Effect of a musculoskeletal based rehabilitation program on stroke related shoulder dysfunctions or pain

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Research context:

A case study was set up to investigate the effect of a musculoskeletal based rehabilitation program in stroke patients on shoulder pain, upper limb functionality, shoulder girdle position and kinematic movement patterns of the scapula.

Shoulder pain is a common problem in stroke rehabilitation and etiology of stroke related shoulder pain is not well known. Therefore it is important to introduce new approaches to handle the pain and to improve the functionality. The searched approaches were from a musculoskeletal point of view because of present dysfunctions in scapular kinematic movement and muscle activation patterns in patients with stroke related shoulder dysfunctions or pain [1]. This rehabilitation program consisted forms of active physical training and forms of passive physical therapy. The active exercises were divided into analytic exercises for scapula setting, trunk control, serratus anterior training and external rotation exercises. This was combined with passive forms of therapy wich focused on capsular stretch and muscle flexibility.

This research contributed to the doctorate of Liesbet De Baets titled ‘Movement and muscle activation patterns of the shoulder girdle in patients with post-stroke shoulder pain’. This is a duo-thesis project that will end in June 2015, performed at the University of Hasselt under the lead of Dr. Van Deun, S. and Dr. De Baets, L.

The study design and method of the study design were determined by the promotor and co- promotor. The co-promotor performed data-acquisition because of her experience in this research area. Master students got the possibility to assist in these assessments of the participants. Furthermore, the students performed analysis of data and described this analysis academically in the form of a case study. Promotor and co-promotor guided these processes and gave advice to improve academic writing skills and illustration methods of data.

This case study aims to provide evidence for a musculoskeletal treatment approach in the rehabilitation of stroke patients with shoulder pain and to provide a starting point for future research.

References:

[1] De Baets et al.; Three-dimensional kinematics of the scapula and trunk, and associated scapular muscle timing in stroke patients: 2015

Abstract:

Purpose: To investigate the effect of a musculoskeletal based rehabilitation program on shoulder pain, upper limb functionality, shoulder girdle position and kinematic movement patterns of the scapula in stroke patients. This case study aims to provide evidence for a musculoskeletal treatment approach in the rehabilitation of stroke patients with shoulder pain and to provide a starting point for future research.

Methods: Four patients were recruited from hospitals located in Belgium. All patients received a musculoskeletal based rehabilitation program. Each patient performed 36 physical therapy sessions, 3 times per week. Measurements were performed at week 0, 6, 12 and a follow-up measurement was performed after 24 weeks.

Results: 4 cases were included with low and moderate upper extremity functionality. All cases showed moderate or good progression on functionality, shoulder pain and amount of scapular lateral rotation. Shoulder girdle position changes were different for each case.

Conclusion: A musculoskeletal based rehabilitation program might be a beneficial addition to the neurologic rehabilitation of stroke patients. Further research is necessary to support this hypothesis.

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Introduction

Shoulder pain is a common problem in stroke rehabilitation, with a reported prevalence between 5% and 84% [1-6]. Almost 75% of stroke patients without shoulder pain show a sufficient independency level, while only 37% of stroke patients with shoulder pain reaches this level [7].

The etiology of post-stroke shoulder pain is not well known. It is associated with soft tissue lesions, impaired motor control and altered peripheral or central nervous system activity [3]. Stroke related shoulder pain is moreover related to the occurrence of adhesive capsulitis (43-77%), shoulder subluxation (44%), rotator cuff tears (22-40%) and shoulder-hand syndrome (16%) [3, 8]. There is furthermore evidence of altered kinematic shoulder movement and muscle activation patterns. More specifically, at the hemiplegic side, a decrease in scapular protraction together with an increased scapular lateral rotation at rest was reported during sagittal plane elevation and abduction[9, 10]. At the glenohumeral joint, a decrease in humeral external rotation during scapular plane elevation was furthermore found at the hemiplegic side [11]. Besides that, stroke patients compensated this with more trunk movements and less shoulder flexion during reaching tasks [12].

In the domain of musculoskeletal rehabilitation, an active treatment approach, focusing on optimizing scapulothoracic and glenohumeral movement patterns, in the rehabilitation of persons with primary shoulder pain and dysfunction has widely been demonstrated to be beneficial [13-15]. For an isolated manual therapy approach, results were not satisfactory compared to other passive techniques like massage, mobilizations with movement, etc. to resolve shoulder dysfunctions in a non-stroke population [16]. The combination of manual therapy and active exercise therapy, however, was reported to be ideal in the rehabilitation of adhesive capsulitis, rotator cuff injuries and supraspinatus tendinopathy [17-19].

In the rehabilitation of post-stroke shoulder pain, an active musculoskeletal exercise approach to optimise kinematic and muscle activation patterns of the shoulder girdle is currently missing. Data was found on the beneficial effect of a daily program of active positional stretches towards abduction, external rotation and flexion of the shoulder to reduce the pain [20]. Resistive arm pull exercises were furthermore linked with a better elbow extension during reaching at the hemiplegic side in stroke patients with shoulder pain and resulted moreover in significantly less motion of the trunk and more motion of the arm during reaching tasks. The reaching movements were also closer to a natural movement pattern [21]. However, results of a complete musculoskeletal approach, including passive capsular glenohumeral mobilizations, muscle stretching and active exercise therapy of the scapulothoracic and glenohumeral joint, is currently not available in the treatment of the painful hemiplegic shoulder.

This study is thus the first to describe the results of such an active musculoskeletal treatment approach for the shoulder rehabilitation of four diverse stroke patients, by means of four case studies. The effect of the musculoskeletal approach on the shoulder pain, scapular movement patterns and functionality of the arm post-stroke is investigated. Thereby, this study wants to provide first evidence for a musculoskeletal treatment approach in the rehabilitation of stroke patients with shoulder pain.

Method

1. Participants

Four stroke patients with post-stroke shoulder pain were included in this study. To be included in this study, they had to experience a first stroke, had to be free of shoulder complaints prior to the stroke, and they had to be between two months to one year post-stroke. They furthermore had to present post-stroke shoulder pain related to the presence of scapular dyskinesia as verified by the scapular assistance test. Patients were excluded for this study if they had neurological disorders other than stroke, a history of trauma or surgery at the upper limb, did not speak Dutch, English or French, or did not understand the instructions.

Patients were recruited from the Ziekenhuis Oost-Limburg (ZOL Lanaken, Belgium). Descriptive characteristics of the four included patients can be found in Table 1.

Table 1: Descriptive characteristics patients

	Date of birth	Age	Date CVA	CVA location	Date pre-maesurement	Weeks post - stroke
Case 1	20/08/1951	62	11/08/2013	ACM left	15/11/2013	12
Case 2	04/02/1964	49	14/11/2013	Capsula interna left	24/02/2013	13
Case 3	10/08/1942	71	22/07/2013	ACM right	22/12/2013	20
Case 4	13/04/1942	71	16/09/2013	Parietal left	13/12/2013	11

CVA: cerebrovascular accident, ACM: Arteria cerebri media

2. Setting

Each patient received a musculoskeletal treatment program lasting for 12 weeks, and which consisted of 3 times 30 minutes treatment per week. At the start, after 6 (18 sessions) and 12 (36 sessions) weeks of treatment and at 24 weeks (follow-up), scapulothoracic movement patterns, pain and upper extremity functionality were evaluated by means of a clinical scapular protocol, the Visual Analogue Scale (VAS) and the Fugl-Meyer (FM), the Action Research Arm Test (ARAT) and the Motor Activity Log (MAL) respectively. Treatment was given by physiotherapists of the hospital, who received an education about the rehabilitation program. All evaluations were performed by a researcher, who was also an experienced physiotherapist.

3. Evaluation

3.1. Clinical Scapular protocol

In order to measure scapular kinematics, a clinical scapular protocol, based on the clinical scapular protocol of Struyf and the clinical scapular protocol of De Baets [22-24], was used. This protocol consisted of (1) observation of winging, tilting, and depression/elevation of the scapula at rest and during an anteflexion movement, (2) static measures of the shoulder girdle position as measured by the pectoralis minor index (PMI), the acromial distance index (AI) and the scapular distance test (SDT), (3) measurement of the amount of lateral rotation at the scapulothoracic joint during different humerothoracic anteflexion angles (0°, 45°, 90°, 135°) using inclinometry. Finally, (4) maximal active anteflexion range of motion (ROM) and (5) the medial rotation test were included to obtain information about the dynamic scapulothoracic control. Below, the different tests are described in more detail.

The presence of winging and tilting of the scapula and the amount of depression/elevation was scored based on a dorsal/lateral inspection, which was performed by an experienced physical therapist. For observation in the resting position, the patient was seated upright and instructed to hold the arm in his anatomical position with the elbow extended and a neutral wrist flexion/extension. The same instructions were given for observation during anteflexion movement. The patient received a score 0 when winging or tilting was not present. The patient received score 1 if winging or tilting was present. The K-value, testing the amount of agreement, for observation of tilting and winging during movement in stroke patients was 0.88, indicating almost perfect agreement. The K-value for observation during rest was rated as good (0,77) [22]**.**

The AI was measured with the patient positioned supine on a table with relaxed arms along the body and the lower arms in pronated position. The acromial angle was localized following a palpation. The distance between this angle and the table was measured using a carpenter. Then this acromial distance (in cm) was divided by the patient's height (in cm) to obtain the AI. The intra-rater intraclass correlation coefficient (ICC) score for the AI was 0,86 in stroke patients, which was rated as high [22]. The minimal detectable change (MDC) for the AI was 1,18 [22].

The PMI was measured with the patient seated upright. The patient was instructed to hold the arms in a relaxed position. The resting length of the muscle was determined by measuring the distance (in cm) between the inferior medial tip of the processus coracoideus and the caudal edge of the fourth rib at its attachment to the sternum. Patients were asked to exhale while performing the palpation and the measurement of the distance. Then this resting length was divided by the patient's height (in cm) to obtain the PMI. The intra-rater ICC score for the PMI was 0,66, which is rated as moderate [22]. The MDC for the PMI was 1,08 [22].

The SDT was measured with the patient seated upright. He was instructed to hold the arms relaxed alongside of the body. The SDT was obtained by dividing the distance in cm between the acromial angle and the spinous process of the third thoracic vertebra in cm by the distance between the acromial angle and the trigonum spina scapulae in cm. The intra-rater ICC score for the AI was 0,81, which was rated as high [22]. The MDC for the SDT was 0,15 [22].

The amount of lateral scapular rotation during glenohumeral anteflexion was scored using an inclinometer. The inclinometer was manually aligned parallel to the scapular spine. The arm of the patient was elevated passively by a second physiotherapist. The test was scored in four positions. The first was at 0° of anteflexion, with the patient's arm in relaxed position alongside of the body. The second position was at 45° of anteflexion, the third position at 90° of anteflexion and the final position at 135° of anteflexion. The intra-rater ICC score at 0° anteflexion was 0,94, at 45° anteflexion 0,88, at 90° anteflexion 0,93 and at 135° anteflexion 0,83. These intra-rater ICC scores were rated as high [22]. The MDC at 0° anteflexion was 4,40°, at 45° anteflexion 4,38°, at 90° anteflexion 4,07° and at 135° anteflexion 9,05° [22].

The maximal active humeral elevation ROM was measured using a goniometer. Patients were seated upright and were instructed to hold the arm in their anatomical position with the elbow extended and a neutral wrist flexion/extension. Then patients were instructed to perform a maximal active humerothoracic anteflexion while holding the elbow extended and the arm in a neutral pronation/supination position. The intra-rater ICC score for the maximal humeral elevation was 0,99, which was rated as very high [22]. The MDC for maximal active humeral elevation was 6,76° [22].

The medial rotation test was performed in supine position with the arm passively supported in 90° glenohumeral abduction in the scapular plane (situated 30° anterior to the frontal plane), and the elbow in 90° of flexion. The patient was instructed to actively perform a glenohumeral internal rotation towards 60° of internal rotation while holding the scapula still. An assessor palpated the caput humeri and processus coracoideus to evaluate the motion of the caput humeri and motion of the scapula. Dynamic control was scored as limited (score 1) when there was more than 4 mm anterior humeral motion or when there was more than 6 mm scapular motion. Dynamic control was scored as appropriate (score 0) when there was less or no humeral or scapular motion then mentioned above. The K-value, testing the amount of agreement for this test, was rated as good (0,73) [22].

3.2. VAS

The VAS scale was used to assess shoulder pain during arm movement. It is a subjective scale to report the amount of pain on a scale from zero to ten. The patients reported these scores themselves during the performance of an active arm anteflexion.

3.3. Fugl-Meyer, ARAT and MAL

The upper limb motor section of the Fugl-Meyer Assessment (maximum 66 points) and a subscore of the proximal shoulder and elbow items of the upper limb motor section of this Fugl-Meyer scale (maximum 36 points) were chosen to rate the functional physical impairments, covering the functional level of the International classification of functioning, disability and health (ICF) scale [25]. This assessment was guided by an experienced physical therapist. This test scored well for intra-rater reliability (0,90-0,995) [26, 27], inter-rater reliability and test-retest reliability with an ICC-score between 0,93 and 0,992 [28-30]. A difference between 4,25 and 7,25 points is furthermore seen as a clinically important difference [31]. The construct validity for physical impairments of the arm [29] and the concurrent validity were rated good with the Action Research Arm Test [26, 27, 30].

The ARAT was used to assess the activity level of the arm in daily life, covering the activity level of the ICF scale [25]. The test contained the following subscales: Grasp, Grip, Pinch and Gross Movements. The maximum score was 57 points. This assessment was guided by an experienced physical therapist. The ARAT ICC score for intra-rater reliability was between 0,97 - 0,99. The test had also a high inter-rater reliability (0,92) and very high test-retest reliability [29, 32, 33].

The MAL was used to assess the perceived performance of the upper limb in daily life, covering the activity level of the ICF scale [25]. This test was divided in two parts: The ''MAL amount scale' and the 'MAL how well scale'. Both scales were analyzed. This assessment was guided by an experienced physical therapist. The responsiveness of the MAL scale was considered as good to measure daily hand use in subacute stroke patients [34]. Internal consistency and test reliability (r>0,91) were also considered as good [35].

4. Treatment program

The treatment program consisted of two parts: (1) passive manual therapy, to resolve capsular and muscular mobility impairments, and (2) exercise therapy, to improve control, strength and functionality of the shoulder.

The manual therapy had two goals. The first one was to resolve capsular tightness. Therefore, tractions and/or translations of the glenohumeral joint were performed. The second goal was to lengthen shortened muscles (m. biceps, m. pectoralis minor and/or the m. pectoralis major), by means of stretching techniques and/or eccentric control exercises. It was instructed that stretch exercises could only be performed from the moment that the patient had good eccentric control of the muscles that had to be stretched. Afterwards, these stretching exercises were performed at home. Manual therapy was performed until capsular mobility was good.

The exercise therapy consisted of three parts: (1) control exercises, (2) isolated muscle exercises, and (3) functional exercises. Therapists were instructed to go to the next part from the moment that the earlier part had improved. The control exercises included (a) trunk control exercises (starting from the lower to the upper trunk): lateroflexion of the trunk, axial rotations and weight displacements initiated from the pelvis with a stable thorax, and (b) scapula setting exercises with a controlled trunk, elevation of the extended arm in supine during the whole range of motion (ROM) to activate serratus anterior, setting of the scapula in sitting position while making the arm long in external rotation with facilitation, and retraction exercises in sitting position and in supine. The isolated muscle exercises were focused on the trapezius pars ascendens and transversa, teres minor and infraspinatus (external rotation in side-lying position, prone extension of the arm). The functional exercises were patient-specific, according to the patients' daily activities. Patients received also advice on how to perform daily upper limb tasks like washing, eating and clothing.

Progression rate depended on the capabilities of the patient. Progression was generally applied by adding more repetitions, more weight, less facilitation and altering the starting posture.

In the appendix at the end of this document, the detailed, individualized treatment program and the different treatment goals per patient according to their clinical assessment at start, are outlined. Furthermore, the focus of the treatment program per case is discussed.

Results and discussion per case

1. CASE 1

1.1 Results

Case 1 reported pain and presented itself with a dysfunctional upper limb.

In general, case 1 showed promising results over 12 weeks (Table 2).

Table 2 Evaluation case 1

	Pre	**18s**	**36s**	**Follow up**
Laterorotation start (°)	-6	-2	0	0
Laterorotation incl. 45° (°)	5	9	4	4
Laterorotation incl. 90° (°)	28	26	20	20
Laterorotation incl 135° (°)			45	45
Maximal elevation (°)	100	130	145	145
Inspection tilt rest	1	1	0	0
Inspection tilt dyn.	1	0	0	0
Inspection winging rest	1	0	0	0
Inspection winging dyn.	1	0	0	0
Elevation (E)/Depression (D)	D	D	D	D
Medial rotation translation	1	1	1	0
Medial rotation tilt	1	0	0	0
PMI	5,63	5,97	6,19	6,25
AI	5,63	5,45	5,34	5,63
SDT	1,51	1,54	1,52	1,58
VAS (max 10)	9	5	3	5
FM-score total (max 66)	29	53	55	46
FM-score shoulder (max 36)	14	29	30	21
ARAT (max 57)	3	19	34	26
MAL amount scale	0,17	1,5	2,54	2,87
MAL how well scale	0,04	1,39	1,5	1,38

The amount of lateral rotation during an elevation task as seen in figure 1.1 tended to diminish over time. At the starting position, the patient showed an improvement towards a neutral scapular position starting from a medial rotated scapula (negative result) in pre-measurement. The amount of lateral rotation at 45° elevation diminished with 1°. At 90° elevation, the amount of lateral rotation diminished with 8°. Between session 18 and 36, this case progressed the most. At 135° elevation, starting data was missing because it was not possible to move the patient's arm passively in 135° elevation at pre-measurement and after 18 sessions. At 36 sessions, case 1 showed 45° of lateral rotation of the scapula at 135° of passive elevation.

The amount of maximal elevation as seen in figure 1.2 increased for 45° in 36 sessions. The first 18 sessions, case 1 attained the double amount of progression in comparison with the last 18 sessions.

The position of the scapula, rated by inspection, evolved positively during the program. The amount of tilting and winging of the scapula improved, both in rest as well as in the dynamic situation, after 18 sessions. On the other hand, the depression position of the scapula remained unchanged after 36 sessions.

Anterior translation of the caput humeri during medial rotation of the shoulder remained unchanged during 36 sessions, while the tilting of the scapula during medial rotation of the shoulder, which was too high at pre-measurement, improved after 18 sessions and was already scored as appropriate.

The PMI showed a small increase, indicating a longer pectoralis minor, the AI showed a small decrease, indicating a less protracted position, and the SDT showed no changes over time after 36 sessions as seen in figure 1.3. A higher PMI, a lower AI and a lower SDT are all positive signs, meaning a more retracted position of the scapula.

The VAS-score as seen in figure 1.4, showed a decrease over time from 9/10 to 3/10. The largest amount of decrease was found between pre-measurement and 18 sessions. The FM-score as seen in figure 1.5 showed improvement over time, both for the total score as well as for the shoulder score. The shoulder-score showed an improvement of 16 points while the total score was improved by 26 points. The ARAT score as seen in figure 1.6 improved by 31 points. The patient showed similar progression between pre-measurement and 18 sessions as between 18 sessions and 36 sessions. The MAL amount scale as seen in figure 1.7 improved by 2,3 points over time and the MAL how well score also seen in figure 1.7 showed an improvement of 1,5 points.

Figure 1.1 / Laterorotation

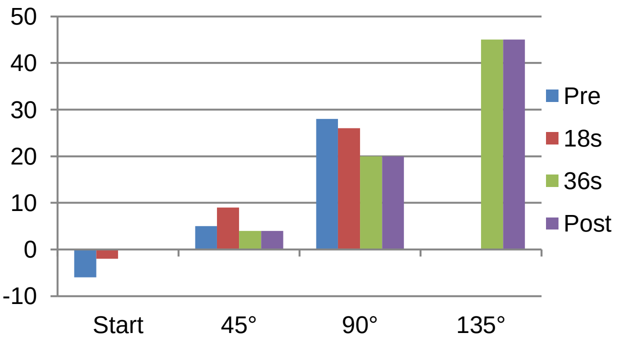


Figure 1.2 / Maximal Elevation

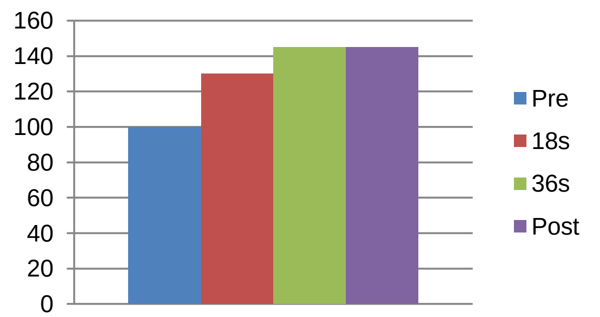


Figure 1.3 / Shoulder Girdle Position

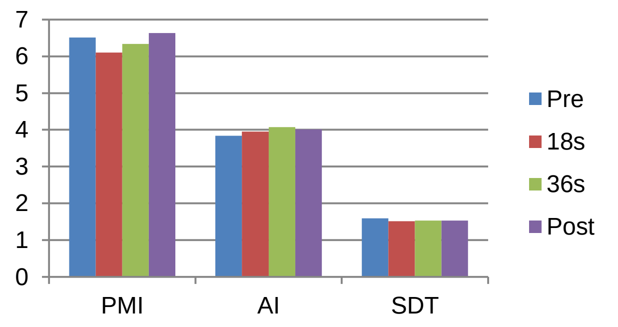
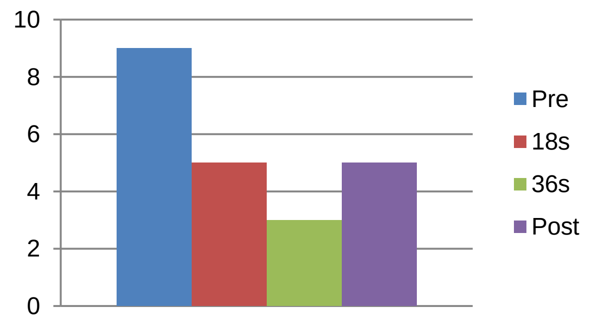


Figure 1.4 / VAS - Score



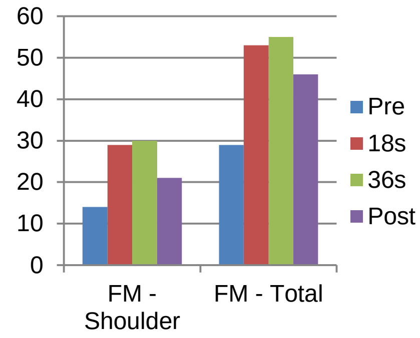


Figure 1.5 / Fugl - Meyer

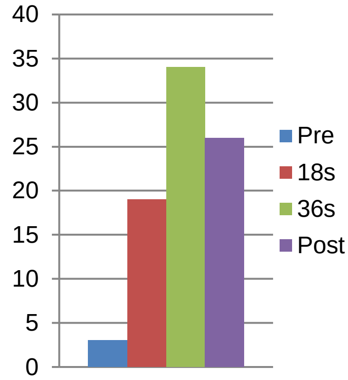


Figure 1.6 / ARAT

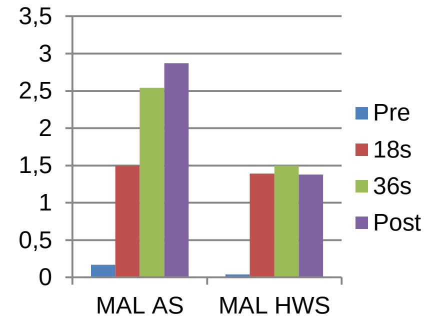


Figure 1.7 / MAL

1.2 Discussion

During this rehabilitation program, case 1 presented with capsular stiffness and poor muscle flexibility. The focus was altered in function of the patient's needs, which were noted in appendix, table 6.

Changes in PMI, AI, SDT and lateral rotation at 45° anteflexion should be interpreted as possible errors of measurements because of smaller changes then the MDC [22].

It is not possible to concretize the program because case 1 had several main goals. This potentially influenced the results since too many goals had to be achieved in 36 physical therapy sessions. On the other hand, case 1 showed promising results on all parameters. This may indicate that gains could be bigger in an even more selective program.

A negative point of the program was that it was interrupted for 2 sessions because of illness. These sessions were not rescheduled, but missing them was probably not of influence on the results after 12 weeks.

In the first weeks, case 1 showed elevation movements in combination with glenohumeral internal rotation. It is plausible that exercise focusing on external rotation could be started earlier than week 5. After week 6, a better motor control was noted but the patient complained of more pain. Despite of the notification, the exercise program was not modified. This possibly had a large influence on the resulting measurements. Functional training was started after 11 weeks. This was timed well, because case 1 reported less pain, less capsular stiffness and better motor control in the scapulathoracic region at that time.

In general, case 1 made a lot of progression in the first 18 physical therapy sessions, except for lateral rotation. This could not be explained by the focus of intervention. A possible cause was that case 1 almost reached the top of his learning abilities.

Looking at the results in general, we found a decrease of lateral rotation during an anteflexion task, an improvement of the shoulder girdle position, an improvement of functionality on both functional ICF level and activity ICF level and a decrease in level of subjectively reported pain. These results could all be interpreted as being positive evolutions.

It was difficult to assess whether the amount of lateral rotation was decreased because of alterations in the passive “articular” system (e.g. decreased posterior capsular stiffness) or the active “muscular” system (e.g. improved interaction between trapezius pars ascendens and descendens, and serratus anterior to optimize scapular lateral rotation). Case 1 had goals both to treat the articular system and the muscular system. It is likely that a combination of improvements in both systems resulted in a lesser amount of lateral rotation during an anteflexion task.

The improvement of the shoulder girdle position of case 1 is likely explained by an improved scapula setting control, a better rest length of the m. pectoralis minor and m. pectoralis maior and a less stiff posterior capsule. Both manual therapy and exercise therapy were used to achieve this goal.

The improvement of functionality according to the ICF-model could be explained by improvement in the kinetic chain, following the kinetic chain model. An improvement of trunk stability and a better scapular control could explain improvements in reaching and grasping tasks. In addition, the external rotation exercises for m. infraspinatus could improve the kinematic patterns and the ROM of an anteflexion task, which influences the functionality indirectly.

A decrease in the reported amount of subjective pain was difficult to explain. It is possible that better kinematic movement patterns contribute to a reduced experience of pain. This is hypothetical because of a lack of evidence.

During the follow-up measurement after 24 weeks, the ARAT-score, the MAL how well scale and the FM-score showed a decrease, whilst the VAS-score, the SDT and AI tended to increase. A higher PMI, a lower AI and a lower SDT are all positive signs, meaning a more retracted position of the scapula. The amount of lateral rotation remained constant in comparison to the post-measurement after 12 weeks. This indicates the importance of maintaining this program to improve longterm effects.

2. CASE 2

2.1. Results

Case 2 reported no pain but presented with clear upper limb dysfunctions, wich can be seen on pre-maesurement values for Fugl-Meyer, ARAT and MAL in table 3.

In general case 2 showed promising results over 12 weeks (Table 3).

Table 3 Evaluation case 2

	Pre	18s	36s	Follow up
Laterorotation start (°)	4	-2	-2	-2
Laterorotation incl. 45° (°)	12	6	4	6
Laterorotation incl. 90° (°)	30	26	18	22
Laterorotation incl 135° (°)	52	45	39	42
Maximal elevation (°)	105	140	160	160
Inspection tilt rest	1	1	1	0
Inspection tilt dyn.	1	1	0	0
Inspection winging rest	0	0	0	0
Inspection winging dyn.	0	0	0	0
Elevation (E)/Depression (D)	D	normal	normal	/-normal
Medial rotation translation	1	1	0	0
Medial rotation tilt	1	1	0	0
PMI	6,51	6,1	6,34	6,63
AI	3,84	3,95	4,07	4,01
SDT	1,59	1,51	1,53	1,53
VAS (max 10)	0	0	0	0
FM-score total (max 66)	32	46	49	62
FM-score shoulder (max 36)	23	29	30	36
ARAT (max 57)	16	40	51	57
MAL amount scale	2,1	4,5	4,89	4,89
MAL how well scale	0,8	3,1	4,42	4,89

The amount of lateral rotation during a passive elevation task (figure 2.1) showed a diminishing trend over time. At rest, case 2 showed a change of 6° from lateral rotation to medial rotation (negative result) of the scapula after 18 sessions. This remained unchanged between 18 and 36 sessions. At 45°, case 2 showed a decrease of 8° towards 4° of lateral rotation mainly during the first 18 sessions. At 90°, the amount of lateral rotation diminished by 12° towards 18° of lateral rotation mainly during the last 18 sessions. At 135°, case 2 showed a decrease of 13° towards 39° of lateral rotation.

The amount of maximal elevation as seen in figure 2.2 increased by 55°. This was mainly attained during the first 18 sessions.

The position of the scapula, rated through inspection, evolved positively during the program. The amount of tilting of the scapula, which was present during the pre-measurement, tended to diminish partially in rest and it disappeared totally in the dynamic situation. Winging of the scapula was not present. The depressed position of the scapula was improved after 18 sessions.
Anterior translation of the caput humeri and tilting of the scapula during medial rotation of the shoulder showed improvement between 18 and 36 sessions.
The PMI tended to decrease in the first 18 sessions and to increase in the last 18 sessions. In total the PMI was diminished 0,2 in 36 sessions. The AI showed an increase of 0,2 in 36 sessions. The SDT tended to decrease in the first 18 sessions and to increase in the last 18 sessions. In total the SDT diminished with 0,06 over 36 sessions as seen in figure 2.3. A higher PMI, a lower AI and a lower SDT are all positive signs, meaning a more retracted position of the scapula. So in this case, the PMI and AI evolved negatively while the SDT evolved positively.
The patient reported no pain on the VAS-scale as seen in figure 2.4.
The FM-score as seen in figure 2.5 showed an increase over time, I.e. the FM shoulder score improved by 7 points. The FM total score improved by 17 points. The ARAT-score as seen in figure 2.6 improved by 35 points. The patient attained the double amount of progression in the first 18 sessions in comparison to the last 18 sessions. The MAL amount scale as seen in figure 2.7 improved by 2,8 points in 36 sessions. The MAL how well scale improved with 3,6 points in 36 sessions. The patient made most progression in functionality in the first 18 sessions.

Figure 2.1 / Laterorotation

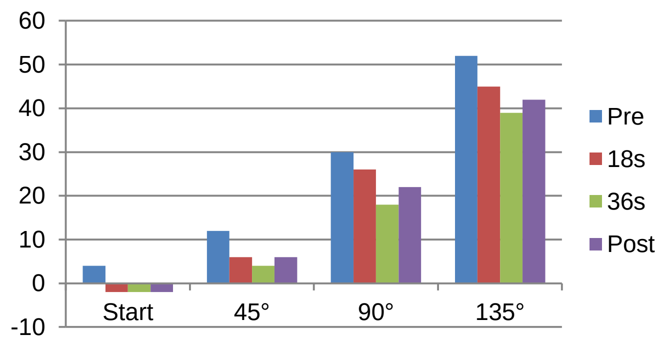


Figure 2.2 / Maximal Elevation

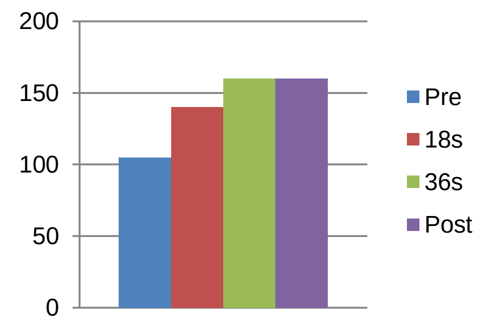


Figure 2.3 / Shoulder Girdle Position

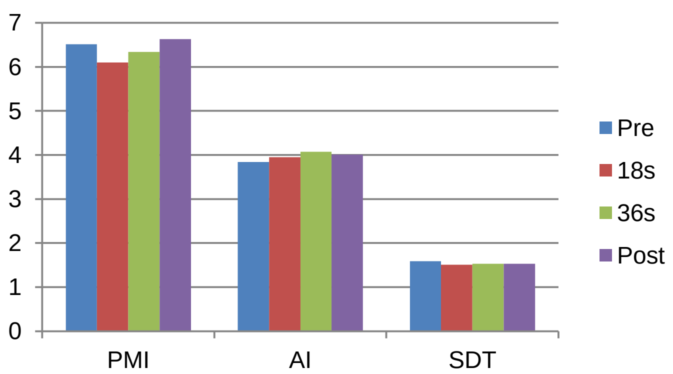
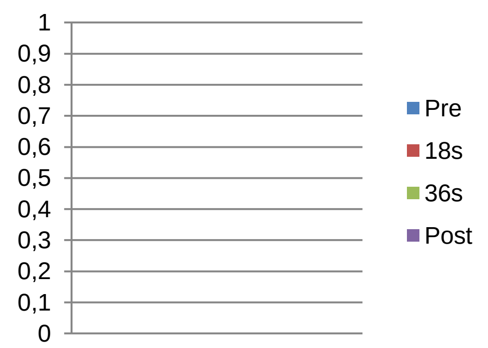
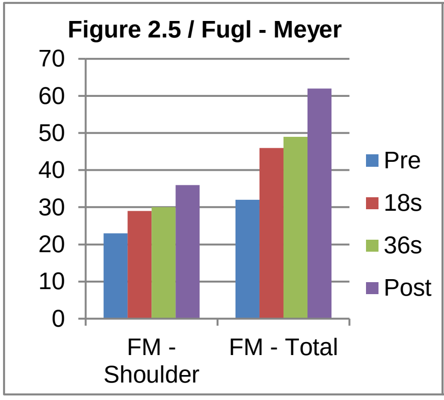
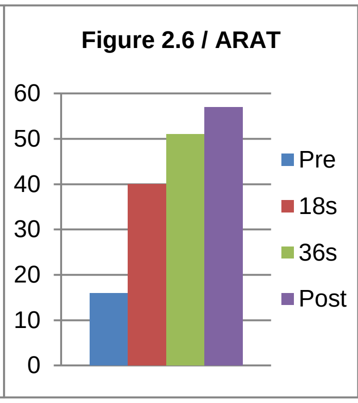
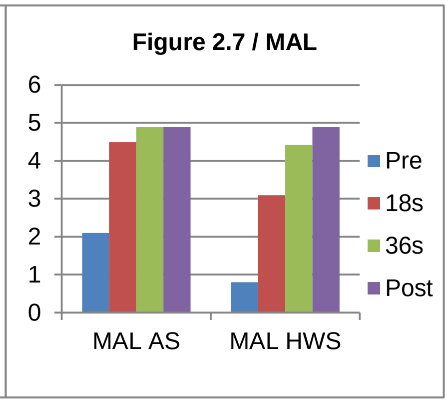


Figure 2.4 / VAS - Score









2.2 Discussion

At the start of the program, case 2 presented with a strong motivation but with a lot of compensating movements during activities of daily living (ADL).

Changes in PMI, AI and SDT should be interpreted as possible errors of measurements because of smaller changes then the MDC [22].

The goals of the rehabilitation program were well defined and rated as attainable in 36 physical therapy sessions. Changes in focus of intervention can be seen in appendix.

A negative point of the program was that it was interrupted for 2 sessions because of a vacation and because of illness of the patient. These sessions were not rescheduled, but this was probably not of influence on the results after 12 weeks. Another critical point is that functional training was started from the beginning while case 2 still used a lot of compensating movement patterns. It would have been better to start with functional training after the analytic exercises were performed well.

Beside the exercises, the role of manual therapy was large. The focus of intervention indicated impairments in both the passive "articular" system and the active "muscular" system. This could also be seen in table 3 in the pre-measurement results. This could explain the decrease in lateral rotation during an anteflexion task and then improved functionality on both functional ICF level and activity ICF level. It is likely that a combination of improvements in both systems resulted in a lesser amount of lateral rotation during an anteflexion task. At 0° of anteflexion, case 2 showed a change from lateral rotation of the scapula towards medial rotation. The amount of medial rotation was minimal and was rated as appropriate.

The improvement of the functionality according to the ICF scale could be explained by improvements in the kinetic chain, following the kinetic chain model. Case 2 presented itself with appropriate trunk control and improved scapular control, which can explain improvements in reaching and grasping tasks. In addition, the external rotation exercises for m. infraspinatus can improve the kinematic patterns and the ROM of an anteflexion task, which can influence functionality passively indirectly.

Despite the fact that the patient received pectoralis minor stretches in the first 18 sessions, The PMI tended to decrease and the AI to increase in the first 18 sessions. A higher PMI, a lower AI and a lower SDT are all positive signs, meaning a more retracted position of the scapula. So these changes were rated as negative evolutions. Afterwards the m. pectoralis minor stretch was stopped. In the last

18 sessions, the PMI and the AI both increased in comparison to the results in the first 18 physical therapy sessions. So, the PMI tended to evolve positively at the end of the program while the AI evolved negatively. Possible causes can be more posterior glenohumeral stiffness, less scapular control of m. trapezius pars ascendens, m. serratus anterior, m. teres minor and m. rhomboideï or the early start of functional training which implied indirectly less focus on analytic scapular training. This is still hypothetical. An EMG-analysis could provide more information.

During the follow-up measurement after 24 weeks, shoulder girdle position, the ARAT-score, the FM-score and the MAL-score all showed progressive results. The amount of lateral rotation of the scapula increased and was the only measure showing a negative evolution over 24 weeks. Hypothetically, this could be explained by an increase in posterior capsular stiffness and a reduced focus on exercises targeting the scapular setting, which may implicate that the automation phase of the exercise was not yet reached.

3. CASE 3

3.1 Results

This case reported shoulder pain and presented with clear upper limb dysfunctions.

Case 3 presented with moderate pre-measurement results and attained moderate progression during 12 weeks of intervention (Table 4).

Table 4 Evaluation case 3				
	Pre	**18s**	**36s**	**Follow up**
Laterorotation start (°)	0	-3	0	0
Laterorotation incl. 45° (°)	4	-2	-2	0
Laterorotation incl. 90° (°)	24	14	15	16
Laterorotation incl 135° (°)	50	38	40	38
Maximal elevation (°)	140	150	160	160
Inspection tilt rest	1	1	1	1
Inspection tilt dyn.	1	0	1	1
Inspection winging rest	1	1	1	1
Inspection winging dyn.	1	1	1	1
Elevation (E)/Depression (D)	D	D	D	D
Medial rotation translation	1	1	1	0
Medial rotation tilt	1	1	0	0
PMI	5,74	5,96	5,57	5,9
AI	3,88	3,66	4,54	4,54
SDT	1,45	1,28	1,25	1,23
VAS (max 10)	8	5	3	0
FM-score total (max 66)	53	58	60	60
FM-score shoulder (max 36)	26	29	31	36
ARAT (max 57)	31	46	50	53
MAL amount scale (max 5)	4,4	5	5	5
MAL how well scale (max 5)	2,78	3,6	3,8	4

The amount of lateral rotation as seen in figure 3.1 tended to decrease over time at all elevation angels. At rest, case 3 showed constant results during 12 weeks. At 45°, the patient went from 4° of lateral rotation to 2° of medial rotation (negative result) after 12 weeks. At 90°, case 3 showed a decrease of 9° in lateral rotation in 12 weeks. This decrease was already gained in the first 18 sessions. At 135°, a decrease of 10° was found over 12 weeks. This decrease was also gained in the first 18 sessions.

The increase of maximal elevation as seen in figure 3.2 was linear over time with a total gain of 20°. The position of the scapula, rated by inspection, did not progressed a lot. The amount of tilting decreased but was still present, the amount of winging of the scapula did not change and the scapula remained in a depressed position after 36 physical therapy sessions.

Anterior translation of the caput humeri during medial rotation of the shoulder remained unchanged during 36 sessions. Tilting of the scapula during medial rotation of the shoulder, which was too large at pre-measurement, improved after 36 sessions and was scored as appropriate.

The PMI tended to increase in the first 18 sessions and to decrease in the last 18 sessions, below pre-measurement values. The AI tended to decrease in the first 18 sessions and to increase in the last 18 sessions to above the pre-measurement values and the SDT tended to decrease over time as seen in figure 3.3. A higher PMI, a lower AI and a lower SDT are all positive signs, meaning a more retracted position of the scapula. So in this case, the PMI and AI evolved negatively over time and the SDT evolved positively over time.

A VAS-score of 8/10 as seen in figure 3.4 was given during maximal elevation. This diminished over time towards 3/10 during maximal elevation.

The FM-score as seen in figure 3.5 tended to increase over time. The FM shoulder score improved by 5 points in 36 sessions and the FM total score improved by 7 points. The ARAT-score as seen in figure 3.6 improved by 19 points. 15 points of improvement were gained during the first 18 physical therapy sessions. The MAL amount score as seen in figure 3.7 improved in the first 18 sessions towards a peak level, which was maintained during the last 18 sessions. The MAL how well scale (figure 3.7) improved over time. Most of progression was attained during the first 18 physical therapy sessions.

Figure 3.1 / Laterorotation

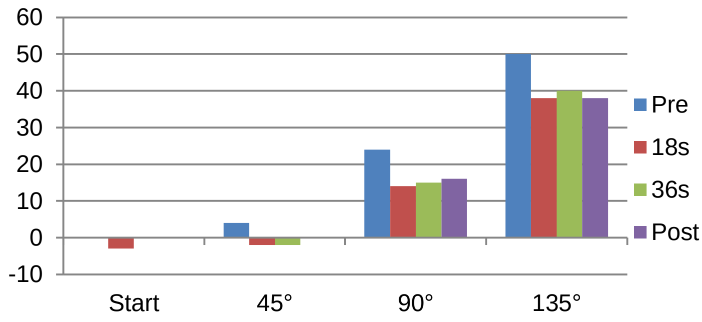


Figure 3.2 / Maximal Elevation

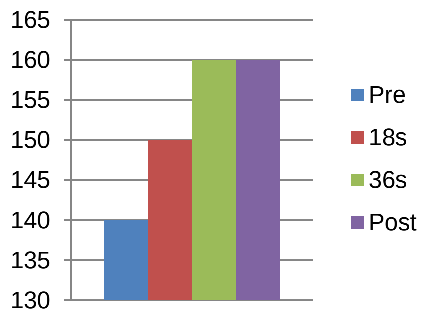


Figure 3.3 / Shoulder girdle position

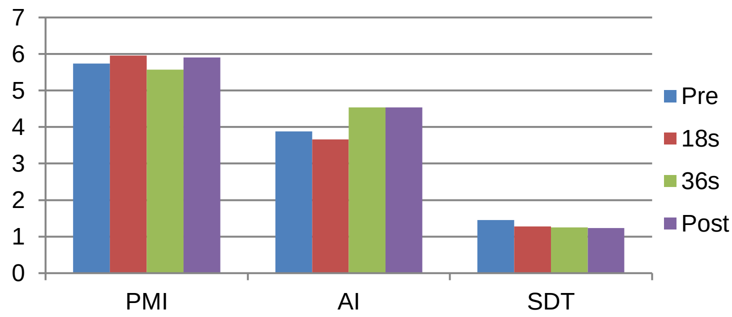


Figure 3.4 / VAS - Score

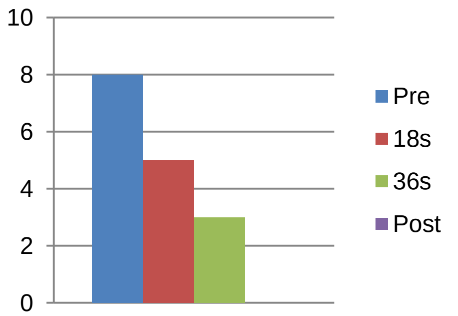


Figure 3.5 / Fugl - Meyer

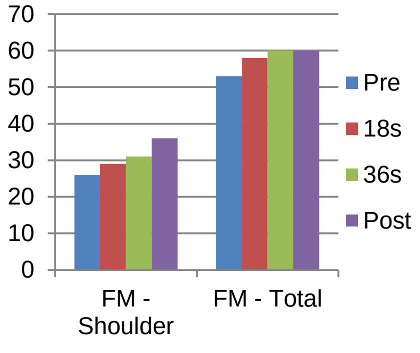


Figure 3.6 / ARAT

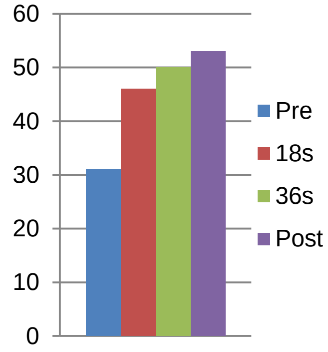
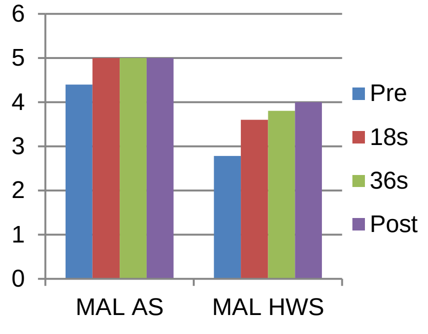


Figure 3.7 / MAL



3.2. Discussion

At the start of the rehabilitation program, case 3 frequently avoided the use of the hemiplegic arm. When this arm was used, it showed poor scapular control.

Changes in PMI and AI should be interpreted as possible errors of measurements because of smaller changes then the MDC [22].

The goals of the rehabilitation program were well defined and rated as attainable in 36 physical therapy sessions. This was clearly seen by changes in focus of intervention.

A negative point of the program was that it was interrupted for 2 sessions. One reason was that this case underwent an analysis of movement. This session was rescheduled. The other session was skipped for unknown reason and was not rescheduled, but this was probably not of influence on the results after 12 weeks. Another critical point was that analytic scapula setting training and analytic trunk control training were stopped while feedback was still necessary, and functional training was started. Afterwards analytic training was again implemented. This sequence of exercises was not in accordance with the exercise prescriptions of Heyward [36]. This can possibly explain why most results of the clinical scapular protocol did not evolve positively.

The focus of intervention seemed to mainly indicate problems in the active “muscular” system.

Looking at the results in general, we found a decrease of lateral rotation during an anteflexion task, an improvement of functionality on both functional ICF level and activity ICF level and a decrease of the level of subjective reported pain. These could all be interpreted as being positive evolutions.

It is difficult to assess whether the amount of lateral rotation was decreased because of alterations in the passive “articular” system or the active “muscular” system. At 45° of anteflexion, case 3 showed a change from lateral rotation of the scapula towards medial rotation. The amount of medial rotation was minimal and could be rated as appropriate. In the last 6 weeks of the program, case 3 showed an increase of the amount of lateral rotation in comparison to the results in the first six weeks. This could possibly be explained by a lesser amount of exercises targeting the scapula setting during the last 18 physical therapy sessions.

Functional improvements could be explained by the large amount of functional training and improvements in the kinetic chain resulting from a better trunk control and scapular motor control during reaching and grasping tasks after twelve weeks.

A decrease in the amount of subjective reported pain was difficult to explain because kinematic movement patterns did not improve looking at the PMI, AI and observation results. A possible explanation is spontaneous tissue healing.

Some results can be seen as negative evolutions. The PMI tended to increase in the first 18 physical sessions but after 12 weeks, it was decreased in comparison to the pre-measurement. The AI tended to decrease in the first 18 sessions but after 12 weeks, it was increased in comparison to the pre-measurement. This could possibly be explained by a lesser amount of exercises targeting the scapula setting during the final 18 physical therapy sessions.

This program had no beneficial effects for the shoulder girdle position while good results were found for functionality. This can possibly be linked to the low amount of analytic training and the high amount of functional training. This may indicate that the analytic part of this protocol is less suitable for patients with higher starting level of functionality.

Follow-up measurements did not much differ from the post-measurement. This may implicate that this rehabilitation program has long-term effects and that other forms of therapy do not have any negative influence on the results achieved.

4. CASE 4

4.1 Results

This case reported pain and presented with good functionality looking at pre-measurement results of the ARAT (Table 5).

In general case 4 showed moderate progress over 12 weeks (Table 5).

Table 5 Evaluation Case 4				
	Pre	**18s**	**36s**	**Follow up**
Laterorotation start (°)	7	2	0	1
Laterorotation incl. 45° (°)	2	4	6	2
Laterorotation incl. 90° (°)	15	18	21	16
Laterorotation incl 135° (°)	46	42	43	42
Maximal elevation (°)	162	170	170	170
Inspection tilt rest	0	0	0	0
Inspection tilt dyn.	1	0	0	0
Inspection winging rest	0	0	0	0
Inspection winging dyn.	1	0,5	0,5	0
Elevation (E)/Depression (D)	D	D	D	D
Medial rotation translation	1	1	1	0
Medial rotation tilt	1	0	0	0
PMI	6,85	6,91	5,86	6,05
AI	4,69	4,94	5,74	
SDT	1,53	1,53	1,59	1,6
VAS (max 10)	6	4	0	0
FM-score total (max 66)	53	64	66	66
FM-score shoulder (max 36)	24	34	36	36
ARAT (max 57)	57	57	57	57
MAL amount scale	4,72	5	5	5
MAL how well scale	3,48	4,04	4,85	4,94

The amount of lateral rotation as seen in figure 4.1 showed a diminishing trend over time at rest and 135° anteflexion and tended to increase at 45° and 90° anteflexion. At rest, case 4 showed a change of 7° from lateral rotation towards a neutral position of the scapula over time. At 45°, case 4 showed a linear increase of 4° towards 6° of lateral rotation in 12 weeks. At 90°, the amount of lateral rotation increases linearly with 6° towards 21° of lateral rotation in 12 weeks. At 135°, case 4 showed a decrease of 3° towards 43° of lateral rotation.

The amount of maximum elevation as seen in figure 4.2 increased with 8°. This was attained during the first 18 sessions, In the last 18 sessions case 4 preserved the amount of 170° elevation.

The tilting and winging position of the scapula, rated by inspection, tended to decrease over time during movement. The tilting position of the scapula was good after 18 physical therapy sessions while the winging position of the scapula remained partially present after 36 physical therapy sessions. The tilting and winging position of the scapula was good in resting position at the pre-measurement. This was preserved during the rehabilitation program. The scapula remained depressed during the whole program.

Anterior translation of the caput humeri during medial rotation of the shoulder remained unchanged during 36 sessions. Tilting of the scapula during medial rotation of the shoulder, which was too large at pre-measurement, improved after 18 sessions and was scored as appropriate.

The PMI tended to increase in the first 18 sessions by 0,06 and to decrease in the last 18 sessions below pre-measurement values by 1,05, the AI tended to increase over time by 1,05 after 36 sessions and the SDT tended to increase by 0,06 in the last 18 physical therapy sessions as seen in figure 4.3.

Case 4 reported pain during elevation at the pre-measurement. After 12 weeks, the VAS-score as seen in figure 4.4 decreased towards 0/10 and pain was no longer a complaint.

The FM-score as seen in figure 4.5 tended to increase over time. The FM shoulder score improved by 12 points in 36 sessions and the FM total score improved by 13 points. These gains were mainly achieved during the first 18 physical therapy sessions. At pre-measurement, case 4 attained the maximal ARAT-score as seen in figure 4.6. This result was preserved during the rehabilitation program. The MAL score (figure 4.7) improved with 0,28 points in the first 18 sessions towards a maximum score, which was maintained during the last 18 sessions. This case improved on the MAL how well scale (figure 4.7) over time. Case 4 showed here an increase of 0,56 points in the first 18 physical therapy sessions and an increase of 0,81 points in the last 18 sessions.

Figure 4.1 / Laterorotation

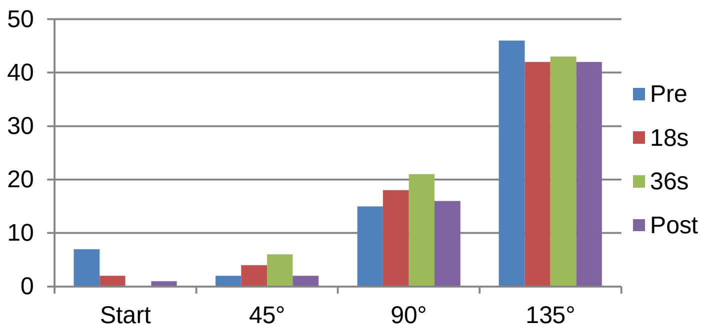


Figure 4.2 / Maximal Elevation

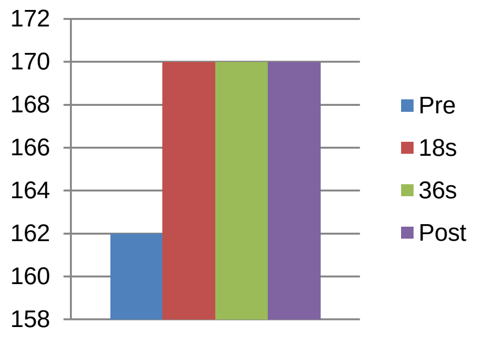


Figure 4.3 / Shoulder Girdle Position

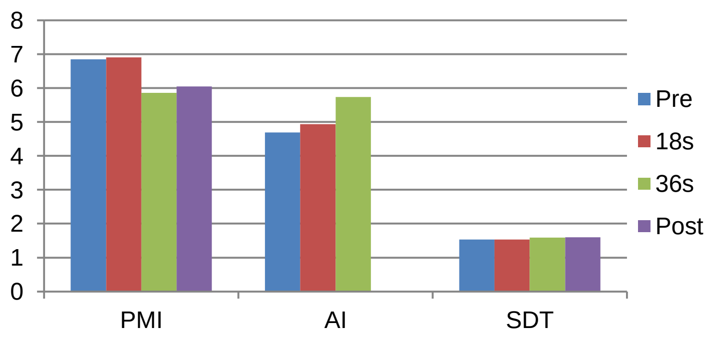


Figure 4.4 / VAS - Score

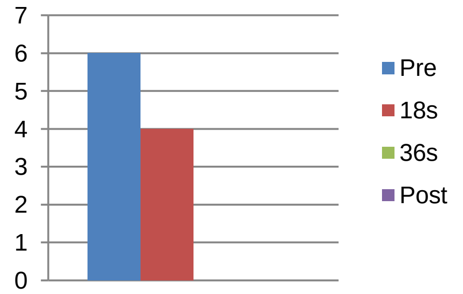


Figure 4.5 / Fugl - Meyer

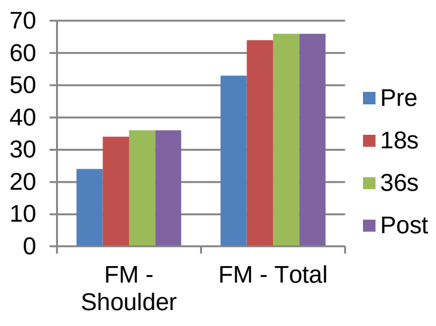


Figure 4.6 / ARAT

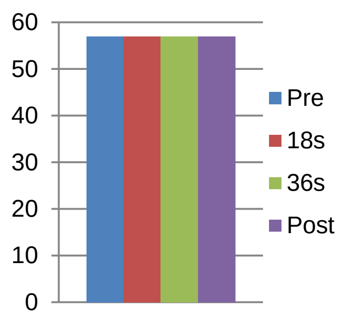
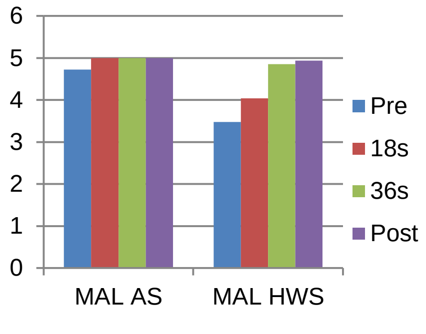


Figure 4.7 / MAL



4.2. Discussion

At the start of the rehabilitation program, case 4 presented itself with poor scapular and muscle control. This could be improved by giving tactile forms of feedback. Trunk control was rated as good and case 4 had good functionality in daily life. This could be seen in high pre-measurements values of the ARAT-score, FM-score and MAL-score.

Changes in PMI, AI, SDT, lateral rotation at 135° anteflexion and the amount of maximal active humeral elevation should be interpreted as possible errors of measurements because of smaller changes then the MDC [22].

It is not possible to concretize this program because case 4 had several main goals. Both manual therapy and exercise therapy were implemented. This indicated that both the passive “articular” system and active “muscular” system were meaningful in the painful situation of the patient. Exercises targeting the scapula setting and trunk control were reduced when feedback was no longer necessary and it was implemented in the functional training exercises. Functional training was started in week 3. This could be rated as appropriate because of low feedback levels during the analytic exercise training and the high level of functionality at the start of the program.

Case 4 got one aqua training session instead of manual therapy. The influence on the results was not known.

Looking at the results in general, we found an improvement of functionality in both functional ICF level and activity ICF level and a decrease in the level of subjective reported pain. These results could be interpreted as positive evolutions and this case indicated that she had minor effort with the exercises during this rehabilitation program..

Functional improvements could be explained by the large amount of functional training, starting from week 3, and further improvements in the kinetic chain following good trunk control and a better scapular motor control during reaching and grasping tasks after twelve weeks.

The reduced reported pain is possibly related to the better kinematic scapular movement patterns.

Some results can be seen as negative evolutions. The PMI tended to increase in the first 18 physical sessions but was decreased after 12 weeks in comparison to the pre-measurement. The AI tended to increase over twelve weeks. Possible causes can be more posterior glenohumeral stiffness or less automated scapular control of specifically trapezius pars ascendens, serratus anterior, teres minor and rhomboideï. This is hypothetical. An EMG-analysis can offer more information.

The amount of lateral rotation increases at 45° and 90° of anteflexion. This can possibly be explained by an alteration of muscle activation patterns. An EMG-analysis could offer more information.
Follow-up measurements did not differ much from the post-measurement. Only the amount of lateral rotation of the scapula during an anteflexion task tended to decrease in comparison with the post-measurements. This may infer that this rehabilitation program had long term effects and that other forms of neurological therapy did not have any negative influence on the results achieved.

General discussion

1. Results interpretation

All four cases made progress over 12 weeks. Positive evolutions were seen at the functional and activity level level in the ICF-model, in the amount of self-reported pain and in the amount of maximal active humerothoracic elevation.

The amount of lateral rotation evolved positively in three out of four cases and the tests for shoulder girdle position gave different results in all cases. Besides these differences, the link between the evolvement of pain is also different in all cases. For example in case 1, shoulder girdle position test for PMI and AI evolved positively over time and also the amount of reported pain improved while in case 4, shoulder girdle position test for PMI and AI evolved negatively and the amount of reported pain evolved positively. For the PMI this can possibly be explained because of low intra-rater ICC scores. For the AI, there is no clear explanation. We can conclude that the evolvements of PMI and AI can probably not be used to predict changes in reported pain. On the other hand, the AI test can be useful to evaluate scapular position. The interpretations provided here should be taken with care and EMG-analysis and 3D-analysis of kinematic movement patterns could provide more information towards the causes of changes in PMI and AI. To explain changes in lateral rotation, an EMG-analysis could also be useful. As described earlier, stroke patients showed an increased amount of scapular lateral rotation during an anteflexion task [9, 10]. All cases tended to diminish the amount of scapular lateral rotation in all anteflexion angels over 12 weeks. This may be assessed as a positive evolution.

The proximal muscles of the hemiparetic arm, like the deltoid muscle, triceps muscle, upper and middle trapezius muscle and the pectoralis major muscle are activated less during the forward reaching and the return phase compared to the non-affected side (ref). There may be a link between this altered muscle activation patterns and the altered kinematic movement patterns [12, 37]. De Baets [38] reported an altered muscle activation pattern for m. trapezius pars ascendens and m. infraspinatus, where activity is prolonged in stroke patients. It could be useful to examine if the cases included in this study showed the same muscle activation patterns. Then it would also be possible to explain gains in the amount of maximal elevation and changes in shoulder girdle position. It is expected that our rehabilitation program results has improved function of m. serratus anterior, m. trapezius and the rotator cuff.

Massie [12] reported that stroke patients have too much trunk movement during an anteflexion task. It might have been useful to add a clinical investigation of the trunk. Then it would have been possible to objectively rate the effect of the trunk control training provided in this rehabilitation program.

It is difficult to provide an explanation for a decrease in shoulder pain in some cases. It could be that a reduction of the shoulder dysfunction provided pain relief. To prove this hypothesis, the addition of 3D-analysis of the kinematic movement patterns and en EMG-analysis could be useful because it has been shown that good trunk functionality has influence on the kinetic chain and the arm movements during a reaching task [39, 40]. This may imply that good trunk functionality can improve the functionality of the arms and also the range of motion in an elevation task.

The shoulder girdle position was rated by inspection, the PMI, the AI and the SDT. The interpretation of these tests gave different results in all cases, mainly for the PMI and AI. It has been shown that the reliability for the PMI is low.

In this multiple case study, case 2, 3 and 4 had moderate shoulder functionality at the pre-measurement according to the FM shoulder-elbow score (17-26 points) and case 1 had low functionality according to this score (<16 points). So cases with different starting levels of functionality were included. However, the sample size was small so it was not possible to explain results by the starting level of functionality.

2. Strengths and weaknesses

First of all, a case study design is of low scientific value. A longitudinal follow-up was used to describe progression over a period of 24 weeks. This indicates that results were possibly influenced by adaptation of the patient because of guidance by one physical therapist over a longer period of time. The limited sample size means that we could not provide any prescription guidelines for clinical usage. This article only provides a starting point for further scientific investigations.

Another critical aspect is that we do not have any reference values that can be used to interpret the results.

This rehabilitation program was done by different physiotherapists. Given that these therapists had moreover a mainly neurologic rehabilitation background, it was difficult to know whether the musculoskeletal approach was successfully integrated into the stroke rehabilitation.

During stroke rehabilitation, there is often presence of disabilities in both the upper as well as the lower limb. The fact that during this rehabilitation program, no focus towards the lower limb was made, is a limitation in this study.

The detailed description of method, intervention and results were considered as a strength of this case study. Furthermore, one blinded assessor performed the assessment.

3. Future perspectives

This case study can be a starting point for a randomized controlled trial. There is a possibility to divide groups in function of severity of stroke or level of upper limb function and to make a distinction between groups relative to the source of pain. An EMG analysis and 3D-analysis of kinematic movement patterns should be integrated in the assessment to enable description of kinematic movement patterns and muscle activation patterns and to link them to changes in self-reported pain and shoulder dysfunction. Furthermore, it is possible to investigate the possibilities to prevent shoulder pain in the stroke population with a musculoskeletal approach. This musculoskeletal approach should be integrated in a neurological approach in stroke rehabilitation to optimize treatment effects.

4. Conclusion

This case study forms a starting point for further research. It showed that a musculoskeletal approach to shoulder pain and/or shoulder dysfunctions might possibly offer a positive long-term effect. Further research is necessary to confirm these findings.

Appendix

1. CASE 1

The detailed treatment program of CASE 1 is given in Table 6 and 7.

Week 1: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior training. The patient needed mainly physical feedback.

Week 2: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectoralis maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior training. The patient needed mainly physical and tactile feedback.

Week 3: Rehabilitation contained forms of manual therapy focusing on capsular stretch and exercise therapy focusing on scapula setting. Patient was sick during session 8 and 9.

Week 4: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals minor and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior training. The patient needed mainly tactile and physical feedback.

Week 5: Rehabilitation contained forms of manual therapy focusing on capsular stretch (longitudinal traction is stopped) and muscle flexibility of m. pectorals minor and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly tactile and physical feedback.

Week 6: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals minor and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly physical, verbal and tactile feedback.

Week 7: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals minor (only in session 19) and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly physical and tactile feedback.

Week 8: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals minor (only in session 24) and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly physical and tactile feedback.

Week 9: Rehabilitation contained forms of manual therapy focusing on capsular stretch (longitudinal traction is started) and muscle flexibility of m. pectorals minor and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly physical, verbal and tactile feedback.

Week 10: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle sflexibility of m. pectorals minor and maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior training. The patient needed mainly physical and tactile feedback.

Week 11: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle flexibility of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior training. Functional training was started (Stick forwards with arm in supination, Reach/grasp to cone on chair 45°, Retroflexion sitting flexed with suported head and with GH exorotation, Place cone on roll at 90°, Elevation arm from te roll> 90°). The patient needed mainly physical and tactile feedback.

Week 12: Rehabilitation contained forms of manual therapy focusing on capsular stretch (longitudinal traction, dorsal and ventral translation were stopped) and muscle flexibility of m. pectoralis maior and forms of exercise therapy focusing scapula setting, and analytic m. serratus anterior training. Functional training was progressed. The patient needed no or little feedback.

Table 6 program case 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
traction				x	x	x	x	1	1	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x
longitudinal traction	x	x	x				x	1	1	x	x	x	x														x	x	x	x	x	x					
ventral translation	x	x	x	x	x	x	x	1	1	5x	10x	10x	10x	5x	5x	10x	10x	7x	5x	7x	10x	10x	x	20x	x	x	20x	15x	5x			10x					
dorsal translation	x	x	x	x	x	x	x	1	1	5x	10x	10x	10x	10x	15x	15x	10x	15x	10x	10x	10x	10x	x	20x	x	x		20x	15x	3x		5x					
caudal translation	x	x	x	x	x	x	x	1	1	r	r	r	25x	r	r	15x	r	r	r	r	r	r	x	r	x	x	r	15x	r	r	x	x	x	x	x	x	x
end-range translation								1	1																												
stretch pect. Min.	5x							1	1	8x	8x		10x	15x	15x	15x	15x	5x	7x					10x	10x		10x	5x	10x		10x	12x	2x7				
ecc. control pect. Ma.	F2 10x	F3 7x	F2 10x	T2 12x		5 10x		1	1	T4 20x	T3 15x	15x	5 10x	15x	15x	15x	F3,4 15x	T4 15x	T4 15x	F4 15x	5 10x	5 10x	4 15x	T4 15x	T4 15x	10x	5 10x	5 15x	5 10x		15x	5 2x10	5 2x10	5 2x10	5 2x10	5 2x10	5 2x10
ecc. control b.b.								1	1																							F2 5x0,5k g					
contained stretch pect.ma./b.b.								1	1																												
stretch posterior capsule								1	1																												
trunk control ecc. axial elevation	F3 5x			5 5x		2		1	1	5x	5x	10x	5 8x	T4 5x	T4 5x		T3 5x	T4 5x	T4 5x					5 5x	T4 5x	TV 5x											
trunk control ecc. axial rotation	F3 2x5					2		1	1	10x	5x	10x	T2 8x	T4 5x	T4 5x		FT4 20x	T4 7x	T4 10x	T4 5x	5 5x		T4 10x		T4 5x	TV 5x		5x									
trunk control ecc. lateroflexion	F3 2x8	F4 2x5			5 10xL 10x R	2		1	1	5x	5x	10x	T3 5x	F3 10x	FT3		FT3 10x	F3 8x	F3 20x	F3 10x			T4 10x	T4 12x	T4 10x	TV 10x	F4 10x	10x	F3 10x	T4 10x		T4 10x					
neutral positioning scapula	F2 3x10	F3 3x	F3 10x		T3 5x	2	5x	1	1	F2 5x	T4	T4 11x	5 5x	F3 5x	FV2 5x	T4 5x	F3 5x	T4 5x	T4 5x	T4 5x	T4 5x	T 5x	5 3x	T4 5x	T4 3x	TV 3x		3x					F3 10x				
making the arm long in external rotation position	F2 2x5	F3 10x	F3 10x		T3 8x	2	F2 25x	1	1	F3 10x	F3	F3 15x	T3 20x	F2- T3 15x	FV2- 3 10x	FV 10x	F3 8x	T3 5x	T3 8x	T4 15x	T4 10x	T3 15x	T4 10x	F3 15x	F3 10x	FV 15x	F3 10x	F3 10x	F3 10x	T4 15x	T4 10x	T4 5x	F4 10xL 10x R			T3 10x	10x
retroflexion arm in external rotation position	F2 2x5	F3 10x	F3 10x		T3 8x	2		1	1	F3 10x	F3	F3 18x	F2 7x	F3 10x	F3 10x	10x		F3 7x				F2 20x										T3 15x					
retraction in prone						2		1	1																												
s.a. ecc. without load	F2 10x	T2 10x	F2 15x	F2 10x	F2 8x2	2		1	1	F3 20x	F3 18x	F4 15x	T4 20x	F2- T3 20x	FV3 20x	15x	F3 20x	F3 15x	F2 20x	F3 15x	F3 10x		F3 10x	F3 20x	F3 15x	FV 15x	T3 15x		T3 15x	F4 5x	F4 10x	TV4 15x	F3 4 10x	V5 4 2x10	F3 4 10x	5 5 10x	T4 5 10x
s.a. ecc. with load 90° antefl.						2		1	1		T3 1 3x	F3 1 5x																		F3 10x	V4 15x		F4 10x		5 10x		
prone extension arm						2		1	1																												
extension arm sitting position						2		1	1																												
external rotation in side lying				F2 12x	F2 10x	2		1	1				F2 10x	T4 2 15x		F4 2 7x			10x 2	F3 2 10x		F2 5x F3 2 20x	V5 3 5x	F2 3 5x	F3 3 5x	FV 3 10x	F3 3 10x	F3 3 5x									

Table 7: Legend of table 6

Case 1	Meaning		Feedback	Meaning
pect. Min.	Pectoralis minor		5	No feedback
pect. Ma.	Pectoralis major		4	Little feedback
ecc.	Eccentric		3	More feedback
b.b.	Biceps brachii		2	Much feedback
s.a.	Serratus anterior		1	Passive feedback
antefl.	Anteflexion		F	Physical feedback
1	Illness, no therapy		T	Tactile feedback
1	Without load		V	Verbal feedback
2	Supine lying exercise			
3	Sitting exercise			
4	90° anteflexion			
5	100° anteflexion			
X	Total of 15 min			
X	Total of 10 min			
X	Total of 5 min			

2. CASE 2

The detailed treatment program of CASE 2 is given in Table 8 and 9.

Week 1: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior training. Functional training was started (elbow extension with 90° shoulder elevation task with supported humerus, shoulder protraction in side-lying). The patient needed mainly tactile and verbal feedback.

Week 2: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectoralis minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior training. Functional training was progressed. The patient needed mainly physical and tactile feedback.

Week 3: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectoralis minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 4: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly verbal, tactile and physical feedback.

Week 5: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly verbal, tactile and physical feedback.

Week 6: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 7: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 8: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 9: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals maior and forms of exercise therapy focusing on scapula setting and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 10: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals maior and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 11: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch of m. pectorals minor and maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Week 12: Rehabilitation contained forms of manual therapy focusing on capsular stretch (longitudinal traction, dorsal and ventral translation were stopped) and muscle stretch of m. pectoralis maior and forms of exercise therapy focusing scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly physical, verbal and tactile feedback.

Table 8: Program case 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
traction	3x10s	3x10s	3x10s	2x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	1	3x10s	3x10s	2	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s
longitudinal traction	3x10s	3x10s	3x10s	2x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s			1	3x10s	3x10s	2	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s
ventral translation																											1			2						
dorsal translation	3x10s	3x10s	3x10s	2x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	1	3x10s	3x10s	2	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s
caudal translation				2x10s	3x10s	3x10s	3x10s	3x10s		3x10s			3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s						1	3x10s	3x10s	2	3x10s	3x10s		3x10s	3x10s	3x10s
end-range translation																											1			2						
stretch pect. Min.			3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s			3x10s		3x10s	3x10s	3x10s	3x15s	3x10s								1			2						
ecc. control pect. Ma.	3x10	3x10	3x10	2x15	3x10	3x10	3x10	3x10	3x10	3x10		3x10	3x15	3x10	3x10	3x20	3x20	3x15	3x10			3x10	3x10	3x10	3x15	3x15	1		3x15	2	3x15	3x15	3x15	3x20	3x20	3x20
ecc. control b.b.																											1			2						
contained stretch pect.ma./b.b.																											1			2						
stretch posterior capsule																											1			2						
trunk control ecc. axial elevation	T4 1 3x10		T4 1 3x10						TV4 10x																		1			2						
trunk control ecc. axial rotation	T4 1 3x10		T4 1 3x10																								1			2						
trunk control ecc. lateroflexion	TV4 1 3x10		T4 1 3x10						TV4 10xL 10xR																		1			2						
neutral positioning scapula	TV4 3x10	TV4 3x10	TV4 3x10				FTV4 3x10	FTV4 3x10		FTV4 15x	FTV4 15x	FTV4 15x				FTV4 3x10	FTV4 3x10		FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10			1			2						
making the arm long in external rotation position							FTV4 3x10	FTV4 3x10		FTV4 15x	FTV4 15x		FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 2x10	FTV4 3x10		FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10		FTV4 3x10	1	FTV4 3x10	FTV4 3x10	2	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10
retroflexion arm in external rotation position							FTV4 3x10	FTV4 3x10		FTV4 15x	FTV4 15x		FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 2x10	FTV4 3x10		FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10			1			2	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10
retraction in prone	T4 3x10	FTV4 3x10	FTV4 3x10	FT5 3x10	FT5 3x10	FT5 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10x5s	FTV4 3x10	FTV4 3x10	FTV4 3x10x5s	FTV4 3x10x5s	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 2x10	FTV4 3x10			FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x20	FTV4 3x20	1	FTV4 3x20	FTV4 3x20	2	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10
s.a. ecc. without load	TV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 2X10	FTV4 3X10	FTV4 3X10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 2 3x10	FTV4 2 3x10	FTV4 2 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3 3x15	FTV4 3 3x15	FTV4 3 2x15	FTV4 3 3x10	FTV4 3 3x10	FTV4 3 3x10					FTV4 3 3x10	1	FTV4 3 3x10	FTV4 3 3x10	2	FTV4 3 3x10	FTV4 3 3x10	FTV4 3 3x10	FTV4 3 3x10	FTV4 3 3x10	FTV4 3 3x10
s.a. ecc. with load 90° antefl.																											1			2						
prone extension arm																											1			2						
extension arm sitting position																											1			2						
external rotation in side lying										FTV4 3x15	FTV4 3x15	FTV4 3x15	FTV4 3x15	FTV4 3x10	FTV4 3x10	FTV4 3x10 0,5kg	FTV4 3x10 0,5kg	FTV4 3x10 0,5kg	FTV4 3x15	FTV4 3x20	FTV4 3x20	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x20	FTV4 3x15	1	FTV4 3x10	FTV4 3x10	2	FTV4 3x15	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10	FTV4 3x10

Table 9: Legend of table 8

Case 2	Meaning		Feedback	Meaning
pect. Min.	Pectoralis minor		5	No feedback
pect. Ma.	Pectoralis major		4	Little feedback
ecc.	Eccentric		3	More feedback
b.b.	Biceps brachii		2	Much feedback
s.a.	Serratus anterior		1	Passive feedback
antefl.	Anteflexion		F	Physical feedback
1	Holiday, no therapy		T	Tactile feedback
2	Illness, no therapy		V	Verbal feedback
1	Exercise using a mirror			
2	45° anteflexion			
3	90° anteflexion			

3. CASE 3

The detailed treatment program of CASE 3 is given in Table 10 and 11.

Week 1: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. biceps brachii, m. pectorals maior and minor and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly tactile and physical feedback.

Week 2: Rehabilitation contained forms of manual therapy focusing on capsular stretch and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly tactile and verbal feedback.

Week 3: Rehabilitation contained forms of manual therapy focusing on capsular stretch and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was started (functional elevation tasks >90°). The patient needed mainly tactile and verbal feedback.

Week 4: Rehabilitation contained forms of manual therapy focusing on muscle stretch/flexibility of m. pectoralis maior and forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little tactile and physical feedback.

Week 5: Rehabilitation contained forms of manual therapy focusing on muscle stretch/flexibility of m. pectoralis maior and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little tactile and physical feedback.

Week 6: Rehabilitation contained forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little tactile and physical feedback.

Week 7: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on analytic rotator cuff training. Functional training was progressed (Functional elevation tasks >90°, functional abduction tasks <90°, reach and grasp tasks). The patient needed little tactile and physical feedback.

Week 8: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on trunk control and analytic rotator cuff training. Functional training was progressed. The patient needed little tactile feedback.

Week 9: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on trunk control and analytic rotator cuff training. Functional training was progressed. The patient needed little tactile and physical feedback.

Week 10: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on trunk control and analytic rotator cuff training. Functional training was progressed. The patient needed no or little feedback.

Week 11: Rehabilitation contained forms of manual therapy focusing on muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on trunk control and analytic rotator cuff training. Functional training was progressed. The patient needed no or little feedback.

Week 12: Rehabilitation contained forms of manual therapy focusing on muscle stretch/flexibility of m. biceps brachii and forms of exercise therapy focusing on trunk control and analytic rotator cuff training. Functional training was progressed. The patient needed no or little feedback.

Table 10: Program case 3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
traction	x																		x		x		x	x	x	x	x	x	x	9							x	
longitudinal traction	x	x		x	x	x		x																						9								
ventral translation	10x	20x	15x	5x	x																									9								
dorsal translation	2x																													9								
caudal translation	r1	r1	r1	r	x	x1,4		x1											x	x	x		x	x	x	x	x	x	x	9							x	
end-range translation																														9								
stretch pect. Min.	5x																													9								
ecc. control pect. Ma.	5x																						10x							9								
ecc. control b.b.	5x								F4 10x 0,5kg	F4 2x10 0,5kg	F4 3x10 0,5kg		F4 2x10 0,5kg	FT4 2x10 0,5kg	T4 2x10 0,5kg			F4 2x10 1kg	F4 2x10 1kg	F4 3x10 1kg	T4 2x10	T4 3x10	2x10	3x10	3x10	T4 10x1kg 10x 1,5kg	10x1kg 10x1,5kg	10x1kg 2x10x 1,5kg	2x10 1,5kg	9	T4 2x10 2kg	T4 2x10 2kg	5 10x 2kg		5 10x 2kg	2x10 1kg	2x10 1kg	
contained stretch pect.ma./b.b.																														9								
stretch posterior capsule																														9								
trunk control ecc. axial elevation																														9								
trunk control ecc. axial rotation																														9								
trunk control ecc. lateroflexion	F3 10x	F3 10x	F3 10x	T4 10x	T4 10x			F4 10x	F3 10x		5 10x										T4 2x10	T4 2x10	T4 2x10	T4 8 2x10	T4 8 2x10	T4,5 2x10	5 2x10	5 2x10	5 2x10	9	5 2x10	5 10x	5 2x10	5 2x10	5 2x10			F4 2x10
neutral positioning scapula	T3 5x	F3 10x		T4 5x	T4 5x							F4 3x		T3 5x	T4 3x	T4 5x														9								
making the arm long in external rotation position	F3 12x	F3 10x	F3 10x	T4 10x	T4 10x																									9								
retroflexion arm in external rotation position	F3 10x		F3 10x	T4 10x	T4 10x		F4 10x	F4 2x10	V4 10x																					9								
retraction in prone		F3				F3 10x																								9								
s.a. ecc. without load	3x			V42 10x	TV3 10x	5 10x 0,5kg	5 2x10	55 25x 0,5kg		5 2x10 0,5kg	5 20x1kg 10x0,5kg	5 3x10 1kg	5 2x10 1kg	5 2x10 1kg	5 2 3x10 1kg	5 2 3x10 1kg		5 2x10 1kg												9								
s.a. ecc. with load 90° antefl.	T3 10x 0kg	T3 10x 0kg				5 10x 1kg	5 10x																							9								
prone extension arm						F3 7 10x			T3 7 8x	T3 7 2x5	T3 7 3x5		F3 7 10x	F3 7 2x10	F3 7 2x10	T4 7 3x10		F4 7 8x10			T4 7 2x10	T4 7 2x10	7 2x10	T4 7 2x10	T4 7 2x10	T4 7 2x10	T4 7 2x10	T4 7 2x10		9	T4 7 10x0kg 10x0,5kg	5 7 2x10 0,5kg			5 7 2x10 0,5kg		T3 2x10	
extension arm sitting position																														9								
external rotation supine	F3 15x		10x	F4 2x10	10x 10x3	4 2x10			5 6 10x	5 6 10x	5 6 2x10	5 6 2x10	5 6 2x10	5 6 2x10	5 6 3x10	5 6 3x10		F4 6 2x10	F4 6 2x10		T3 6 2x10	T3 6 2x10	T3 6 2x10	T4 6 2x10	T4 6 2x10	T4 6 2x10	T4 6 2x10	T4 6 2x10	T4 6 2x10	9	T4 6 20x	T4 § 10x	F4 6 2x10	F4 6 10x	F4 6 2x10			

Table 10: Legend of table 11

Case 3	Meaning		Feedback	Meaning
pect. Min.	Pectoralis minor		5	No feedback
pect. Ma.	Pectoralis major		4	Little feedback
ecc.	Eccentric		3	More feedback
b.b.	Biceps brachii		2	Much feedback
s.a.	Serratus anterior		1	Passive feedback
antefl.	Anteflexion		F	Physical feedback
1	120° abduction		T	Tactile feedback
2	5 repetitions low, than 90°		V	Verbal feedback
3	10x sitting			
4	140° elevation			
5	110° anteflexion			
6	Sitting position			
7	Sitting flexed, supported head			
8	On TOGU dynair sit and exercise pillow			
9	Analysis of movements			
X	Total of 15 min			
X	Total of 10 min			
X	Total of 5 min			

4. CASE 4

The detailed treatment program of CASE 4 is given in Table 12 and 13.

Week 1: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals maior and minor and forms of exercise therapy focusing on trunk control, scapula setting, and analytic m. serratus anterior and rotator cuff training. The patient needed mainly tactile feedback.

Week 2; Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectoralis aminor and forms of exercise therapy focusing on trunk control, scapula setting, and analytic rotator cuff training. The patient needed mainly tactile and verbal feedback.

Week 3: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals minor and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was started (reach and grasp tasks <90° in sitting position). The patient needed mainly tactile feedback.

Week 4: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals minor and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly tactile feedback.

Week 5: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals minor and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed mainly tactile feedback.

Week 6: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals minor and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little tactile and verbal feedback.

Week 7: Rehabilitation contained forms of manual therapy focusing on capsular stretch and forms of exercise therapy focusing on scapula setting, and analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little verbal feedback.

Week 8: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals minor and forms of exercise therapy focusing on scapula setting, and analytic rotator cuff training. Functional training was progressed (reach and grasp tasks <90° in standing position, rowing). The patient needed little verbal feedback.

Week 9: Rehabilitation contained forms of manual therapy focusing on capsular stretch and forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little verbal feedback.

Week 10: Rehabilitation contained forms of manual therapy focusing on capsular stretch and forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little verbal feedback.

Week 11: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals maior and minor and forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little verbal feedback.

Week 12: Rehabilitation contained forms of manual therapy focusing on capsular stretch and muscle stretch/flexibility of m. pectorals maior and minor and forms of exercise therapy focusing on analytic m. serratus anterior and rotator cuff training. Functional training was progressed. The patient needed little verbal feedback.

Table 12: Program case 4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
traction	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	A		3x10s	3x10s	3x10s
longitudinal traction	3x10s	3x10s	3x10s	3x10s		3x10s				3x10s	3x10s		3x10s	A				
ventral translation	3x10s	3x10s	3x10s	3x10s			3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	A				
dorsal translation	3x10s	3x10s	3x10s	3x10s	5x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	A		3x10s	3x10s	3x10s
caudal translation	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	A		3x10s		
end-range translation														A				
stretch pect. Min.	3x10s	3x10s		3x10s	5x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	A		3x10s	3x10s	3x10s
ecc. control pect. Ma.	3x	3X												A				
ecc. control b.b.	3X													A				
contained stretch pect.ma./b.b.	2x20s													A				
stretch posterior capsule	3x20s	3x20s	3x20s	3x10s	4x10s	3x10s	3x10s	3x10s	3x10s	3x30s	3x30s		3x30s	A		3x15s	3x15s	5x30s
trunk control ecc. axial elevation	5 1x10s			5 5x	5 5x													
trunk control ecc. axial rotation	3 2x5			5 5x	5 5x													
trunk control ecc. lateroflexion	4 2x20			5 5x	5 5x													
neutral positioning scapula	T4 10x	T4 10x	T4 10x	T4 10x		T4 10x	V5 5x	TV4 10x	T4 10x	TV4 3x10	TV4 2x10	TV4 10x	TV4 10x	TV4 10x	TV5 10x	5 3x		
making the arm long in external rotation position	TV3 5x	T4 10x	TV4 10x	TV4 3x10		T4 10x	TV4 10x	TV4 10x	TV4 2x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV5 3x10			
retroflexion arm in external rotation position	T3 5x	T4 10x	TV4 10x	TV4 10x		TV3 10x	TV4 10x	TV4 10x	T4 10x	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV5 3x10			
retraction in prone		T5 10x	V5 10x	V4 20x	TV 20x	5V 10x	4FT 10x	T4 2x10	T4 2x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV5 3x10	TV4 3x10	TV4 3x10	
s.a. ecc. without load	F4 10x	F4 10x	T5 10x		T4 10x			TV4 10x	TV4 10x	TV4 10x	TV4 10x	TV4 10x	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	TV4 3x10	5V 3x10
s.a. ecc. with load 90° antefl.					T4 10x			TV4 10x	TV4 10x	TV4 10x	TV4 10x 1kg	TV4 10x 1kg		TV5 3x10				
prone extension arm	FTV4 10x	FTV4 10x	TV5 20x	FV2 10x	TV 10x	TV3 10x	TV4 10x	TV4 10x	TV4 10x					TV4 2x10	TV4 2x10	TV3 15x	TV4 3x10	V5 3x10
extension arm in sitting position																		
external rotation in side lying		T5 3x10 1kg	T5 3x10 1kg	TV4 3x10 1kg	TV3 2x10		FTV 1x10 1kg	TV5 3x10 1kg	T5 10x 1kg	5V 3x10	TV5 3x10	TV5 3x10	TV5 3x10 1kg	TV5 3x10 1kg	TV5 2x15 1kg	3x10 1kg	TV5 3x10 1kg	V5 3x10 1kg

Table 12: Program case 4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
traction	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s	3x10s	3x10s
longitudinal traction	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s	3x10s	3x10s
ventral translation			3x10s															
dorsal translation	3x10s	3x10s	3x10s				3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s	3x10s	3x10s	3x10s
caudal translation	3x10s	3x10s	3x10s				3x10s	3x10s	3x10s	3x10s	3x10s	3x10s		3x10s	3x10s			
end-range translation																		
stretch pect. Min.	3x10s	3x10s	3x10s											3x10s	3x10s	3x10s	3x10s	3x10s
ecc. control pect. Ma.													3x20 1 1kg	3x20 1 1kg	3x20 1 1kg	3x15 1 1kg	3x20 1 1kg	3x20 1 1kg
ecc. control b.b.																		
contained stretch pect.ma./b.b.																		
stretch posterior capsule	3x10s	3x10s	3x10s	3x10s	3x10s	3x10s	3x30s	3x30s	3x30s	3x30s	3x15s	3x15s	3x15s	3x20s	3x20s	3x15s	3x15s	3x15s
trunk control ecc. axial elevation																		
trunk control ecc. axial rotation																		
trunk control ecc. lateroflexion																		
neutral positioning scapula	V5 10x	V5 10x																
making the arm long in external rotation position	V5 10x	V5 10x		V5 2 3x10 1kg	V5 2 3x10 1kg	V5 2 3x10 1kg												
retroflexion arm in external rotation position	V5 10x	V5 10x																
retraction in prone	V5 10x	V5 10x	5V 3x15	V5 3x10	V5 3x10	V5 3x10									V5 3x10			
s.a. ecc. without load	V5 10x	V5 10x					V5 3 3x10	V5 3 3x10	V5 3 3x10	V5 3 3x10	V5 3,4 3x10	V5 3,4 3x10						
s.a. ecc. with load 90° antefl.					V5 2 3x10 1kg					V5 3x10 1kg	V5 4 3x10 1kg	V5 4 3x10 1kg	FTV5 3 3x10		FTV5 3 3x10	V5 3 3x15	V5 3 3x15	V5 3 3x15
prone extension arm	V5 10x	V5 10x 1kg	V5 10x 1kg	V4 3x10	V5 3x10	V5 3x10	V5 3x10 1kg	V5 3x10	V5 3x10	V5 3x10			V5 3x10 1kg		V5 3x10 1kg	V5 3x10 1kg	V5 3x10 1kg	V5 3x10 1kg
extension arm in sitting position													V5 3x10					
external rotation in side lying	TV4 3x5 2kg	TV4 3x5 2kg	5V 3x10 1kg	V5 3x20s	V5 3x20s	V5 3x20s	5V 3x10 1kg	5V 3x10 1kg	5V 3x10 1kg	V5 3x20 1kg	V5 3x20 1kg	V5 3x20 1kg	V5 3x10 1kg	V5 3x10 1kg	V5 3x10 1kg	V5 3x20 1kg	V5 3x20 1kg	V5 3x20 1kg

Table 13: Legend of table 12

Case 4	Meaning		Feedback	Meaning
pect. Min.	Pectoralis minor		5	No feedback
pect. Ma.	Pectoralis major		4	Little feedback
ecc.	Eccentric		3	More feedback
b.b.	Biceps brachii		2	Much feedback
s.a.	Serratus anterior		1	Passive feedback
antefl.	Anteflexion		F	Physical feedback
1	Bilateral		T	Tactile feedback
2	Combined elevation task, in sitting position		V	Verbal feedback
3	First till 90°			
4	Performed while sitting			
A	Aqua training			

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Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2015**

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