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Scapula alata: description of a physical therapy program and its effectiveness measured by a shoulder-specific quality-of-life measurement

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Background: To date, there are no published outcomes-based treatment programs to guide clinicians when managing patients with scapula alata. The purposes of this study were to describe a physical therapy program in patients with scapula alata and to evaluate its effect using a shoulder-specific quality-of-life measurement.

Methods: In this case series and retrospective study, 22 patients (11 female patients) with a median age of 34 years (interquartile range, 28-44 years), diagnosed with scapula alata caused by injury to the long thoracic nerve, were successively referred as outpatients to a physical therapy program at a university hospital. The program included (1) physical examination, (2) thoracic brace treatment, and (3) muscular rehabilitation. The treatment frequency and duration were determined individually. The effect was evaluated by a shoulder-specific quality-of-life questionnaire, the Western Ontario Rotator Cuff (WORC) Index. The WORC Index is grouped into 5 domains: physical symptoms, sport/leisure time, work, lifestyle, and emotional health.

Results: The results showed a highly significant improvement ($P < .001$) from pretest to post-test as measured by all 5 domains in the WORC Index.

Conclusions: This study described in detail a physical therapy program; the program showed significant benefit. Further research is needed before recommending the program as a potential treatment option.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Brace; physical therapy; rehabilitation; thoracic nerve; scapula alata

Scapula alata (SA), also called scapular winging, is a clinical condition in which the medial border and inferior angle of the scapula protrude prominently from the thorax.[38] SA has been reported over many years in adults[1,11,31,40] and, more recently, in children[8,35]; however, prevalence studies are lacking.[1]

Multiple pathologies lead to SA. Palsy of the serratus anterior muscle caused by injury to the long thoracic nerve (SALT) is estimated to be the most common cause.[4,16] SALT can be caused by infection[2,39] or by traction or compression of the long thoracic nerve.[13] The latter two have been reported in athletes,[7,33,34,44] in industrial workers with repetitive use of the shoulder,[22] and as a sequela to surgical procedures.[1]

The majority of patients with SALT are characterized by sudden shoulder pain, followed 2 to 3 weeks later by

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muscle weakness, fatigue, and inability to elevate the affected arm above shoulder level. Patients have difficulty in activities of daily living, need to stop sporting activities, and have an increased probability of having to take sick leave, and their quality of life (QoL) is affected.

The long thoracic nerve, which innervates the serratus anterior muscle, originates at the C5, C6, and C7 cervical nerves; it travels beneath the brachial plexus and clavicle and over the first rib. The contributions from C5 and C6 pierce the scalenus medius, whereas the C7 contribution passes in front of the muscle. The superficial location along the lateral aspect of the chest wall, together with the length of the nerve (22-24 cm),[9,13] makes it susceptible to injury.[12,22]

The serratus anterior muscles arise from the first through the ninth ribs and insert onto the costo-medial border of each scapula. The upper fibers of the serratus anterior insert onto the superior angle of the scapula and act to stabilize the scapula during the initial states of abduction. The middle fibers insert onto the vertebral border of the scapula and are instrumental in protraction of the scapula. The lower fibers of the serratus anterior insert onto the inferior angle of the scapula. They are a primary upward rotator of the scapula during abduction.[33] Together with the lower trapezius muscle, the serratus anterior muscle plays a major role in stabilizing the scapula during arm movements.

Some injuries to the long thoracic nerve recover spontaneously within 1 year,[24,42] but full recovery, if it occurs, may take up to 2 years. The recovery period depends on the degree of demyelination.[23,37]

To date, there are no published outcomes-based treatment programs to guide clinicians when managing patients with SALT. Proposed conservative treatments include "relative rest,"[1] use of a brace and orthotic device,[1,11,14,25] and physical therapy.[1,14,25,41]

The overall goal of physical therapy is to regain optimal function in the scapulothoracic and glenohumeral joints. Rehabilitation of patients with SALT emphasizes pain relief and preservation or restoration of joint range of motion.[22]

The use of a thoracic brace prevents downward rotation and winging of the scapula, and a thoracic brace is used in the treatment of SALT to support the scapula function as a stable base. In 1993, Kauppila[13] speculated that repeated scapular winging (eg, in the absence of a stabilizing brace) may delay recovery of patients with SALT because of excessive long thoracic nerve tensioning.

Accordingly, an interdisciplinary team (physical therapists, orthopaedic shoulder specialists, and a surgical appliance manufacturer) has devised a rehabilitation protocol for patients with SA that combines use of a thoracic brace with muscular rehabilitation.[21] This protocol has been used and refined in a clinical environment, but its effect on patient-perceived QoL has not been evaluated until now.

The objectives of this study were (1) to describe a physical therapy program in patients with SALT and (2) to evaluate its effect measured by a shoulder-specific QoL measurement.

Materials and methods

Participants

In total, 97 patients with multiple pathologies of SA were referred to undergo physical therapy at the Department of Physiotherapy and Occupational Therapy by rheumatologists at the Department of Rheumatology, Glostrup Hospital, University of Copenhagen, Glostrup, Denmark, between January 1, 2008, and December 31, 2011. Initially, all the patients treated by specialized medical doctors at primary health services and other university hospitals, as well as by general practitioners, were referred for diagnosis to the outpatient clinic at the Department of Rheumatology.

The sample for this study represented a subgroup of patients with SA according to the inclusion and exclusion criteria. The inclusion criteria were (1) outpatients diagnosed with SALT, (2) patients aged 15 years or older, and (3) patients who received evaluation with the Western Ontario Rotator Cuff (WORC) Index[20] before and after intervention. The exclusion criteria were (1) history of shoulder injury, (2) additional neurologic disorders, and (3) bone abnormality.

Procedure

A hospital-based, case-series, retrospective design was used. All participants had a 4-week start-up period including physical examination by an experienced shoulder physiotherapist (PT), preparation of a brace, instruction on the use of the brace, and instruction regarding the first exercises.

The physical examination included a detailed history (onset, pain rating on a visual analog scale, previous treatment) and inspection of cervical, thoracic, and scapular posture and symmetry (assessed by photographs); atrophy of the scapula-related muscles; prolongation or shortness of shoulder-related muscles; shortness of muscles fixated at the coracoid process (musculus pectoralis minor, short head of biceps brachii, and coracobrachialis); and tightness of the glenohumeral posterior capsule.

Functional detailed examination included range of motion (assessed by photographs and video) in the glenohumeral joint during dynamic humeral motions—forward flexion to horizontal level (90°), forward flexion to maximal level, abduction to horizontal level (90°), and abduction to maximal level—and the position of the scapula during dynamic humeral motions—forward flexion to horizontal level, forward flexion to maximal level, abduction to horizontal level, and abduction to maximal level. Range of motion in the glenohumeral joint was also assessed by a passive-motion individual-muscle test, as well as palpation of the muscles, ligaments, and myofascia in the shoulder and scapula (tenderness, crepitus, or snapping).

The examination took place with the participant's upper trunk undressed (female patients wore bras) in the following positions: (1) at rest, with the participant standing with the arms at the side, elbows extended, and thumbs pointed forward ("rest position"), and (2) active motion, starting in the rest position. Participants unable to achieve 90° of elevation on the affected side were asked to elevate the non-affected side naturally and the affected arm to the maximum angle.

Photographs of the scapula were taken from a posterior aspect point with the patient in the rest position and with the arms in forward flexion to 90° and in abduction. A videotape was made of the scapula position during dynamic motion. Four locations were visibly marked on the scapula for analysis: the superior angle, inferior angle, and medial border of the spine and the spinous process on the spinal column. Similarly, the following muscles were marked: the upper part of the trapezius, the levator scapula, the lower part of the trapezius, the rhomboid, and the serratus anterior from the ribcage to the scapula.

The participants were asked to perform, in a standing position, forward flexion and abduction of the affected and non-affected arms. The video recording was taken from the posterior and frontal aspect of the participants.

All participants were informed about the aim of the study, were instructed on the procedures, and had signed consent forms before photograph and video recording. The photograph and video sessions took place at a warm up (20°C-22°C) and quiet room at the Department of Physiotherapy and Occupational Therapy.

The photograph and video recordings were performed to document and evaluate the scapula position in the rest position and during dynamic motion before and after intervention. The performances were repeated during the treatment at intervals of 3 to 6 months.

Scapular Assistance Test

The Scapular Assistance Test[19,30] was used to evaluate increased glenohumeral range of motion obtained when the scapula was supported. The inferior-medial border of the scapula was held close to the thoracic wall and supported during upward rotation by the PT's palm while the participant was asked to raise the affected arm in forward flexion from the rest position to maximum elevation. If the manual support of the scapula resulted in increased active elevation of the affected arm, the test was regarded as positive and treatment with a brace was considered to be indicated.

The Scapular Assistance Test has accepted inter-rater reliability for clinical use.[32] Baseline characteristics for each participant were extracted from medical records and PT notes.

Physical therapy program

Thoracic brace treatment

The thoracic brace treatment started with an individual production of the thoracic brace by a shoulder team. The brace was produced from polypropylene and carbon fiber reinforcement (Sahva, Aalborg, Denmark) (Fig. 1). Participants were instructed to wear the brace increasingly during the first 3 to 6 weeks until they were able to wear it constantly, except during exercise, sleep, bathing, and sexual activity.

After the habituation period, a pelotte (10 × 2.5 × 1 cm), made of a polyethylene foam/plast material, was placed inside the brace close to the medial border of the scapula. The pelotte prevents downward rotation of the scapula and stops inward rotation of the inferior scapular angle. The brace was continuously evaluated and, if necessary, adjusted by remolding the edges of the brace or adjusting or increasing the support of the scapula with a thin pad inside the brace.

Muscular rehabilitation

Muscular rehabilitation comprised the following:

1. If pain was present, pain reduction was achieved by analgesics, relief, and correction in resting and working postures.
2. Patients were instructed in passively positioning the scapula upward rotated with full glenohumeral motion performed in the supine or prone position (Fig. 2). Coracoid-based inflexibility and tightness, as well as posterior glenohumeral capsular stiffness, if present, were treated manually and/or through exercises (Figs. 3 and 4).[16,22]
3. Patients were instructed to have improved awareness of scapular biomechanics and muscular function, aiming toward conscious muscle control, using the photographs, a mirror, and anatomic models.[10]
4. Patients were instructed to establish scapular control, starting with an emphasis on (a) core stability, (b) correction of spinal posture while sitting and standing, and (c) active control of scapular orientation by retraction exercises starting in the supine position.

The level of exercises depended on the individual degree of muscular disorder and taking into account that SA patients initially have a severe lack of function. Conscious muscle control to selectively activate the lower trapezius was highly prioritized in the very early stages to achieve control of scapular posterior tilt and upward rotation.[6] The retraction exercises, activating the lower trapezius, were also included in the home exercises as soon as the participants performed them correctly (Figs. 3-6).

The next stage was exercises with focus on muscle control. Exercises were individually selected with respect to the degree of SA dysfunction. The chosen exercises and starting positions never allowed winging, shrugging, or downward rotation of the scapula; they aimed to achieve optimal length and working conditions of the lower trapezius and serratus anterior, enabling co-contractions of the scapular muscles and optimizing the chances of serratus anterior activity. Initially, non–weight-bearing exercises were performed in a closed chain, semi-closed chain (supporting the arm) (Figs. 7-9), and open chain.[6] The exercises were performed in supine, prone, and side-lying positions, avoiding excess activation of the upper trapezius[5,6] and being consistent with the individual stage of muscle control,[26] including the level of serratus anterior impairment.

As the serratus anterior function gradually recovered, the exercises progressed through increased endurance, repetitions, and resistance. In step with beginning function of the musculus serratus anterior and incipient improved scapular stability and kinesis, kinetic chain components including diagonal patterns were integrated into the exercise program to achieve increased muscle activity in the lower trapezius and the serratus anterior muscles[5,6] and preferably exercises with minimal activity in the upper trapezius muscle.[5,15,25,27]

In time, with restored neuromuscular conditions and regained activity of the serratus anterior muscle, the exercises were gradually progressed, becoming more functional and eventually including plyometric exercises.[17]

The muscular rehabilitation program aimed toward optimal scapular recruitment patterns, trained with optimal intermuscular and intramuscular balance ratios scapulothoracic, scapulohumeral and glenohumeral.[10,18]

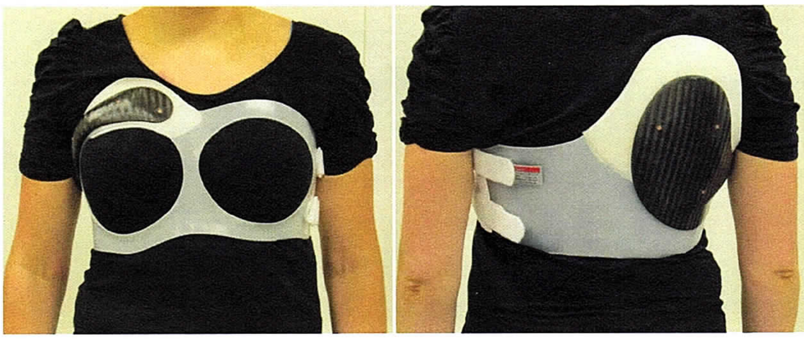

Figure 1 SA brace (Sahva) in a woman with right-sided injury: front view and back view.

Figure 2 Prone scaption, with general shoulder mobilization and capsular stretch upward with rotation of scapula.

Home exercises

Home exercises were included from the start of rehabilitation using the following training equipment: rubber bands with different levels of resistance, softballs, medicine balls, and light dumbbells. The exercises always had a starting and working position not allowing winging, downward rotation of the scapula, or shrugging.

Exercise choices, as well as the progression and number of repetitions, were planned individually, and exercises were recommended to be performed 3 times per day. The first session with the PT lasted 45 minutes, and the following sessions lasted 30 minutes each. All examinations and training sessions were supervised by the same 2 experienced shoulder PTs.

Measurement

The outcome was measured by a shoulder-specific QoL questionnaire, the WORC Index,[20] using the Danish version. The WORC Index consists of 21 health-related items to assess QoL in the week before the response. The items are grouped into 5 domains: physical symptoms, sport/leisure time, work, lifestyle, and emotional health.

Each participant rated the impact of each item on a visual analog scale (0-100 mm). A score of 0 points indicates that the symptom has no impact on QoL, whereas a score of 100 points indicates the worst-case scenario. The scores were summed, with a possible range of 0 to 2,100 points. To present the results in a more clinically meaningful format, it is recommended to report the score as a percentage of normal by subtracting the total score from 2,100, dividing by 2,100, and multiplying by 100.

Neurophysiology

A neurophysiological examination was performed at the Department of Clinical Neurophysiology and consisted of a neurologic

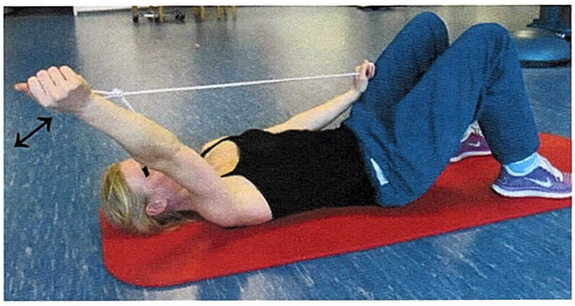

Figure 3 Woman in supine position performing lower trapezius exercise. Upward rotation of the scapula is performed. An open chain is used with the scapula kept in place between the floor and the thorax. The knees are bent. The patient presses the lower back into the floor to include core stability. Fixation of the rubber band is performed with the opposite hand. The direction of pull is from a vertical position, backward, down toward the floor, and slowly back to vertical at a steady pace, performing an agreed number of repetitions.

examination and needle electromyography test[33] of the serratus anterior muscle and measurement of latency to the muscle with the amplitude of the muscle response.

Statistics

Statistical analysis was performed using SPSS software (version 18.00; IBM, Armonk, NY, USA). The results are presented as median and interquartile range (IQR) for data measured by continuous scales and as number and percent for data measured on short ordinal scales. The null hypotheses are tested by the Wilcoxon signed rank test within the group. For all tests, the level of significance was set at 5%.

Results

In total, 22 participants (11 female and 11 male patients) diagnosed with SALT met the inclusion criteria and completed this study. The median age was 34 years (IQR 28-44 years; range, 16-57 years). All participants were referred for diagnosis from other hospitals (n = 7),

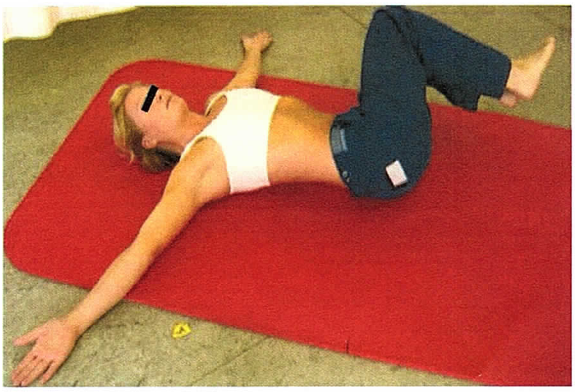

Figure 4 Core stability, stretching, and inhibition of coracoid structures. The patient is instructed to "keep shoulders and arms on the floor while moving your legs slowly from side to side." The palm of the hands are facing upward to achieve stretch of the coracoid structures and activate the backside stabilizers.

Figure 5 Prone retraction. The patient lifts the arms and upper body slightly off the floor and back at a steady pace, performing an agreed number of repetitions. The PT should check that retraction is performed and not adduction of the scapulae.

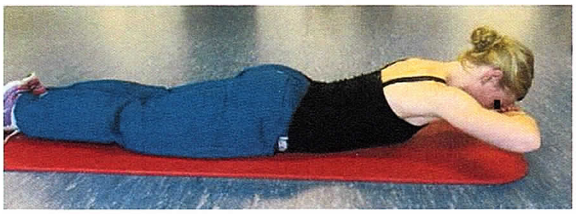

Figure 6 The patient is prone, performing a stabilizing exercise with an upward rotated scapula.

specialists (n = 2), or general practitioners (n = 13). The demographic baseline characteristics of the 22 participants are presented in Table I, and the physical therapy baseline characteristics are shown in Table II.

WORC Index

The results measured by the WORC Index (Table III) showed improvement in all 5 domains. The median value for the WORC Index total score was 932 points (IQR, 617-1,338 points) at pretest and 159 points (IQR, 40-269 points) at post-test. There was a highly significant improvement from pretest to post-test ($P < .001$).

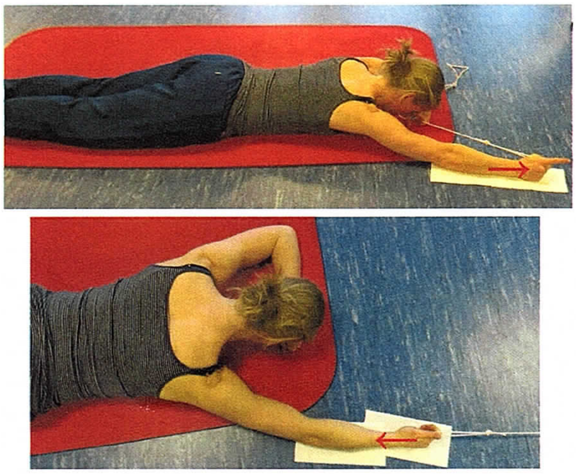

Figure 7 Prone scaption of the scapula with light resistance (or without resistance in very early stages), in which the arm is moved forward ("make the arm longer") and slowly back to starting position, and depression of the scapula, in which the stretched arm is pulled downward ("make the arm shorter") and slowly back to starting position.

Figure 8 Scapula stabilizing and retraction. External glenohumeral rotation is performed with the upper arm supported and a light weight in the hand (or with no weight in the very early stages).

Discussion

This study describes in detail a physical therapy program in patients with SALT. For the first time for such patients, the program has been evaluated by the WORC Index; the results showed a significant effect measured by QoL measurement.

Previous studies

Several studies have reported physical therapy examination and treatment programs in patients with SA.[28,36] However, there are no detailed descriptions for comparison.

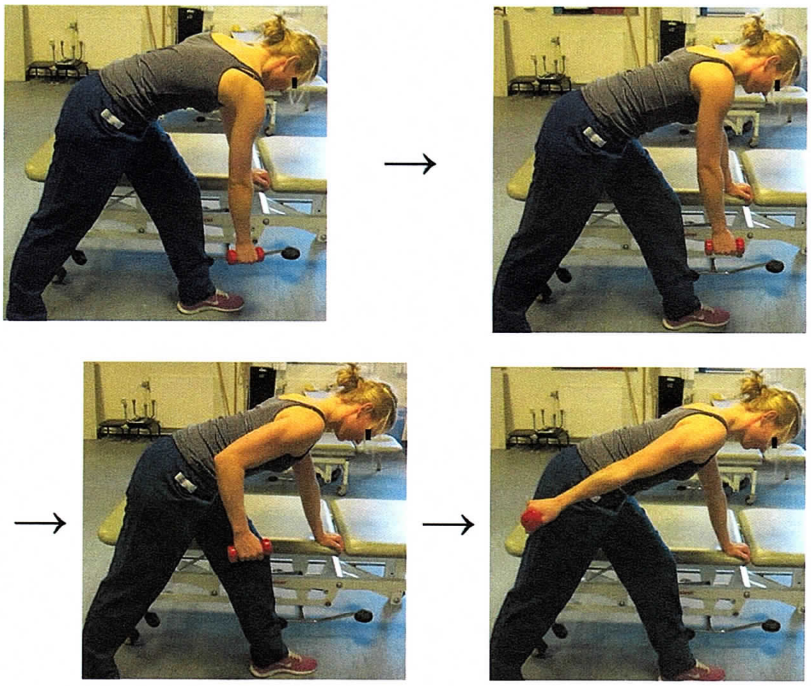

Figure 9 Scapular retraction with modified "lawnmower" exercise. The patient must be aware that scapular retraction is performed and not adduction of the scapula. No shrugging should be allowed.

Table I Demographic baseline characteristics of 22 patients with SA caused by injury to long thoracic nerve

Characteristic	Data
Age [median (IQR)] (y)	34 (28-44)
Gender [n (%)]	
Female	11 (50)
Male	11 (50)
Employment status [n (%)]	
Employed	13 (59)
Studying	8 (36)
Sick leave >1 mo	1 (5)
Level of education [n (%)]	
Short	2 (9)
Medium	6 (27)
Academic	5 (23)
Studying	8 (36)
No information	1 (5)
Distance from home address to hospital [median (IQR)] (km)	20 (12-38)
Pathology [n (%)]	
Trauma	1 (5)
Neuritis	13 (59)
Stress/overloading	6 (27)
Cancer MaMa	2 (9)
Scapula side affected [n (%)]	
Left	5 (23)
Right	17 (77)

Table II Physical therapy baseline characteristics of 22 patients with SA caused by injury to long thoracic nerve

Characteristic	Data
Duration of condition to start of therapy [median (IQR)] (mo)	5 (3-11)
Other shoulder disease [n (%)]	
Yes	2 (9)
No	20 (91)
Hand dominance [n (%)]	
Left	4 (18)
Right	18 (82)
No. of brace adjustments [median (IQR)]	1 (0-1)
Duration of brace use [median (IQR)] (mo)	11 (6-17)
No. of physical therapy sessions [median (IQR)]	13 (9-17)
Duration of physical therapy treatment [median (IQR)] (mo)	13 (10-20)
Duration of physical therapy sessions [median (IQR)] (h)	7 (5-9)

Adriaenssens et al[1] reported a physical therapy examination program in women with breast cancer after post-surgical radiotherapy. Their aim was to identify whether the patients had SA, whereas our aim was to describe and evaluate a physical therapy program.

Safran[33] described injury to the long thoracic nerve including SALT in athletes. The description of the clinical examination and treatment was comparable with our study, though not reported in detail. Furthermore, Safran discussed the use of braces and found inconsistent experiences.

Table III Results of physical therapy program measured by WORC Index in 22 patients with SA caused by injury to long thoracic nerve

	Pretest (n = 22) (points)	Post-test (n = 22) (points)	*P* value
Domain			
Physical symptoms	156 (115-297)	31 (18-78)	<.001*
Sport/leisure time	242 (134-292)	40 (12-75)	<.001*
Work	252 (178-307)	37 (6-69)	<.001*
Lifestyle	165 (31-224)	4 (0-31)	<.001
Emotional health	158 (63-218)	4 (0-11)	<.001*
Total score	932 (617-1,338)	159 (40-268)	<.001*

Data are presented as median (interquartile range). The WORC Index scales range from 0 points (no impact) to 100 points (worst impact) for each item, and the total score ranges from 0 points (no impact) to 2,100 points (worst impact).

* Significant level at $P < .05$.

According to Schultz and Leonard[34] and Wiater and Flatow,[42] use of a brace in conservative treatment of SA is limited because of its intrusive nature and patients' decreased tolerance in practice. Other authors recommend using a brace.[25] In our study, all participants used the thoracic brace, experiencing its intrusiveness. However, we did not assess the degree of patient compliance. Thus, the number of brace adjustments was minimal (Table II).

Watson and Schenkman[41] reported a single case of injury to the long thoracic nerve with full recovery after physical therapy intervention but without use of a brace. However, in that patient, no contractures developed, thus maintaining more optimal muscle balance around the scapula.

According to the review by Martin and Fish,[26] isolated serratus anterior palsy is resolved in most cases with conservative treatment within 1 to 24 months. Which outcome measures they used to assess the effect of physical therapy interventions was unreported.

In our study, we evaluated the physical therapy program only using the WORC Index, knowing that it was a part of a broad test battery of both subjective and objective measures. The WORC Index was the most relevant shoulder-specific instrument available for shoulder outcome measurements.[43]

Perspectives

In this study, video was used to document our clinical visual inspection and for motion analysis. The latter is suggested to be an important objective outcome measurement for assessing patient performance and function. For standard evaluation, a questionnaire needs to be developed, followed by validity and reliability[29] testing in patients with SALT.

To recommend our physical therapy program as a potential treatment option, research designed with randomized controlled trials with blinded assessors evaluating the effect of different types of physical therapy intervention is needed.

Study limitations

Terminology differences are the first limitation. Some authors describe the condition of SA as "scapula alata"; others use "Winged scapular," "scapular winging," or "alar scapula." Standardized terminology is needed in both clinical practice and research.

The second limitation is the multiple pathologies of SA. A classification of SA in subgroups may be important regarding prevention and treatment strategies. In our study, we included a subgroup (n = 22) defined as having SALT among a larger sample of SA patients (N = 97).

Third is the missing clinometric quality of the WORC Index. According to the checklist of clinometric properties in measurement instruments,[3] the WORC Index needs to be tested for validity and reliability in patients with SALT. Hence, the selection of the WORC Index for our sample was based on its design to assess particularly physical functionality, sport/leisure time, work, lifestyle, and emotional health. In addition, the WORC Index was short and translated into Danish.

Fourth, it appears that registrations of pain, compliance, and muscle tests were not systematically performed in this study.

Finally, no follow-up study has been carried out. A long-lasting evaluation of physical activities and QoL in patients with SALT may be an important contribution in both clinical and research strategies.[14]

Conclusion

This study described in detail a physical therapy program in patients with SALT; the therapy program showed significant positive effects measured by a shoulder-specific QoL. It is recommended, given the physical therapy program's promising potential, to evaluate this program in a randomized controlled trial.

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