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A structured exercise programme combined with proprioceptive neuromuscular facilitation stretching or static stretching in posttraumatic stiffness of the elbow: a randomized controlled trial

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Abstract

Objectives: To compare the different stretching techniques, proprioceptive neuromuscular facilitation (PNF) stretching and static stretching, in patients with elbow stiffness after a treated elbow fracture.

Design: Randomized-controlled, single-blind study.

Setting: Department of physiotherapy and rehabilitation.

Subjects: Forty patients with posttraumatic elbow stiffness (24 women; mean age, 41.34 ± 7.57 years).

Intervention: PNF stretching group ($n = 20$), hold-relax PNF stretching combined with a structured exercise programme (two days per week for six weeks); static stretching group ($n = 20$), static stretching combined with a structured exercise programme (two days per week for six weeks).

Main measures: The primary outcome is the Disabilities of the Arm, Shoulder and Hand (DASH). The secondary outcomes are active range of motion (AROM), visual analogue scale (VAS), Tampa Scale for Kinesiophobia, Short Form-12 and Global Rating of Change. Participants were assessed at baseline, after a six-week intervention period and one-month later (follow-up).

Results: After treatment, improvement in the mean DASH score was slightly better in the PNF stretching group (8.66 ± 6.15) compared with the static stretching group (19.25 ± 10.30) ($p = 0.03$). The overall group-by-time interaction for the 2 × 3 mixed-model analysis of covariance (ANCOVA) was also significant for elbow flexion AROM (mean change for PNF stretching group; static stretching group; 41.10, 34.42, $p = 0.04$), VAS-rest (–1.31, –1.08, $p = 0.03$) and VAS-activity (–3.78, –3.47, $p = 0.01$) in favour of PNF stretching group. The other outcomes did not differ significantly between the two groups.

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Conclusion: The study demonstrated that the structured exercise programme combined with PNF stretching might be effective in patients with posttraumatic elbow stiffness with regard to improving function, elbow flexion AROM, pain at rest and during activity.

Keywords
Contracture, exercise, function, range of motion, pain

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Introduction

Posttraumatic elbow stiffness is a common complication of elbow fracture which is treated either conservatively or surgically followed by a period of immobilization with casting or splinting.[1,2] Elbow stiffness is characterized by a reduction in joint range of motion that might remarkably interfere with participating in personal, occupational and daily living activities.[3,4] Even a mild limitation in elbow joint range of motion which is accompanied by pain and fear of movement can lead to reducing the ability of upper limb function, thereby decreasing the health-related quality of life.[4,5]

Physiotherapy eliminates the detrimental consequences of immobilization and helps patients return to pre-fracture functional level.[5] Therapeutic exercise, especially stretching exercises, is an important component of physiotherapy in the management of elbow stiffness.[4] The key role of stretching exercise is to improve the ability of connective tissue to respond to tensile loading by elastic and plastic deformation properties.[6] Proprioceptive neuromuscular facilitation stretching and static stretching are the commonly used stretching techniques in physiotherapy.[7–9] The effectiveness of these techniques has been compared, but the available evidence is contradictory. Many researchers indicate that proprioceptive neuromuscular facilitation and static stretching techniques have similar effects[8,10] while some studies reported that proprioceptive neuromuscular facilitation is more effective than static stretching in terms of improvement in the range of motion.[11,12]

There is a paucity of evidence regarding conservative management in the stiff elbow and there is no evidence as to whether proprioceptive neuromuscular facilitation stretching and static stretching have an effect on posttraumatic elbow stiffness.[4,7] In addition, the studies investigating the effectiveness of stretching exercises have mostly focused on the range of motion in both athletes and healthy individuals rather than patients with joint limitation induced by immobilization.[8,11,12] Therefore, our primary purpose is to compare the efficacy of two different stretching exercises, proprioceptive neuromuscular facilitation stretching and static stretching, on function in patients with posttraumatic stiff elbow. Our secondary purpose is to determine their effects on the active range of motion, pain intensity, kinesiophobia, quality of life and patient satisfaction.

Methods

This study is a randomized, controlled and single-blinded clinical trial with a parallel design conducted in the clinical laboratory of the Physiotherapy Department of Istanbul University from January 2017 to July 2017. Ethical approval for this study was obtained from the Human Research Ethics Committee of Biruni University (IRB:015-KAEK-43). This study was registered in the ClinicalTrials.gov with registration number NCT03161782.

All participants were patients who had sustained an elbow fracture and were treated either conservatively or surgically, and they were recruited from the Clinics of Orthopedic and Traumatology in Bakirkoy Dr. Sadi Konuk Training & Research Hospital (S.A.). The participants with elbow stiffness after an elbow fracture were directed to the clinical laboratory of the Physiotherapy Department of Istanbul University following a confirmation by an orthopaedist that the bone fracture healed based on the physical examinations and diagnostic imaging. The patients who were between 18 and 55 years of age were either conservatively or surgically treated for an elbow fracture six weeks before the study and had an elbow limitation in flexion or extension after an elbow fracture were included in the study. The patients who had malunion or nonunion elbow fracture, complex regional pain syndrome, peripheral nerve injury, heterotopic ossification, myositis ossification or posttraumatic ankylosing, non-healing wound or infection, neurological disorders, rheumatic diseases or psychiatric diseases, and who previously received physiotherapy for elbow limitation were excluded from the study.

The sample size and power calculations were performed with G*Power 3.1 power analysis programme. The calculations were based on a standard deviation of 18.12 points,[13] a between-group difference of 17 points[14] (it was the minimal clinically important difference of the Disability of the Arm, Shoulder and Hand (DASH) for the distal part of the upper extremity), an alpha level of 0.05, a β level of 20%, and a desired power of 80%. These parameters generated a necessary sample size of at least 19 participants in each group. To allow for dropouts, we recruited 40 subjects into the study.

The participants were randomly assigned to one of two parallel groups to receive either proprioceptive neuromuscular facilitation stretching or static stretching (ratio 1:1). An online Research Randomizer was used in order to allocate the participants (https://www.randomizer.org/). Simple randomization procedures (a computer-generated list) were used to randomize eligible participants. An investigator without clinical involvement in the study administered the list and prepared sequentially numbered index cards containing the random assignments. Then, the index cards were folded and placed into sealed envelopes. The physical therapist, performing the interventions, opened each envelope and allocated the participants into the groups according to the selected index card. The participants were blinded to their treatment allocation. In addition, the same physical therapist (T.B.) applied the interventions in the clinical laboratory of the Physiotherapy Department and another physical therapist (A.R.O.) made the assessments.

Outcome measurements

The primary outcome measure for this study was the functional level of upper extremity which was assessed by the DASH score. The secondary outcome measures were the active range of motion in the elbow joint, pain intensity, kinesiophobia, quality of life and patient satisfaction. Assessments of primary and secondary outcome measures were performed at baseline, after a six-week intervention period and one month after the intervention period (follow-up).

The DASH outcome measure is a self-administered questionnaire designed to evaluate single or multiple disorders and impairment level in the upper limbs. It comprises 30 core questions and optional additional 8 questions that are scored on a 5-point Likert-type scale (no difficulty–unable). The cumulative DASH score is ranged from 0 to 100, where the higher scores indicate an increased degree of disability.[15,16]

The active range of motion of elbow flexion-extension and forearm supination-pronation was measured using 360° scale (1°-increments) plastic universal goniometer with two 25 cm arms (3 M© Modular Shoulder System, 3 M©, St Paul, MN, USA). For elbow flexion-extension active range of motion assessment, participants were positioned in supine, with the shoulder in 0° of flexion, abduction, and forearm in full supination with the palm of the hand facing the ceiling. The measurement was performed by placing the distal arm of the goniometer with the lateral midline of the radius, using the radial head and the radial styloid process for reference. For forearm supination-pronation assessment, the participants were positioned in sitting, with the shoulder in 0° of flexion, extension, abduction, adduction, rotation, and elbow in 90° flexion with the forearm in full midway position. The measurement was performed by placing the distal arm of the goniometer with the dorsal aspect of the forearm, just proximal to the styloid process of the radius and ulna.[17] It was reported that the test–retest reliability of goniometric measurement was 0.94–0.97 in elbow joint.[18]

Pain intensity was measured using the visual analogue scale (VAS). The participants were asked to indicate their perceived pain at rest, during activity and at night on the 10 cm line between no pain and terrible pain. The score was determined by measuring the distance on 10 cm line using a ruler.[19]

The subjective rating of kinesiophobia or fear of movement was measured by the Tampa Scale for Kinesiophobia, a 17-item questionnaire scored on a 4-point Likert-type scale (strongly disagree–strongly agree). The total score of the scale ranged from 17 to 68, with higher scores indicating more kinesiophobia.[20,21]

Short Form-12 was used to evaluate the health-related quality of life perception. It consists of 12 items: seven items dealing with the physical components scores and five items measuring the mental components scores of Short Form-12. The range of both scores is 0–100, where the higher scores indicate the better health-related quality of life.[22,23]

Patient satisfaction regarding improvement in elbow function was assessed by the Global Rating of Change scale.[24] The participants were asked to rate their condition after a six-week intervention period compared to baseline by indicating whether they had improved significantly, improved slightly, unchanged, deteriorated slightly, or deteriorated significantly in this study.

Interventions

The participants who were assigned to the proprioceptive neuromuscular facilitation stretching group received hold-relax proprioceptive neuromuscular facilitation stretching combined with a structured exercise programme for posttraumatic stiffness of the elbow (Supplemental Appendix 1). The hold-relax proprioceptive neuromuscular facilitation stretching procedure consisted of three stages. In the first stage, participants were comfortably positioned in a supine lying position, and the physical therapist moved the elbow joint to the end of the passive range of motion according to the direction of limitation in the elbow joint. In the second stage, the physical therapist asked the participants for a submaximal isometric contraction of the target muscle with emphasis on rotation for 10 seconds. Following the submaximal isometric contraction, the participants were instructed to relax for 5 seconds.[25] In the third stage, the elbow joint was repositioned actively to the new limit of the range of motion and then the physical therapist applied a stretching force for an additional 10 seconds.[26,27] This procedure was repeated 10 times with a rest period of 10 seconds between two successive stretchings.

The participants who were assigned to the static stretching group received static stretching combined with a structured exercise programme for posttraumatic stiffness of the elbow (Supplemental Appendix 1). They were comfortably positioned in a supine lying position, and the physical therapist moved the elbow joint to the end of the passive range of motion according to the direction of limitation in the elbow joint and then the physical therapist applied a stretching force for 20 seconds.[9] Holding static stretching for 20–30 seconds is recommended because most of the relaxation in passive stretches occur in the first 20 seconds.[6] This procedure was repeated 10 times with a rest period of 10 seconds between two successive stretchings.

The proprioceptive neuromuscular facilitation stretching and static stretching exercises combined with a structured exercise programme for posttraumatic stiffness of the elbow were performed two times per week for six weeks for 12 sessions. Following the six-week intervention period, the participants were instructed to continue the home exercise programme for four weeks. The home programme was similar to the structured exercise programme for posttraumatic stiffness of the elbow, but the intensity and repetition of the exercises were depending on the participant's compliance. The participants were encouraged to exercise at least five times a week and they visited the physical therapist to discuss their home programme during the second week across the period of the home exercise programme.

Data analysis

The Statistical Package for the Social Sciences 21.0 (SPSS Inc., Chicago, IL, USA) programme for Windows was used for all statistical analyses. Before conducting the statistical analysis, a

Kolmogorov–Smirnov test was used to assess the distribution of data. The data were normally distributed, thus a parametric test was used for statistical analysis. Demographic and clinical baseline variables were compared between the groups using an independent sample *t*-test for continuous variables and a chi-square test for categorical data. Changes in variable scores within the groups were measured by means (95% confidence interval) of the paired sample *t*-test. Analysis of covariance (ANCOVA) was used to carry out the effect of two different stretching techniques on the level of function, active range of motion, pain intensity, kinesiophobia and health-related quality of life. Separate 2×3 mixed-model ANCOVA was conducted with time (baseline, after a six-week intervention period and one-month follow-up) as a within-subject variable and group (proprioceptive neuromuscular facilitation stretching or static stretching) as a between-subjects variable. The type of orthopaedic management (surgery or conservative) was used as a covariate for all analysis, as it has an impact on the healing process in elbow fracture. Partial eta square was used as an indicator of effect size which is elucidated as small 0.01; medium 0.06 and large 0.14.[28] Significance level was set at $p < 0.05$.

Results

A total of 20 patients with posttraumatic elbow stiffness were randomized to the proprioceptive neuromuscular facilitation stretching group and 20 to the static stretching group; please see the CONSORT diagram (Figure 1). The delay between randomization and initiation of the intervention was average three to five days for each participant. Neither the proprioceptive neuromuscular facilitation stretching group nor the static stretching group participants reported an adverse effect during the intervention. The demographic and clinical baseline variables of the participants are presented in Table 1. At baseline, no significant differences were observed between groups for any of the demographic and clinical variables ($p > 0.05$).

A comparison of differences for primary and secondary outcome measurements between the groups and intra-group changes is shown in Tables 2 and 3. The overall group-by-time interaction for the 2×3 mixed-model ANCOVA was found to be significant for DASH ($F_{1,35} = 4.89$, $p = 0.03$), elbow flexion active range of motion ($F_{1,35} = 3.87$, $p = 0.04$), VAS-rest ($F_{1,35} = 5.04$, $p = 0.03$) and VAS-activity ($F_{1,35} = 7.25$, $p = 0.01$) in favour of the proprioceptive neuromuscular facilitation stretching group. The type of orthopaedic management did not have a significant impact on all outcome measures (both primary and secondary) as a covariate ($p > 0.05$).

In the proprioceptive neuromuscular facilitation stretching group, 85% of the participants ($n = 17/20$) indicated that they were much better after the six-week intervention period, whereas the ratio was 55% ($n = 11/20$) for those in the static stretching group in this category. Fifteen percent of the participants ($n = 3/20$) in the proprioceptive neuromuscular facilitation stretching group and 45% of the participants ($n = 9/20$) of the static stretching group reported that they felt slightly better ($p = 0.03$).

Discussion

The results of this study with a small sample demonstrated that the structured exercise programme combined with proprioceptive neuromuscular facilitation stretching might be more effective in patients with posttraumatic elbow stiffness at one-month follow-up in the measures of function, elbow flexion active range of motion, pain at rest and during activity when compared to static stretching. In addition, patient satisfaction was higher in participants receiving proprioceptive neuromuscular facilitation stretching relative to static stretching participations.

The elbow, which is the intermediate joint of the upper limb, has a crucial role in upper limb functions.[3,29] A systematic review reported that there was insufficient evidence regarding the effectiveness of the currently prescribed exercise programmes in functional improvement after upper limb fracture including the elbow fracture due to poorly described intervention.[30] In contrast to that, this study indicated that the magnitude of improvement in function was clinically important in both groups after a six-week intervention, as

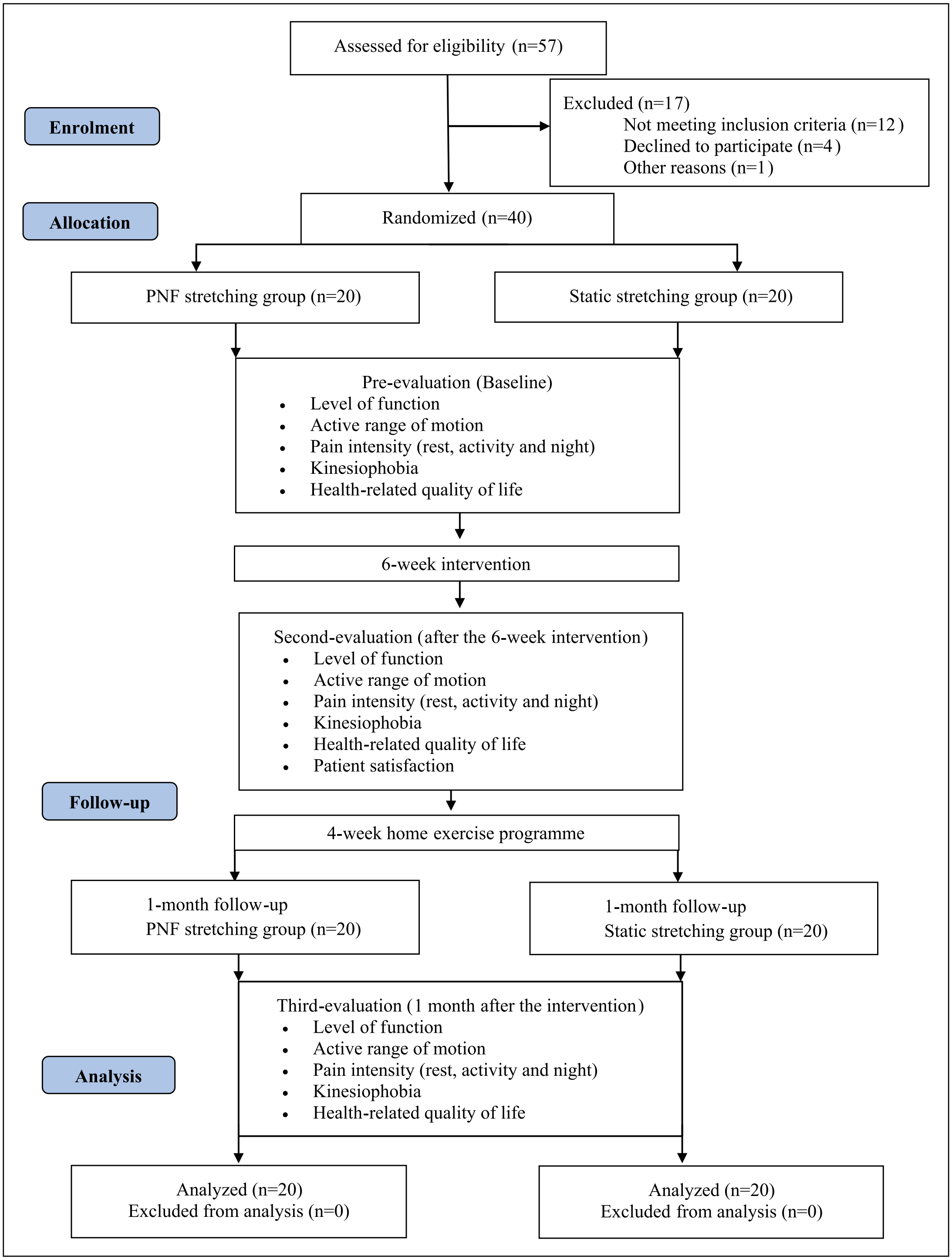

Figure 1. Design of the study (CONSORT flow diagram).

Table 1. Baseline characteristics of groups.

	PNF stretching group (*n* = 20)	Static stretching group (*n* = 20)	*p**
	Mean (SD)	Mean (SD)	
Age (years)	39.21 (7.28)	43.47 (7.43)	0.18
Sex (Female/Male)	13/7	11/9	0.73
BMI (kg/m2)	26.70 (3.41)	27.26 (4.79)	0.07
Fracture side	*n* (%)	*n* (%)	
Olecranon	2 (10)	2 (10)	
Radius head	8 (40)	7 (35)	0.66†
Lateral epicondyle	1 (5)	0 (0)	
Coronoid	0 (0)	1 (5)	
Distal humerus	9 (45)	10 (50)	
Affected side	*n* (%)	*n* (%)	
Right	5 (25)	7 (35)	0.72†
Left	15 (75)	13 (65)	
Immobilization (weeks)	4.47 (1.26)	4.58 (1.30)	0.70
Orthopaedic management	*n* (%)	*n* (%)	
Surgery	12 (60)	13 (65)	0.74†
Conservative	8 (40)	7 (35)	
DASH	41.92 (16.13)	43.16 (11.82)	0.78
Range of motion (°)			
Elbow flexion	90.58 (12.03)	91.53 (13.70)	0.82
Elbow extension	–34.47 (14.54)	–30.63 (12.90)	0.39
Supination	68.16 (21.99)	62.95 (21.26)	0.46
Pronation	69.63 (17.01)	65.53 (23.30)	0.53
Pain intensity (cm)			
VAS-rest	1.63 (1.92)	1.14 (1.44)	0.37
VAS-activity	4.42 (1.74)	4.84 (1.67)	0.45
VAS-night	1.63 (1.80)	1.75 (2.37)	0.86
TSK	43.26 (7.77)	42.79 (6.39)	0.83
Short Form-12			
PCS-12	36.45 (6.56)	45.33 (3.84)	0.52
MCS-12	40.29 (15.17)	39.17 (9.20)	0.78

BMI: body mass index; DASH: Disabilities of the Arm, Shoulder and Hand; MCS: mental component score; PCS: physical component score; PNF: proprioceptive neuromuscular facilitation; TSK: Tampa Scale for Kinesiophobia; VAS: visual analogue scale.
*Independent samples *t*-test.
†Chi-square test.

noted by within-group differences in DASH, which was greater than the minimal clinically important difference of 17 points.[14] Besides, the proprioceptive neuromuscular facilitation stretching group showed a significant improvement of function with a medium effect size compared to the static stretching group. The DASH comprises ability-related items to perform certain activities involving mainly elbow flexion.[15,16] Thus, this difference in function in favour of proprioceptive neuromuscular facilitation stretching might be related to the improvement in elbow flexion range of motion and pain was higher in the proprioceptive neuromuscular facilitation stretching group.

Table 2. Comparison of the level of function and range of motion between groups.

Assessment	Group	Baseline	After treatment	Within-group score change	One-month follow-up	Within-group score change	ANCOVA		
		Mean (SD)	Mean (SD)	Mean [95% CI]	Mean (SD)	Mean [95% CI]	F	$p^{\dagger}$	Effect size (partial eta^2)
Level of function									
DASH	PNF	41.92 (16.13)	12.73 (11.25)	–29.18 [34.23–24.09]*	8.66 (6.15)	–33.25 [27.14–39.37]*	4.89	0.03†	0.12
	SS	43.16 (11.82)	23.49 (13.85)	–19.66 [24.83–14.49]*	19.25 (10.30)	–23.91 [19.61–28.20]*			
Range of motion (°)									
Elbow flexion	PNF	90.58 (12.03)	127.95 (9.77)	37.30 [32.24–42.48]*	131.68 (6.46)	41.10 [35.49–46.71]*	3.87	0.04†	0.10
	SS	91.53 (13.70)	117.84 (7.44)	26.31 [22.43–30.19]*	125.94 (9.84)	34.42 [26.14–42.69]*			
Elbow extension	PNF	–34.47 (14.54)	–7.47 (7.11)	27.00 [21.93–32.06]*	–5.15 (4.53)	29.31 [22.96–35.66]*	0.74	0.39	0.02
	SS	–30.63 (12.90)	–14.63 (8.12)	16.00 [11.75–20.24]*	–8.52 (8.84)	21.57 [15.44–27.71]*			
Supination	PNF	68.16 (21.99)	87.00 (6.90)	18.84 [9.27–28.40]*	87.84 (4.23)	19.05 [11.41–26.68]*	2.98	0.09	0.07
	SS	62.95 (21.26)	77.53 (13.04)	14.57 [7.38–21.77]*	84.94 (6.56)	22.00 [11.17–32.82]*			
Pronation	PNF	69.63 (17.01)	86.84 (5.86)	17.21 [10.68–23.73]*	88.68 (3.26)	19.68 [9.72–29.64]*	3.32	0.07	0.08
	SS	65.53 (23.30)	78.58 (17.72)	13.05 [4.82–21.27]*	83.63 (9.93)	18.10 [5.35–30.86]*			

CI: confidence interval; DASH: Disabilities of the Arm, Shoulder and Hand; PNF: proprioceptive neuromuscular facilitation; SS: static stretching; ANCOVA: analysis of covariance.
*Paired samples t-test ($p < 0.05$).
†Significant group × time interaction (ANCOVA, $p < 0.05$).

Table 3. Comparison of the level of pain, kinesiophobia and quality of life between groups.

Assessment	Group	Baseline	After treatment	Within-group score change	One-month follow-up	Within-group score change	ANCOVA		
		Mean (SD)	Mean (SD)	Mean [95% CI]	Mean (SD)	Mean [95% CI]	*F*	$p^{\dagger}$	Effect size (partial eta^2)
Pain intensity (cm)									
VAS-rest	PNF	1.63 (1.92)	0.53 (0.90)	−1.10 [0.31–1.89]*	0.32 (0.67)	−1.31 [0.37–2.25]*	5.04	0.03†	0.12
	SS	1.14 (1.44)	0.05 (0.22)	−1.08 [0.36–1.81]*	0.05 (0.22)	−1.08 [0.45–1.71]*			
VAS-activity	PNF	4.42 (1.74)	0.74 (1.09)	−3.68 [2.76–4.60]*	0.63 (1.16)	−3.78 [2.85–4.72]*	7.25	0.01†	0.17
	SS	4.84 (1.67)	2.05 (1.22)	−2.78 [2.06–3.51]*	1.37 (1.67)	−3.47 [2.55–4.38]*			
VAS-night	PNF	1.63 (1.80)	0.21 (0.71)	−1.42 [0.64–2.19]*	0.53 (1.34)	−1.10 [0.19–2.01]*	0.45	0.50	0.01
	SS	1.75 (2.37)	0.74 (1.44)	−1.01 [0.04–1.97]*	0.68 (1.56)	−1.06 [0.09–2.13]*			
Kinesiophobia									
TSK	PNF	43.26 (7.77)	36.52 (6.21)	−6.73 [9.18–4.29]*	34.78 (7.24)	−8.47 [4.63–12.31]*	0.09	0.76	0.11
	SS	42.79 (6.39)	39.05 (4.70)	−3.73 [6.01–1.45]*	39.05 (4.70)	−8.73 [4.18–8.73]*			
Quality of life									
PCS-12	PNF	36.45 (6.56)	46.40 (6.44)	9.93 [6.34–13.53]*	47.26 (6.29)	10.80 [6.53–15.06]*	0.08	0.77	0.002
	SS	45.33 (3.84)	45.53 (6.19)	10.19 [7.36–13.02]*	48.04 (7.21)	12.70 [8.12–17.28]*			
MCS-12	PNF	40.29 (15.17)	46.84 (7.89)	6.55 [0.40–12.70]*	45.34 (8.45)	5.05 [3.31–13.45]*	0.22	0.64	0.006
	SS	39.17 (9.20)	44.90 (7.66)	5.73 [0.27–11.19]*	45.31 (11.59)	6.14 [0.32–12.61]*			

CI: confidence interval; MCS: Mental Component Score; PCS: Physical Component Score; PNF: proprioceptive neuromuscular facilitation; SS: static stretching; TSK: Tampa Scale for Kinesiophobia; VAS: visual analogue scale; ANCOVA: analysis of covariance.
*Paired samples *t*-test ($p < 0.05$).
†Significant group × time interaction (ANCOVA, $p < 0.05$).

Functional elbow range of motion for daily living activities and contemporary tasks are defined as 30° to 130° flexion-extension and 50° each of supination-pronation.[3] Loss of elbow flexion range cannot be usually well tolerated because the elbow joint allows the hand to reach every position.[31] This study showed that there was an increase in elbow range of motion following the six-week intervention period and one-month follow-up in both groups. This is not a surprising result because a recent systematic review pointed out that a three- to eight-week stretching intervention leads to an increase in the extensibility and tolerance to greater tensile force, thereby gaining a range of motion in joint.[32]

Active range of motion of elbow reached and resumed that of functional range motion of elbow following the six-week intervention period and one-month follow-up in both groups, but the proprioceptive neuromuscular facilitation stretching group showed slightly better improvement in the elbow flexion range of motion with a medium effect size. Yildirim et al.[11] also indicated that proprioceptive neuromuscular facilitation stretching and Mulligan traction straight leg raise technique are superior to static stretching in terms of increasing in hip flexion range of motion. In addition, Sharman et al.[27] reported that proprioceptive neuromuscular facilitation stretching and static stretching are effective at enhancing the range of motion, but proprioceptive neuromuscular facilitation stretching provides a greater improvement and gain in the range of motion may occur quicker than that of static stretching. This might be explained by the autogenic inhibition that refers to a reduction in excitability of a target muscle along with target muscle lengthening and that occurs as a result of the static contraction of the stretched target muscle.[7,27] However, it should be noted that this difference can be based on the small sample size of this study.

Elbow pain is one of the most common complaints after an elbow fracture. It exacerbates by activity, especially activities involving elbow flexion-extension and forearm rotation beyond the existing elbow range of motion.[2,33] The magnitude of improvement in pain was clinically important in both groups, as noted by within-group differences in VAS which was greater than the minimal clinically important difference of three points in this study.[34] Besides, the participants in the proprioceptive neuromuscular facilitation stretching group showed a slightly greater improvement in pain intensity with a medium-large effect size. This can be related to the gate control theory which is one of the identified theoretical mechanisms of proprioceptive neuromuscular facilitation stretching. It is argued that a large force and stretch that is produced in the elongated muscle is sensed as noxious stimuli.[7] The other explanation might be associated with submaximal voluntary isometric contraction component of proprioceptive neuromuscular facilitation stretching, as it is concluded that low-intensity and long-duration isometric contractions lead to an analgesic response.[35] However, this finding should be confirmed on a larger group of people to come to a definitive conclusion.

This is the first study in which the structured exercise programme for posttraumatic stiffness of the elbow is described and the effectiveness of different stretching techniques is compared in elbow stiffness after a treated elbow fracture in the literature. However, this study has some limitations that should be highlighted. First, the assessment of outcome measures was performed at baseline, after a six-week intervention and one-month follow-up by the physical therapist who was not kept blind to allocation. Second, there was a difference between stretching protocols with respect to both duration of stretching. However, optimal stretch duration of both stretching techniques was preferred to achieve the maximum improvement in muscle flexibility. Third, the study sample consisted of patients managed conservatively or surgically followed by a period of immobilization with casting or splinting after elbow fracture. However, the type of orthopaedic management (conservative or surgery) was used as a covariate for all analysis to eliminate its impact, and the numbers were roughly equal and were dominated by surgical treatment. Finally, this study has a relatively small sample size even though a desired statistical power of 80% is obtained. Thus, the findings of this study should be interpreted with caution because there is much evidence that statistically significant differences found in small trials often disappear when studies are conducted in larger groups of people.

In conclusion, this study obtained that proprioceptive neuromuscular facilitation stretching might be effective with regard to functional improvement, elbow flexion range of motion, pain at rest and during activity in patients with elbow stiffness after a treated elbow fracture. However, it is unclear whether stretching actually provides benefits for patients undergoing conservative treatment because of the small numbers of participants. Therefore, a larger study sample is needed to confirm the findings. Further studies need to be performed to investigate pure effects of different stretching techniques and to investigate whether or not structured exercise is helpful in elbow limitation, thereby promoting evidence-based practice in the rehabilitation of posttraumatic elbow stiffness.

Clinical messages

- A six-week structured exercise programme combined with different stretching techniques, proprioceptive neuromuscular facilitation stretching and static stretching, has benefits in dealing with the problem of stiffness occurring late after fracture.
- A structured exercise programme combined with proprioceptive neuromuscular facilitation stretching provides a slightly greater overall improvement in posttraumatic elbow stiffness.

Acknowledgement

This study has been registered in the ClinicalTrials.gov with registration number NCT03161782.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical approval

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