Thirty Minutes of Positioning Reduces the Development of Shoulder External Rotation Contracture After Stroke: A Randomized Controlled Trial

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ABSTRACT. Ada L, Goddard E, McCully J, Stavrinos T, Bampton J. Thirty minutes of positioning reduces the development of shoulder external rotation contracture after stroke: a randomized controlled trial.Arch Phys Med Rehabil 2005;86: 230-4.

Objective: To determine the efficacy of positioning the affected shoulder in flexion and external rotation to prevent contracture shortly after stroke.

Design: Prospective, parallel-group, randomized controlled trial.

Setting: Four metropolitan mixed rehabilitation units.

Participants: A volunteer sample of 36 subjects (minus 5 dropouts), whose mean age was 68 years and had had their first stroke within the past 20 days.

Interventions: The experimental group received two 30-minute sessions a day, 5 days a week, for 4 weeks, during which the affected upper limb was placed in maximum comfortable external rotation and 90° of flexion. Both the experimental and control groups received up to 10 minutes of shoulder exercises and standard upper-limb care.

Main Outcome Measures: Contracture was measured as the maximum passive shoulder external rotation and flexion of the affected side as compared with the intact side. Measures were taken at 2 and 6 weeks after stroke by an assessor blinded to group allocation.

Results: The 30-minute program of positioning the shoulder in maximum external rotation significantly reduced the development of contractures in the experimental group, compared with the control group ($P=.03$). The 30-minute program of positioning the shoulder in 90° of flexion did not prevent contractures in the experimental group as compared with the control group ($P=.88$).

Conclusions: At least 30 minutes a day of positioning the affected shoulder in external rotation should be started as soon as possible for stroke patients who have little activity in the upper arm.

Key Words: Contracture; Hemiplegia; Randomized controlled trials; Range of motion, articular; Rehabilitation; Shoulder.

CONTRACTURE IS A MAJOR secondary problem after stroke. Immobilization of muscles and periarticular tissues in a shortened position results in permanent changes to their structure—called contractures—that manifest as a decrease in range and an increase in stiffness. Paralysis of the affected upper limb after stroke means that it often rests in the lap, which predisposes muscles and tissues, such as the shoulder extensors, adductors and internal rotators, inferior and anterior capsule, and glenohumeral and coracohumeral ligaments, to shorten. Loss of shoulder flexion,[1-9] abduction,[3,9] and external rotation[1,3,7,10-14] have been documented after stroke. On average, 56% of patients have less than 70° of external rotation[10] and 42% have less than 90° of elevation[8] 3 months after stroke. In addition to the loss of function as a result of loss of range, contracture is associated with pain.[1,3,5,6,8,11,14-16]

Studies with both animal and humans have provided us information about the mechanisms of length-associated changes in muscle and periarticular tissues.[17,18] When a muscle is held in a shortened position, protein synthesis decreases, which leads to a decrease of sarcomere number and connective tissue remodeling and results in a decrease in range and an increase in stiffness. Conversely, when a muscle is held in a lengthened position, there is an increase in protein turnover and synthesis increases, with no connective tissue remodeling. Williams[19] found that holding the muscle in a lengthened position for 30 minutes maintained the sarcomere number in mouse muscle that was immobilized in a shortened position for the remainder of the day. In humans, positioning muscles in lengthened positions for long periods of time is more effective than brief positioning.[20,21]

Paralysis early after stroke often means that a patient's only opportunity to move is during therapy sessions. If patients receive 1 to 2 hours a day of therapy,[22-25] it is likely that about 10 minutes of that time will be devoted to shoulder retraining. This means that therapy alone cannot provide a stimulus of sufficient duration to maintain shoulder range of motion (ROM). Our purpose in this study was to determine whether a program in which at-risk muscles and periarticular tissues were held in a lengthened position would maintain shoulder ROM after stroke. Results of a study by Dean et al[26] were inconclusive as to whether 20 minutes of positioning the affected shoulder in external rotation and abduction twice a day prevented loss of ROM in chronic stroke subjects. Therefore, our research questions were (1) In stroke patients with little or no activity in the upper arm early after stroke, does a 30-minute program of positioning the shoulder in maximum external rotation prevent loss of external rotation? (2) In such patients, does a 30-minute program of positioning the shoulder in 90° of flexion prevent loss of flexion? and (3) Does prevention of contracture in the shoulder result in better upper-limb function for these patients?

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Table 1: Subject Characteristics

	Age (y)		Entry to Study (days since stroke)		Time in Study (d)	
Measures	Exp	Con	Exp	Con	Exp	Con
Mean	70	64	14	14	26	25
SD	7	9	4	3	5	6
Range	58–79	51–79	7–19	6–18	14–30	14–29

Abbreviations: Con, control; Exp, experimental.

METHODS

Design

The study was a randomized controlled trial. Subjects were measured before and after 4 weeks of participation in a shoulder positioning program consisting of two 30-minute sessions a day 5 days a week. Patients were measured at discharge if their stay was less than 4 weeks. Measurement and positioning was done at separate times to eliminate possible short-term effects of the intervention. An assessor blinded to group allocation carried out measurements.

Participants

Subjects were recruited from the rehabilitation wards of 4 metropolitan hospitals by a therapist blinded to the sequence of group allocation. Subjects were included if they had experienced their first stroke within the previous 20 days, had hemiplegia, were between 50 and 80 years old, and were at risk for developing contracture as a result of having little or no upper-limb function—defined as a score of 0 to 4 on item 6 of the Motor Assessment Scale (MAS) for stroke.[27] There are scoring criteria for each item of the MAS along a 7-point ordinal scale from 0 (worst performance) to 6 (best performance). Subjects were excluded if they already had a shoulder problem that was defined as pain or loss of greater than 20° of intact shoulder ROM in either external rotation or flexion, or if they had cognitive problems that precluded them from participating in the positioning program. Relevant institutional ethics committees approved the experimental procedures and informed consent was obtained before data collection.

The subjects were measured at an average ± standard deviation (SD) of 14±3 days after stroke and centrally randomized into either the experimental or the control group. They were stratified on the basis of MAS item 6 to equalize the groups for level of initial disability. In total, 36 patients agreed to participate and gave their informed consent; 18 were randomized to the experimental group and 18 to the control group. Five subjects withdrew from the study, 3 from the experimental group and 2 from the control group. Their reasons for withdrawing were recurrent stroke, hip fracture, corticosteroid injection of the shoulder, and severe depression. One subject died. Although 7 subjects were discharged before 4 weeks, their data were collected and included in an intention-to-treat analysis. Final analysis, therefore, included data for 31 subjects, (15 experimental, 16 control) who had been in the study an average of 25±5 days. The experimental group was comprised of 9 women and 6 men, 6 with right hemiplegia and 9 with left hemiplegia. The control group was comprised of 9 women and 7 men, 4 with right hemiplegia and 12 with left hemiplegia. Age, days since stroke, time in the study (table 1), and initial upper-arm function (table 2) were similar between the groups.

Intervention

Intervention for the experimental group consisted of two 30-minute sessions of shoulder positioning. In 1 position, the subject was supine, with the shoulder at 45° of abduction and in maximum external rotation (fig 1A). In the other position, the subject sat at a table, with the shoulder at 90° of shoulder flexion and 90° of elbow flexion so that both the single joint extensors (latissimus dorsi) and the multijoint extensors (triceps brachii) were lengthened (fig 1B). Positioning was done at approximately the same time each day. Generally, the flexion positioning was carried out in the morning, after breakfast and showering, and before therapy sessions began. The external rotation positioning was conducted in the afternoon during the subjects' rest period. Subjects were checked frequently to ensure they were not in discomfort and, where possible, a call button was placed within easy reach to summon assistance if needed. In addition, shoulder therapy was standardized so that both groups received up to 10 minutes of shoulder exercises and routine upper-limb care such as the provision of slings and supports.

Outcome Measures

Maximum passive shoulder external rotation was measured by using the procedure described by Andrews and Bohannon.[10] A fluid-filled gravity goniometer was attached to the anterior distal third of the forearm. The shoulder was abducted to 45°, the elbow was flexed to 90°, with the forearm in neutral and positioned perpendicular to the bed. The hand was moved firmly toward the bed, so that the shoulder was in external rotation, and held for a few seconds. It was then released so that the arm was maintained in external rotation solely by the weight of the forearm (gravity) and the degree of passive external rotation was then recorded. Maximum passive shoulder flexion was measured by using a fluid-filled gravity goniometer that was attached to the posterior aspect of the humerus, midway between the olecranon process and the head of the humerus. The humerus was moved to end of range flexion and held for a few seconds. The arm was then released and main-

Table 2: Mean Scores and Change Scores of All Outcome Measures for the Experimental Group (n=15) and the Control Group (n=16)

	Pretest		Posttest		Posttest-Pretest	
Outcome Measures	Exp	Con	Exp	Con	Exp	Con
Max passive ER (deg)	71.0±10.5	74.3±11.8	64.9±11.4	56.4±21.5	−6.1±11.2	−17.9±19.6
Contracture ER (% intact)	8.5±10.9	2.1±9.1	15.8±15.3	25.9±25.3	7.3±14.8	23.8±24.9
Max passive F (deg)	158.5±12.7	164.3±13.5	146.8±13.7	155.3±16.6	−11.7±13.7	−9.0±13.0
Contracture F (% intact)	3.4±5.8	2.5±5.6	10.5±8.0	7.9±7.8	7.0±8.1	5.4±7.8
Item 6 MAS (score 0–6)	0 (1)	0 (0)	1 (2)	0 (1.5)	1 (2)	0 (1)

NOTE. Values are mean ± SD or median (interquartile range).
Abbreviations: ER, external rotation, F, flexion; Max, maximum.

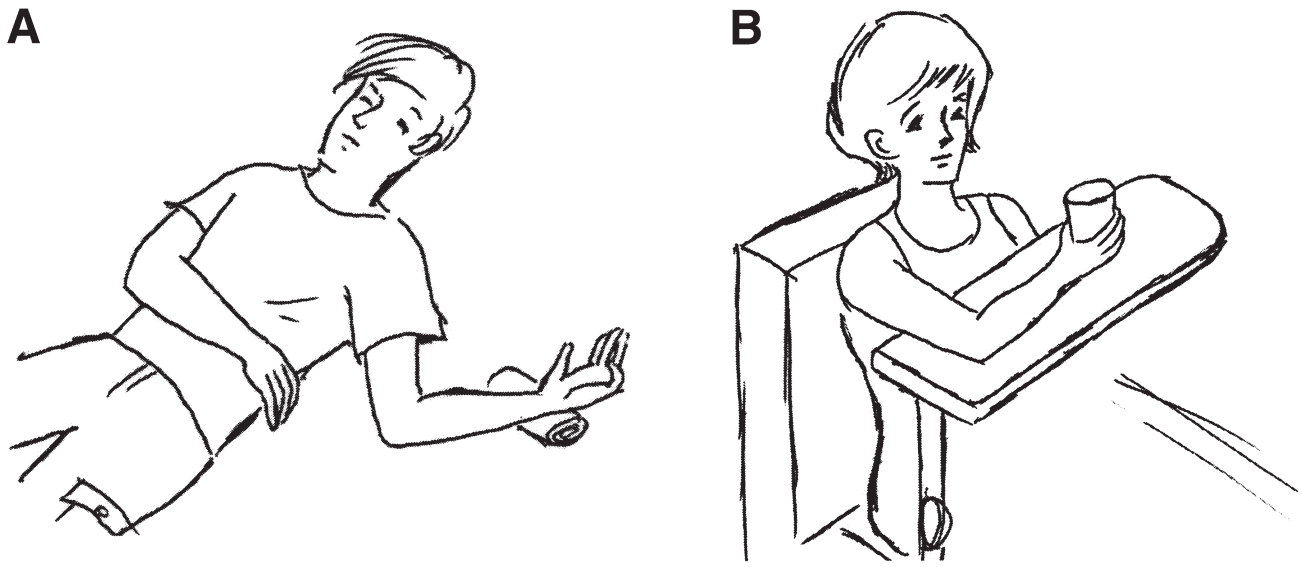

Fig 1. (A) Position for maintenance of shoulder external rotation range. Subjects were positioned supine with the affected shoulder abducted to 45° and the elbow flexed to 90° and placed in maximum comfortable external rotation, with towels or pillows to support the forearm. (B) Position for maintenance of shoulder flexion range. Subjects sat with the affected upper-limb resting on a table, with the shoulder at 90° of flexion, the elbow at 90° of flexion, and the forearm in neutral (mid) position with the hand resting around a cylindrical object. When necessary, sandbags were used to maintain this position.

tained in flexion solely by its weight (gravity) and the degree of passive flexion recorded. Pain experienced during the measurement was recorded. Measures of both the affected and intact shoulder were collected so that any change could be defined as a contracture by comparing the affected side to the intact side.

Function was also assessed. Item 6 of the MAS provides a measure of upper-limb function related specifically to the upper arm. Scores were assigned from 0 to 6; 0 equals no activity and 6 is the maximum score possible.

Data Analysis

The data provided variables for maximum passive external rotation and flexion for both the affected and intact shoulder and the score on item 6 of the MAS before (pretest) and after intervention (posttest). Loss of ROM was converted to contracture by subtracting maximum passive range of the affected shoulder from that of the intact shoulder. We then divided the remainder of that subtraction by the maximum passive ROM of the intact shoulder and converted the quotient to a percentage. There were 2 factors: group and time, with repeated measures on the time factor. To determine whether the positioning program had an effect, we used 2-way analyses of variance with repeated measures for the parametric data and we used the Kruskal-Wallis test for nonparametric data. We used the chi-square test to assess whether pain was more frequent in the experimental group than in the control group. We used the Pearson correlation coefficient to test for a relation between shoulder ROM and upper-arm function. The data are described as means and SDs, and effect sizes and 95% confidence intervals (CI) are presented.

RESULTS

Contracture

By posttest, loss of shoulder external rotation range was significantly greater ($F_{1,29}=4.2$, $P=.05$) in the control group than in the experimental group (fig 2A). The result was the same if the loss of ROM was expressed as a contracture (ie, loss as a percentage of intact range). By posttest, the control group had developed a significantly larger internal rotator contracture than the experimental group ($F_{1,29}=4.9$, $P=.03$). In addition, there were fewer subjects with pain on maximum passive shoulder external rotation in the experimental group (33%) than in the control group (50%) by posttest, but this difference was not significant ($P=.55$). Table 2 shows group means and SDs.

In contrast, by posttest, there was no difference ($P=.58$) in the loss of flexion between the control and the experimental groups (fig 2B) nor had any greater contracture developed ($P=.88$). In addition, the same numbers of subjects ($P=.92$) had pain on maximum passive shoulder flexion in the experimental group (40%) as in the control group (38%) by posttest. Again, table 2 shows group means and SD.

Function

Both groups showed small improvements in the function of the upper arm that did not differ significantly from each other ($P=.37$). Table 2 shows the group medians and interquartile range. Furthermore, there was a moderate correlation between change in ROM and change in function for both external rotation ($r=.37$, $P=.04$) and flexion ($r=.34$, $P=.06$), that is, the less ROM loss, the greater gain in function.

Compliance to Intervention

Adherence to the protocol, which was good, was not perfect. On average, subjects received 84% of the intended positioning. The main reason for noncompliance with the protocol was that subjects were off the ward at the time positioning therapy was scheduled.

DISCUSSION

This study's major finding is that implementing the positioning program described here early after stroke for people who

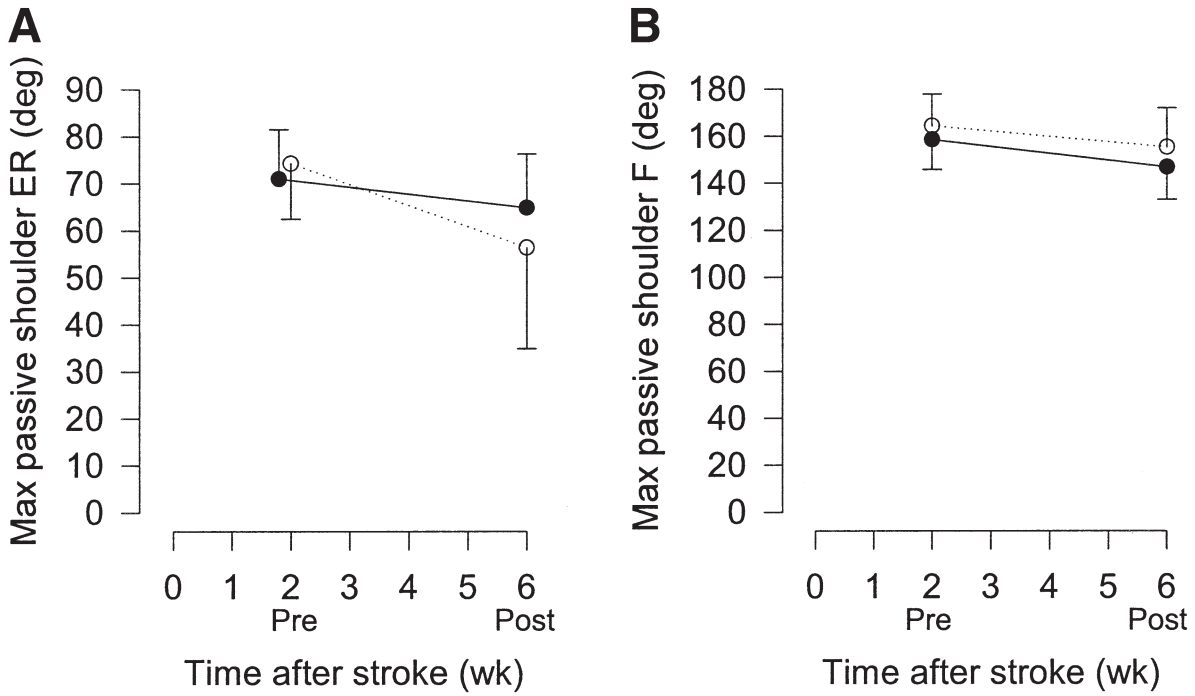

Fig 2. Means and SDs for the experimental group (closed circles) and control group (open circles) at pretest and 4 weeks later at posttest for (A) maximum passive shoulder external rotation (*P*=.05) and (B) maximum passive shoulder flexion (*P*=.58).

have little or no upper arm activity inhibits the development of external rotation but not of flexion contracture. In addition, the partial prevention of external rotation contracture had no effect on upper-arm function, although there was little recovery of function in either group during the 4-week intervention period.

This is the first study to show a significant effect of positioning on the prevention of contracture. Thirty minutes of positioning with the shoulder in 45° of abduction and maximum external rotation prevented 12° (95% CI, 0°–24°) of loss of shoulder external rotation, which translates into the prevention of a 17% contracture (95% CI, 1%–32%). This is arguably a clinically significant result. Furthermore, the result is diluted by the inclusion of 8 subjects who were discharged before the 4-week intervention period ended. Had these subjects been excluded from the analysis, the effect would have been even more striking—prevention of 18° (95% CI, 4°–33°) of loss of shoulder external rotation or a 25% contracture (95% CI, 7%–43%).

Our findings are in line with expectations created from studies with animals of contracture intervention. Williams[19] found that 30 minutes of maintaining the muscle in a lengthened position retained the sarcomere number in mouse muscle that was immobilized in a shortened position for the remainder of the day, whereas 15 minutes every 2 days in that position did not. In our study, 30 minutes was enough to prevent two thirds of the contractures developed in the control group, that is, there was partial prevention of contracture. It appears from other studies with humans that the longer the duration that the contracture has been present and the larger the magnitude of contracture, the longer the positioning time needed. For example, Dean et al[26] used two 20-minute positioning sessions in an attempt to maintain shoulder external rotation in subjects who were twice as long after their strokes as stroke subjects in the current study. In addition, Dean's subjects started with only 57° of external rotation range, compared with 73° our patients, which itself was 5° less than in the intact shoulder. The positioning program did not produce significant results, but their study was underpowered and was therefore inconclusive. Positioning muscles in lengthened positions for more than 2 consecutive hours[20,21] is effective in reducing long-term contracture, whereas such positioning for 30 minutes is not.[28,29] Taken together, these findings suggest that positioning should be started as early as possible after stroke and that the program should be extended. Given that patient compliance in our study was good, 45 minutes of positioning should be feasible as a routine intervention in the clinic.

Animal studies suggest that positioning closest to maximum range has the greatest effect on contracture. Herbert and Balnave[30] found that the shorter the position of immobilization, the greater the loss of muscle length in rabbits. This may explain why, in our study, 30 minutes of positioning with the shoulder in 90° of flexion did not prevent any more loss of flexion in the experimental group than in the control group. In contrast to external rotation, the maximum position in flexion was about 70° off full range maximum. Lying with the arm above the head in maximum flexion may have prevented the flexion contracture that developed; however, it is questionable whether a 6% contracture is so clinically significant as to be worth preventing. Nevertheless, the findings from Herbert and Balnave[30] suggest that positioning in nonmaximum lengths should still have an effect, albeit a reduced one. In our study, patients spent the time that they were not being positioned in maximum external rotation with the arm in near full internal rotation with it either resting in the lap or supported in a hemisling to prevent subluxation. If a lapboard or arm trough were to replace the hemisling in preventing subluxation, the forearm could rest pointing straight ahead, thereby positioning the shoulder in neutral rotation for most of the day rather than in internal rotation. This may be an effective way to prevent shoulder external rotation contracture; however, this possibility needs to be tested against the effects of increasing the duration of positioning.

Animal studies indicate that alterations to muscle length are not dependent on an intact nerve supply. Goldspink et al[31] found that mouse muscles, when denervated and immobilized in the shortened position, behave in the same way as immobilized muscles and shed sarcomeres. Although the muscles in our subjects were not denervated, patients in both groups had very low levels of upper-arm function both at the beginning and the end of the study. External rotation contracture as a result of the positioning program, therefore, was partially prevented even in paralyzed or very weak shoulder muscles.

Finally, it is worthwhile to address the issue of pain. Clinicians are sometimes reluctant to introduce a positioning program after stroke because of the perception that positioning can cause pain by overstretching the surrounding tissues. In our patients, however, the arm was carefully supported in maximum comfortable external rotation without undue force being applied to the shoulder. Six weeks after stroke, this position caused no more pain to the experimental group during maximum passive external rotation of the shoulder joint than it did to the control group. This suggests that this position can be used with confidence.

CONCLUSIONS

We recommend that stroke patients with little upper-limb function undergo a program of positioning the affected shoulder in maximum comfortable external rotation at least 30 minutes a day. The program should be commenced as soon as possible after the stroke.

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