ORIGINAL ARTICLE

Pain tolerance in upper limb disorders: findings from a community survey

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Aims: To test the hypothesis that non-specific upper limb pain arises from altered pain perception with reduced tolerance of sensory stimuli.**Methods:** Subjects undergoing clinical examination as part of a community based survey of upper limb disorders were invited to return for an assessment of pain tolerance. A standardised algorithm was used to classify the 94 participants according to whether they had specific upper limb disorders ($n = 22$), non-specific arm pain ($n = 15$), or no arm pain ($n = 57$). Pain tolerance was assessed at three anatomical sites in each arm in response to electrocutaneous stimulation with alternating currents up to a maximum of 10 mA at three frequencies (5, 250, and 2000 Hz). A proportional odds model was used to compare pain tolerance thresholds according to sex, age, and diagnosis.**Results:** Women were less tolerant of pain than men (OR 0.13) and tolerance also declined with age (OR for one year increase in age 0.97). After allowance for sex and age, there was no indication that pain tolerance was lower in subjects with non-specific arm pain than in those with specific upper limb disorders or those who had no arm pain.**Conclusions:** The study hypothesis was not supported. However, before the hypothesis is dismissed, it should be tested further in patients with more severe and disabling arm pain.

Pain in the upper limb is a common symptom in western countries, and an important cause of lost working time. A recent survey in Britain found an annual incidence of 91 per 1000 adults for self reported work related disorders of the upper limb and neck with an estimated loss of 5.4 million working days per year.¹ In some patients pain arises from specific pathology in the arm or neck such as nerve entrapment, enthesiopathy, or tenosynovitis. Often, however, the exact pathogenesis is unclear. One possibility is that symptoms occur in some individuals because pain perception has been modified, either through central or peripheral mechanisms.²

In support of this hypothesis, reduced tolerance of electrocutaneous stimuli has been reported in patients with refractory cervicobrachial pain,³ and of vibratory stimuli in keyboard users suffering from "repetitive strain injury".⁴ Both of these studies were small, however, and further confirmation of the phenomenon is required. We have therefore used electrocutaneous stimulation to assess pain tolerance in subjects with arm pain who were identified in the course of a general population survey.

METHODS

Approval for the study was obtained from Southampton and Southwest Hampshire local research ethics committee. The subjects were a subset of participants from an ongoing community based survey of upper limb disorders. As part of this survey, all men and women aged 25–64 years, who were registered with a Southampton general practice were sent a postal questionnaire about pain and neurological symptoms in the upper limb and neck. Within the practice concerned, questionnaires were returned by 3991 (62%) of the men and women mailed. Those who reported symptoms lasting a day or longer during the past week ($n = 2162$) and a random sample ($n = 150$) of those who were symptom free were then invited to undergo physical examination and clinical evaluation (response rate = 62%). This was carried out according to a standard schedule, and an algorithm was used to classify subjects according to whether they had any of 11 specific

disorders (table 1). The algorithm was similar to a version that had been tested previously in hospital patients,⁵ but with minor modifications. Subjects who complained of pain in an arm, but who did not satisfy the diagnostic criteria for any of the 11 specific disorders in that arm, were deemed to have "non-specific arm pain".

Subjects who attended for physical examination during a six month period were invited to take part in the investigation of pain tolerance. Those who agreed were tested at a separate clinic up to 18 weeks after the initial examination (90% of symptomatic responders were tested within five weeks).

Pain tolerance was assessed in response to electrocutaneous stimulation using an alternating current stimulator known as a "Neurometer" (Neurotron Inc., Baltimore, USA). This produces a constant alternating current of up to 10 mA in steps of 0.01mA, at three possible stimulus frequencies (5, 250, and 2000 Hz), and can be used to establish thresholds of both sensory perception and pain tolerance. The three frequencies are intended selectively to stimulate C nerve fibres (5 Hz), A-delta fibres (250 Hz) and A-beta fibres (2000 Hz). The current is delivered via two standard gold electrodes, joined by a plastic strip and applied to clean skin with a gel to ensure adequate contact. Following measurement of sensory perception (results not reported here), the subject was asked to depress a button while the stimulus was progressively increased. It was explained in advance that the sensation produced would become at first uncomfortable and then painful, and the subject was asked to release the button when the stimulus could no longer be tolerated. The stimulus then ceased immediately and the threshold reached was read off. The stimuli delivered had maximum intensities of 10.0 mA for the 2000 Hz and 250 Hz frequencies and 9.8 mA for the 5 Hz frequency. If these were reached, the machine automatically switched off the current.

In each subject the test was performed for all three frequencies at each of six anatomical sites in a set order: left index finger (electrodes placed over the palmar and dorsal aspects of the distal interphalangeal joint); right index finger; left forearm (volar surface at the mid-point of a line between

Table 1 Specific disorders distinguished by the diagnostic algorithm

Disorder	Definition
Rotator cuff tendinitis	1) Pain anywhere in the shoulder; <i>plus</i> 2) Induced shoulder pain on <i>either</i> resisted external rotation, internal rotation or abduction, or a painful arc
Bicipital tendinitis	1) Pain in the anterior shoulder region; <i>plus</i> 2) Induced pain over the anterior shoulder on resisted elbow flexion or forearm supination
Shoulder capsulitis	1) Pain anywhere in the shoulder; <i>plus</i> 2) Deficit in active <i>and</i> passive movements for <i>either</i> abduction or external rotation or internal rotation. Deficits were defined as: <140° for abduction, <70° for external rotation and <90° for internal rotation
Acromioclavicular joint disorder	1) Pain over the acromioclavicular joint; <i>plus</i> 2) Tenderness over the acromioclavicular joint; <i>plus</i> 3) A positive acromioclavicular joint stress test
Subacromial bursitis	1) Pain over the subacromial bursa; <i>plus</i> 2) Tenderness over the subacromial bursa
Lateral epicondylitis	1) Pain over the lateral elbow; <i>plus</i> 2) Tenderness over the lateral elbow; <i>plus</i> 3) Induced pain over the lateral elbow on resisted wrist extension
Medial epicondylitis	1) Pain over the medial elbow; <i>plus</i> 2) Tenderness over the medial elbow; <i>plus</i> 3) Induced pain over the medial elbow on resisted wrist flexion
Olecranon bursitis	1) Pain over the posterior elbow; <i>plus</i> 2) Tenderness over the posterior elbow; <i>plus</i> 3) Fluid filled swelling over the posterior elbow
Carpal tunnel syndrome	1) Pain or sensory symptoms in median nerve distribution or sensory loss in the median nerve distribution (impairment of light touch in thumb and index but not little finger) or hand pain; <i>plus</i> 2) At least one of: • positive Tinel's sign • positive Phalen's test • motor loss (wasted thenar eminence or weakness of thumb abduction or weakness of thumb opposition) • disturbed sleep in the past 7 days due to numbness or tingling in the arms or hands
Tenosynovitis	1) Pain over the dorsal wrist <i>plus</i> induced pain over the dorsal wrist on resisted finger extension; or 2) Pain over the palmar wrist <i>plus</i> induced pain over the palmar wrist on resisted finger flexion; or 3) Pain over the ulnar aspect of the wrist <i>plus</i> induced pain over the ulnar aspect of the wrist on resisted ulnar flexion of the wrist; or 4) Pain over the radial aspect of the wrist <i>plus</i> induced pain over the radial aspect of the wrist on resisted radial flexion of the wrist, <i>in the absence of De Quervain's disease of the wrist</i>
De Quervain's disease of the wrist	1) Pain over the radial aspect of the wrist; <i>plus</i> 2) Tenderness over the radial aspect of the wrist; <i>plus</i> 3) Pain on resisted thumb extension or a positive Finkelstein's test

the middle of the elbow and wrist skin creases); right forearm; left shoulder (over the acromioclavicular joint); and right shoulder. A note was made of whether the subject had used analgesics on the day of testing.

Statistical analysis was carried out with the STATA software package,⁶ and used a proportional odds model⁷ to compare pain tolerance thresholds according to sex, age, and diagnosis. The main analysis incorporated all 18 measurements of pain tolerance from each subject, and classified these measurements to three levels corresponding to thirds of their distribution for each stimulus frequency across all subjects. The model assumed that for each risk factor the odds of being in the highest pain tolerance level compared with the lower two levels were the same as those of being in the upper two levels relative to the lowest level. These odds ratios (ORs) and associated 95% confidence intervals (CIs) were estimated from a single model that included sex, age, and diagnosis as

independent variables and also terms for the frequency of the stimulus and the anatomical site tested (finger, forearm, or shoulder). The model made allowance for the fact that multiple measurements from the same individual were unlikely to be statistically independent by specifying that the observations were independent across individuals but not necessarily within individuals (using the "cluster" option in STATA⁶). This affected the estimated standard errors and variance-covariance matrix of the estimators (and thus the CIs), but not the point estimates of ORs.

RESULTS

During the period of data collection, 515 subjects attended for clinical examination, and of these, 94 (18%) agreed to undergo assessment of pain tolerance. Table 2 shows the distribution of participants by sex, age, and diagnosis. Among the 51 men and 43 women whose pain tolerance was tested, 22 had one or

Table 2 Distribution of participants by sex, age, and diagnosis

	Subjects tested for pain tolerance (n=94)	Subjects clinically examined (n=515)
Sex		
Male	51 (54%)	217 (42%)
Female	43 (46%)	298 (58%)
Age (years)		
Mean	49.5	48.5
Median	51.4	49.8
Range	26–65	26–65
Diagnosis		
Specific disorder(s)	22 (23%)	126 (25%)
Only non-specific arm pain	15 (16%)	137 (27%)
No arm pain	57 (61%)	252 (49%)

more specific disorders of the upper limb, 15 had only non-specific arm pain, and 57 had no arm pain at the time of the examination. The specific disorders diagnosed most frequently were medial or lateral epicondylitis (six subjects), acromioclavicular joint disorder (three subjects), shoulder capsulitis or rotator cuff tendonitis (14 subjects), carpal tunnel syndrome (five subjects), and tenosynovitis (four subjects). Fourteen subjects had pain in both arms, including six with bilateral specific disorders and four with a specific disorder in one arm and non-specific pain in the other. Among the 57 subjects who had no arm pain when examined, 24 had reported no symptoms on the original questionnaire and remained symptom free; 21 had reported arm pain on the original questionnaire but this had resolved by the time of the examination; and 12 suffered from neck pain and/or neurological symptoms in the arm, but not arm pain.

Figure 1 shows the distribution of pain tolerance thresholds in the 57 subjects with no arm pain according to sex and the

Figure 1 Pain tolerance thresholds in subjects with no arm pain according to stimulus frequency and sex. **Figure 2** Median pain tolerance thresholds in subjects with no arm pain according to stimulus frequency, age, and sex. The dotted regression lines are for males, and the solid regression lines are for females.

Table 3 Association of pain tolerance with sex, age, and diagnosis

Risk factor	*OR (95% CI)
Sex	
Male	1
Female	0.13 (0.07 to 0.26)
Age (one year increase)	0.97 (0.95 to 1.00)
Diagnosis	
Asymptomatic	1
One or more specific disorders	0.7 (0.3 to 1.6)
Non-specific upper limb pain	1.0 (0.5 to 2.0)

*Analysis was by ordered logistic regression. For interpretation of the odds ratios see text. Odds ratios for the three risk factors are mutually adjusted.

frequency of the electrical stimulus. Each person was tested at six anatomical sites (three in each arm), and the subjects are ranked according to their median threshold at the 5 Hz frequency. Tolerance tended to be lower at lower frequencies, but the ranking of subjects by median threshold was similar for each frequency. Women were generally less tolerant than men. After stratification by sex, levels of pain tolerance in the subset of 24 subjects with no symptoms, either at baseline or when examined, were similar to those in the remainder of the group. Figure 2 summarises the relation of pain tolerance to age, again in the 57 subjects who had no arm pain. At each stimulus frequency, tolerance tended to decline with age, both in men and in women.

Table 3 summarises the association of pain tolerance with sex, age (treated as a continuous variable), and diagnosis from the proportional odds analysis. The lower pain tolerance of women compared with men was highly significant statistically (OR 0.13, 95% CI 0.07 to 0.26), and the decline in pain tolerance with age was also significant (OR per one year increase in age = 0.97, 95% CI 0.95 to 1.00). There was no clear difference in pain tolerance by diagnostic category, but if anything, tolerance was higher in subjects with non-specific upper limb pain than in those who had specific disorders. A repeat analysis excluding five subjects who had used analgesics on the day of testing gave similar results.

Further analyses were also carried out separately for each of the anatomical sites tested (shoulder, forearm, finger). Subjects were classified according to whether they had specific pathology adjacent to the site (for example, epicondylitis or tenosynovitis for the forearm), non-specific pain locally, or neither. Again, there was no indication that non-specific pain was associated with lower pain tolerance.

DISCUSSION

In this survey of subjects selected from the general population we found that women were less tolerant of the pain induced by electrocutaneous stimulation than men, and that in both sexes tolerance declined with age. However, there was no indication that people with non-specific upper limb pain were less tolerant than subjects who did not have arm pain or those with specific disorders.

The rate of participation in the study among those eligible for testing was relatively low, mainly because of difficulty in arranging appointments at a convenient time and reluctance to undergo testing. It is possible that people who were less tolerant of pain were less willing to take part than those with higher tolerance. However, a selection effect of this sort would only have biased associations between pain tolerance and risk factors if the differential recruitment by pain tolerance varied according to the presence or absence of risk factors (for example, it was greater in men than women). This seems less likely.

Another possible source of error was inaccuracy in the assessment of pain tolerance thresholds. Before undertaking

Main messages

- In contrast to other investigators, we found no evidence of reduced pain tolerance in a sample of people with non-specific upper limb pain.
- The discrepancy may have occurred because the participants, who were identified in the course of a community based survey, had less severe disease than those investigated previously.
- Before reduced pain tolerance is dismissed as a mechanism underlying non-specific upper limb pain, its potential role should be further investigated in patients suffering from more severe and disabling illness.

Policy implication

- Research should now focus on pain tolerance in patients with non-specific upper limb pain whose symptoms are severe and disabling.

the study we carried out a pilot investigation in which we established that measurements were repeatable for individual subjects and did not depend critically on the precise placement of the stimulating electrodes. Thus, when 17 healthy men and women were ranked according to their tolerance of a 5 Hz stimulus and then retested on another day, 13 were classified to the same rank ± 1 ; and when 20 subjects were tested first at prescribed anatomical sites and then at adjacent locations, 14 retained the same rank to within one place. In the current study, the broad correlation between thresholds at different frequencies and anatomical locations in the same individual (fig 1) gives further reassurance that measurements were reliable.

The risk factor most strongly associated with pain tolerance was sex, men being notably more tolerant than women. This difference may have been influenced by the study design. There was an element of challenge in the testing procedure in that subjects were asked to maintain the electrical stimulus as long as it was tolerable, and this challenge may have driven men more than women. The lower tolerance at older ages was also statistically significant, and was apparent in both sexes. It may reflect differences in response to the challenge inherent in the testing method or a genuine reduction in tolerance with aging.

After adjustment for sex and age there was no indication that subjects with non-specific upper limb pain had lower pain tolerance than those with specific disorders or those who had no arm pain. This contrasts with the findings of two earlier studies that used electrocutaneous³ or vibratory⁴ stimulation. The confidence intervals in table 3 imply that any association of reduced pain tolerance with non-specific upper limb pain is much weaker than that with sex, and not at the level that would be expected if differences in pain tolerance were the main determinant of non-specific arm pain. The explanation for the discrepancy could lie in the method by which subjects were selected for investigation. Our study sample was identified as part of a community survey in which the prevalence of reported upper limb pain was high (some 33%), and in most cases the symptom caused minimal, if any, disability. Only one subject with non-specific pain had taken time off work because of the problem. It may be that differences in pain tolerance are only apparent in people with more severe and disabling disease.

Another possibility is that in some of our subjects with non-specific arm pain, the symptom arose from disorders that were not included in our diagnostic schedule. In particular, the pain in some may have resulted from nerve root impingement in the neck, for which currently there are no well established

diagnostic criteria. This could perhaps have diluted the prevalence of reduced pain tolerance in the group with non-specific arm pain.

Thus, before the hypothesis that non-specific upper limb pain results from altered pain perception is dismissed, it should be tested further in patients whose symptoms cause greater disability, if possible using refined diagnostic procedures to exclude those with underlying pathology in the neck.

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