Scand J Rehab Med 28: 193–200, 1996

INFLUENCE OF ANTHROPOMETRIC AND PSYCHOLOGICAL VARIABLES, PAIN AND DISABILITY ON ISOMETRIC ENDURANCE OF SHOULDER ABDUCTION IN PATIENTS WITH ROTATOR TENDINOSIS OF THE SHOULDER

Jens Ivar Brox,[1] John Ivar Brevik,[2] Anne Elisabeth Ljunggren[3] and Peer H. Staff[1]

From the [1]Department of Physical Medicine and Rehabilitation, [2]Centre for Social Network and Health and [3]Research Forum, Ullevaal University Hospital, Oslo, Norway

ABSTRACT. Predictors of isometric endurance of shoulder abduction were investigated in 18- to 75-year-old women (*n*= 59, mean age 48 years) and men (*n*= 53, mean age 46 years) with unilateral rotator tendinosis of the shoulder (median duration 1–2 years). They were asked to keep both shoulders abducted at 45°, both wrists loaded with 2 kg, for as long as possible. The average force exerted to keep the required position was 17% higher in men compared to women. Mean times to exhaustion were: 103 seconds (SD 109) for the involved shoulder and 160 seconds (SD 81) for the uninvolved shoulder in women; compared to 159 seconds (SD 109) and 289 seconds (SD 109) in men. Increased pain, emotional distress and disability were associated with decreased endurance in the involved shoulder. Gender and emotional distress were the most powerful predictors of time to exhaustion in the uninvolved shoulder, and accounted for 41.7% of the total variance (R^2). Age, body weight, self-efficacy for pain and active coping were poor predictors. This study indicates that isometric endurance is a psychophysiological measure in patients with shoulder pain. Reported pain, emotional distress and disability should be taken into account for interpretation of results.

Key words: emotional distress, isometric muscle endurance, pain, rotator cuff.

INTRODUCTION

Shoulder pain is often related to work situations with prolonged elevated arm position (21) and hand tools (23). Herberts & Kadefors (24) using spectral analysis of electromyographs found a premature state of fatigue in the supraspinatus muscle of welders suffering from chronic tendinitis.

Fatigue is semantically the opposite of muscular endurance. More precisely, according to physiological terminology, fatigue is defined as decreased force-generating capacity. This is distinct from muscular exhaustion, which occurs when the required force can no longer be maintained (43). It is often questioned whether the cause of fatigue is located in the central nervous system or within the muscle. In well-motivated individuals a number of experimental studies of various forms of exercise indicate that fatigue is confined to the muscle and not to the central nervous system (2, 35). The maximal endurance time varies widely, and is influenced by factors such as force, muscle fibre composition, muscle structure and ischaemia.

Muscle strength correlates with age, body weight and gender (20, 29, 30, 36). However, recent studies have failed to observe the expected decrease in strength by age (29), and in women compared to men (17). Bäckman et al. (1) found that men had better shoulder abduction endurance than women, but did not observe a decline by age. Although recent findings may be explained by the wide variability observed for muscular strength and endurance, the presence of other significant predictors in these studies is suspected. In the clinical setting muscular exhaustion is usually measured as the endurance time in a standardized isometric test. Such tests are simple and inexpensive, and may be included at the clinical examination. Time to exhaustion for isometric trunk extension predicted the occurrence of low-back pain in a healthy population (9). Isometric shoulder flexion and abduction endurance times have previously been used as an outcome measure in patients with shoulder and neck pain (14, 15, 38). It has been claimed, however, that such tests induce pain and require a high motivation (1, 9).

The degree of central activation of the muscle is affected by several factors including motivation, possible inhibition via nociceptors and other afferents arising in the muscle (18, 42). Studies examining muscle performance in patients with pain have reported conflicting results. In patients with rotator tendinosis of the shoulder, pain did not influence rotation strength, but reduced flexion strength and made isokinetic tests of abduction strength before treatment impossible in most patients (8). Reduced endurance which corresponded with electromyographic (EMG) signs of fatigue, was observed in patients with myofascial shoulder pain (21). In patients with the chronic fatigue syndrome no signs of contractile failure or lack of central motor drive were observed in a voluntary isometric endurance sequence as compared to electrical stimulation or controls (31).

Measures are indicators of an underlying phenomenon. A muscle strength or endurance test requires subjective action by the testee, and the result can thus be regarded as a manifestation of the patients' behaviour. Previous studies describe that pain-coping efforts and self-efficacy are associated with physical and psychological functioning (e.g. 7, 10, 27). Self-efficacy is a personal conviction that one can perform certain behaviours successfully in a given situation, for example continue with most activities despite pain. This is distinct from measures of coping with pain, which assess the kind of strategy the patient actually uses when he has pain, for example if he remains active.

Recently, in low-back pain patients, pain and disability ratings were found to have negative effects on isokinetic muscle strength, but self-efficacy was the most powerful predictor (17). The anthropometric variables were poor predictors.

Psychological variables have not been included in studies evaluating muscular strength and endurance in patients with shoulder pain. The aim of the present study was therefore to investigate how age, gender, anthropometric (height, body weight and the calculated shoulder torque) and psychological (emotional distress, coping strategies and self-efficacy beliefs) variables, pain and disability predicted the time to exhaustion in an isometric abduction test in patients with rotator tendinosis of the shoulder.

MATERIAL AND METHODS

Patients

One hundred and twelve patients (59 women and 53 men) aged 18–75 years who had unilateral shoulder pain and fulfilled the clinical criteria for rotator tendinosis, participated in the study. The patients were referred to the Department of Physical Medicine and Rehabilitation at Ullevaal University Hospital in Oslo, Norway for diagnostic evaluation and treatment. The clinical criteria for inclusion were dysfunction and pain on abduction; normal passive glenohumeral range of movement; pain on two of three isometric–eccentric tests (abduction at 0° and 30° and external rotation) and a positive impingement sign (37), that is pain on passive internal rotation/flexion. The diagnosis was confirmed if pain was appreciably reduced on re-examination 15 minutes after injecting 6 ml Xylocaine (10 mg/ml) into the subacromial space (positive impingement test). The duration of symptoms ranged from 3 months to more than 3 years, with 1–2 years as the median range. The dominant side was involved in 68 of the patients. Men and women differed on anthropometric variables and disability scores, but not on psychological variables and pain. Further patient characteristics are given in Table I. The time to exhaustion was 980 seconds bilaterally, twice as long as any other patient, in a 44-year-old male hairdresser and bodybuilder. He is not included in Table I. His shoulder torque was 21.7 N m, scores on psychological measures in the normal range and pain scores in the lower range (27 for the involved and 5 for the uninvolved shoulder).

Predictors

Before the endurance test the body height (cm) and body weight (kg) were measured, and a standardized questionnaire comprising information about age in years, hand dominance, emotional distress, coping strategies, self-efficacy for pain and disability, was filled in by the patient. Emotional distress was assessed by the 25-items Hopkins Symptom Check List (13). Symptoms were ranged from 1 (not at all) to 4 (extremely). Active coping was scored from 1 (never use this strategy) to 7

Table I. *Characteristics of the patient population ($n = 111$). Mean values ($\pm SD$) for females and males are given*

	Females ($n = 59$)	Males ($n = 52$)
Age (years)	47.7 ± 11.1	45.9 ± 12.3
Weight (kg)	63.0 ± 10.2	79.3 ± 13.2
Height (cm)	165.2 ± 5.8	178.3 ± 7.4
Shoulder torque (N m)	16.2 ± 1.4	19.3 ± 2.3
Active coping (1–7)	3.9 ± 1.1	3.5 ± 1.3
Self-efficacy for pain (1–7)	3.3 ± 1.2	3.5 ± 1.4
Disability (1–7)	4.7 ± 1.9	3.0 ± 2.1
Emotional distress (1–4)	1.5 ± 0.3	1.5 ± 0.4
Pain (I) (0–100)	55.3 ± 24.4	55.4 ± 20.5
Pain (UI) (0–100)	17.8 ± 20.1	20.7 ± 19.7
Endurance time (I) (seconds)	103.0 ± 109.0	159.4 ± 109.4
Endurance time (UI) (seconds)	159.6 ± 80.7	289.3 ± 108.7

I, involved shoulder; UI, uninvolved shoulder.

(always use this strategy) (7). Self-efficacy was rated from 1 (low) to 7 (high) (32). The mean scores for self-efficacy for pain, active coping and emotional distress, respectively, were calculated.

Disability consisted of 16 categories of activity. By example the patients were asked: "can you carry a shopping bag (5 kg)", "can you put on a sweater", "can you take down things from a wall cupboard". Disability was scored from 1 (low) to 7 (high). For the purpose of this study one single question: "can you carry a shopping bag (5 kg)", was used as a relevant indicator. This single item correlated 0.68 with the mean item score.

The internal consistency (Cronbach's alpha) for the psychometric instruments used was in the present study 0.94 for emotional distress, 0.90 for disability and 0.73 for active coping and pain self-efficacy.

Pain at exhaustion of the endurance test was recorded separately for each shoulder on a visual analogue scale (0 = no pain, 100 = worst pain).

The Spearman correlations among pain severity, emotional distress, active coping, efficacy and disability were as follows: pain and disability, $r = 0.17$; pain and active coping, $r = -0.07$; pain and efficacy, $r = 0.09$; pain and emotional distress, $r = 0.09$; disability and emotional distress, $r = 0.22$; efficacy and coping, $r = 0.33$.

Endurance test

The isometric abduction muscle endurance test was performed with the arms at 45° abduction in the scapular plane, the elbows extended and neutral rotation in the shoulder (Fig. 1). Each wrist was loaded with 2 kg. Both shoulders were tested at the same time, and the patients were asked to endure the position as long as possible. They were instructed to keep the arms and shoulders in the same position throughout the test. The patients were given verbal feedback during the test in order to adjust the position if one of shoulders were elevated. The exercise was performed until exhaustion, and the endurance time was recorded for each shoulder. One physician (JIB) guided the tests and examined all patients.

Each patient exerted a muscular force that includes the gravitational force of the arm–hand segments and the weight applied on the wrist. The lever arms can either be measured manually in each subject or calculated from anthropometrical data (29). In this study the latter method was applied, and the weight of the upper extremity (W_{arm}), length of the arm for the centre of upper extremity mass ($L_{arm\ segment}$) and the length of the lever arm for the weight on the wrist $L_{hand\ segment}$), were calculated from measurements of body height and body weight. The torque (T) was calculated from the equation:

$$T\ shoulder = (W_{arm} \times L_{arm\ segment} + W_{on\ the\ wrist} \times L_{hand\ segment}) \times 9.8 \times \sin 45^{\circ}$$

Correlation coefficients for T shoulder and body weight or body height were 0.94 and 0.86, respectively.

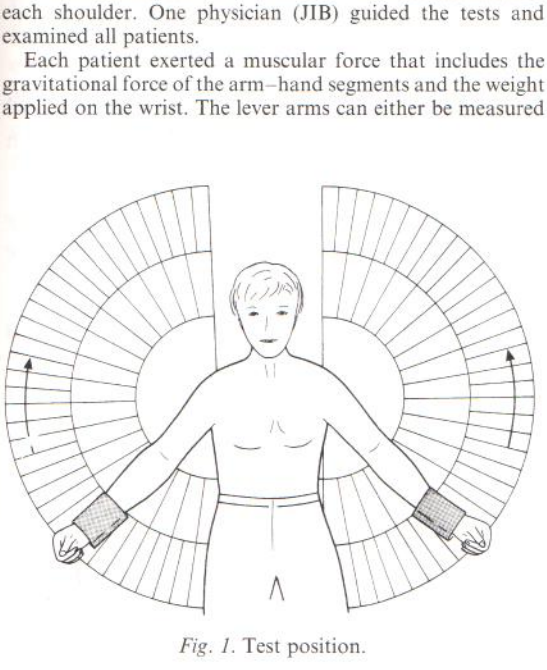

Fig. 1. Test position.

Statistical analysis

Paired t-tests were used to compare the side difference in pain scores in men and women. The association between side differences in time to exhaustion and pain, were assessed by Spearman correlation coefficients. Multiple linear regressions were performed in three stages. In each stage two dependent variables were considered: time to exhaustion in the involved (I) and uninvolved (UI) shoulder. Residual analysis was used to assess the appropriateness of each model. The assumptions for multiple linear regression analyses were improved by excluding the male patient with the extreme endurance. Analyses including this patient are commented in the results section. The significance of the effects in the equations was evaluated by t-testing. The computer package SPSS for Windows, version 6.0 was applied for statistical analyses.

In the first stage we examined how well the anthropometric measures (gender, age, shoulder torque) predict the patient's performance. Then we investigated how well the psychological variables (self-efficacy for pain, active coping and emotional distress) predict the time to exhaustion controlling for the anthropometric measures. The aim of the third stage was to evaluate how well pain intensity and disability predict the performance, controlling for anthropometric and psychological variables. Gender was treated as an indicator variable (1 = female, 2 = male), all others as numeric, linear predictors. The following models were fitted:

- Model 1 Time to exhaustion = Age + gender + torque
- Model 2 Time to exhaustion = Age + gender + torque + coping + efficacy + distress
- Model 3 Time to exhaustion = Age + gender + torque + coping + efficacy + distress + pain + disability

RESULTS

The mean time to exhaustion (Table I) in the involved shoulder was 64.5% that of the uninvolved shoulder in women and 55% in men. Pain scores at exhaustion were significantly ($p < 0.001$) higher in the involved shoulder in men and women. The difference in women was 37 (95% confidence interval: 30–44) and in men 34 (27–41). Significant (Spearman) correlations for

Table II. *Regression coefficients for model 1 separately fitted to the two dependent variables, and the percentage of variance (R^2) explained by model*

	Involved	Uninvolved
Age (years)	0.8	0.3
Sex (female = 1)		
(male = 2)	27.7	110.6***
Shoulder torque (N m)	10.6*	7.2
Total R^2 (%)	10.9	34.4

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

the side difference in endurance times and in pain scores appeared. The association was stronger in men: 0.63 compared to 0.38 in women.

Anthropometric variables

Table II shows the results from model. 1. The interpretation of the regression coefficients is the following: with the uninvolved shoulder men perform on average 110.6 seconds better than women when age and torque are controlled for. For the involved shoulder torque is a better predictor than gender, time to exhaustion increases 10.6 seconds per N m of torque. Age did not achieve significance. The variation (total R^2) in endurance explained by the model was 10.9 (I) and 34.4% (UI). The analyses were controlled using body height, body weight or body mass index (BMI = body weight/body height^2) instead of torque. Body height replaced torque as a significant predictor, body weight or BMI were insignificant.

Isometric endurance as a function of psychological variables

The regression coefficients for model 2 are presented in Table III. Gender remained a significant predictor in the uninvolved shoulder and torque in the involved shoulder. Emotional distress was a highly significant predictor; increased reported distress was associated with a decreased endurance in both shoulders. Self-efficacy for pain and active coping did not achieve significance for either of the two dependent variables. By adding the psychological variables to the anthropometric measures, the explained variance increased considerably, and was 19.4% (I) and 43.0% (UI).

Table III. *Regression coefficients for model 2 separately fitted to the two dependent variables, and the percentage of variance (R^2) explained by model*

	Involved	Uninvolved
Age (years)	0.3	−0.4
Sex (female = 1)		
(male = 2)	28.7	112.7***
Shoulder torque (N m)	9.6*	5.5
Coping score	−5.0	−9.1
Efficacy score	10.3	5.8
Distress score	−69.8**	−80.9***
Total R^2 (%)	19.4	43.0

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Isometric endurance as a function of pain and disability ratings

Pain and disability were significant predictors in the involved shoulder (Table IV). Emotional distress remained a significant predictor, but the influence of torque was reduced ($p = 0.11$). In the uninvolved shoulder no linear effects of pain and disability were found. Gender and emotional distress remained highly significant predictors. The analyses were controlled for handedness and duration of symptoms, but this did not influence results. The total variance accounted for by the model was 30.6% (I) and 41.7% (UI).

The main findings in the three models were not changed if the male patient with the extreme endurance was included in the analyses.

DISCUSSION

In the present study the effect of anthropometric and psychological variables, pain and disability ratings on

Table IV. *Regression coefficients for model 3 separately fitted to the two dependent variables, and the percentage of variance (R^2) explained by model*

	Involved	Uninvolved
Age (years)	0.6	−0.5
Sex (female = 1)		
(male = 2)	16.1	116.3***
Shoulder torque (N m)	8.0	5.0
Coping score	−2.4	−10.7
Efficacy score	4.5	4.3
Distress score	−52.4*	−86.9**
Pain score	−1.3**	−0.1
Disability score	−10.7*	−2.1
Total R^2 (%)	30.6	41.7

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

isometric abduction endurance, were studied in a sample of patients with rotator tendinosis of the shoulder. The results indicate that the isometric endurance test should be regarded as a psychophysiologic test more than a pure measure of physical capacity.

Following the introduction of the concept of perceived exertion by Borg and Dahlström (3) in 1959, this field has been extensively examined in healthy individuals (3–6, 22). Borg (6) proposed that cues from muscles and joints are important for estimating exertion during short-term, high-intensity work and that cues arising from the circulatory and pulmonary systems become more important during long work periods. Mechanoreceptors and lactate are suggested as cues that derive from the muscles and tendons (22). Since compartment muscles are involved in arm abduction, either as stabilizers (infraspinatus, teres minor and subscapularis) or as a prime mover (supraspinatus), the pain at and limitations of isometric abduction endurance may be well correlated to local lactate production. This was not investigated in the present study. Also, high tension in the rotator cuff and increased pressure in the subacromial bursa (40) may irritate mechanoreceptors and increase pain.

The patients in the present study were asked to rate pain and not fatigue at exhaustion. Grandejan (19) describes muscular fatigue as an acute painful phenomenon originating in overstressed muscles. Following this, equal pain intensity should be expected in the involved and uninvolved shoulder at exhaustion. As the observed scores were significantly different, we believe that we have measured pain and not fatigue.

The magnitude of various predictors for physical performance may be different in patients compared to healthy controls. By example perceived exertion correlates well with pulse rate and even better with blood lactate, but Borg & Linderholm (5) found generally higher rates of exertion in relation to pulse in patients with hypertonia and coronary diseases than in a healthy reference group. Waddel et al. (44) described that fear of avoidance beliefs about physical activity accounted for 23% of the variance in disability scores in low-back pain patients. Psychological measures scored in advance of the endurance test were significant predictors in the present study. Furthermore, our results supports the conclusion in a previous study on isokinetic performance in patients with low-back pain (17). However, the specific information about the factors related to performance is different.

Body weight or body mass were poor predictors in both studies, but in the present study gender and shoulder torque were significant predictors of performance. The torque in men was larger than in females, but it may be assumed that the relative torque was considerably higher in women. Maximal voluntary contraction (MVC) was not measured in this study. A recently published study found a large interindividual variation (29) with a mean MVC of 68 N m in men and 29 N m in women for abduction at 0°. If these results are used as a rough estimate of MVC in the present study, it means that women exerted a relative force about twice as high as men. This probably explains the large sex difference observed for the uninvolved shoulder, and the influence of torque on both sides. Nevertheless, when women are using the same kind of tools as men, the relative force is usually higher and may represent an increased risk of overload.

Age was a non-relevant predictor of endurance in this study which is in agreement with a previous report (1). As physically heavy work is less common than formerly, one possible explanation is that muscular strength has adapted to the reduced demands.

Self-efficacy and disability

Self-efficacy is judged in post-life experience and is a more or less realistic estimate of the capacity for certain behaviours. Estlander et al. (17) constructed a self-efficacy scale which measured how long the patient believed she would be able to endure eight separate activities, for example carry weights of 4–5 kg in both hands. Self-efficacy was the most powerful predictor of isokinetic trunk extension muscle strength. In the present study self-efficacy for pain and active coping were poor predictors, but the (dis)ability to carry a shopping bag of 5 kg contributed significantly on the involved side. For the patient the meaning of "Do you believe that you can?" may not be different from "Can you?". Self-efficacy and disability may not be conceptually different, and future studies should compare these scales judging the same specific activities.

Disability is a composite measure, and in the present study, the (dis)ability to carry a shopping bag was best correlated with torque, gender and emotional distress. Previous studies in patients with osteoarthritis of the knee or hip (12), and in elderly, have described disability as a result of physical impairment and emotional distress (45). This is not in disagreement with the findings in the present study, but disability may as well lead to decreased physical activity and result in decreased isometric endurance. Other types of evidence are necessary for further inference about causality.

Emotional distress and pain

Endurance time in both shoulders declined with increased emotional distress. Patients who reported increased emotional distress, independent of pain severity, were less able to endure the burden of a 2 kg handload. This finding supports the results reported by McCue & Newham (34) who investigated hand grip strength in 30 patients after surgery. Voluntary muscle force after intermediate and major surgery correlated with the patient's state of well-being, but maximal tetanic (stimulated) contraction was unaltered.

The present study measured endurance time, included a larger number of patients, and did not use stimulation or EMG registration to assess the degree of fatigue at exhaustion. Emotional distress and pain may inhibit neural input to the muscles, and therefore the patients may have terminated the test before they were exhausted in the physiological meaning of the word.

However, it has been postulated that pain may increase muscle activation (28). This hypothesis is supported by other authors reporting an inability to relax muscles that are painful (16). Although the present study included patients with symptoms and signs of tendinopathy, inability to relax shoulder muscles, dysfunctional movement patterns and painful muscles were commonly present at clinical examination. A premature state of fatigue, caused by physiological and possibly psychological, factors, may have been revealed upon EMG examination, as shown previously for this patient group (24). Emotional distress is a composite measure, which includes depression, various aspects of anxiety and somatization. These components may not have a uniform effect upon muscle activity. Future studies should address the impact of emotional distress and pain on fatigue, and preferably differentiate between various aspects of emotional distress.

In contrast to other studies including patients with chronic musculoskeletal pain (11, 33, 41) emotional distress was not correlated with pain in the present study. This is difficult to explain, but different from previous studies pain was assessed at exhaustion in a particular muscle test. Other factors which may have contributed to the reported increased emotional distress, appeared at the clinical examination such as personality traits, family conflicts, economic difficulties, retired from job for other reasons than the painful shoulder or poor social support.

Side difference

Emotional distress contributed to 7.2 and 11.4% of the explained variance in the involved and uninvolved shoulder, respectively. For the uninvolved shoulder, independent of sex, torque and pain, the endurance time decreased by 80.9 seconds for a 1.0-point increase in emotional distress. Thus, at least in patients who reported increased emotional distress, it seems not reasonable to consider the endurance time in the uninvolved shoulder as a normal value. Nevertheless, the mean endurance time in the involved shoulder was less than 60% of the uninvolved shoulder. In a previous study isometric shoulder flexor endurance was measured in 75 women with unilateral shoulder/neck pain (15, 38). The endurance time before treatment was 74–80% of the uninvolved shoulder, and 65–75% of the mean values for a comparable group without shoulder/neck pain. Improvements after 3 months were found only in those who subjectively stated that their symptoms were reduced.

In previous investigations the activity in the supra- and infraspinatus muscles were found to be more hand–load dependent and vulnerable for ischaemia than the trapezius and deltoid muscles (25, 26, 39). However, since registration of intramuscular pressure, muscle size or fatigue was not included, this study does not allow for further speculations about the limiting factors.

The concept of endurance in everyday language refers to toleration of an even painful and uncomfortable state, and goes beyond the physiological limitations. According to this definition, the influence of emotional distress, pain and disability is not surprising. This study illustrates the presence of these predictors in patients with chronic shoulder pain.

ACKNOWLEDGMENTS

The study was supported by grants from the Norwegian Research Council. We want to thank Kari Ruud for drawing the figure.

REFERENCES

1. Bäckman, E., Johansson, V., Häger, B., Sjöblom, P. & Henriksson, K. G.: Isometric muscle strength and muscular endurance in normal persons aged between 17 and 70 years. Scand J Rehabil Med *27:* 109–117, 1995.
2. Bigland-Ritchie, B., Furbush, F. & Woods, J.: Fatigue of intermittent submaximal voluntary contractions. J Appl Physiol *61:* 421–429, 1986.
3. Borg, G. & Dahlström, H.: Psykofysisk undersøkning av arbete på cykelergometer. Nord Med *62:* 1383–1386, 1959.
4. Borg, G.: Physical performance and perceived exertion. Thesis, Lund, Sweden, 1962.
5. Borg, G. & Linderholm, H.: Perceived exertion and pulse rate during graded exercise in various age groups. Acta Med Scand, Suppl *472:* 194–196, 1967.
6. Borg, G.: Psychophysical basis of perceived exertion. Med Sci Sports Exer *14:* 377–381, 1982.
7. Brown, G. K. & Nicassio, P. M.: Development of a questionnaire for the assessment of active and passive coping strategies in chronic pain patients. Pain *31:* 53–64, 1987.
8. Brox, J. I., Holm, I., Ludvigsen, P. & Steen, H.: Pain influence on isokinetic shoulder muscle strength in patients with rotator tendinosis (impingement syndrome stage II). Eur J Med Rehabil *6:* 196–199, 1995.
9. Biering-Sørensen, F.: Physical measurements as risk indicators for low back trouble during a one year period. Spine *9:* 106–119, 1984.
10. Council, J. R., Ahern, D. K., Follick, M. J. & Kline, C. L.: Expectancies and functional impairment in chronic low back pain. Pain *33:* 323–331, 1988.
11. Croft, P., Schollum, J. & Silman, A.: Population study of tender point counts and pain as evidence of fibromyalgia. Br Med J *309:* 696–699, 1994.
12. Dekker, J., Tola, P., Aufdemkampe, G. & Winkers, M.: Negative affect, pain and disability in osteoarthritis patients: the mediating role of muscle weakness. Behav Res Ther *31:* 203–206, 1993.
13. Derogatis, L. R., Lipman, R. S., Rickels, K., Uhlenhut, E. H. & Cori, L.: The Hopkins Symptom Checklist (HSCL): a self-report inventory. Behav Sci *1:* 1–15, 1974.
14. Dyrssen, T., Svedenkrans, M. & Paasikivi, J.: Muscle training for neck/shoulder trouble. Läkartidningen *88:* 1120–1121, 1991 (in Swedish).
15. Ekholm, J., Schüldt, K., Yincharoen, K. & Harms-Ringdahl, K.: Methods for measuring isometric endurance in patients with chronic neck-shoulder-arm pain. Abstract, 9th International Congress of ISEK, p.77, Florence, 1992.
16. Elert, J. E., Dahlquist, S. B. R., Henriksson-Larsen, K. & Gerdle, B.: Increased EMG activity during short pauses in patients with primary fibromyalgia. Scand J Rheumatol *18:* 321–323, 1989.
17. Estlander, A. M., Vanharanta, H., Moneta, G. B. & Kaivanto, K.: Anthropometric variables, self-efficacy beliefs, and pain and disability ratings on the isokinetic performance of low back pain patients. Spine *19:* 941–947, 1994.
18. Gandevia, S. C. & McKenzie, D. K.: Activation of human muscles at short muscle lengths during maximal static efforts. J Physiol *407:* 599–613, 1988.
19. Grandejan, E.: Fitting the task to the man: an ergonomic approach, pp. 167–177. Taylor and Francis Ltd., London, 1981.
20. Grimby, G. & Saltin, B.: The aging muscle. Clin Physiol *3:* 209–218, 1983.
21. Hagberg, M. & Kvarnström, S.: Muscular endurance and electromyographic fatigue in myofascial shoulder pain. Arch Phys Med Rehabil *65:* 522–525, 1984.
22. Hassmen, P.: Perceived exertion: applications in sports and exercise. Thesis. Department of Physiology, University of Stockholm, Sweden, 1991.
23. Herberts, P. & Kadefors, R.: A study of painful shoulders in welders. Acta Orthop Scand *47:* 381–387, 1976.
24. Herberts, P., Kadefors, R., Høgfors, C. & Sigholm, G.: Shoulder pain and heavy manual labor. Clin Orthop *191:* 166–178, 1984.
25. Järvholm, U., Styf, J., Suurkula, M. & Herberts, P.: Intramuscular pressure and muscle blood flow in supraspinatus. Eur J Appl Physiol *58:* 219–224, 1988.
26. Järvholm, U., Palmerud, G., Herberts, P., Høgfors, C. & Kadefors, R.: Intramuscular pressure and electromyography in the supraspinatus muscle at shoulder abduction. Clin Orthop *245:* 102–109, 1989.
27. Jensen, M. P., Turner, J. A. & Romano, J. M.: Self-efficacy and outcome expectancies: relationship to chronic pain coping strategies and adjustment. Pain *44:* 263–269, 1991.
28. Johansson, H. & Sojka, P.: Pathophysiological mechanisms involved in genesis and spread of muscular tension in occupational muscle pain in chronic musculoskeletal pain syndromes: a hypothesis. Med Hypothesis *35:* 196–201, 1991.
29. Lannersten, L., Harms-Ringdahl, K., Schüldt, K. & Ekholm, J.: Isometric strength in flexors, abductors, and external rotators of the shoulder. Clin Biomech *8:* 235–242, 1993.
30. Laubauch, L. L. & McConville, J. T.: The relationship of strength to body size and typology. Med Sci Sports *1:* 189–194, 1969.
31. Lloyd, A. R., Gandevia, S. C. & Hales, J. P.: Muscle performance, voluntary activation, twitch properties and perceived effort in normal subjects and patients with the chronic fatigue syndrome. Brain *114:* 85–98, 1991.
32. Lorig, K., Chastian, R. L., Ung, E., Shoor, S. & Holman, H. R.: Development and evaluation of a scale to measure perceived self-efficacy in people with arthritis. Arthritis-Rheum *32:* 37–44, 1989.
33. Magni, G., Marchetti, M., Moreschi, C., Merskey, H. & Luchini, S. R.: Chronic musculoskeletal pain and depressive symptoms in the National Health and Nutrition Examination. I. Epidemiologic follow-up study. Pain *53:* 163–168, 1993.
34. McCue, J. & Newham, D.: Postoperative muscle strength. Ann R Coll Surg Eng *72:* 291–295, 1990.
35. Merton, P. A.: Voluntary strength and fatigue. J Physiol *23:* 553–564, 1954.
36. Murray, M. P., Gore, D. R., Gardner, B. S. & Mollinger, L. A.: Shoulder motion and strength of normal men and women in two age groups. Clin Orthop *192:* 268–273, 1985.

37. Neer, C. S.: Impingement lesions. Clin Orthop *173:* 71–77, 1983.
38. Schüldt, K., Harms-Ringdahl, K. & Ekholm, J.: Principles for medical rehabilitation of patients with chronic neck- and shoulder pain. Scand J Rehab Med Suppl *32:* 57–66, 1995.
39. Sigholm, G., Herberts, P., Almstrøm, C. & Kadefors, R.: Electromyographic analysis of shoulder muscle load. J Orthop Res *1:* 379–386, 1984.
40. Sigholm, G., Styf, J., Körner, L. & Herberts, P. Pressure recording in the subacromial bursa. J Orthop Res *6:* 123–128, 1988.
41. Smedstad, L. M., Vaglum, P., Kvien, T. K. & Moum, T.: The relationship between self-reported pain and socio-demographic variables, anxiety, and depressive symptoms in rheumatoid arthritis. J Rheumatol *22:* 514–520, 1995.
42. Stokes, M. & Young, A.: The contribution of reflex inhibition to arthrogenous muscle weakness. Clin Sci *67:* 7–14, 1984.
43. Vøllestad, N. K. & Sejersted, O. M.: Biochemical correlates of fatigue. Eur J Appl Physiol *57:* 336–347, 1988.
44. Waddel, G., Newton, M., Henderson, I., Sommerville, D. & Main, C. J.: A fear-avoidance beliefs questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. Pain *52:* 157–168, 1993.
45. Williamson, G. M. & Schulz, R.: Pain, activity restriction, and symptoms of depression among community-residing elderly adults. J Geront *37:* 367–372, 1992.

Accepted March 1, 1996

Address for offprints:

Jens Ivar Brox
Department of Physical Medicine and Rehabilitation
Ullevaal University Hospital
N-0407 Oslo
Norway