Clinical Rehabilitation 2006; **20:** 656–667

Contracture preventive positioning of the hemiplegic arm in subacute stroke patients: a pilot randomized controlled trial

LD de Jong Rehabilitation Centre 'de Vogellanden', Zwolle, The Netherlands, **A Nieuwboer** Faculty of Physical Education and Physiotherapy, Department of Biomedical and Rehabilitation Sciences, University of Leuven, Belgium and **G Aufdemkampe** University of Professional Education, Faculty of Health Care, Research Department of Health and Lifestyle and Department of Physical Therapy, Utrecht, The Netherlands

Received 9th September 2005; returned for revisions 21st November 2005; revised manuscript accepted 3rd January 2006.

Objective: To investigate the effectiveness of a contracture preventive positioning procedure for the hemiplegic arm in subacute stroke patients in addition to conventional physio- and occupational therapy.
Design: A single-blind pilot randomized controlled trial.
Setting: Inpatient neurological units from three rehabilitation centres in the Netherlands.
Subjects: Nineteen subacute stroke patients (minus two drop-outs) with a severe motor deficit of the arm.
Interventions: All subjects underwent conventional rehabilitation care. Nine subjects additionally received a positioning procedure for two 30-min sessions a day, five days a week, for five weeks.
Main measures: Passive range of motion of five arm movements using a hydrogoniometer and resistance to passive movement at the elbow using the Ashworth Scale. Secondary outcome measures were pain at the end range of passive motions, the arm section of the Fugl-Meyer Assessment and Barthel Index scores for ADL-independence. Outcome measures were taken after five weeks and additional measurements after 10 weeks by two assessors blinded to group allocation.
Results: Comparison of the experimental ($n = 9$) with the control subjects ($n = 8$) after five weeks showed that additional positioning significantly slowed down development of shoulder abduction contracture ($P = 0.042$, -5.3 degrees versus -23 degrees). No other differences were found between the groups.
Conclusions: Applying a contracture preventive positioning procedure for the hemiplegic arm slowed down the development of shoulder abduction contracture. Positioning did not show significant additional value on other outcome measures. Since the sample size was small, results of this study need future verification.

Address for correspondence: Lex D de Jong, Rehabilitation Centre 'de Vogellanden', Department of Physiotherapy, PO Box 1057, 8001 BB Zwolle, The Netherlands.
e-mail: l.de.jong@vogellanden.nl

© 2006 SAGE Publications 10.1191/0269215506cre1007oa

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

Introduction

Hemiplegic shoulder pain is one of the most frequent complications after stroke.[1–5] Reviews of the literature[6–9] provide an overview of the different impairments of the shoulder joint and summarize the most effective therapeutic interventions to prevent hemiplegic shoulder pain. One of the factors associated with shoulder pain seems to be the loss of shoulder range of motion (ROM).[2,4,5,10]

Poststroke contractures, as reflected by the loss of range of motion, are not surprising since increasing evidence supports the hypothesis that immobility after stroke is associated with changes in muscle due to adaptive mechanical and morphological changes in muscle fibres.[11,12] The proportion of patients with contracture in the hemiplegic arm approximately five months post stroke was reported to be as high as 54%.[13] In conjunction with contracture, resistance to passive movement[14] and spasticity develops in some patients.[13] Spasticity was found to be present in 26% of acute hemiparetic patients and in 28% three months after stroke in the study by Sommerfeld *et al*.[15] Spasticity (or more specifically, hypertonus) seems to be another cofactor in the development of hemiplegic shoulder pain.[6] It is related to a decrease in joint passive range of motion[16] and correlates both to motor impairments[15,17] and limitations in activities of daily living (ADL).[18]

Considering the above discussed impairments in and around the hemiplegic shoulder it is hypothesized that prevention of contracture[11,12,14,19] and maintaining an optimal pain free range of joint motion[6] is an important therapeutic intervention in stroke rehabilitation. Several authors suggest and describe different methods to prevent contracture (i.e. different positioning procedures).[11,20]

Recently, Ada *et al*.[21] showed for the first time that upper-limb positioning prevented shoulder external rotation contracture. However, questions remain as to whether recovery of selective arm movements, spasticity, pain and independence in ADL were affected by this intervention. Therefore, the present pilot trial addressed the following questions: Does a positioning procedure for the hemiplegic arm prevent (1) contracture as reflected by a decrease in passive range of motion and (2) increased resistance to passive movement. Second, does a positioning procedure have an effect on pain, motor performance of the arm and independence in ADL.

Methods

Study design

A single-blind randomized controlled, multicentre trial was designed to investigate the effectiveness of a well-defined positioning procedure for the hemiplegic arm in subacute stroke patients. Rather than the positioning procedure(s) used in previous studies by Dean *et al*.[22] and Ada *et al*.[21] we additionally applied stretch to the elbow flexors. The study was approved by the local medical ethics committee. All subjects gave written informed consent prior to participation.

Participants/subjects

Using a sampling method of convenience, subjects were recruited from three rehabilitation centres in the Netherlands (Apeldoorn, Doorn and Zwolle). All stroke patients admitted between March 2003 (one centre participated as from January 2004) and January 2005 were initially screened by a physician.

Subjects had to meet the following inclusion criteria: (1) first ever stroke as defined by the World Health Organization[23] and maximally 12 weeks post stroke; (2) a medial cerebral artery stroke, established by means of computerized tomography/magnetic resonance imaging (CT/MRI); (3) no premorbid impairments of the affected arm; (4) no severe shoulder pain; (5) no use of antispasticity drugs; (6) no use of pain-reducing drugs except for paracetamol, (7) no planned date of discharge and (8) able to give written informed consent. Subjects with fair to good recovery of the arm (as defined by Brunnstrom's stages of recovery 4, 5 or 6[24] and judged by the physician) were excluded. Patients who met the inclusion criteria were then referred to a physiotherapist, who administered tests to exclude patients with (9) severe neglect (a difference of more than three O's on the letter cancellation test,[25] severe loss of position sense (scores 2 and 3 on the Thumb Finding Test[26,27]) and cognitive impairment scoring lower than 23 points on the

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

Mini-Mental State Examination.[28–30] Subjects with aphasia that could not answer the questions of the Mini-Mental State Examination were tested by means of the language comprehension subitems of the Akense Afasie Test[31] (minimum 67 points). Finally, patients who were able to prevent contracture by producing voluntary movement, having a Fugl-Meyer arm score of more than 18 points on the shoulder/elbow/forearm subscales,[32] were excluded.

Primary outcome measures

Primary outcome measures were (1) passive range of motion using a masked fluid-filled goniometer (MIE Medical Research Ltd., Leeds, UK) and (2) resistance to passive movement using a Dutch translation of the original 5-point Ashworth Scale.[33]

Passive range-of-motion measurements

For standardization purposes of the passive range of motion testing procedures the assessors were trained beforehand,[34,35] shoulder abduction was applied during several shoulder movements[34,36,37] and two raters were used simultaneously. The first rater carried out one 'warming-up' movement prior to the actual passive movement, the second rater measured the maximum range with a masked goniometer. Inter-rater reliability of the measurement protocol was explored simultaneously. Intraclass correlation coefficients (ICC type 3,1) were calculated for three different datasets, representing the three different evaluations with respectively 18, 13 and 12 subjects. ICCs were high, ranging between 0.78 and 0.99 (detailed procedures and results will be published elsewhere).

Ashworth grading of resistance to passive movement

Reliability of the original Ashworth Scale in stroke subjects was established for the elbow flexors.[38] We developed and used a Dutch translation of the original Ashworth Scale and simultaneously explored the interrater reliability of this translation. Agreement between our two raters when rating the resistance to passive extension of the elbow during the three different evaluations was fair to moderate (percentages of agreement between 67% and 83%, weighted kappa ranging from 0.484 to 0.773). The Ashworth gradings were administered according to the recommendations of Bohannon and Smith[39] and Koolstra *et al*.[40]

Secondary outcome measures

Secondary outcome measures were (3) pain, (4) motor performance of the hemiplegic arm and (5) independence in ADL. Subjects were asked to report if they felt pain at the end range of each passive motion (0 = no pain, 1 = pain). Motor performance was assessed using the 66-point arm section of the Fugl-Meyer Assessment,[32] a test that is both valid[41,42] and reliable[42–45] and assesses the subject's reflexes, the ability to perform 21 different volitional arm movements and co-ordination on an ordinal scale. Independence in ADL was assessed using a validated and reliable Dutch translation of the Barthel Index.[46]

Sample size

A pretrial power analysis was conducted using published data of shoulder external rotation range of motion of the involved shoulder joint in hemiplegic people.[2,4,10,37,47,48] When a power of 80% was used with a standard deviation of 20 degrees and a significance level of 0.05 (two sided), 17 participants were required for each group.

Procedure

Subjects were randomly assigned to one of the two groups using opaque, sealed envelopes containing leaflets with either a capital A (experimental group) or a capital B (control group). Anticipating a patient drop-out of 10%, a total of 38 envelopes (19 As, 19 Bs) were distributed over three separate boxes to make sure that both groups were evenly distributed over both arms of the study. An independent person carried out the randomization procedure. The envelopes were shuffled and drawn blindfolded. Treatment was initiated immediately after baseline measurement and within one week of the randomization procedure. Outcome measurements were taken five weeks later. Final measurements took place 10 weeks after baseline measurements. The same two raters, unaware of group allocation and not involved in the treatment of subjects, carried out all the measurements. Blinding was achieved by reminding the subjects before every measurement

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

that they should not reveal allocation to the observers.

Intervention: the positioning procedure

All subjects received 'conventional' rehabilitation treatment according to their clinical need as prescribed by the subject's primary care rehabilitation physician. Additionally, the subjects allocated to the experimental group were asked to carry out the prescribed positioning procedure for five weeks, twice a day for half an hour on weekdays (a total of 25 h in five weeks). Subjects still admitted after five weeks were asked to participate for another five weeks for follow-up purposes. Positioning was carried out by the nursing staff under supervision of trained research physical therapists who instructed how the positioning procedure should be carried out. Care was taken that while moving the arm into position, the shoulder was moved with sufficient external rotation to avoid impingement or damage to the rotator cuff muscles. The arm was positioned with as much shoulder abduction, shoulder external rotation, elbow extension and supination of the forearm as the subject could endure without any pain. The arm was always supported by a pillow and, if necessary, held in position with a sandbag (Figure 1). Patients were instructed not to change the position of the trunk to keep the m. pectoralis major elongated. Nursing staff registered whether the procedure was carried out as prescribed and noted possible deviations. Subjects allocated to the control group received no additional therapy or positioning procedures.

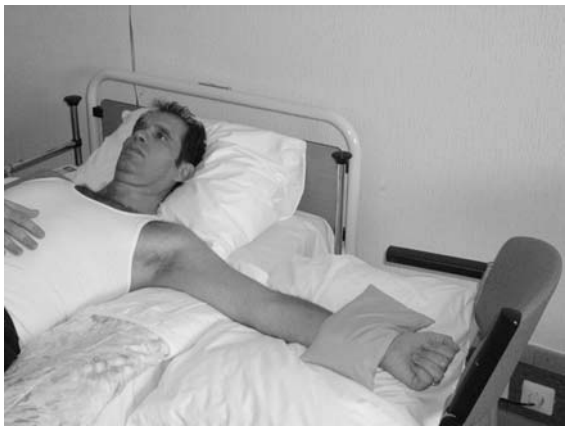

Figure 1 The experimental positioning procedure.

'Contents of treatment sessions'

To document the contents of each physio- and occupational therapy session during the 10 weeks of the experiment, therapists were asked to complete a checklist after every therapy session. The checklist was based upon the International Classification of Functioning, Disability and Health (ICF) of the World Health Organization.[49] By keeping this sort of therapy diary, possible confounding effects of the type and amount of (movement) therapy for the arm were recorded.

Statistical analysis

Ratio-level characteristics of subjects in the experimental and control group were compared using a Student's t-test and nominal level characteristics by means of a chi-square test. All primary and secondary outcome measures were compared at baseline and at five weeks between groups using the Student's t-test (range of motion), Mann–Whitney U-test (Ashworth Scale, Fugl-Meyer Assessment, Barthel Index) and a chi-square test (pain score). One subject from the experimental group (who became too ill to participate any further) and one from the control group (who developed severe shoulder pain and refused further measurements) were not included in the analyses because of drop-out before the five week measurement (Figure 2). Results of the 10-week measurements between the groups were not analysed statistically due to the small sample size and high drop-out rate. All statistical procedures were carried out using SPSS for Windows (version 10.0.5). Level of significance was set at $P = 0.05$.

Results

Figure 2 shows the flow of subjects through each stage of the trial. Half of all eligible subjects were judged as already having reached Brunnstrom's fourth stage of recovery on admission, and were thus excluded. Eventually, only 19 subjects met all inclusion criteria and were randomly assigned to the experimental group ($n = 10$) or the control group ($n = 9$). The nine men and eight women who

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

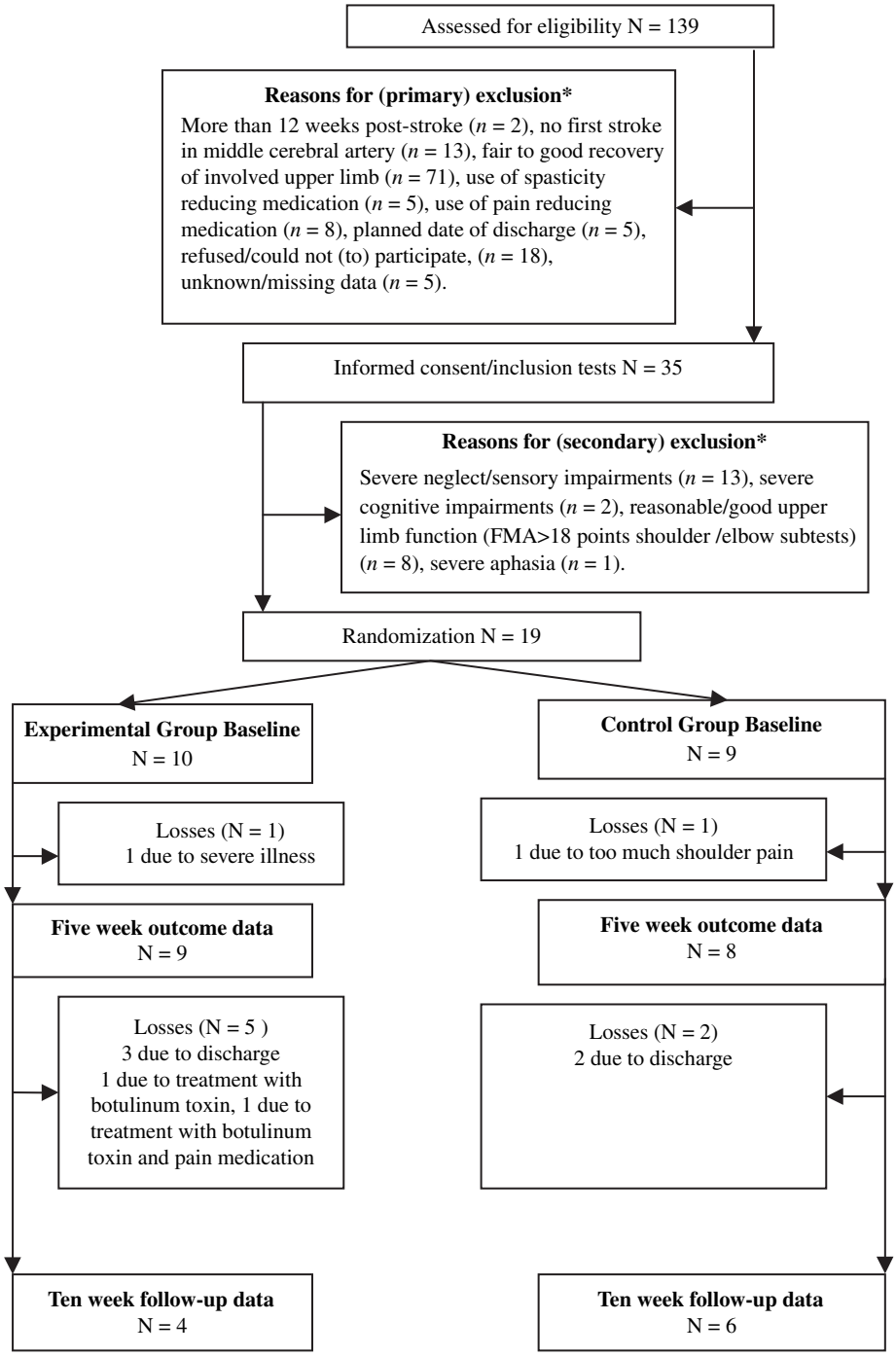

Figure 2 Flow of subjects through each stage of the trial from initial screening by rehabilitation physician to outcome measurement. *If subjects were excluded for more than one reason all reasons were mentioned separately.

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

completed the study were between 36 and 63 years of age. Eleven out of 17 subjects had an affected left side (right hemisphere). Subjects from the experimental group started to use the positioning procedure around a mean (SD) of 35.7 (8.2) days post stroke. There were no differences between the groups with respect to these characteristics.

As shown in Table 1, both groups received a comparable total amount of time spent on physio- and occupational therapy. The experimental group received more physiotherapy and less occupational therapy for the hemiplegic arm after five weeks, but the differences were not statistically significant. The nine subjects from the experimental group had the hemiplegic arm positioned for an average of approximately 20 hours (80% compliance to intervention).

Five-week outcome measurements

Mean passive range of all motions were comparable in both groups at entry into the study (Table 2). It is of note that the shoulder external rotation and flexion ranges tended to be larger in the experimental group, but these differences were not significant. In the course of the first five weeks a clear decrease was seen in the range of motion of both groups, especially in the shoulder movements. After five weeks, shoulder abduction range of motion was significantly greater in the experimental group ($P = 0.042$). Table 2 also shows that none of the other movement directions were significantly different between the groups.

Table 3 shows that the median Ashworth gradings were not different between the groups on entry into the study ($P = 0.60$). Despite a slight increase in both groups after five weeks, the differences between the groups did not reach significance ($P = 0.917$). Subjects from the experimental group started out with higher median scores on the Fugl-Meyer Assessment than the controls (16 versus 8.5 points), but this difference was not significant between the groups. After five weeks the subjects from the experimental group improved their ability to make selective movements of the hemiplegic arm. The control group on the other hand hardly showed any improvements at all. The difference between the groups was significant ($P = 0.038$). Both groups showed improvements in independence in ADL during the five weeks of participation. Barthel Index scores did not differ significantly at entry of the study or after five weeks. Of all participating subjects, approximately 65% reported pain at the end range of the shoulder movements and 35% of the elbow and forearm movements. There were no significant differences between the groups at this point. The pain at end of motion the subjects reported in the elbow and forearm hardly changed over the first five weeks, but increased for the shoulder movements to approximately 76% of the subjects. Again, there were no significant differences between the groups.

Ten-week measurements

Having participated for five weeks in the primary study, 10 subjects were able to participate for a further period of five weeks. During these five weeks, the remaining four subjects

Table 1 Means (standard deviations) of content of treatment sessions and time spent in the positioning procedure at five weeks

	At five weeks		
Variable	EXP ($n = 9$)	CON ($n = 8$)	*P*-value
Total of OT (h)	7 (1.8)	7,1 (3,4)[a]	0.915
Upper limb OT (h)	2.1 (1.7)	3.2 (2.4)[a]	0.282
Total of PT (h)	11.7 (3.2)	11.6 (2.6)	0.930
Upper limb PT (h)	1.6 (1.4)	0.9 (0.6)	0.246
Total of positioning (h)	19.9 (1.9)	0 (0)	< 0.001

EXP, experimental group; CON, control group; OT, occupational therapy; PT, physiotherapy.
[a] Data from one control subject missing.

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

Table 2 Between-group comparisons of the mean passive range of motion (SD) and pre–post change scores after five weeks

	At baseline			At five weeks			Change scores	
Variable	EXP ($n=9$)	CON ($n=8$)	*P*-value	EXP ($n=9$)	CON ($n=8$)	*P*-value	EXP ($n=9$)	CON ($n=8$)
ER	50.9 (24.9)	40.9 (24.5)	0.417	31.7 (24.5)	22.5 (14.7)	0.372	−19.2 (8.4)	−18.4 (15.6)
FLX	143.4 (21.8)	132.9 (26.8)	0.384	120.1 (31.7)	104.1 (27.5)	0.287	−23.3 (19.6)	−28.8 (27.5)
ABD	82.9 (11.6)	84.6 (13.1)	0.775	77.6 (12.9)	61.6 (16.7)	0.042	−5.3 (18)	−23 (13.1)
EXT	93.8 (11.7)	97.4 (8.8)	0.489	94.4 (10.7)	93.4 (11.2)	0.843	0.6 (3.3)	−4 (5.6)
SUP	77.1 (16.1)	72.1 (12.7)	0.493	65.6 (14.5)	69.4 (23.5)	0.688	−11.5 (9.5)	−2.7 (12.7)

ER, shoulder external rotation; FLX, shoulder flexion; ABD, shoulder abduction; EXT, elbow extension; SUP, forearm supination.

Table 3 Between-group comparisons of the medians (interquartile range) of the Ashworth Scale, Fugl-Meyer arm score and Barthel Index and pre–post change scores after five weeks

	At baseline			At five weeks			Change scores	
Variable	EXP ($n=9$)	CON ($n=8$)	*P*-value	EXP ($n=9$)	CON ($n=8$)	*P*-value	EXP ($n=9$)	CON ($n=8$)
AS-EE	1 (1–2)	1,5 (1–2)	0.597	2 (1–2.5)	2 (1–2)	0.917	1 (0–1)	0 (0–0.75)
FMA	16 (8.5–21[a])	8,5 (7.25–22[a])	0.440	25 (15–38)	9 (8–26.5)	0.038	11 (3.5–20)	1 (0–5.75)
BI	13 (8.5–15.5)	14 (11.25–14.75)	0.530	18 (16–19.5)	17.5 (15.25–19.75)	0.770	6 (3–7)	4 (1.5–6.75)

AS-EE, Ashworth grade for elbow extension; FMA, Fugl-Meyer Assessment arm score; BI, Barthel Index.
[a] Three subjects from the experimental group and two from the control group improved to >18 points on the FMA between inclusion test and baseline measurement.

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

from the experimental group received considerably more hours of physio- and occupational therapy and had the hemiplegic arm positioned for an additional average of 19 h (76% of compliance to intervention). Added to the first five weeks, this made a total of 39 h of positioning (78% compliance to total intervention). Ten-week data are shown in Table 4.

Discussion

The aim of this pilot study was to investigate the effectiveness of a contracture preventive positioning procedure for subacute stroke patients with a severe motor deficit of their hemiplegic arm. Despite this therapeutic intervention, both groups showed a clear decrease in the passive range of motion of most arm movements. Applying the positioning procedure for five weeks slowed down the development of shoulder abduction contracture. Descriptive analysis of the 10-week measurements showed further decreases of passive range of motion in both groups. No significant differences were found between the groups with respect to resistance to passive stretch at five weeks. Fugl-Meyer Assessment scores in the experimental group were already larger on entry into the study, a difference that reached significance after five weeks. This trend seemed to continue after 10 weeks for the remaining subjects of the experimental group, but was probably biased by baseline differences. The percentage of subjects with pain at the end range of the shoulder movements remained high in both groups from baseline to 10 weeks. Especially in the first five weeks of the trial the participating subjects of both groups gained more independence of ADL function as indicated by the Barthel Index.

Table 4 Means (standard deviations) of the different variables of the remaining 10 subjects after 10 weeks of positioning

Variable	Experimental group ($n = 4$)	Control group ($n = 6$)
Total of OT (h)	17.2 (6.8)	13.9 (7.6)[a]
Upper limb OT (h)	6.2 (8)	3.2 (2.8)[a]
Total of PT (h)	24.1 (6.7)	20 (3.6)
Upper limb PT (h)	5.2 (3.6)	0.9 (0.7)
Total of positioning (h)	38.8 (5.2)	0 (0)
PROM-ER	26.3 (23.7)	5.17 (5.64)
PROM-FLX	121 (27.8)	89.5 (22.7)
PROM-ABD	76 (16.8)	61.67 (8)
PROM-EXT	102.8 (16.1)	88.33 (6.4)
PROM-SUP	60.3 (17.7)	56.3 (16.4)
AS-EE (median ± IQR)	2 (1.25–2)	1.5 (1–3)
FMA (median ± IQR)	30.75 (40.5–45.75)	10 (8–17.25)
BI (median ± IQR)	20 (18.5–20)	18.5 (15.75–20)

PROM, passive range of motion; ER, shoulder external rotation; FLX, shoulder flexion; ABD, shoulder abduction; EXT, elbow extension; SUP, forearm supination; AS-EE, Ashworth grade for elbow extension; IQR, interquartile range; FMA, Fugl-Meyer Assessment armscore; BI, Barthel Index.
[a] Data from one control subject missing.

One major limitation of this study was that it was underpowered. We aimed to select 34 subacute stroke patients, but after nearly two years the trial had to be terminated because of set time limits, leaving only 19 subjects who met all inclusion criteria. This suggests that the inclusion criteria were too strict. However, most patients were excluded because we considered their arm function as too 'active' for a 'passive' preventive positioning procedure. Therefore, the patients included in this study were representative of the target population, confirming the appropriateness of this inclusion criterion. Since only stroke patients eligible for clinical rehabilitation services were included in this study, people with severe stroke and/or severe cognitive disabilities were excluded, hence reducing the external validity of the study.

Another possible limitation of the study was that the positioning procedure was carried out by several different nurses under the supervision of four physiotherapists trained in carrying out the positioning procedure. Regular checks of the positioning procedure by an independent assessor would have increased the rigour of this methodology. The current procedure however reflected the standard method of working in a Dutch rehabilitation centre. Compliance to the protocol was not perfect (80%) because some subjects went on an early weekend leave.

Prevention of contracture in stroke patients is deemed very important in the stroke rehabilitation literature.[11,20] Dean *et al*.[22] reported unclear effects of a contracture preventive positioning protocol, mainly attributed to limited sample size and insufficient dosage. Ada *et al*.[21] found that 30 min of daily positioning for four weeks

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

significantly prevented shoulder external rotation contracture. Compared with the procedures used by Dean *et al*. and Ada *et al*. we also stretched the elbow flexors using a positioning procedure that was prescribed for 60 min each working day for five consecutive weeks over and above standard physio- and occupational therapy.

As in the study of Dean *et al*., our subjects started the experimental positioning procedure in or around their fifth week post stroke, three weeks later than the subjects in the study by Ada *et al*. Dean *et al*. found a mean decrease in shoulder external rotation of respectively 11 and 14 degrees in the experimental and control groups after six weeks of positioning. Ada *et al*. found decreases of 6.1 and 17.9 degrees respectively after five weeks. In line with those results, our subjects showed not only a 19.2 (experimental group) and 18.4 (control group) decrease in shoulder external rotation, but also decreases in shoulder abduction and flexion. Despite the apparent decreases in the range of motion, shoulder abduction was significantly larger in our experimental group after five weeks. Given the nearly similar positioning procedures to the study of Ada *et al*., no other explanation can be given for the lack of benefit in shoulder external rotation except for the difference in statistical power or the differences in fixation, allowing the weight of the lower arm to pull the shoulder joint into more or less external rotation. Resistance to passive movement of the elbow flexors as quantified by the Ashworth Scale was not influenced by the positioning despite the (submaximal) stretching of the elbow flexors.

Clinical messages

- Preventive positioning of the hemiplegic arm has a small beneficial effect on passive shoulder abduction passive range of motion in addition to conventional physio- and occupational therapy.
- Effects of positioning procedures on spasticity, motor performance, pain and independence in activities in daily life still remain unclear.

In this study, motor performance was assessed by the arm section of the Fugl-Meyer Assessment. The score on this measure represents the capability of making several synergistic movements, and so it is not an objective measure of useful *functional* motor performance. Despite the fact that motor performance recovered significantly more in the experimental group, it is unlikely that the passive stretching procedure alone led to significant differences in motor performance. The experimental group's higher baseline scores possibly emphasized the motor scores after five weeks. The effect of more arm therapy between five and 10 weeks probably biased this difference even more. At the start of the study, nearly 65% of all subjects ($n = 17$) had pain at the end range of shoulder motions. This is in concordance with the findings of other authors.[1,4,5] Five weeks into the study, 76% of all subjects reported pain at end of motion and of the remaining 10 participants after 10 weeks 83% still reported pain. Pain felt at the end range of motion was present and increased in both groups during the trial. It is unlikely that this was caused by the positioning procedure. As no single subject reported an inconvenience during the positioning procedure it seems justified to conclude that this kind of positioning is safe and harmless as long as it is performed within the patient's pain limits.

Fifteen to thirty minutes of daily stretching may be enough for healthy active animal muscles to prevent contracture[50,51] but positioning procedures for hemiparetic arms of stroke patients examined so far at the very most only seem to slow down the development of some contracture(s). To uncover larger significant effects, maybe the positioning procedure should be applied for more than 1 h each day. However, we doubt that this is feasible within a clinical rehabilitation setting because of all the other time-consuming therapeutic activities during the day.

Slowing down the development of contractures using positioning procedures may be a prerequisite for the recovery of arm function, but we argue that combinations of more types of treatment are needed to have more impact on hemiplegic arm recovery. Especially stroke patients with very poor arm function could benefit from combined preventive measures since they have limited abilities to

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

'actively' train their hemiplegic arm. Positioning procedures in conjunction with the use of electrical stimulation, for example, could be one such measure. Future randomized trials with larger sample sizes need to be performed to be able to support either a single- or multimodality treatment hypothesis.

Conclusion

We set out to investigate if a positioning procedure for the severely affected hemiplegic arm prevented contracture as reflected by a decrease in passive range of motion. We found some, but no solid evidence that a five-week positioning procedure slowed down the development of shoulder abduction contracture. Positioning had no clear influence on motor performance of the arm, resistance to passive movement of elbow flexors ('spasticity'), pain at the end range of five different arm motions and ADL-independence. In conclusion, preventive effect of a single-modality positioning procedure in addition to conventional physio- and occupational therapy still remains unclear for patients more than five weeks post stroke.

Acknowledgements

Authors wish to pay gratitude to all patients involved. Special thanks go out to the raters Mireille de Wissel (MRC Aardenburg, Doorn) and Floris Menkveld (Meander Medisch Centrum, Amersfoort). Furthermore we would like to express our gratitude to the trial-coordinating physiotherapists Gerard Hommes, Geralda Kooi (de Vogellanden, Zwolle), Maartje Gebhard (MRC Aardenburg, Doorn) and Miranda van Hooff (Kastanjehof, Apeldoorn), all the (rehabilitation) physicians, physio- and occupational therapists and nursing staff involved in the project. This project was financially supported by the dr. WM Phelps-Stichting voor Spastici.

References

1 Aras M, Gokkaya N, Comert D, Kaya A, Cakci A. Shoulder pain in hemiplegia. Results from a national rehabilitation hospital in Turkey. *Am J Phys Med Rehabil* 2004; **83**: 713–19.
2 Wanklyn P, Forster A, Young J. Hemiplegic shoulder pain (HSP): natural history and investigation of associated features. *Disabil Rehabil* 1996; **18**: 497–501.
3 Braus D, Krauss J, Strobel J. The shoulder-hand syndrome after stroke: a prospective clinical trial. *Ann Neurol* 1994; **36**: 728–33.
4 Bohannon R. Relationship between shoulder pain and selected variables in patients with hemiplegia. *Clin Rehabil* 1988; **2**: 111–17.
5 Bohannon R, Larkin P, Smith M, Horton M. Shoulder pain in hemiplegia: statistical relationship with five variables. *Arch Phys Med Rehabil* 1986; **67**: 514–16.
6 Vuagnat H, Chantraine A. Shoulder pain in hemiplegia revisited: contribution of functional electrical stimulation and other therapies. *J Rehabil Med* 2003; **35**: 49–56.
7 Gardner M, Ong B, Liporace F, Koval K. Orthopedic issues after cerebrovascular accident. *Am J Orthop* 2002: 559–68.
8 Snels I, van der Lee J, Lankhorst G, Beckerman H, Bouter L. Treating patients with hemiplegic shoulder pain. *Am J Phys Med Rehabil* 2002; **81**: 150–60.
9 Turner-Stokes L, Jackson D. Shoulder pain after stroke: a review of the evidence base to inform the development of an integrated care pathway. *Clin Rehabil* 2002; **16**: 276–98.
10 Joynt R. The source of shoulder pain in hemiplegia. *Arch Phys Med Rehabil* 1992; **73**: 409–13.
11 Carr J, Shepherd R. *Stroke rehabilitation*, first edition. Butterworth/Heinemann, 2003.
12 Farmer S, James M. Contractures in orthopaedic and neurological conditions: a review of causes and treatment. *Disabil Rehabil* 2001; **23**: 549–58.
13 O'Dwyer N, Ada L, Neilson P. Spasticity and muscle contracture following stroke. *Brain* 1996; **119**: 1737–49.
14 Pandyan A, Cameron M, Powell J, DJ S, Granat M. Contractures in the post-stroke wrist: a pilot study of its time course of development and its association with upper limb recovery. *Clin Rehabil* 2003; **17**: 88–95.
15 Sommerfeld D, Eek E, Svensson A, Holmquist L, von Arbin M. Spasticity after stroke: its occurrence and association with motor impairments and activity limitation. *Stroke* 2004; **35**: 134–40.
16 Lo S, Chen S, Lin H, Jim Y, Meng N, Kao M. Arthrographic and clinical findings in patients with

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

hemiplegic shoulder pain. *Arch Phys Med Rehabil* 2003; **84**: 1786–91.
17 Katz R, Rovai G, Brait C, Rymer W. Objective quantification of spastic hypertonia: correlation with clinical findings. *Arch Phys Med Rehabil* 1992; **73**: 339–47.
18 Watkins C, Leathley M, Gregson J, Moore A, Smith T, Sharma A. Prevalence of spasticity post stroke. *Clin Rehabil* 2002; **16**: 515–22.
19 Vattanasilp W, Ada L, Crosbie J. Contribution of thixotropy, spasticity and contracture to ankle stiffness after stroke. *J Neurol Neurosurg Psychiatry* 2000; **69**: 34–39.
20 Ada L, Canning C. Anticipating and avoiding muscle shorthening. In Ada L, Canning C eds. *Key issues in neurological physiotherapy*. Butterworth/ Heinemann, 1990: 219–36.
21 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**: 230–34.
22 Dean C, Mackey F, Katrak P. Examination of shoulder positioning after stroke: a randomised controlled pilot trial. *Aust J Phys* 2000; **46**: 35–40.
23 Hatano S. Experience from a multi centre stroke register: a preliminary report. *Bull World Health Organ* 1976; **54**: 541–53.
24 Brunnstrom S. *Movement therapy in hemiplegia: a neurophysiological approach*. Harper and Row, 1970.
25 Beers K. *De o-zoek test*. Stichting Revalidatie Limburg, 2001, 1 November.
26 Lanska D, Kryscio R.'Thumb localizing test' for detecting a lesion in the posterior column-medial lemniscal system. Letter to the editor. *J Neurol Sci* 2000; **174**: 152–53.
27 Hirayama K, Fukutake T, Kawamura M.'Thumb localizing test' for detecting a lesion in the posterior column-medial lemniscal system. *J Neurol Sci* 1999; **167**: 45–49.
28 Agrell B, Dehlin O. Mini Mental State Examination in geriatric stroke patients. Validity, differences between subgroups of patients, and relations to somatic and mental variables. *Aging Clin Exp Res* 2000; **12**: 439–44.
29 Tombaugh T, McIntyre N. The Mini Mental State Examination: a comprehensive review. *J Am Geriatr Soc* 1992; **40**: 922–35.
30 Folstein M, Folstein S, McHugh P. 'Mini-mental state'. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; **12**: 189–98.
31 Graetz P, de Bleser R, Willmes K. *Akense Afasie Test, Handleiding*. Zwets & Zeitlinger, 1992.
32 Fugl-Meyer A, Jääsko L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient. 1: a method for evaluation of physical performance. *Scand J Rehabil Med* 1975; **7**: 13–31.
33 Ashworth B. Preliminary trial of carisoprodol in multiple sclerosis. *The Practitioner* 1964; **192**: 540–42.
34 Chesworth B, MacDermid J, Roth J, Patterson S. Movement diagram and 'end feel' reliability when measuring passive lateral rotation of the shoulder in patients with shoulder pathologhy. *Phys Ther* 1998; **78**: 593–601.
35 Armstrong A, MacDermid J, Chinchalkar S, Stevens R, King G. Reliability of range-of-motion measurement in the elbow and forearm. *J Shoulder Elbow Surg* 1998; **7**: 573–80.
36 MacDermid J, Chesworth B, Patterson S, Roth J. Intratester and intertester reliability of goniometric measurement of passive lateral shoulder rotation. *J Hand Ther* 1999; **12**: 187–92.
37 Andrews A, Bohannon R. Decreased shoulder range of motion on paretic side after stroke. *Phys Ther* 1989; **69**: 768–72.
38 Brashear A, Zafonte R, Corcoran M *et al*. Inter- and intrarater reliability of the Ashworth Scale and the Disability Assessment Scale in patients with upper-limb poststroke spasticity. *Arch Phys Med Rehabil* 2002; **83**: 1349–54.
39 Bohannon R, Smith M. Interrater reliability of a modified Ashworth Scale of muscle spasticity. *Phys Ther* 1987; **67**: 206–207.
40 Koolstra M, Burgers-Bots I, Lemmens C, Smeets C, Kwakkel G. *Klinimetrie na een beroerte*. Nederlands Paramedisch Instituut/VU medisch centrum, 2001.
41 Deakin A, Hill H, Pomeroy V. Rough guide to the Fugl-Meyer Assessment. *Physiotherapy* 2003; **89**: 751–63.
42 Gladstone D, Danells C, Black S. The Fugl-Meyer Assessment of motor recovery after stroke: a critical review of its measurement properties. *Neurorehabil Neural Repair* 2002; **16**: 232–40.
43 Croarkin E, Danoff J, Barnes C. Evidence-based rating of upper-extremity motor function tests used for people following a stroke. *Phys Ther* 2004; **84**: 62–74.
44 van der Lee J, Beckerman H, Lankhorst G, Bouter L. The responsiveness of the Action Research Arm Test and the Fugl-Meyer Assessment scale in chronic stroke patients. *J Rehabil Med* 2001; **33**: 110–13.
45 Sanford J, Moreland J, Swanson L, Stratford P, Gowland C. Reliability of the Fugl-Meyer Assessment for testing motor performance in

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.

patients following stroke. *Phys Ther* 1993; **73**: 447–54.
46 de Haan R, Limburg M, Schuling J, Broeshart J, van Zuylen P. Klinimetrische evaluatie van de Barthel-index, een maat voor beperkingen in het dagelijkse functioneren. *Ned T Geneesk* 1993; **137**: 917–21.
47 Faghri P, Rodgers M, Glaser R, Bors J, Ho C, Akuthota P. The effects of functional electrical stimulation on shoulder subluxation, arm function recovery and shoulder pain in hemiplegic stroke patients. *Arch Phys Med Rehabil* 1994; **75**: 73–79.
48 Linn S, Granat M, Lees K. Prevention of shoulder subluxation after stroke with electrical stimulation. *Stroke* 1999; **30**: 963–68.
49 WHO. *International Classification of Functioning, Disability and Health (ICF)*. World Health Organization, 2001.
50 Williams P. Use of intermittent stretch in the prevention of serial sarcomere loss in immobilised muscle. *Ann Rheum Dis* 1990; **49**: 316–17.
51 Williams P. Effect of intermittent stretch on immobilised muscle. *Ann Rheum Dis* 1988; **47**: 1014–16.

Downloaded from http://cre.sagepub.com at UNIV MAASTRICHT on April 26, 2007
© 2006 SAGE Publications. All rights reserved. Not for commercial use or unauthorized distribution.