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A STUDY OF PAINFUL SHOULDER IN WELDERS

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By means of clinical examination, soft tissue radiography and quantitative electromyography, the effect of heavy industrial work was evaluated on welders at a shipyard. The study revealed that the older workers with shoulder pain have a chronic tendinitis of the rotator cuff. The supraspinatus muscle was shown to be consistently fatigued during overhead welding. It is believed that this is an important factor in the aetiology of the shoulder pain commonly occurring in older welders.

Key words: shoulder pain; supraspinatus tendinitis; electromyography; soft tissue radiography; occupational disease; welding

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Next to low back pain shoulder pain is the most frequent complaint among orthopaedic patients. Despite the frequency of shoulder lesions and the consequent pain and disability, much confusion still exists as to aetiology, terminology and treatment. This confusion stems from our incomplete understanding of the basic pathophysiology of shoulder pain. Clinically, supraspinatus tendinitis and adhesive capsulitis account for the vast majority of cases of shoulder pain (Bateman 1972, Lundberg 1969, Moseley 1969, Pasila 1965). These two conditions can be easily differentiated during clinical examination. In supraspinatus tendinitis the range of motion is normal whereas in adhesive capsulitis shoulder motion is restricted.

Manual labour as a source of shoulder pain has been of great concern for many decades. Many writers have postulated an area of degenerative changes and necrosis in a critical zone of the rotator cuff, resulting from the ischaemia of chronic postural strain, or repeated minor trauma, as important aetiological factors (Codman 1934, Wilson 1943). However, previous investigations have failed to show how heavy manual labour affects the development of progressive degenerative changes and hence subsequent shoulder pain (Olsson 1953, Pasila 1965). Most studies have been made on selected clinical materials and on autopsy specimens.

During a recent investigation, heavy static shoulder work, viz., welding at a shipyard, was studied by means of quantitative electromyography (Kadefors et al. 1976). It was concluded that localized muscle fatigue was common, among inexperienced welders, in the deltoid, trapezius (upper portion), and supraspinatus muscles during prolonged overhead work. Experienced workers showed signs of fatigue in the supraspinatus muscle only. On completing this in-

vestigation we became aware of the fact that complaints of shoulder pain were very common among older welders. We postulated that shoulder pain may be aggravated or perhaps even caused by the occupation of welding. Welding is a largely static type of work with typical postures that are characterized by specific patterns of motion of the shoulder joint complex.

This investigation was undertaken,

(a) to elucidate more clearly the clinical and roentgenographic features of shoulder pain in older welders,
(b) to evaluate the impact of static loading on their shoulder muscles (and the subsequent localized muscle fatigue) by quantitative electromyography.

MATERIALS AND METHODS

Subjects

The study was performed on ten welders aged between 50 and 65 years. The subjects were picked from various workshops at the Arendal shipyard of Götaverken, Ltd. in Gothenburg. All of them experienced pain around their loaded shoulder while welding. None of them had a history of any major trauma to the shoulder joint or had any other specific joint disease. For the greater part of their productive lifetime they had been working as shipyard welders.

With respect to pain, the following criteria had to be fulfilled:

1. Located in the deltoid area.
2. Chronic in its duration.
3. Aggravated by shoulder motion especially loading of the arm above 60° of abduction and/or flexion.

Great care was taken to exclude subjects with possible differential diagnoses accounting for the shoulder pain. Out of 15 subjects initially selected, five were excluded because subsequent evaluation revealed a radicular syndrome from the cervical spine (4 cases) or a lateral humeral epicondylitis (1 case).

Clinical examination

The clinical examination consisted of inspection, palpation and assessment of range of motion and gross power. Both shoulders were studied and compared. The total range of motion, active and passive, was measured in the sitting position using a goniometer. Static gross power was evaluated in the supine position according to Clarke et al. (1950) utilizing a special dynamometer (Zadig 1963). Pain in resisted movements was recorded.

Roentgenographic technique

The soft tissue radiographic technique described by Deichgräber & Olsson (1975) was used. This technique allows demonstration of local inflammation in tendinitis even in the absence of calcific deposits. It is assumed that inflammatory reactions cause the surrounding tissues to become oedematous, thus reducing the differences in attenuation capacity between them. For the subacromial region, this means that the subdeltoid fatty layer should become blurred or displaced on the film in cases of tendinitis. Two anteroposterior projections were taken of the shoulder, one with the arm rotated inwards, the other with outward rotation, to demonstrate the tissues adjacent to the greater and lesser tubercles of the humerus, respectively.

Electromyographic investigations

Recordings of the myoelectric activity of shoulder muscles were performed during overhead welding. The methods employed in acquisition and analysis were identical to those reported by Kadefors et al. (1976). In the present study, particular attention was paid to three muscles (deltoid, trapezius, supraspinatus) in which significant effects were found in the basic investigation. Surface electrodes (Medelec Ltd.) were applied to pick up EMG from m. trapezius and m. deltoideus (anterior portion). Myoelectric signals from the supraspinatus were obtained using a monopolar Karma wire electrode inserted by means of a cannula. A surface electrode applied over the spinal processus at level Th 5 served as a reference for the supraspinatus lead.

The dynamic power spectrum analysis method was described by Kadefors et al. (1968). The particular instrument used, developed by Örtengren (1975), consists of an octave filter bank with full-wave rectifiers for each filter output. In the present study only the 500 Hz filter, covering the range of approximately 350–700 Hz, was employed. The rectified signal is logarithmically converted and compared with the level of the rectified and logarithmically converted total EMG. The differences between these two signal levels expresses the portion of high frequency signal content in the total signal.

Figure 1. The working posture investigated. Overhead welding involves shoulder flexion and abduction.

This variable (given in decibels) is studied as a continuous function of time.

Myoelectric signals were recorded during overhead welding, illustrated in Figure 1. Four welding electrodes were melted at 40 cm height above the shoulder, at a normal working pace. The spectral content of the myoelectric signals was characterized as described above, and then normalized to the initial value taken at the onset of melting the first welding electrode. Readings were taken at the beginning of each of the subsequent weldings. Statistical treatment was carried out as described by Kadefors et al. (1976). The relation between high-frequency spectral content and the welding electrode number was studied using the linear regression method.

The subjects were called in for a clinical electromyographic routine investigation of the three muscles involved in the study. Conventional concentric needle electrodes were utilized.

RESULTS

The most consistent finding in the clinical examination was a reduced muscle power and pain on resisted movements in the painful shoulder. At inspection all subjects had normal shoulders. Mild local tenderness of the rotator cuff was always present. There was full range of active motion in all cases. Measurement of the isometric muscle power revealed reduced power in the painful shoulder in abduction, outward rotation and flexion. The results are depicted in Figure 2. In extension, inward rotation and abduction the gross power was found to be the same in both shoulders. Pain in resisted movements was noted by most subjects in outward rotation and flexion (8 out of 10 cases) and in abduction by less than half of them (4 out of 10 cases).

The radiographic appearance was normal in three shoulders only. The main abnormality observed, blurring of the fatty layer, was found in six cases. One such shoulder is illustrated in Figure 3.

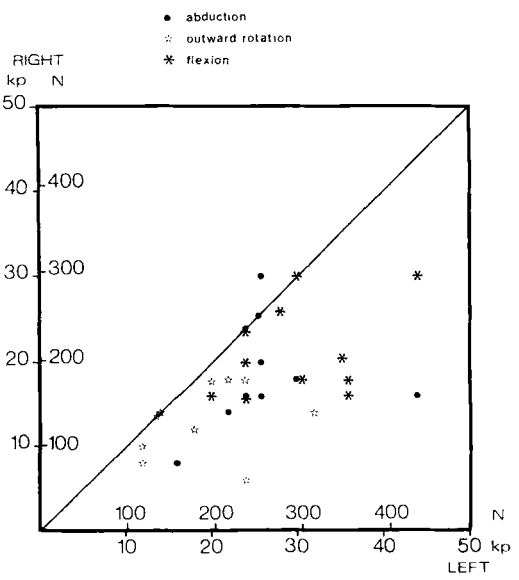

Figure 2. Maximal force in resisted movements, comparing left and right side.

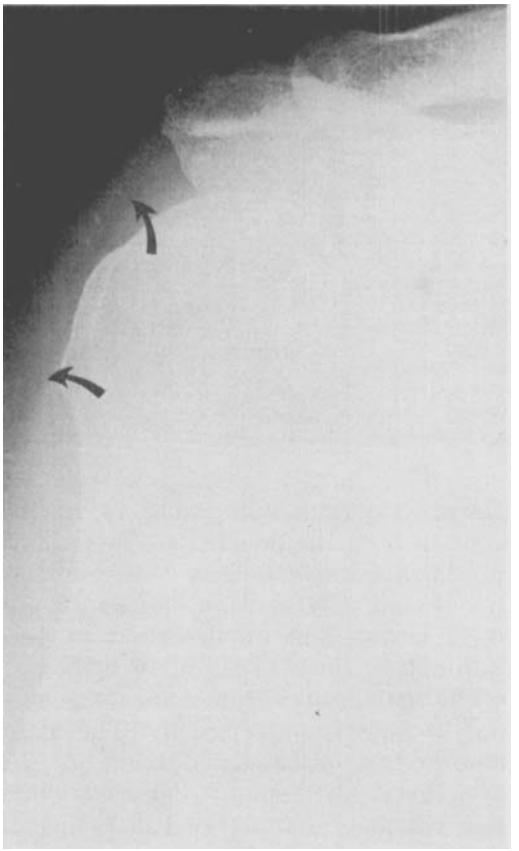

Figure 3. Shoulder joint in which the fatty layer is indicated by the arrow at the top. In the tubercular area (indicated by the lower arrow) local blurring of the fatty layer is seen.

In a majority of cases the fatty layer was invisible over a distance of 0.5 to 1 cm close to the most protruding part of the greater tubercle. The degree of blurring did not seem to indicate the severity of the condition from the clinical point of view. Two of the same six subjects had calcifications in addition to the blurring. Lateral displacement of the fatty layer was encountered in one case only.

It is seen in Table 1, summarizing the results of the myoelectric signal analysis, that the high frequency content for the supraspinatus muscle in particular tends to be higher in welding electrode no. 1 than in subsequent welding electrodes. This is further underlined in the regression analysis (see Figure 4). Computation of confidence intervals of the slope yields that the decline of the supraspinatus high frequency component is significant at the 5 per cent level. Neither of the remaining two muscles shows significant changes.

Analysis of the EMG from the three muscles concerned, according to conventional neurophysiological criteria, revealed no pathological findings.

DISCUSSION

The present study has revealed that the older welders with shoulder pain have a

Table 1. The portion (in dB) of the total myoelectric activity within the 500 Hz band at the onset of melting the different welding electrodes. Mean values and standard errors (italics). Individually normalized data.

Muscle	Welding electrode no.				Linear regression analysis	
	1	2	3	4	Slope (dB/weld)	5 % slope confidence interval
Deltoideus	— 0.22 *0.73*	— 0.44 *0.39*	0.78 *0.61*	— 0.11 *0.82*	+ 0.16	± 0.59
Trapezius	0.86 *0.31*	— 0.69 *0.27*	— 0.03 *0.52*	— 0.14 *0.26*	— 0.23	± 0.35
Supraspinatus	1.05 *0.42*	— 0.05 *0.34*	— 0.75 *0.55*	— 0.25 *0.29*	— 0.46	± 0.38

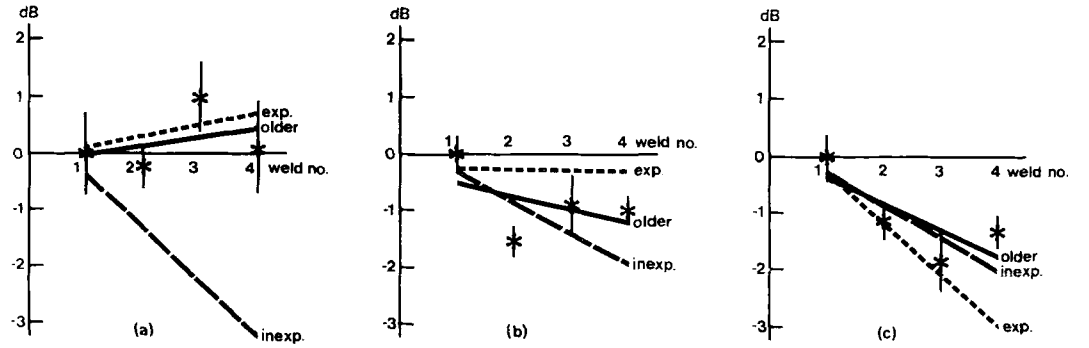

Figure 4. The development of the 500 Hz myoelectric signal component as a function of the welding electrode number. Mean values and standard errors are given for each weld according to Table 1. Regression lines are shown for the present material of older welders, as well as for experienced (exp.) and inexperienced (inexp.) welders (Kadefors et al. 1976). (a) deltoideus, (b) trapezius, (c) supraspinatus muscle. Overhead welding.

chronic tendinitis of the rotator cuff. The tenderness and the amount of pain on resisted movements suggest that the lesion is located in the supraspinatus area of the cuff, an area that has been shown to be most often affected (Codman 1934, DePalma 1950). According to Pasila (1965) the symptoms were termed mild or moderate since the subjects had almost normal active range of motion and since night pain was occasional and working disability rare. Nonetheless the pain was of considerable duration and constantly present at work and in leisure time as well. It is important to note that older workers often have to give up welding before the age of 60 because of chronic shoulder pain.

Soft tissue radiography demonstrated inflammatory abnormalities in the majority of cases. The results agree with Deichgräber & Olsson (1975) who also found this type of local inflammation in patients with tendinitis.

The supraspinatus tendinitis present in these welders is certainly due to degenerative changes. It is well known that such changes appear in the tendons in the third and fourth decades (Ingelmark 1948). Varying degrees of rotator cuff ruptures are most common in the supraspinatus area close to the tendon insertion into bone (DePalma 1950, Olsson 1953). In the majority of cases they arise without appreciable trauma. Many authors have attributed the degeneration of the cuff to repeated minor trauma but there is disagreement as to how this takes place. Codman (1934) thought that the small accidents of everyday life were responsible and Meyer (1937) suggested that the tendons were subjected to trauma between the humeral head and the acromion during normal movements of the shoulder.

Progressive impairment of the blood supply to the cuff has been discussed as a factor contributing to degeneration with increasing age. Several investigations have shown areas of relative avascularity in the supraspinatus tendon adjacent to its point of insertion (Lindblom 1939, Moseley & Goldie 1963). Recently Rathburn & Macnab (1970) studied the vascular supply by microangiography and were thus able to compare the findings with the histological appearance of the same part of the tendon. The most remarkable feature of this investigation was that the zone of avascularity was constantly seen in the supraspinatus tendon whereas the other tendons comprising the rotator cuff showed good filling of the vascular bed. They attributed this

to the anatomical disposition of the vessels running mostly longitudinally along the flat tendon. This disposition of the vessels renders them susceptible to traction and direct pressure.

Analysis of electromyographic signals recorded in actual welding work revealed significant changes in the supraspinatus muscle as overhead welding proceeded. No statistically significant modifications were evident in the trapezius or in the deltoid muscle. Overhead welding was studied in a previous investigation (Kadefors et al. 1976) on fairly young experienced and inexperienced welders and it was noted that the characteristics of the older welders investigated here were similar to those of the experienced group in the basic investigation.

The spectral changes evident here are attributed to an increase in the average duration of the potentials of motor units active in the muscle (Kadefors et al. 1968, Lindström et al. 1970), caused by a decrease in action potential propagation velocity of the muscle fibres concerned (Broman 1973, Lindström et al. 1970). Such spectral changes occur as an adjunct to heavy isometric contractions (Kadefors et al. 1968, Kaiser & Petersén 1963) and represent interference with the blood supply of the muscle with resultant "localized muscle fatigue" (Chaffin 1973).

The significant spectral changes in myoelectric signals obtained from the supraspinatus muscle during prolonged overhead work imply that this muscle is under sustained heavy strain in this working situation. It is interesting to note that acquisition of skill in welding does not entail immunity as far as loading the supraspinatus muscle in overhead work is concerned, in contrast to the situation with the trapezius and deltoid muscles. The supraspinatus muscle is constantly fatigued in overhead welding.

In conclusion, we agree with the general view that the degenerative changes present in the supraspinatus tendon of elderly people are primarily due to a diminished vascularity of the tendon with advancing age. Overhead welding presents an undesirable working situation involving heavy static loading on the supraspinatus muscle. The constant traction in the tendon probably accelerates the degeneration by circulatory impairment. We believe that this is a major aetiological factor for the subsequent shoulder pain occurring in older welders.

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