Shoulder function in patients with frozen shoulder before and after 4-week rehabilitation

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Key words: *shoulder joint, range of motion, isometric strength, frozen shoulder.*

Summary. *This study evaluated changes in shoulder function in patients with frozen shoulder after 4-week rehabilitation combining exercise with electrical therapy and massage.*

Material and methods. Ten patients with frozen shoulder (mean ± standard error (SE) age 50.2±4.6 years) and 10 control subjects (49.8±4.6 years) participated in the study. Standard goniometric measurements were used to assess shoulder flexion, extension, abduction, adduction, internal and external rotation active range of motion. Isometric maximal force of the shoulder flexors, abductors, adductors, internal and external rotators was measured by hand-held dynamometer. Shoulder muscle isometric endurance was characterized by net impulse assessed during weight (30% of maximal force) holding in hand till exhaustion. Shoulder pain was assessed by visual analogue scale.

Results. Before rehabilitation, patients with frozen shoulder had less ($p<0.05$) active range of motion and shoulder muscle maximal force for all measured directions, and less ($p<0.05$) net impulse during shoulder muscle isometric endurance test for involved extremity compared to controls. In patients with frozen shoulder, shoulder flexion, abduction, adduction and adduction active range of motion, maximal force of shoulder muscles in all measured force directions and net impulse during shoulder muscle isometric endurance test for involved extremity increased ($p<0.05$) after rehabilitation. No significant changes in shoulder internal and external rotation active range of motion for involved extremity in patients with frozen shoulder were observed with rehabilitation.

Conclusion. A 4-week rehabilitation program improved shoulder flexion, extension, abduction and adduction active range of motion in patients with frozen shoulder coupled with non-significant changes in external and internal rotation range of motion. A significant increase in shoulder muscle isometric strength and endurance and decrease in shoulder pain in patients with frozen shoulder was observed after treatment.

Introduction

Frozen shoulder (FS) or adhesive capsulitis or shoulder periarthritis affects 2–5% of the population and is most common in the 40–60-year-old age group (1). FS is characterized by an insidious and progressive loss of active and passive mobility in the glenohumeral joint presumably due to capsular contracture (2). Despite intensive measurement, the etiology and pathology of FS remain enigmatic (3). Frequent or sustained shoulder elevation at or above 60° in any plane during occupational tasks has been identified as a risk factor for the development of shoulder traumatic injuries, non-specific shoulder pain and FS (4). Pain of the shoulder region often keeps FS patients from performing activities of daily living (ADL) and this is one reason of decreasing the shoulder muscle strength and endurance (5). The patients attempted to compensate the rate of movement (ROM) loss by using other muscles and increasing scapular rotation to accomplish various activities. This places additional strain on the other muscle groups, leaving them overloaded and tender (6). Many FS patients complain of sleeping disorders due to the pain and their inability to lie on the affected shoulder (2).

FS results in a gradual loss of shoulder range of motion (ROM) and strength of surrounding muscles (7, 8). The increase of the shoulder active ROM and strength of the shoulder muscles and decrease of the

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pain are important component for reduction of physical disability and improvement of the shoulder function in of FS patients during rehabilitation (9). The rehabilitation of FS patients is frequently prolonged despite multiple therapeutic methods (10). The rehabilitation program of FS patients commonly includes exercise aimed at restoring normal shoulder kinematics and/or shoulder muscle activity (9, 11). Usually the studies determine for FS outcome active and passive ROM of the shoulder (12), use different self-administered shoulder questionnaires (13), apply visual analogue scale (VAS) (14) and measure shoulder muscle strength (15). However, there are no data determining whether rehabilitation can alter pattern of shoulder muscle endurance in FS patients.

The present study was designed to investigate changes in shoulder function in FS patients after 4-wk individualized rehabilitation combining exercise therapy in gym and swimming pool, massage and electrical therapy. More specifically, we were interested in examining the shoulder active ROM, shoulder muscle maximal isometric force (MF) and endurance in FS patients for involved and uninvolved extremity before and after the treatment. All measured characteristics of FS patients were compared with those of the subjects with asymptomatic shoulders.

Material and methods

Subjects

Two groups of subjects participated in this study: (1) FS patients (7 women and 3 men) and (2) subjects with asymptomatic shoulders as controls (7 women and 3 men). The physical characteristics of the subjects are presented in Table. FS was diagnosed in Tartu University Clinic by an orthopedist. The etiopathogenesis was idiopathic in all patients. Patients were asked to fill in the questionnaire in regard to the presence of shoulder pain and difficulties in ADL. The period of shoulder pain for patients before the rehabilitation ranged between 2 weeks and 3 months. Asymptomatic control subjects were of similar age range and gender distribution with the FS patients. Additional inclusion criteria for control subjects were full pain-free shoulder motion and no history or current symptoms of shoulder pathology. The subjects were moderately physically active, however no professional athletes were included. They had no orthopaedic or neurological limitations or contraindications for exercise testing or training.

Four-week rehabilitation program for all FS patients was performed by the same physiotherapist in the Center of Sports Medicine and Rehabilitation of Tartu University Clinic. The rehabilitation program consisted of 10 individualized exercise therapy procedures in gymnasium and swimming pool with the duration of 30 min/day, 5–10 massage procedures with the duration of 20 min/day and 5–10 electrical therapy procedures with the duration of 5–10 min/day. The subjects were informed about procedures and their written consent was obtained. The study carried the approval of the Ethics Committee of the University of Tartu.

Experimental set-up

The shoulder flexion, extension, abduction and adduction active ROM was measured by gravitational goniometer Bubble Inclinometer (Fabrication Enterprises Inc., USA). The shoulder internal and external rotation active ROM was measured by goniometer Myrin (Follo A/S, Norway). Subjects were positioned standing for all ROM tests according to standard guidelines (16). All assessments were performed by the same physiotherapist.

Isometric MF of the shoulder flexors, abductors, adductors, internal and external rotators was measured using hand-held dynamometer Lafayette Manual Muscle Test System (Lafayette Instrument Company, USA). During the strength testing the subject was seated on a standard chair. During shoulder flexion strength assessment the fully extended upper extremity was positioned with the shoulder flexed to 45°. Hand-held dynamometer was placed laterally on the distal end of the humerus approximately 5 cm superior to elbow joint. During shoulder abduction and adduction strength testing the raised upper extremity was positioned with the shoulder abducted to 45°. Shoulder external and internal rotation strength assessment was performed with the shoulder in the vertical position and the elbow flexed to 90°. Hand-held dynamometer was placed laterally and medially on the distal part of the elbow approximately 5 cm superior to the wrist during shoulder external and internal rotation testing, respectively. The forearm was pronated all through the strength test. The position was carefully supervised by a researcher and the subjects were verbally encouraged to perform the exercise. The subjects were asked to exert maximal voluntary isometric force production during pushing against the dynamometer for approximately 3 s. Before each contractions the subjects were instructed to "push as strongly as possible". The best result out of the 3 attempts was taken as isometric MF. A rest period of 1 min was allowed between attempts. All shoulder muscle strength assessments were performed by the same physiotherapist.

During shoulder muscle isometric endurance tes-

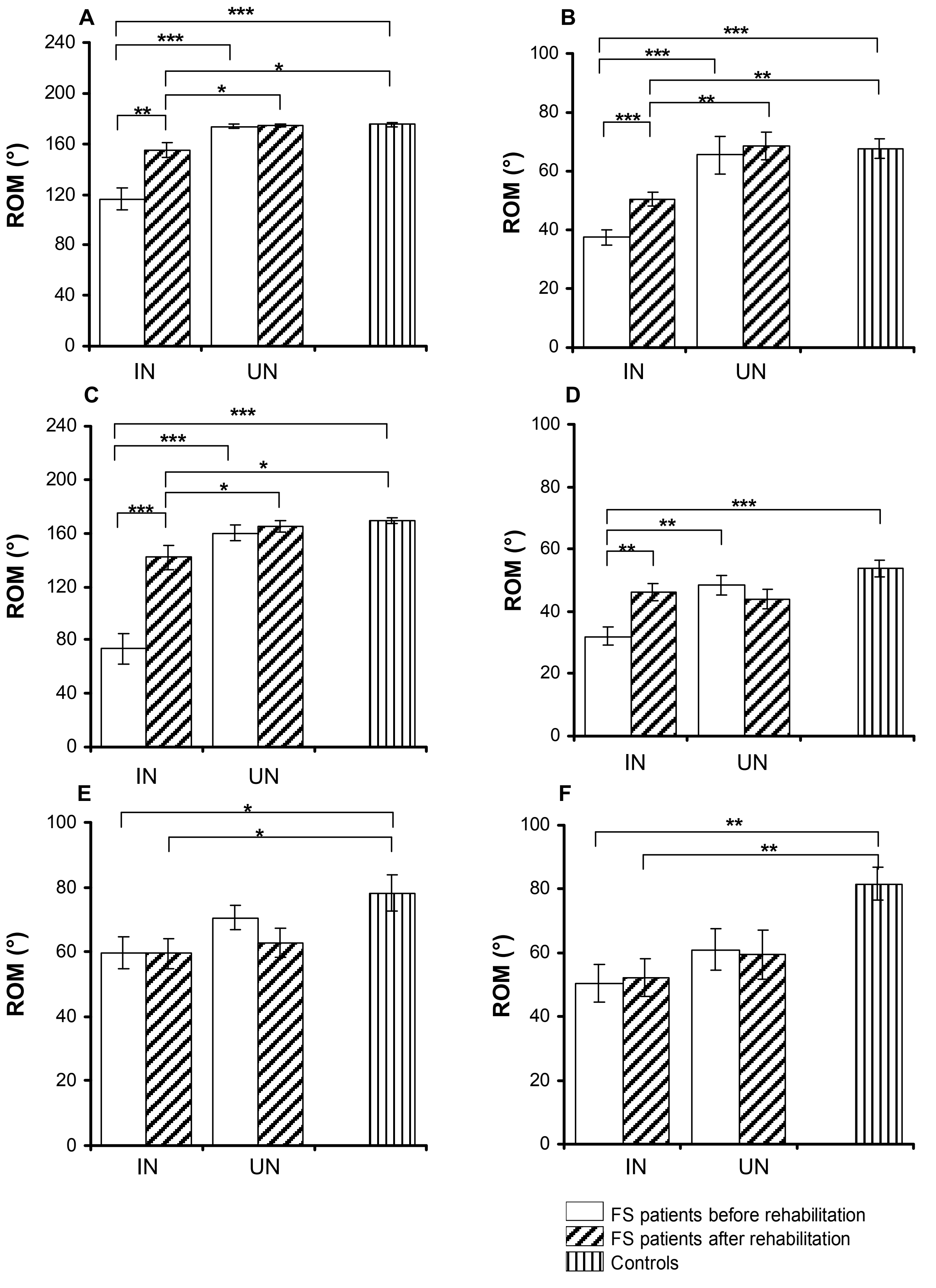

Fig. 1. **Mean (±SE) shoulder flexion (A), abduction (B), extension (C), adduction (D), and internal (E) and external (F) rotation active range of motion (ROM) in patients with frozen shoulder (FS) and controls**

IN – involved extremity, UN – uninvolved extremity. *p<0.05, **p<0.01, ***p<0.001.

ting the subject was seated on a standard chair and the fully extended upper extremity was positioned with the shoulder flexed and adducted 45°. In this position the subject held the weight (30% MF assessed beforehand by hand-held dynamometer) in hand till exhaustion. Shoulder muscle isometric endurance was characterized by net impulse (NI, N×s) calculated by formula

$$NI = F \times t,$$

where F is hand-held weight × 9.81, and t is endurance test time.

Shoulder pain was measured by 10-points VAS (17).

Procedure

Subjects were instructed and shoulder active ROM, and shoulder muscle strength and endurance testing procedures were demonstrated 24–48 hours before collecting the first data. This was followed by a practical session to familiarize the subjects with the procedures. Before testing, each subject underwent a 10-min warm-up of gymnastics and stretching exercises.

In FS patients, shoulder active ROM, shoulder muscle isometric strength and endurance for involved and uninvolved extremity, and shoulder pain for involved extremity were tested before and after 4-wk rehabilitation. The measured characteristics in control subjects were tested once and only for dominant limb.

Data analysis

Data are means and standard errors (±SE). One-way analysis of variance (ANOVA) followed by Turkey *post hoc* comparisons was used to evaluate differences between the groups and between involved and uninvolved extremity. A paired t-test was used to evaluate differences between pre- and post-rehabilitation characteristics. A level of $p<0.05$ was selected to indicate statistical significance.

Results

Before the rehabilitation, FS patients demonstrated a reduction ($p<0.05$) in the shoulder flexion, extension, abduction and adduction active ROM for involved extremity compared with uninvolved extremity and to controls (Fig. 1 A, B, C, D). FS patients also showed a reduction ($p<0.05$) in shoulder internal and external rotation active ROM for involved extremity compared to controls before rehabilitation (Fig. 1 E, F). There were no significant differences ($p>0.05$) in the shoulder internal and external rotation active ROM for involved and uninvolved extremities in FS patients before rehabilitation.

After 4-wk rehabilitation, the shoulder flexion, extension, abduction and adduction active ROM in FS patients for involved extremity were increased ($p<0.05$) compared with the pre-rehabilitation level. However, in FS patients, the shoulder flexion, extension and abduction active ROM for involved extremity remained significantly lower ($p<0.05$) compared with uninvolved extremity and to controls after rehabilitation. There were no significant differences ($p>0.05$) in the shoulder adduction active ROM in FS patients for involved extremity compared with uninvolved extremity and controls after 4-wk rehabilitation. The shoulder internal and external rotation active ROM for involved extremity in FS patients did not change significantly ($p>0.05$) with rehabilitation.

Before the rehabilitation, FS patients showed a reduction ($p<0.05$) in isometric MF of the shoulder flexors and internal rotators for involved extremity compared with uninvolved extremity (Fig. 2 A, E), and reduction ($p<0.05$) in MF of shoulder flexors, abductors, adductors and external rotators compared to controls (Fig. 2 B, C, D).

After 4-wk rehabilitation, MF of the shoulder flexors, abductors, adductors, internal rotators in FS patients for involved extremity was increased ($p<0.05$) as compared with the pre-rehabilitation level. However, MF of the shoulder external and internal rotators in FS patients for involved extremity remained lower ($p<0.05$) compared with uninvolved extremity after rehabilitation. In FS patients, MF of the shoulder external rotators for involved extremity was significantly lower ($p<0.05$) compared to controls after rehabilitation.

Before the rehabilitation, FS patients showed lower ($p<0.05$) NI during the shoulder muscle isometric endurance test for involved extremity as compared to controls (Fig. 3 A). There was a significant increase in NI during the shoulder muscle endurance test in FS patients for involved extremity after 4-wk rehabilitation as compared with the pre-rehabilitation level. No significant differences ($p>0.05$) in NI during shoulder endurance test in FS patients for involved extremity were observed as compared to controls and with uninvolved extremity after rehabilitation.

In FS patients, shoulder pain was decreased ($p<0.05$) after the rehabilitation as compared with the pre-rehabilitation level (Fig. 3B).

Discussion

This study examined the effect of rehabilitation on shoulder function in FS patients. A marked shoulder active ROM deficit was observed in FS patients before rehabilitation. Shoulder flexion, extension, abduction, adduction, internal and external rotation ac-

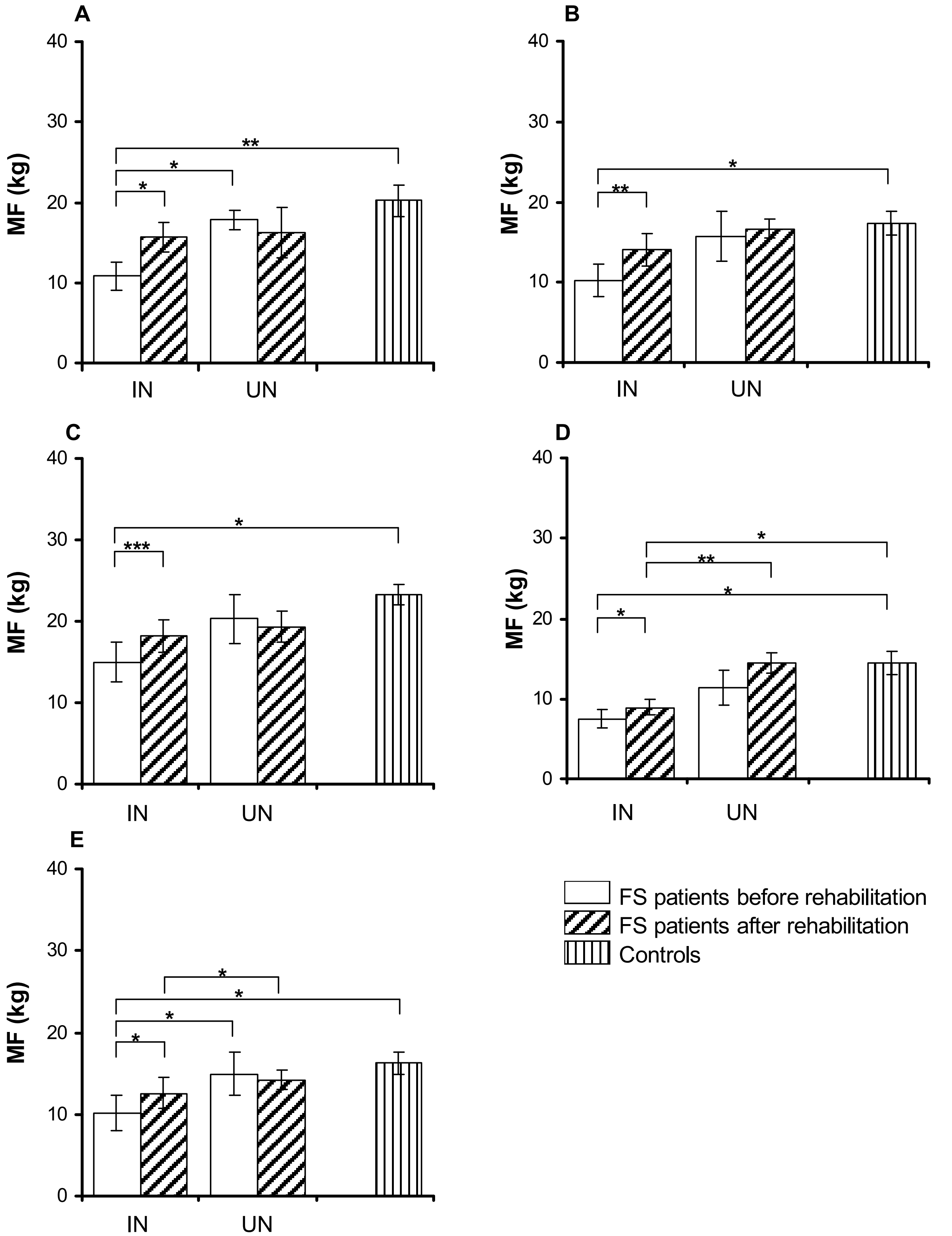

Fig. 2. **Mean (±SE) maximal isometric force (MF) of the shoulder flexors (A), abductors (B), adductors (C), and internal (D) and external (E) rotators in patients with frozen shoulder (FS) and controls**

IN – involved extremity, UN – uninvolved extremity. *$p<0.05$, **$p<0.01$, ***$p<0.001$.

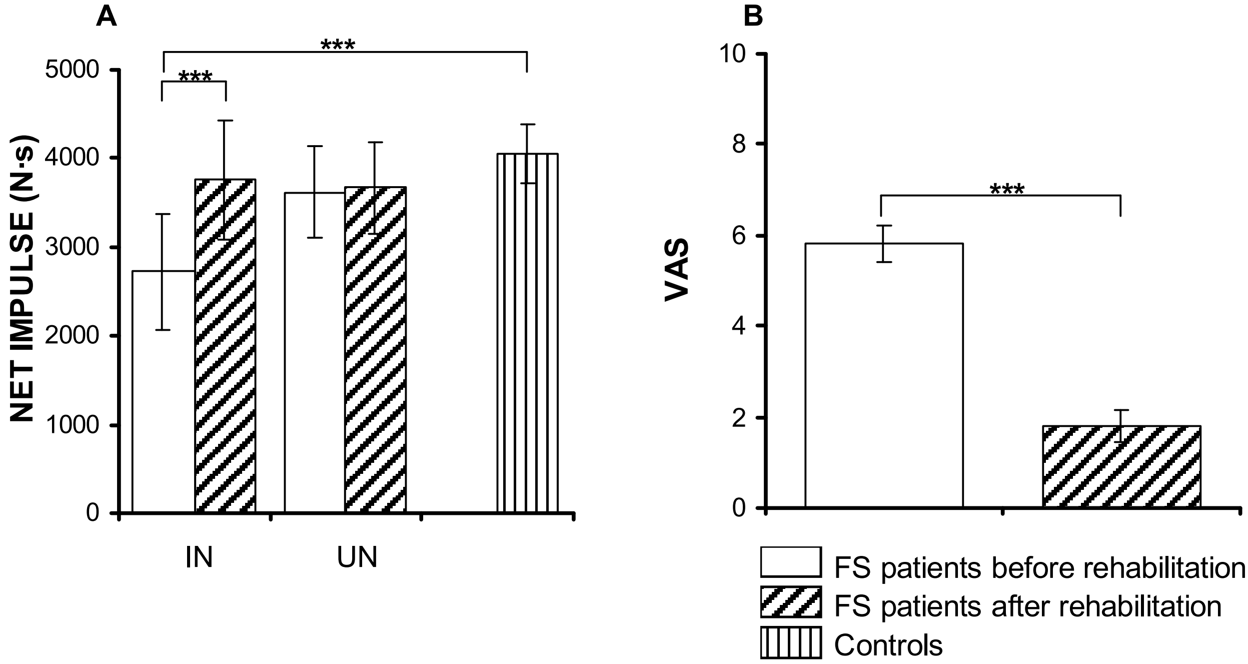

***Fig. 3.* Mean (±SE) net impulse during shoulder muscle isometric endurance test (A) in patients with frozen shoulder (FS) and controls, and shoulder pain in FS patients measured by visual analogue scale (VAS) (B)**

***p<0.001.

tive ROM in FS patients for involved extremity were 35, 44, 59, 41, 25, and 37% less, respectively, as compared to controls. Several previous studies demonstrated a reduced shoulder active ROM in different directions in FS patients (12, 18).

The pathogenesis of primary FS is unknown. Adhesive capsulitis, loss of dependent fold, decreased capsular volume and capsular contractions have been demonstrated in FS patients (19). Additionally, contracture of the coracohumeral ligament, and capsular and intraarticular subscapularis tendon thickening have been reported (3). Wolf et al (1) published that in patients with idiopathic adhesive capsulitis shoulder pain on the 10-point VAS was 5.9 points before rehabilitation. In the present study, pre-rehabilitation shoulder pain in FS patients measured by VAS was 5.8 points. Thus, the occurrence of the above-mentioned destructive changes might be the cause of shoulder active ROM deficit in FS patients observed in this study.

In our study, FS patients showed substantial improvement in shoulder flexion, extension, abduction and adduction active ROM for involved extremity after 4-wk rehabilitation coupled with non significant changes in shoulder internal and external rotation active ROM. Several authors (12, 20) have found a marked increase in the shoulder active ROM in different directions in FS patients after rehabilitation.

One important factor for rehabilitation of FS patients is decreasing the shoulder pain by multiple therapeutic maneuvers (massage, electrical stimulation, exercise and analgesics) (9). In the present study, the shoulder pain in FS patients was significantly decreased after rehabilitation as compared with the pre-rehabilitation level. Thus, improvement of shoulder active ROM in FS patients after treatment might be caused, partly, by reduced shoulder pain. Kibler et al (21) showed that after rehabilitation program the shoulder muscles became more elastic permitting major movements in the shoulder girdle. However, the present study indicated that after the rehabilitation shoulder flexion, extension and abduction active ROM in FS patients for involved extremity remained significantly lower compared with uninvolved extremity and to controls. Shaffre et al (22) showed that post-rehabilitation deficit of shoulder active ROM in FS patients was fairly long-standing. Binder et al (23) found that 48 months after rehabilitation shoulder active ROM in FS patients was significantly decreased compared to controls. It is possible that a rehabilitation period of more than 4 weeks might be necessary to determine relevant improvement in shoulder active ROM in FS patients.

This study demonstrated a significant deficit in shoulder muscle isometric strength and endurance in FS patients before rehabilitation. In FS patients, shoulder muscle isometric MF for involved extremity as-

***Table.* The physical characteristics of the subjects**

Subjects and gender	Age (years)	Height (cm)	Body mass (kg)	BMI (kg·m^{-2})
Patients:				
1. F	52	164.5	71.0	26.4
2. F	55	164.0	80.0	29.7
3. F	48	172.8	79.9	26.7
4. F	62	161.4	59.7	23.0
5. F	51	160.0	56.3	21.9
6. F	60	159.0	78.0	30.8
7. F	34	168.2	60.5	21.4
8. M	18	178.0	73.0	23.0
9. M	68	173.5	72.2	24.1
10. M	55	181.2	95.8	29.2
Mean±SE	50.2±4.6	168.7±2.8	72.7±3.8	25.6±1.0
Controls:				
1. F	51	160.6	73.2	28.6
2. F	49	159.3	85.2	33.7
3. F	35	176.0	89.0	30.0
4. F	63	162.5	82.1	31.3
5. F	49	155.5	59.8	24.9
6. F	63	167.0	72.0	25.8
7. F	56	164.3	64.0	23.8
8. M	18	180.0	70.0	21.6
9. M	66	168.5	63.0	22.3
10. M	55	179.0	90.0	28.0
Mean±SE	49.8±4.6	167.3±2.7	74.8±3.5	27.0±1.3

BMI – body mass index; F – female; M – male.

sessed by hand-held dynamometer was 38–48% lower in different force directions, and NI during shoulder muscle endurance test was 33% lower than in controls. Brox et al (24) showed that increased pain, emotional stress and muscle weakness were the limiting factors for shoulder muscle isometric endurance in patients with rotator tendinitis of shoulder. FS is accompanied by pain and the patients tried to use the hand sparingly (21, 25). It has been shown that ADL was markedly decreased in FS patients as compared to healthy subjects (26). The decreased physical activity and shoulder immobilization are important factors of shoulder muscle atrophy, decreased strength and endurance. Kithahara et al (27) showed that three-week hand immobilization decreased the hand muscle strength by 18–45%.

The present study indicated a significant improvement in shoulder muscle isometric strength in FS patients in all measured force directions after 4-wk rehabilitation. The observed increase in shoulder flexors, abductors, adductors, internal and external rotators in FS patients for involved extremity was 31, 27, 17, 19, 15%, respectively. Thus, shoulder muscle strength improvement in FS patients was more pronounced for shoulder flexors, abductors and adductors than internal and external rotators. This study also showed significant improvement in shoulder muscle isometric endurance in FS patients after rehabilitation. FS patients demonstrated 27% increase in net impulse during shoulder muscle endurance test for involved extremity after rehabilitation as compared to pre-rehabilitation level. This improvement in shoulder muscle function might primarily result from neural adaptation observed, especially during the earlier weeks of exercise training (28). The musculature of the shoulder joint can be divided into intrinsic (centering and stabilizing) and extrinsic (mobilizing) muscle groups (29). It is known that more than in other joints, shoulder movements require a control system for constant readjustment of the intramuscular coordination of all muscles involved. It has been speculated that improved intra- and intermuscular coordination, reduced shoulder pain, shoulder muscle atrophy, and increased shoulder joint mobility are possible factors for improvement in shoulder muscle function in FS patients after rehabilitation.

In conclusion, the rehabilitation program used in this study improved shoulder function in FS patients. However, exercise therapy of higher intensity and/or duration combined with other treatment maneuvers is required for promoting more significant changes in shoulder active ROM and shoulder muscle strength in FS patients. It is very important that patients continue the exercising at home. Additional studies are needed to evaluate treatment effect on shoulder muscle strength and endurance in different directions of force production in subjects with FS.

Conclusions

In summary, FS patients demonstrated a marked deficit in shoulder active ROM, shoulder muscle isometric strength and endurance for involved extremity before rehabilitation. An individualized 4-wk rehabilitation program combined with exercise therapy in gym and swimming pool, massage and electrical therapy significantly improved shoulder flexion, extension, abduction and adduction active ROM in FS patients. However, the rehabilitation had no effect on shoulder external and internal rotation ROM. A significant improvement in shoulder muscle isometric endurance and strength, and decrease in shoulder pain were observed in FS patients after treatment. The observed increase in isometric strength was more pronounced for shoulder flexors, abductors and adductors than internal and external rotators.

Sustingusio peties sąnario funkcija iki reabilitacijos ir jos pokyčiai po keturių savaičių reabilitacijos

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Raktažodžiai: peties sąnarys, judesių amplitudė, izometrinė jėga, sustingęs petys.

Santrauka. Šis tyrimas vertino sustingusio peties sąnario funkcinius pokyčius po keturių savaičių reabilitacijos pratimus derinant su elektroterapija bei masažu.

Medžiaga ir metodai. Tyrime dalyvavo 10 pacientų, kuriems nustatytas sustingęs peties sąnarys, tiriamųjų amžiaus vidurkis – 50,2±4,6 metų) (vidurkis plius/minus standartinė paklaida) ir 10 kontrolinės grupės pacientų (49,8±4,6 metų). Įprastiniai goniometriniai tyrimai buvo atlikti vertinant peties lenkimo, tiesimo, atitraukimo, pritraukimo, vidinės ir išorinės rotacijos aktyvių judesių amplitudes. Maksimali izometrinė peties lenkėjų, tiesėjų, atitraukėjų, pritraukėjų, išorinių ir vidinių rotatorių jėga matuota rankiniu dinamometru. Peties raumenų izometrinė ištvermė matuota bendru impulsu, vertinamu svorį (30 proc. nuo maksimalios jėgos) laikant rankoje iki išsekimo. Peties skausmas buvo vertinamas naudojant analogišką vizualinę skalę.

Rezultatai. Iki reabilitacijos pacientų, kuriems nustatytas sustingęs peties sąnarys, aktyvių judesių amplitudė ir peties raumenų jėga visomis matuotomis kryptimis buvo mažesnė, mažesnis ir bendras impulsas ($p<0,05$) raumenų izometrinio ištvermės testo metu palyginus su kontrolinės grupės pacientų analogiškais duomenimis. Sustingusio peties lenkimo, atitraukimo, pritraukimo aktyvių judesių amplitudė ir peties raumenų jėga visomis matuotomis kryptimis ir bendras impulsas peties raumenų izometrinės ištvermės testo metu padidėjo ($p<0,05$) po reabilitacijos. Jokių reikšmingų peties vidinių ir išorinių rotatorių aktyvios judesių amplitudės funkcijos pokyčių po reabilitacijos nepastebėta.

Išvada. Keturių savaičių reabilitacijos programa pagerino peties lenkimo, tiesimo, atitraukimo ir pritraukimo aktyvių judesių amplitudę, o išorinės ir vidinės rotacijos aktyvių judesių amplitudės pokyčiai buvo nereikšmingi. Po gydymo pacientams, kuriems buvo diagnozuotas sustingęs peties sąnarys, nustatytas reikšmingas izometrinės peties raumenų jėgos ir ištvermės padidėjimas bei skausmo sumažėjimas.

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