analyzed using the Wilcoxon signed ranks test. Heart rate, MAP, C_{rs}, and V_T were analyzed with Friedman variance analysis. Significant interactions were determined with the Wilcoxon signed ranks test; the Bonferroni correction was used to detect significantly different time periods. Data are expressed as medians in combination with quartiles and percentiles. Statistical significance was defined as $P<0.05$.

Results

Patient enrollment

Twenty-two patients (16 males) fulfilled the inclusion criteria for the study and no patients were withdrawn during the trial. Table I lists the patient characteristics and ventilator settings. None of the patients suffered deleterious effects (*e.g.*, a drop in arterial saturation, hemodynamic instability, or barotrauma).

Total static lung compliance

Mean baseline C_{rs} values in the two treatment periods were similar. C_{rs} improved by approximately 11 mL/cmH_2O relative to the baseline at 5 min postintervention ($P<0.01$) and remained

TABLE I.—*Characteristics of the patients.**

Age *(mean±SD)*	59.50±17.7
Gender *(N. % male)*	16 (73)
Acute Physiology Score *(mean±SD)*	19.6±6.2
Diagnosis at ICU admission *(N. %)*	
Medical	5 (22.7)
Surgery	17 (77.3)
Chest radiograph findings *(N. %)*	
Atelectasis	19 (90.4)
Mechanical ventilation mode *(N. %)*	
Pressure controlled	12 (54.5)
Pressure regulated volume control	10 (45.5)
Fraction of inspired oxygen *(N. % 0.4)*	22 (100)
Positive end expiratory pressure *(mean±SD)*	8.3±0.7

*N.=22

above baseline at 20 min postintervention (P<0.01; Table II).

Tidal volume

Mean baseline V_T values in the two treatment periods were also similar. However, while V_T increased significantly at 5 min post-intervention, this increase was not maintained at 20 min post-intervention (P<0.01; Table II). Nonetheless, although statistically not significant, V_T remained higher than baseline for up to 20 min after each intervention.

Gas exchange

Likewise, mean baseline PaO_2/FiO_2 values were similar and without significant differences between the two treatment protocols. Additionally, no significant differences were observed in pre- and post-intervention PaO_2/FiO_2 for the two treatment periods (P>0.05; Figure 1).

The mean baseline $PaCO_2$ values in the two treatment periods were also similar, with no significant differences between the two different post-intervention measurements. Additionally, no significant differences were seen in $PaCO_2$ between pre- and post-interventions for the two treatment periods (P>0.05; Figure 1).

Weight of aspirated secretions

The weights of the aspirated secretions obtained during the two interventions did not differ significantly (P>0.05; Figure 2).

Hemodynamic variables

Mean baseline HR and MAP values were similar for the two periods, and significant differences between the two post-intervention periods were not detected. Additionally, no significant differences in HR and MAP were observed between pre- and post-interventions for either treatment period (P>0.05; Table II).

Discussion

This study shows that the addition of expiratory rib-cage compression to manual hyperinflation

TABLE II.—*Respiratory mechanics and hemodynamic variables (expressed as median and range interquartile).*

	MH With RCC			MH Without RCC		
	Base line	Post-suction 5 min	Post-suction 20 min	Base line	Post-suction 5 min	Post-suction 20 min
Crs *(mL/cmH₂O)*	44.2 (36.5-52.4)	51.8* (40.7-61.3)	46.2* (36.1-53.5)	46.8 (40.8-62.5)	48.5* (38.0-57.9)	45.3* (37.1-63.6)
V_T *(mL)*	505.0 (431.0-528.2)	519.5* (487.7-556.0)	506.5 (455.7-546.5)	492.0 (422.2-522.5)	507.5* (470.2-545.5)	501.0 (442.7-533.7)
HR *(beats/min)*	104.5 (86.2-118.0)	95.5 (86.7-114.5)	106.0 (87.5-118.2)	104.5 (93.7-117.7)	97.0 (87.7-113.5)	102.0 (88.5-119.0)
MAP *(mmHg)*	80.5 (76.7-89.5)	82.0 (76.7-91.5)	80.0 (76.2-89.7)	82.0 (73.5-90.0)	83.5 (73.0-88.7)	82.0 (76.2-89.7)

MH: manual hyperinflation; RCC: rib-cage compression; Crs: total static lung compliance; V_T: tidal volume; FiO_2: fraction of inspired oxygen; HR: heart rate; MAP: mean arterial pressure. *Statistically different from baseline value (P<0.01).

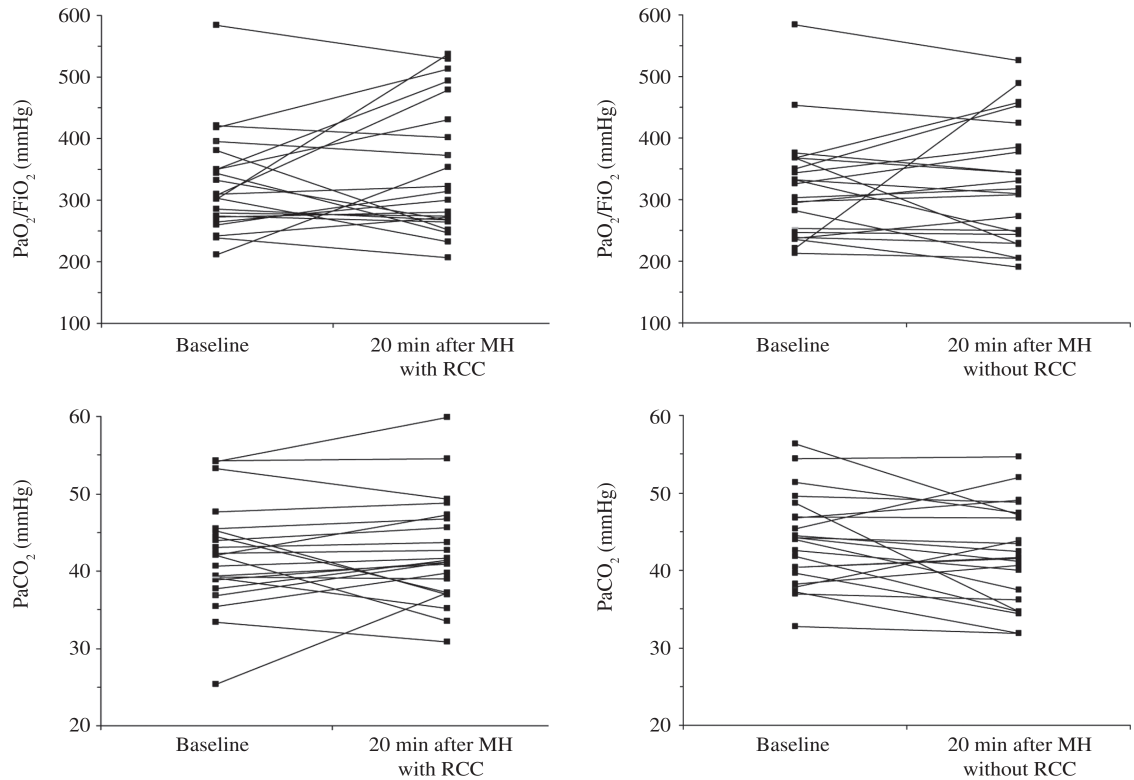

Figure 1.—Individual values for ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO_2/FiO_2) and $PaCO_2$ before and 20 min after manual hyperinflation (MH) with and without expiratory rib-cage compression (RCC).

does not provide further beneficial effects on lung compliance, gas exchange, or secretion clearance.

Respiratory mechanics and gas exchange

Consistent with previous findings, C_{rs} and V_T improved after manual hyperinflation.[5, 11-14] The mean improvement in C_{rs} of approximately 25% (11 mL/cmH_2O) obtained in our study is comparable to the 23% increase (8.5 mL/cmH_2O) at 20 min post-intervention reported by Hodgson *et al.*[3] This positive effect may have been due to secondary recruitment of alveolar units followed by volume restoration, as manual hyperinflation may result in the use of collateral pulmonary ventilation in addition to facilitating the mobilization of airway secretions and the recruitment of atelectatic lung units.[15] Tidal volume was also found to have increased after manual hyperinflation, as reported in previous studies.[11] However, the differences in lung compliance and tidal volume between the two interventions were nonsignificant, thus showing that the addition of expiratory rib-cage compression has no further beneficial effects on respiratory mechanics.

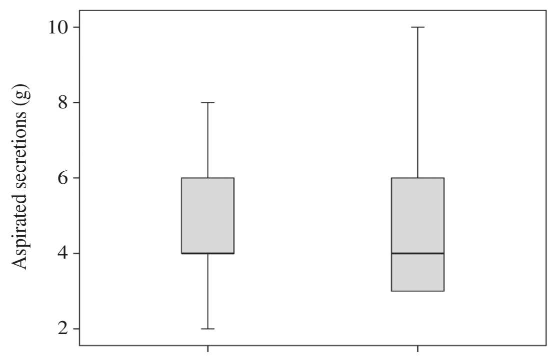

Figure 2.—Weight of airway secretions collected with manual hyperinflation (MH) with and without expiratory rib-cage compression (RCC). The horizontal lines inside the boxes encompass the 25th through 75th percentile, and the error bars indicate the 10th and 90th percentiles.

Previous studies found no significant difference in PaO_2/FiO_2 after manual hyperinflation.[3, 5, 16, 17] Similarly, in this study, although C_{rs} and V_T increased in response to either intervention, gas exchange did not improve significantly. However, an improvement in gas exchange after manual hyperinflation may be difficult to demonstrate, especially if the lung's protective mechanisms are very effective such that blood flow is diverted away from the hypoxic area of the lung (hypoxic pulmonary vasoconstriction). McCarren and Chow reported that patients might be underventilated during manual hyperinflation as a result of a slow inflation rate that reduces minute ventilation.[18] Although minute ventilation was not measured in the present study, $PaCO_2$ values did not differ significantly following either of the interventions.

Airway-secretion clearance

While manual hyperinflation has been shown to enhance the removal of airway secretions by increasing the peak expiratory flow rate, few studies have examined the effects of rib-cage compression on mucus clearance in a clinical setting.[3, 12] In this study, the addition of rib-cage compression to manual hyperinflation did not improve secretion clearance, in agreement with the results of Unoki *et al.*[10] Those authors showed that rib-cage compression prior to endotracheal suctioning did not enhance secretion clearance in mechanically ventilated patients or rabbits.[8-10] Unlike in their study, our patients were well sedated/paralyzed, with an absent cough reflex. This might have reduced the effectiveness of manual hyperinflation and rib-cage compression.[19, 20] In addition, Unoki et al. conceded that achieving statistically significant improvements in the amount of aspirated secretion using rib-cage compression was difficult because none of their study patients had excessive fluid secretion (*e.g.*, as in bronchiolitis or cystic fibrosis), which was also the case in our study patients.[9]

Hemodynamic variables

Changes in HR and MAP are variable with manual hyperinflation, and a longer inspiratory pause at the end of inspiration may be deleterious in acutely ill patients due to potential effects on the cardiovascular system.[15, 21] In our study, neither HR nor MAP changed during the two study periods, and hemodynamic stability was also maintained during the measurement period. However, significant hemodynamic deterioration may occur in patients who are hypotensive, hypovolemic, and have low cardiac output.

Study limitations

The major limitation of this study was the small sample size (N.=22). According to post hoc power analysis, the study was underpowered to detect effects in gas exchange and airway-secretion clearance. However, a post hoc power analysis for C_{rs} showed that the study had adequate power (0.99) for alpha = 0.05 and effect size greater than 1.4.

Conclusions

The treatment of hemodynamically stable mechanically ventilated patients with expiratory rib-cage compression combined with manual hyperinflation did not improve lung compliance, gas exchange, or secretion clearance. Consequently, the routine addition of rib-cage compression to manual hyperinflation in unselected mechanically ventilated patients is not recommended. However, the effects on longer-term outcomes and on selected patient populations (*i.e.*, those with excessive airway secretions) remain to be determined.

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CASE REPORT

Assessment and manual treatment of adhesive scars: a case report

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ABSTRACT

Scar adhesion is defined as failure of the tissues to successfully establish independent layering, i.e., failure of their capacity to glide. The evidence base for the use of many current treatments advocated for scar adhesion is poor and empirical, but a reliable method to measure changes has been recently introduced. The aim of this study was to describe the use of a massage therapy technique – called "Soft Tissue Mobilization" (STM) – for adhesive scar, and show how improvement can be objectively measured. A patient with a fracture on the left third metacarpal underwent STM. Outcome measures were range of motion (ROM), adherence severity index (AS), and maximal isometric grip strength. Clinically significant improvements in ROM, AS index and strength were observed. Although it is difficult to know objectively whether this patient would have recovered as quickly, or shown similar functional gains, without STM, we retain that the techniques employed greatly assisted in increasing his active ROM and AS index. *(It J Physiother 2011;1:55-9)*

Key words: Cicatrix - Soft tissue injuries - Musculoskeletal manipulations - Outcome assessment.

Early diagnosis of pathologic scars after surgical intervention can have a considerable impact on the final outcome, and the assessment usually includes evaluation of physical characteristics (height, pliability, relief, adhesion), cosmetic appearance (color, cosmetic defects), and patient's symptoms (pain, itching).[1] Scar adhesion is defined as the failure of the tissues to successfully establish independent layering, *i.e.*, their incapacity to glide, and is different from pliability, which is the capacity of the skin to stretch.[2] The outcome of scar adhesion is not necessarily related to other parameters, *e.g.*, a scar might be esthetically acceptable, asymptomatic, flat, with supple or yielding pliability, but nevertheless it may compromise the range of motion (ROM), decrease muscular strength, or alter the proprioceptive input of the region. This is particularly noticeable in the hand, where even a small restriction in skin movements can lead to significant functional limitation, protective postural patterns, increased neurovascular activity and pain syndromes.[3]

The purpose of this manuscript was to describe the current concepts of management for scar adhesions, with special emphasis on outcome assessment using a new specifically designed instrument - called Adheremeter [4] - and manual therapy techniques.

Case report

Baseline case description

Our patient was a 21-year-old male, right hand dominant, employed as a bartender. He fell while cycling on June 15, 2010, resulting in a composed spiral fracture on

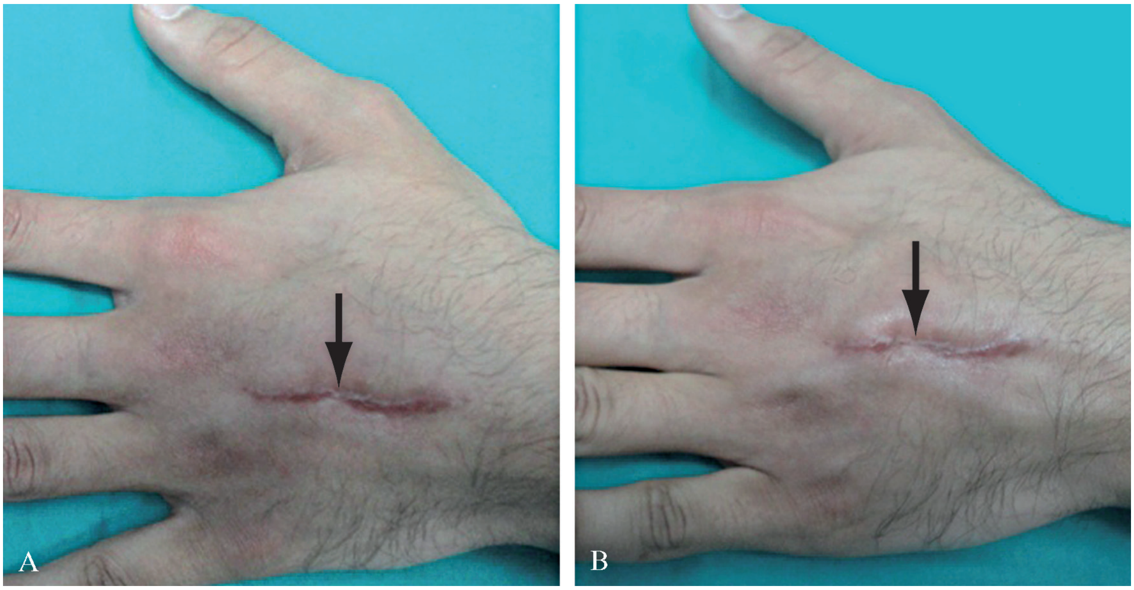

Figure 1.—The arrows show the most adhesive point in the scar when (A) the hand is in a rest position, and (B) when active finger extension is performed. In this condition blanching in the scar and surrounding skin was observed.

the 3rd metacarpal of his left hand. The fracture was repaired the day after using 4 pins in compression *via* a dorsal approach. The hand was then immobilized in a static splint for 4 weeks. On the basis of X-ray-confirmed complete healing of the fracture, on July 17, 2010 the patient was referred to a physiatrist, who prescribed 10 rehabilitation sessions.

Measure

The patient was seen by the physiotherapist on August 2, 2010 (T1), 1½ months after surgery. At that time the wound was closed, and observation revealed blanching in the area of surgical scar while the patient tried to make a fist or extend fingers (Figure 1). The evaluation was completed by the following standardized methods: 1) active and passive ROM measurement of fingers and wrist; 2) hand grip measurement; and 3) scar adhesion assessment.

Finger joints were measured by a metal finger goniometer (dorsal alignment), and total finger flexion of the 3rd finger - measured from pulp of distal phalanx to proximal palmar crease - was recorded by a ruler. Wrist and forearm motion was measured by a standard goniometer. The patient had movement restrictions in the metacarpophalangeal (MCP) joint of the third finger, as shown in Table I. Passive ROM was slightly affected, while active ROM showed a marked deficit in both directions. The other fingers had full joint mobility, as did the rest of his upper-extremity joints. All measurements were performed according to the American Society of Hand Therapists' recommendations.[5-7]

Hand grip measurement with the Jamar hydraulic hand dynamometer (Lafayette Instrument Co, Lafayette, USA. Product no. PC 5030J1) revealed approximately 50% strength loss in the affected hand, compared to the right side.[8]

Severity of scar adhesion was measured by the Adheremeter, an inexpensive and easy-to-use instrument consisting of 9 concentric rings with radii of 1, 2, 4, 6, 8, 10, 12, 14 and 15 mm, printed on flexible transparency film for copiers (Figure 2). The Adheremeter has been validated in postsurgical scar assessment, and could be used in a clinical

Table I.—*Clinical assessments at the initial examination (T1) and at the end of treatment (T2) (deficits* vs *right side are in brackets; extension beyond the 0-degree starting position of metacarpo-phalangeal joint are recorded as negative numbers).*

	AROM			PROM			Grip (Jamar)		AS
	F MCP	E MCP	TFF	F MCP	E MCP	TFF	Left	Right	
T1	65° (30°)	15° (55°)	2 cm	85° (15°)	-30° (20°)	0.4 cm	24 kg (51%)	49 kg	0.01
T2	80° (15°)	-5° (35°)	0.7 cm	95° (5°)	-40° (10°)	0 cm	38 kg (24%)	50 kg	0.35

AROM: Active Range of Motion; PROM: Passive Range of Motion; F: Flexion; E: Extension; MCP: Metacarpo-Phalangeal joint; TFF: Total Finger Flexion; AS: Adherence Severity index.

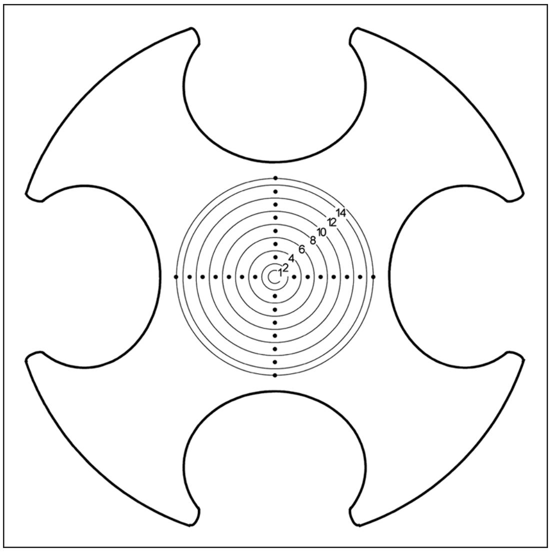

Figure 2.—The Adheremeter. The diameter of the largest concentric ring is 28 mm, and the external edge of the device is 17.5 mm from the center.

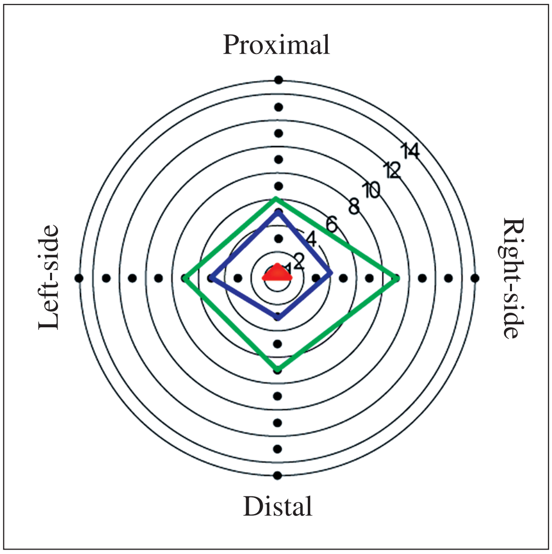

Figure 3.—Graphic representation of the surface mobility index. The figure clearly shows an improvement in scar mobility area between the initial examination (SM_A T1: 1 mm^2, red line) and after the treatment (SM_A T2: 36 mm^2, blue line). The area for the normal contralateral skin is demarcated by the green line (SM_N: 104 mm^2). SM_A: Adherence's Surface Mobility index for the scar; SM_N: Surface Mobility index for Normal skin.

setting.[4] It was positioned so that the rings were centered on the worst adhesive point, identified by the physiotherapist and recorded by measuring its distance from the two extremities of the scar. The rater held the device in the hand, supporting the hand on the patient's body in such a way that there was no contact between the device and the patient's skin. The other thumb was positioned close to the external edge of the device, and traction was applied centrifugally in four directions: proximal, distal, right side, and left side. For every traction, the rater read on the Adheremeter the position of the landmark at the maximal excursion. The same procedure was repeated on the contralateral healthy hand, at the same point. Two indexes of surface mobility - the Adherence's Surface Mobility index for the scar (SM_A) and the Surface Mobility index for the normal skin (SM_N) - were obtained by calculating the area of the quadrilateral whose diagonals are the side-to-side and proximal-to-distal landmark maximal excursions. The ratio between SM_A and SM_N gave the index of Adherence Severity (AS) ranging from 0 to 1, where 0 represents scar immobility in at least one diagonal and 1 represents completely normal scar mobility.

The severity of scar adhesion was very high, with an AS index of 0.01. Graphic representation of the surface mobility indexes is shown in Figure 3.

Intervention

Based on observation and evaluation, we assumed that the reduction in ROM was primarily caused by restriction in proximal and distal gliding of the extensor finger tendon by adhesion formation below the site of scarring.

Soft Tissue Mobilization (STM) techniques for scar treatment and passive joint mobilization of the 3rd MCP joint were initiated. STM is a system of manual techniques employing specific, graded and progressive forces - matched as closely as possible to the stage of the healing process - applied in multidirectional vectors to improve mobility between overlying and adjacent connective tissue layers.[9, 10]

In the first two sessions, scar massage consisted of pushing into or pulling away from the soft-tissue barrier ("push-pull" technique). Treatment then progressed to a more aggressive pushing into the scar, and on the 4th session two other STM techniques were introduced: the "J stroke" technique, which involves multidirectional forces applied with the fingertips as if making a "J" over and into the area of restriction; and the "S" maneuver, where the physiotherapist uses both thumbs in approximating the location of the restriction and then thrusts them in opposite directions to apply pressure in this area, which ends up stretching the tissue into an "S" shape. Pressure was advanced on resolution of passive restrictions, and from the 7th session onwards the STM techniques involved active patient participation, who extended the 3rd finger while the physiotherapist pushed distally the scar, or actively flexed his MCP joints while the physiotherapist pulled proximally on the perceived restriction.

Treatment sessions were of 45 minutes' duration, three times a week for a total of 10 sessions. In addition, the patient was encouraged to perform self-STM as a part of a home program consisting in exercises for muscle strengthening and functional activities of the hand.

Post-treatment case description

The patient was last seen on September 1, 2010 (T2), 2½ months after surgery. At this time passive ROM was only slightly affected, active ROM was -5° to 80° in the 3rd MCP joint (for a total active motion of 85°), and active total finger flexion showed a deficit of 0.7 cm (Table I). Although the patient did not reach full active ROM, he had functional ROM and use of his hand. Grip strength of the left hand was 38 Kg, and AS was 0.35.

Discussion

It is well recognized that soft tissue scarring affects hand function more than fracture healing, and the correct identification of the site of soft tissue dysfunction is a challenge for the physiotherapist.[11] In this case, we assumed that deficits were caused primarily by scar adhesion. When the patient removed the static splint, active MCP flexion and extension of the third finger was more severely affected than passive ROM, and muscle contraction revealed blanching under the scar. Moreover, the AS of the firm adhesive point observed in the scar was near to 0. This suggested little stiffness in capsuloligament joint structures, but serious failure of the gliding ability between the scar and underlying tissues (probably the extensor tendon). The deficit in grip strength was most likely caused by immobilization, but we could not exclude that the restriction in proximal-to-distal gliding of the extensor finger's tendon had an additional effect on strength loss.

Based on our findings, a therapeutic strategy was established to restore the tissue's biophysical properties in relation to specific functional demands. STM is aimed at restoring skin stretch close to the scar, and making all soft tissue layers affected shift normally one against the other.

At the end of the treatment course, improvement in ROM, AS and strength were observed. To be adequately confident that changes were not attributable to measurement error or chance variation, they were compared to the minimal detectable change (MDC). All of the changes observed in ROM exceeded the MDC value of 5°,[12, 13] with greater improvements in active than in passive ROM. This was probably due to the type of treatment, focused mainly on scar treatment rather than joint mobilization.

The MDC for AS index is about 0.20, even if patients with an AS baseline score close to 0 showed lower values (about 0.15-0.17).[4] Our patient had an AS improvement of 0.34, indicating a good treatment effect.

Strength improvement was not the primary objective of manual treatment. We can only speculate that without improvement in active ROM and scar restriction, changes in strength would have been lower than those observed. With time we expect our patient to regain full grip strength and further increase his MCP joint active movement.

Conclusions

In this paper we described an emerging method used to measure objectively the severity of scar adhesions, and demonstrated that scar adhesions can be treated with specific manual therapy. Although it is difficult to know objectively whether this patient would have recovered as quickly, or shown similar functional gains, without the use of STM, we retain that the techniques employed greatly assisted in freeing the patient's extensor tendon or restrictions as well as in increasing his active ROM and AS.

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Shoulder position sense and upper limb balance: suggestion for rehabilitation from a comparison of elite mountain bike riders and healthy athletic controls

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Dear Editor,

The term "proprioception" indicates the recognition of an active or passive movement and the perception of both muscular tension and joint positions.[1, 2] While several studies investigated the shoulder proprioception as perception of joint position,[3] no one has investigated the role of shoulder position sense during the performance of athletes, like gymnasts or mountain bike riders, who use their arms to control both the trunk and the bike on uneven terrain. Differently than for lower limbs,[4, 5] there is no information about the involvement of proprioception to control body balance by the upper limbs as, for example, is requested to subjects with spinal cord injury during gait with crutches and orthosis.

The aim of this work was to study the shoulder position sense in dynamic situations and the balance by the upper limbs in a group of elite mountain bike riders and in athletic people who do not practice sports involving balance control.

Eight male elite mountain bike riders (four from the Italian National Mountain Bike Team) and twelve athletic young males were enrolled in the study. All participants signed an informed consent form and the local ethical Committee approved the study.

The study was conducted in the Laboratory of Movement Analysis of Vita-Salute San Raffaele University in Milan (Italy). All participants performed two tests: the Limb-Repositioning Test (LRT) [6] for the dynamic analysis of shoulder position sense and the Balance Test (BT) for the analysis of balance by the upper limbs.

During the LRT participants were seated with their non-examined hand resting on the thigh and wore a mask covering their eyes. Participants were asked to elevate the examined upper arm to a self-selected position and maintain this position for 3 seconds. This movement was performed 10 consecutive times at self-paced velocity and each time the aim of the subject was to reach exactly the previously reached end-point of the movement. The LRT test was performed with both arms.

During the BT participants lay prone with the pelvis on a ball (diameter 70 cm) and a mask covered their eyes. The hands leaned on a force platform, closed in a fist (Figure 1). The goal of the test was to steady maintain balance on the upper limbs in that position. The test lasted ten seconds and was performed three times with a minute of rest between each trial. One hour prior to the tests participants tried the BT three times to acquire confidence with the procedure. The experimental acquisition started when subject had acquired a stable position, or after 20 seconds of attempts. All participants performed the LRT first to avoid upper limb fatigue and, consequently, proprioception decrease.[7]

The upper arm position was analysed with an optoelectronic system and passive markers. Mean errors in reproducing the same position were calculated with the formula:

$$\frac{\sum_{n-2}^{10}\sqrt{(x_n - x_{n-1})^2 + (y_n - y_{n-1})^2 + (z_n - z_{n-1})^2}}{9}$$

where *x, y, z* are the space coordinate expressed in millimetres and *n* the repetition number.[6]

For each subject, the mean error for the two arms was calculated. The sway of the centre of pressure (COP) was used to analyse the balance performance during the BT. The anterior-posterior and lateral COP sway, the length of COP sway track and equivalent area were considered. The sample rate used for both kinematics and COP sway analysis was 100Hz.

Non parametric analysis was used (SPSS13.0 software). Tests significance was fixed at $p<0,05$.

The two groups were homogeneous with regard to body height and weight, but not with regard to age: participants in

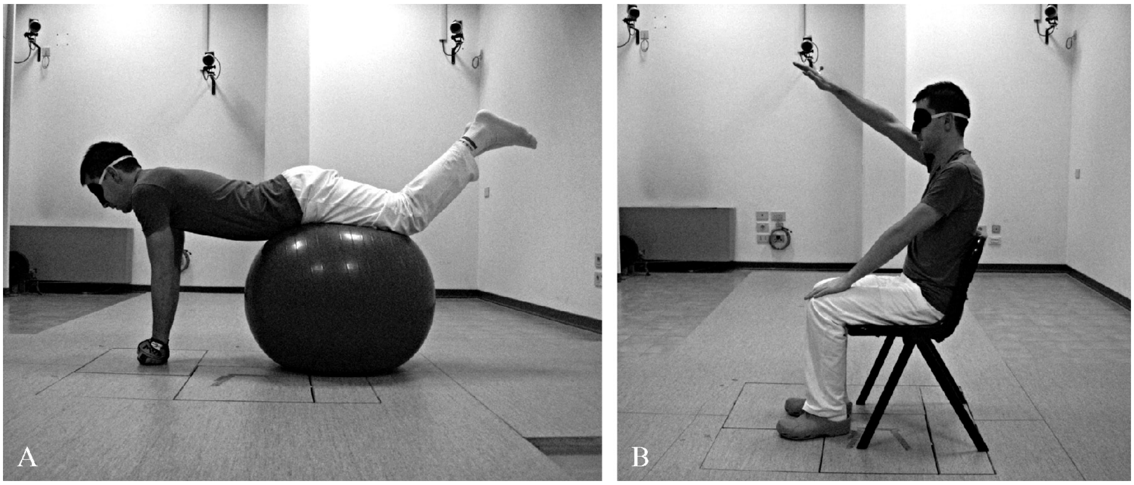

Figure 1.—Upper Arm Balance Test (BT, left) and Limb-Repositioning Test (LRT, right).

the group of mountain bike riders were older than the control group (P=0.033). The second group included athletic people used to train at least 4 times a week: six played soccer, one was a swimmer, and five attended a fitness centre where they practice strength training.

During the BT mountain bike riders performed smaller anterior-posterior and lateral sways, smaller length of track and smaller equivalent area than the control group, even though these differences did not reach any significance (Table I).

During the LRT, the mean error was significantly smaller for the group of mountain bike riders than the control group (P=0.045)

A sub-group analysis was performed between the four athletes of the Italian National Team and the other four bikers included who had practiced intensive mountain biking for many years but were not champions. No differences in proprioception or balance were observed between these two groups of bikers.

Mountain bike riders performed better than the control group both in the balance test and in position sense test.

Mountain bike riders must maintain balance while their bicycle is moving on uneven terrain and this is possible only with perfect control of the handlebar by the arms.

But why do mountain bike riders show better position sense? It must also be considered that the mountain bike riders in our study were older than the participants in the control group. According to the literature balance and proprioception worsen with advancing age,[8] but in our study we found that those athletes, despite being older, have better position sense.

The literature has described a link between proprioception and balance for tasks that involve the lower limbs.[4, 5] There are no similar data concerning the upper limbs, but the fact that some athletes use their upper limbs for balance control could lead to increased arm proprioception. Athletes' results could be due to superior core strength. It's important however to underline that bike riders develop endurance more than muscle strength.[9] Bike riders could also be genetically predisposed [10] to be more efficient with balance and proprioception, but no differences in these variables were observed between the Elite riders and the other mountain bike riders.

Normally, during everyday activities the shoulder is active in tasks that involve the orientation of the hand in the environment rather than the transmission of force to the COP to maintain balance.

It is plausible to think that the difference between the per-

Table I.—*The table shows the results of proprioception sensitivity (LRTEST) and of anterior-posterior COP sway (APCOP), transversal COP sway (LCOP), length of the COP sway track (LTRACK) and area included in the COP sway track (AREA). Bikers group always has better performances than control group.*

	BIKERS GROUP ($\overline{X}$±SD)	CONTROL GROUP ($\overline{X}$±SD)
APCOP (mm)	5.04±5.4	5.81±3.12
LCOP (mm)	154.01±89.7	222.53±57.6
LTRACK (mm)	868.85±148.3	982.86±147.57
AREA (mm^2)	1938.75±764.84	2454.24±625.67
LRTEST*	28.83±5.17*	36.11±8.39*

*The differences between the two groups are significances only in the LRTEST (P=0.045) formances in the two groups is tightly connected to the intensive training of bikers that includes a lot of motor tasks with the upper limbs that deeply involve proprioception.

The possibility to train the control of body balance by the upper limbs could give suggestions for the training of subjects for whom the use of crutches during gait is important.

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