

## PROPRIOCEPTION SENSE IN LYMPHEDEMA AFFECTED UPPER LIMB

M. Cardone, F. Cappellino, S. Vincenzo, G. Moneta, A. Failla, M. Iosa, B. Monni, M.R. Fantegrossi, V. Rubegni, S. Michelini

Ospedale San Giovanni Battista (MC,FC,SV,GM,AF,MRF,VR,SM), Order of Malta, Rome; Clinical Laboratory of Experimental Neurorehabilitation (MI), Fondazione Santa Lucia IRCCS, Rome; and Ortopedia Olimpica (BM), Rome, Italy

### ABSTRACT

*This study aimed to provide information on proprioception alterations in lymphedema-affected limbs. Blindfolded subjects sat at a table with their forearms positioned on paddles. The hinges of the paddles were aligned with the elbow joint and an electronic goniometer was positioned to measure the angle of the forearm. Paddles were moved by an electric servomotor with a slow angular speed that was barely appreciated by the subjects. Subjects were then asked to guess the position of the affected arm in comparison with the unaffected arm to study the position sense of the lymphedema-affected arm. The study investigated 50 women affected by secondary upper limb lymphedema by measuring the difference in terms of degrees of arch of movement in comparison with the unaffected arm and also both duration of lymphedema and the circumference of the forearm. Results were matched with a control group of 50 unaffected women providing proof of compromised proprioception in lymphedema-affected arms. In addition, results also showed a correlation with duration of lymphedema but not with size (stage) of the lymphedematous arm.*

**Keywords:** lymphedema, upper limb, proprioception, kinesthesia

Proprioception was first defined in 1906 by Sherrington as a signal flow from muscles, tendons, joints (1). Kinesthesia is used to refer to sensations of limb position and movement (2,3). The difference between what is expected and the actual position and movement of the limb occurs through feedback. The study of proprioception in lymphedema, as far as we can determine, has been very sparsely investigated. Lymphedema is a condition in which lymph fluid accumulates within tissues causing fibrosis between the skin and subcutaneous tissue with damage and chronic inflammation and degeneration in peripheral tissues (4). This pilot study was designed to investigate whether proprioception was altered in lymphedema-affected limbs. We aimed to test both movement sensation and joint position sense in a large number of patients to provide information on impaired proprioception in lymphedema. Hand edema negatively impacts daily activities and functional mobility (5), and loss of sensation in the upper extremity is a post-surgical problem that can be exacerbated by edema (6). Most patients with upper limb lymphedema experience loss of sensation and loss of kinesthetic sense of the hand which may result in inability to perform many functional skills of the hand consequently causing difficulty performing activities of daily living



Fig. 1. Electronic goniometer used in this study.

(7). Among the most frequent symptoms of upper limb lymphedema are swelling, fatigue, heavy arm, tight arm, and pain in the arm (8). Loss of kinesthetic sense is hypothesized as responsible for inability or difficulty in performing many functional skills in upper limb lymphedema (9).

#### MATERIALS AND METHODS

This study involved 50 women (mean age of  $62.2 \pm 12.4$  standard deviation) with secondary upper arm lymphedema at stage II or III lymphedema according the ISL (10,11). All subjects did not have neurological (either central or peripheral) problems, and all subjects underwent measurement of the circumference of the forearm at the middle point for affected and unaffected arms. Duration of the lymphedema was 6.0 years  $\pm 6.0$ . The control group consisted of 50 healthy women (mean age of  $54.4 \pm 14.1$ ). The study was approved by the Local Ethical Committee and signed informed consent was obtained from each patient.

Blindfolded subjects sat at a table with their forearms positioned on paddles. The hinges of the paddles were aligned with

the elbow joint and an electronic goniometer (Fig. 1) was used to measure the angle in positioning the forearm.

One of the paddles could be moved by an electric servomotor with a slow angular speed of 1.3 degrees per second. The speed could barely be appreciated by the muscles, which are the proprioceptors mainly responsible for kinaesthesia (12,13).

Subjects in the lymphedema group were asked to guess the position of the affected arm as the paddle moved in comparison with the other one fixed at a standard position of 45 degrees (Fig. 2). The subjects also were asked to guess when the paddle of the affected arm was moving to provide a test for the sense of movement (14).

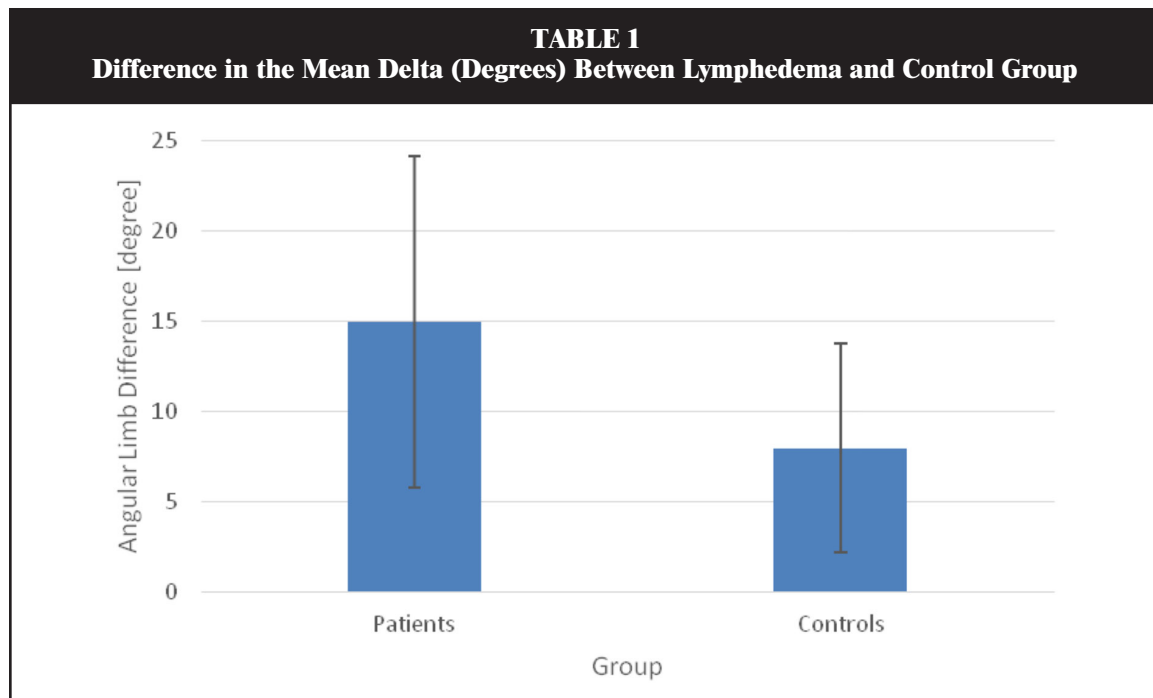
Statistical analysis was conducted computing means and standard deviations for describing data and applying appropriate tests after an analysis of normality distribution (Shapiro-Wilk test). According to the results of the normality tests, we used parametric t-test for comparing the differences in the two groups of subjects and non-parametric Spearman's coefficient for assessing correlation in patients' group of differences with other parameters. The alpha-level of significance for all the tests was set at 0.05.

#### RESULTS

In examining motion at the moment in which the subject appreciates the sensation of movement, all subjects could appreciate movement at the very beginning. On the other hand, most of the patients could not match the position on the contralateral upper limb, obtaining a variable difference (delta) in the sense of a too early valuation of the position of the affected arm corresponding to the unaffected arm. This feature was found in common with, and it was interesting to match, the mean delta of the control group with the lymphedema group which produced a statistical significant difference. Patients showed a difference between the inclinations of the two limbs in the test of  $14.9 \pm 9.2^\circ$  with



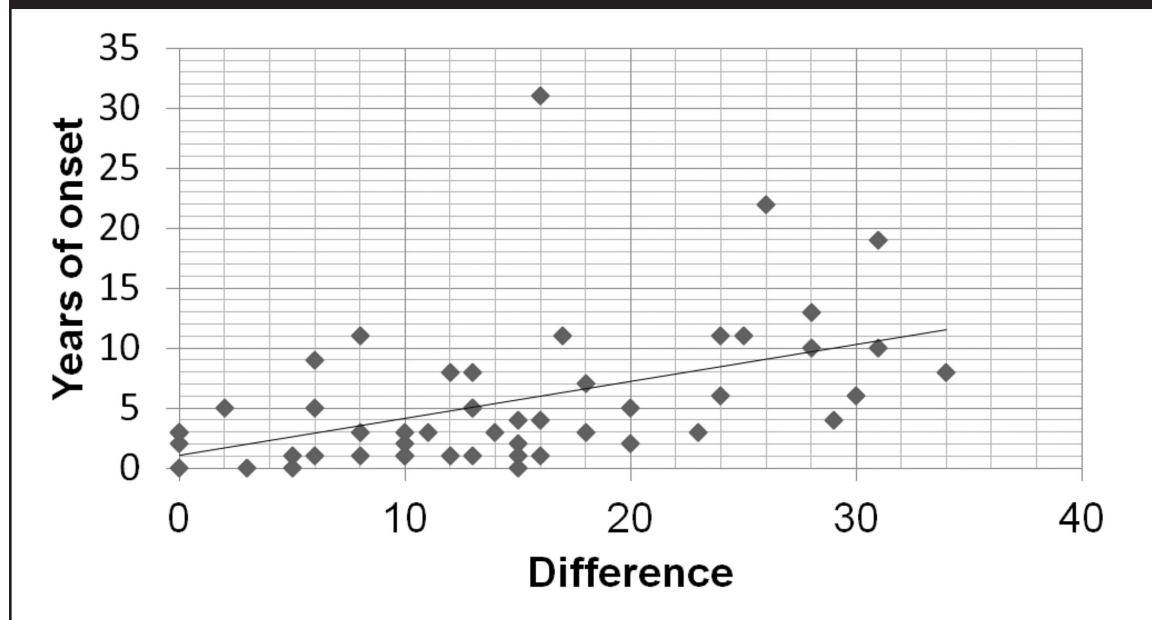
Fig. 2. Paddles for evaluation of proprioception. The central paddle is moved by electric controlled servomotor.



a reduced inclination of the affected limb. The analogous difference recorded for the control group was  $8.0 \pm 5.8^\circ$ . The difference between the two groups was statistically significant ( $p < 0.001$ , t-test) (Table 1).

Next, we attempted to match the altered proprioception in lymphedema subjects with the stage of lymphedema taking into account the circumference at the middle point of the forearm. The recorded difference for patients

**TABLE 2**  
**Correlation Between Duration of Lymphedema and**  
**the Difference in Proprioception of the Limbs**



was found significantly correlated with duration of lymphedema (Spearman correlation coefficient:  $R=0.553$ ,  $p<0.001$ ) (Table 2), but not with the circumference of the limb ( $R=0.079$ ,  $p=0.591$ ) (Table 3). The last correlation tested was in the lymphedema group examining the differences in the affected and unaffected limbs with the difference between the circumference of the forearm at the middle point of the affected and of the unaffected arm. Correlation between the difference in these circumferences and the degree for inclination of the lymphedema arm positioned on the moving paddle as patients guessed it also reached significance ( $R=0.315$ ,  $p=0.028$ ) (Table 4). In two cases the difference between the circumferences at the middle point of the forearm of the affected and unaffected arm was 0 since lymphedema involved other parts of the upper limb and not the forearm.

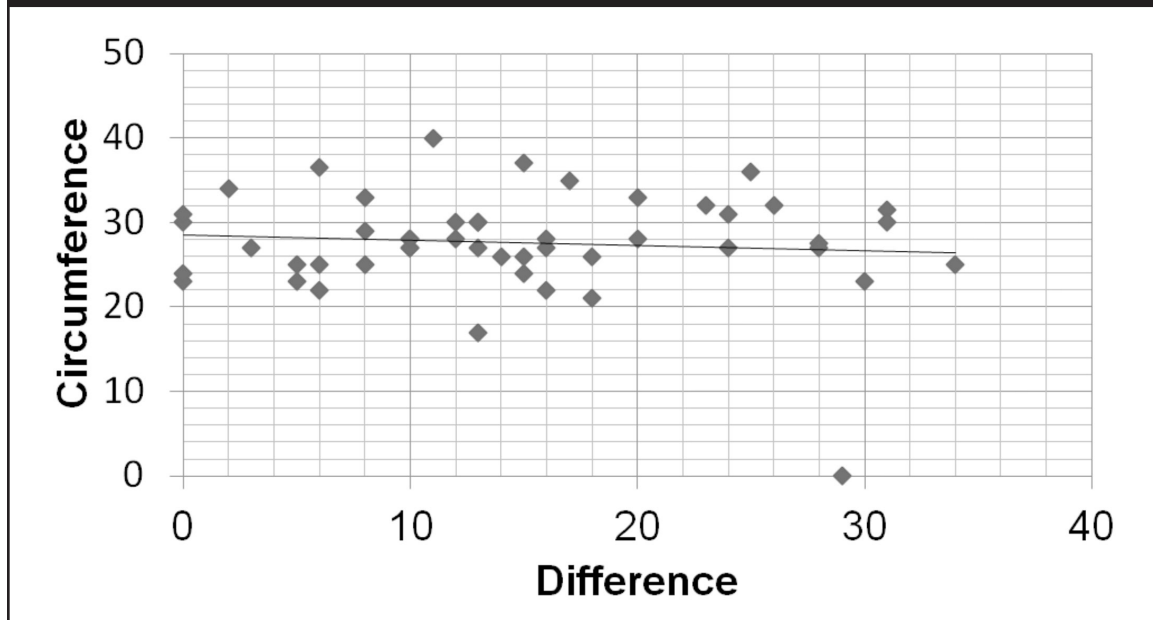
In general, our results showed statistically significant impairment in joint position sense

in the accuracy of joint-angle replication measured in joint position matching tests (measuring subject's ability to detect an externally imposed passive movement). Less impaired appears to be the movement sensation with the method used. The most significant correlation was in impaired proprioception for upper limb lymphedema with duration of lymphedema followed by the difference of circumference between affected and unaffected limb. Trend lines show that the longer a lymphedema lasts and the worse the lymphedema stage, the wider were errors in matching upper limb position.

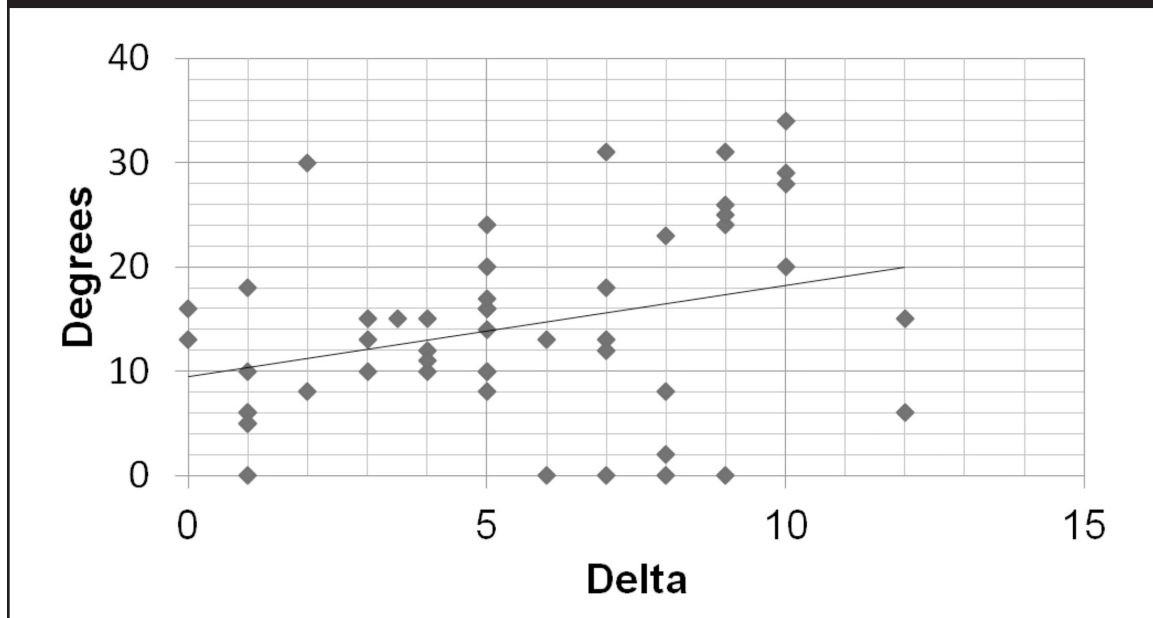
#### CONCLUSIONS

Fat accumulation and fibrosis are the clinical result of lymphedema as subcutaneous tissue hypertrophies and accumulates increased number of adipocytes. Chronic lymphedema also results in fibrosis of the skin and subcutaneous tissues (15).

**TABLE 3**  
**Correlation Between Circumference of the Limb with Lymphedema**  
**and Proprioception of the Limbs**



**TABLE 4**  
**Correlation Between Difference of Inclination (Degrees) and**  
**Difference of Circumference Between Upper Limbs**



Proprioceptive deficits have been shown in other connective tissue disorders, specifically Ehlers-Danlos syndrome, hypermobility syndrome, and benign joint hypermobility syndrome, revealing significantly less precision (16-18). Similarly, obesity and excessive adipose tissue appears to have negative consequences on gait alterations and posture deficits. Patients affected by upper limb lymphedema experience a sense of heaviness in the arm, muscle weakness, restricted shoulder mobility, and definite difficulty performing activities of daily living (19).

This study aimed to demonstrate impairment of proprioception in lymphedema patients. This deficiency is something that could be perceived by clinicians (but rarely demonstrated) mostly related to duration of lymphedema rather than the stage. On the contrary, proprioception was not found to be correlated with the circumference of the forearm probably because this measurement does not strictly depend on the stage of lymphedema and relies more on anthropometric values such as individual body type.

Similar results have been found in 12 hour upper limb immobilization since it causes a more extended position and decreased elbow angle (10°) in proprioception testing (20). Results may be correlated since women with upper limb lymphedema often avoid lifting or carrying causing an overall activity avoidance and also in secondary lymphedema when the arm has less strength (atrophy), less sensitivity, and restricted range of motion of the joints (21). Results of SEP studies suggest that limb immobilization and also avoiding the use of the lymphedema affected limb can lead to plasticity changes in the sensory cortex (22) as well as in motor maps, which have been demonstrated to change even after short periods (23).

In conclusion, the kinesthetic sense in daily living skills can be negatively affected in upper limb lymphedema in relation to the difference between the circumference of the forearm, of the affected and of the unaffected

arm but mainly with the duration of lymphedema. This may be due to fibrosis of tissues (probably damaging proprioceptors) and also a proprioceptive differentiation resulting from avoiding use of the lymphedema-affected limb. Therefore, importance should be placed on understanding the proprioception impairment in patients with upper limb lymphedema, which can seriously impact daily activities.

#### CONFLICT OF INTEREST AND DISCLOSURE

All authors declare that no competing financial interests exist.

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**Marco Cardone, MD**  
**Ospedale San Giovanni Battista**  
**Via L. Ercole Morselli 13**  
**Rome, Italy 00166**  
**Phone: 00393386200772**  
**E-mail: marco\_cardone@fastwebnet.it**