REVIEW

Repetitive strain injury

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Pain in the forearm is relatively common in the community. In the workplace forearm pain is associated with work involving frequent repetition, high forces, and prolonged abnormal postures. Nevertheless, other factors are involved in the presentation and the continuation of the pain. Notable among these factors are psychosocial issues and the workplace environment—the attitude to workers and their welfare, the physical conditions, and design of the job. Primary prevention may be effective but active surveillance is important with early intervention and an active management approach. Physical treatments have not been extensively evaluated. In the established case, management should be multidisciplinary, addressing physical aspects of the job but also addressing the ''yellow, blue, and black flags'' which should be viewed as obstacles to recovery. For the worker ''on sick'' a dialogue should be established between the worker, the primary care physician, and the workplace. Return to work should be encouraged and facilitated by medical interventions and light duty options. Rehabilitation programmes may be of use in chronic cases.

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THE PROBLEM OF THE NAME

''Repetitive strain injury'' (RSI) is a poorly named condition usually applied to people with non-specific upper limb pain in occupational settings. The name ''transgresses the basic principles of taxonomy through the use of terms which assume or imply findings and causality that have not been established''.[1] Use of the term ''RSI'' was strongly discouraged by the Royal Australasian College of Physicians in 1986. Although the nomenclature has been vigorously debated for nearly 20 years, the existence of people with upper limb pain in and out of occupational settings is hardly controversial. The problem was nicely articulated by Richard Asher as long ago as 1957: ''If this condition had some reasonable name…then we could profitably discuss whether it was caused by a neuritis or by costo-clavicular compression or by compression of the median nerve in the carpal tunnel…''. Description and case definition of the syndrome without implying causality is a prerequisite for adequate clinical investigation into the pathophysiology of the disorder.[2] Other labels that have been applied to this condition are ''non-specific work-related upper limb disorder'',[3] ''occupational overuse syndrome'',[4] ''repetitive strain disorder'', and ''cumulative trauma disorder''.[5]

It is difficult to know sometimes whether these terms refer to specific soft tissue syndromes that affect the upper limb (such as carpal tunnel syndrome or lateral epicondylitis) as well as to non-specific pain syndromes such as complex regional pain syndrome (also known as reflex sympathetic dystrophy) or fibromyalgia, or to a ''specific'' form of non-specific upper limb pain that occurs in occupational settings. The legal environment has a significant influence upon how these disorders are named. Different jurisdictions have defined the problem differently. In New Zealand, the state owned insurer for injuries (Accident Compensation Corporation) has classified ''occupational overuse syndrome'' into three groups of disorders: localised inflammations, nerve compression syndromes, and pain syndromes. In the UK regulatory authorities have a prescribed list of compensable disorders—for example, A4: cramp of the hand or forearm due to repetitive movements; A5–7: beat conditions, mostly bursitis in miners; A8: tenosynovitis; A11: vibration white finger; A12: carpal tunnel syndrome in users of vibrating hand tools.

Given the problems with naming these conditions, it is not surprising that communication about them and appropriate research are both difficult. What exactly are we talking about? We fall back on time honoured descriptive methods—the case study. In our practice, the typical case of ''RSI'' is a female office or production line worker, conscientious in her job, who develops forearm pain after a change in work practice, additional demands, or pressure from supervisors.[6] There are few abnormal physical findings—non-specific tenderness and possibly some impairment of fine movements.[3] There may be symptoms of anxiety and anhedonia. Pain generally subsides over the weekend, returning quickly while at work. Unless there is a change to the organisation of work and resolution of relationship issues, the pain becomes more troublesome leading to work disability and sometimes spread of symptoms to involve the shoulder girdle and neck. Classification criteria for fibromyalgia[7] may be met.

Patients who present with defined soft tissue syndromes such as tenosynovitis or carpal tunnel syndrome where the physical findings and investigations confirm the diagnosis, may respond appropriately to physical work task modifications,

Abbreviations: DEA, disability employment advisor; RDS, Regional Disability Service; RSI, repetitive strain injury

local injections, or surgery. Such patients are thought to be distinct from those with ''typical RSI'', although a recent article has demonstrated a high prevalence of psychological symptoms in people with carpal tunnel syndrome awaiting surgery.[8] In these cases successful decompression may not completely resolve their symptoms. In our view, patients with upper limb pain who do not have a specific soft tissue syndrome should be diagnosed with an anatomically based regional pain disorder—for example, ''non-specific diffuse forearm pain''.[9]

EPIDEMIOLOGY, CAUSATION, AND ATTRIBUTION

There remain difficulties even with apparently well defined soft tissue syndromes as there is little agreement in the epidemiological literature as to how such syndromes should be named or defined.[10] This comprehensive review of classification systems for upper limb disorders found 88 different disorders and 14 that appeared in more than five of the 27 different classification systems examined. There is clearly a need for consensus upon how upper limb disorders should be named and defined.

Upper limb pain (defined by anatomic region) is very common in the general population. By self report, 10% to 20% of the population have had shoulder pain that lasted more than one week in the previous month, 5% to 10% report elbow pain, and 5% to 15% report hand pain.[11] About 10% of community UK samples report forearm pain.[12] Even more (34%) report shoulder pain that lasted more than one day in the previous month.[13] Upper limb pain is associated with significant disability in the community: 57% of working age adults who reported shoulder pain had reduced working capacity and 35.5% of them needed help at least occasionally.[14]

We have already referred to different definitions of ''RSI'' in different jurisdictions. The major difference between upper limb disorders in occupational settings and those in non-occupational settings, is attribution of causation—did the workplace contribute to development of the condition? This will influence the liability of the employer in exposing the worker to potentially injurious circumstances and the extent to which compensation is payable. The debate is often muddied by confusion between legal evidence and medical evidence, and by persistence in the belief that the basis of illness or injury is *either* physical *or* psychological rather than considering a broader biopsychosocial model. Hadler has argued that there is no convincing evidence of causation, most studies being cross sectional.[15 16] However, the evidence from cross sectional studies is now reinforced by prospective longitudinal studies confirming associations previously described (see below).

Issues of causation for compensation purposes pose significant problems as medical evidence is often probabilistic, being based upon epidemiological studies that involve statistical comparisons between groups of people. In contrast, in a legal setting the entire focus is on a single person and whether *in this particular case*, causation is reasonable. Notions of causation in Anglo-American law tend to be deductive and require the existence of a clearly delineated causal chain leading to injury rather than a statistical discussion of risk exposure.[17] In instances of non-specific upper limb pain where (by definition) no specific diagnosis is made, the lack of epidemiological studies may make it difficult for some doctors to accept a work related causation. Nevertheless, the courts have found that chain of causation type of evidence sufficient to award damages to people with non-specific upper limb pain. Legal decisions may be made on the basis of casual chain reasoning that underlies a hypothesis even when that evidence has not been proven by experimental or epidemiological evidence. Such decisions usually rest upon a temporal relationship between a change in work demands and the development of pain (for example see Alexander and Others *v* Midland Bank Plc 1999[18]).

The National Institute for Occupational Safety and Health review of the epidemiological evidence for work relatedness does not actually include non-specific upper limb pain among the conditions reviewed.[19] Many studies that do look at risk exposure and complaints of forearm pain are cross sectional, which creates interpretation problems. In particular, the ''healthy worker'' effect cannot be untangled from cross sectional studies. From one of very few population based longitudinal studies, there appears to be evidence for both physical and psychosocial factors in the aetiopathogenesis of forearm pain.[12 20] The most important risks appeared to be high levels of psychological distress, repetitive movements of the arm or wrist, monotonous work, and lack of autonomy. It is also noteworthy that a substantial number of people with new onset of forearm pain also meet criteria for chronic widespread pain.[21] Risks of a similar magnitude were found in a longitudinal study of newly employed workers, with respect to the development of musculoskeletal pain in a number of anatomical sites.[22] This study did not measure physical work exposures but found that psychological factors, both workplace related and personal, were associated with the development of regional pain disorders.

PATHOPHYSIOLOGY

What are the possible mechanisms by which physical factors may cause pain? Heavy lifting may damage tissue by imposing loads which exceed the physical capacity of the tissue producing muscle or ligament injury. More importantly, in terms of prolonged exposures, is the phenomenon of creep where collagenous structures lengthen in response to prolonged submaximal loading. Creep can occur at relatively low loads and can be accelerated by vibration. The effect is to impart a temporary length change in the tissue (for example, a ligament) which may in turn alter the biomechanics of the structure to which the tissue contributes. The time course of recovery from these changes may be several hours rendering the tissue vulnerable to damage from forces that would otherwise be harmless. Experiments in anaesthetised animals have shown recovery times of three hours for muscle and seven hours for ligaments after five minutes of cyclic loading.[23] There is, however, no evidence for tissue damage in non-specific forearm pain.

Prolonged submaximal loading of as little as 5% could cause a rise in intramuscular pressure and ischaemia.[24] In support of this some experimental work has shown a modest rise in muscle enzymes as a result of a submaximal lifting task.[25] In addition, a single study of chronic work related arm pain found morphological changes in muscles but this study has not been replicated.[26] Our own observations would suggest that abnormal muscle fatigability may contribute to the pain in work related non-specific arm pain.[27]

Other authors have suggested a neurogenic origin for non-specific forearm pain. Greening and colleagues reported evidence of median nerve dysfunction in this disorder and complemented this by using magnetic resonance imaging to illustrate both a reduced carpal tunnel area and reduced mobility of the median nerve.[28 29] However, Harris has hypothesised that non-specific forearm pain may result from incongruence of signals from proprioceptive afferents, vision and motor intention, similar to phantom limb pain.[30] A number of therapeutic approaches follow from this hypothesis, one of which has already been fruitful with reflex sympathetic dystrophy.[31] There is also evidence that people with non-specific arm pain have abnormal sympathetic vasoconstrictor responses in comparison with normal controls and unaffected office workers.[32]

AN APPROACH TO DIAGNOSIS AND MANAGEMENT

Notwithstanding the problems of classification definition, for clinical purposes, we believe the list of disorders in table 1 represents a fair description of identifiable conditions that may be separated from non-specific upper limb pain.[2] It is important to remember that classification criteria are primarily designed for clinical research (groups of subjects) and may not be very useful in clinical settings where the problem of an individual with pain is the main concern. The absence of agreed case definitions makes it difficult to describe an evidence based approach to the diagnosis and management of these conditions since the research base is relatively deficient.

In many respects low back pain provides a suitable paradigm for non-specific forearm pain. A number of guides for the management of low back pain have been published (for example, http://www.acc.govt.nz/acc-publications/pdfs/ip/nz-back-pain-guide.pdf). Many of the principles of these guides can be sensibly applied to the person presenting with regional upper limb pain, in particular the notion of ''flags'' which should be seen as risk factors for the development of pain and obstacles to the recovery from pain (see http://www.acc.govt.nz/acc-publications/pdfs/ip/psychosocial-guide.pdf). These can be summarised as follows:

(1) Acknowledge the symptoms exist and that the level of discomfort can be high.

(2) Identify ''red flags''—that is, items that may suggest alternative diagnoses or referral for further investigation and/or management:

- Neurological deficit.
- Joint swelling.
- Vascular changes.
- Age greater than 55 years or less than 15 years.
- Systemic symptoms.

(3) Consider specific diagnoses for which there may be appropriate investigations or treatment (table 1 summarises key features of how some specific diagnoses may be made. It should be noted that the reliability and validity of diagnosing most of these disorders is not well established).

(4) Identify physical factors which are important risk factors for these disorders:

- High rates of repetition.
- Prolonged abnormal postures.
- High force requirement.

(5) Identify ''flags'' which are important in as risk factors and are obstacles to recovery:

- ''Yellow flags'' (psychological):
  - Maladaptive illness beliefs (for example, catastrophising, fear avoidance).
  - Depression or psychological distress (the General Health Questionnaire is a good screening tool).

Table 1 Key clinical features of specific disorders that may present with upper limb pain

General class of disorder	Examples	Key signs
Nerve compression syndrome	Carpal tunnel (median nerve at the wrist)	Paraesthesiae and altered sensation in thumb and index finger, sparing the palmer triangle; Tinel's sign; Phalen's sign
	Cubital tunnel (ulnar nerve at the elbow)	Paraesthesia in little finger and ulnar border of the hand, worse with elbow flexion; Tinel's sign
	Pronator syndrome (median nerve in forearm)	Paraesthesiae and altered sensation in thumb and index finger, including the palmer triangle; pain in the forearm, worse with resisted pronation with elbow extended but not so much with elbow flexed
	Ulnar tunnel syndrome (ulnar nerve at the wrist)	Weakness, paraesthesiae, and altered sensation of little and ulnar half of ring finger but not ulnar border of the hand; confirm by electrophysiology
	Radial tunnel syndrome (radial nerve in the forearm)	Pain in the extensor mass just below the elbow; no sensory or motor loss; middle finger extension test; pain with resisted supination of fully extended elbow
	Thoracic outlet syndrome	Adson's test: pain, numbness, and weakened pulse with hyperextension of shoulder and chin thrust forward
	Cervical radiculopathy	Appropriate dermatomal signs; Spurling's test: pain radiating down arm with top of head compression and slight neck extension
Musculotendinous problems	Tenosynovitis	Swelling, crepitus, and pain on active movement of tendon; triggering (especially digital flexor tendons)
	Bicipital tendonitis	Pain in shoulder region with pain on resisted elbow supination
	Frozen shoulder	Shoulder pain with limited passive ROM in all planes
	Rotator cuff syndrome	Shoulder pain with normal passive ROM but pain on resisted shoulder motion; painful arc of motion
	Medial epicondylitis	Localised tenderness; pain on resisted wrist flexion
	DeQuervain's tenosynovitis	Pain in anatomical snuff box; positive Finklestein's test
	Lateral epicondylitis	Localised tenderness; pain with full wrist flexion in extended elbow; pain with resisted wrist extension
Arthritis	Osteoarthritis	Heberden's nodes, Bouchard's nodes, squaring of carpometacarpal, loss of passive ROM
	Acromioclavicular syndrome	Tenderness to palpation of the acromioclavicular joint
	Rheumatoid arthritis	Pain and stiffness considerably worse in the morning; boggy swelling of joint; late changes include gross joint destruction

ROM, range of movement.

- ''Blue flags'' (workplace issues):
  - Monotony.
  - Low degree of control.
  - Poor relationships.
  - High work demands.
- ''Black flags'' (workplace organisational issues):
  - Financial reliance on disability benefits or workers' compensation issues.
  - Surveillance and attitudes to sick worker.

(6) Reassurance that there is no evidence of damage and that continued activity will not lead to damage.

(7) Recommend *not* to take time off work if possible.

(8) Advice about activity modification. This will often need to be in coordination with the person's work supervisor or employer.

(9) Simple analgesics if necessary for symptom control, prescribed regularly rather than ''as required''.

(10) Review within seven days.

In a similar way to the Acute Back Pain Guidelines, the emphasis is on encouraging activity, reassurance about the absence of damage (''hurt'' rather than ''harm''), and acknowledging the role of psychosocial factors in contributing to prolonged disability from arm pain.

It is *possible* that ergonomic interventions in the workplace will make the workplace more comfortable for someone with arm pain. There is evidence that ergonomic interventions prevent episodes of arm pain related disability and sickness absence.[33] It is possible to extend the ''flag'' concept to workplace factors which may be important in initiating and prolonging the pain, the ''blue'' flags. In this way attention to general features of the work environment and work tasks may identify problem areas: work overload, uncomfortable surroundings, poor relationships between staff and supervisors which will tend to affect the ability of the worker with arm pain to tolerate those symptoms.

All people with arm pain that has persisted for four weeks with significant activity limitation should be fully reviewed with history and examination. Full blood count and erythrocyte sedimentation rate should be performed and depending on the symptoms and signs other investigations and referral may be justified. At this point it is important that a work site assessment and interview with the employer occur. For people whose musculoskeletal symptoms are likely to be work related or are causing significant work disability, management of the work place is crucial for effective resolution. For most medical practitioners this is difficult and time consuming. In the UK the disability employment advisor (DEA) can be very helpful in managing the occupational aspects of upper limb pain. The DEA works as part of the Employment Service, District Service Team (formerly known as Placement Assessment and Counselling Service). This team includes the services of an occupational psychologist. Each region of the Employment Service also has a Regional Disability Service (RDS) which vary across the country in terms of organisation and staff. The DEAs will use the RDS when they need more specialist advice, for example from occupational health physiotherapists, occupational therapists, ergonomists, and technical consultants. A demonstration and assessment area may be available at the RDS. Physiotherapists or occupational therapists with ergonomic training can be very helpful in facilitating workplace or job task modifications necessary to get the patient back into work quickly without exacerbating symptoms.

It is possible that managing people slow to return to normal activities with arm pain can best be achieved with a multidisciplinary team, although this is yet to be proven.

Key points

- Pain in the forearm is relatively common in the community with prevalence rates of 10%–15%.
- Both specific and non-specific disorders probably occur more often in work involving frequent repetition, high forces, and prolonged abnormal postures. Nevertheless, other factors are involved in the presentation and the continuation of the pain. Notable among these factors are the workplace environment—the attitude to workers and their welfare, the physical conditions and design of the job.
- Primary prevention may be effective but active surveillance is important with early intervention and an active management approach.
- Physical treatments have not been extensively evaluated. In the established case, management should be multidisciplinary, addressing physical aspects of the job but also addressing the ''yellow, blue, and black flags'' which should be viewed as obstacles to recovery.
- For the worker ''on sick'' a dialogue should be established between the worker, the primary care physician, and the workplace. Return to work should be encouraged and facilitated by medical interventions and light duty options.
- Rehabilitation programmes for chronic cases, although promising, need further evaluation.

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Non-randomised studies are encouraging.[34] This small study of multicomponent rehabilitation for upper limb pain (included physical conditioning, work conditioning, pain and stress management, ergonomic consultation, and vocational counselling/placement) compared with usual care found a much greater return to work or retraining rate (74% compared with 40%). The control group were patients referred to the programme but ineligible for various reasons. This work is certainly encouraging but it isn't clear which components of the programme are key and since the outcome of the control group was almost certainly influenced by the reason that they were ineligible for the rehabilitation programme, it is very difficult to interpret the results.

Unfortunately there is little evidence for the effectiveness of any specific intervention for non-specific upper limb pain. Physiotherapy, splints, topical medications, injected steroids, and surgery are all administered without good evidence.[27] It is likely that activity is *good* and that excessive rest and time away from the workplace are not beneficial to the overall health of the person with the symptoms, although this is purely conjecture based on the back pain literature. Ergonomic interventions *may* make the workplace more comfortable and possibly prevent work disability.[35 36] There is poor quality evidence from industry of possible strategies to prevent upper limb disorders—often a number of changes are implemented simultaneously and it is therefore impossible to know which, if any given the observational nature of these reports, are of benefit.[37–39]

The only randomised controlled trial of any intervention for chronic non-specific regional arm pain compared relaxation or electromyography biofeedback or both to waiting list controls.[40] This small study (only 12 subjects in each group) showed that all treatment groups improved with respect to depression, anxiety, and distress compared with the waiting list control. Pain appeared to be reduced in comparison with the no treatment control but this wasn't statistically significant. There were no differences between any of the three treatment conditions. Pain was measured by multiplying the intensity (0 to 10) of pain by the number of hours that pain was present over an eight hour period. Three eight hour periods per day over seven days were used and an average score per eight hour period was obtained. This means that the maximum score would be 80. The pretreatment pain scores were about 20 and they reduced by 16% to 32% among the treated groups. It is always difficult to know whether this is a clinically important change, but the effect size for these treatments were small (ranging from 0.29 to 0.54). It appeared that relaxation training might be better than electromyography biofeedback or combined treatments, although statistically, one can't make that inference.

SUMMARY

Pain in the forearm is relatively common in the community. Both specific and non-specific disorders probably occur more often in work involving frequent repetition, high forces, and prolonged abnormal postures. Nevertheless, other factors are involved in the presentation and the continuation of the pain. Notable among these factors are the workplace environment—the attitude to workers and their welfare, the physical conditions, and design of the job. Primary prevention may be effective but active surveillance is important with early intervention and an active management approach. Physical treatments have not been extensively evaluated. In the established case, management should be multidisciplinary taking a wider look at the problem but rehabilitation programmes for chronic cases, although promising, need further evaluation.

MULTIPLE CHOICE QUESTIONS (TRUE (T)/FALSE (F); ANSWERS AFTER REFERENCES)

1. The following diagnostic labels are appropriate for a 46 year old office worker with bilateral forearm pain and paraesthesia, who has a normal physical examination and normal nerve conduction tests:

(A) Carpal tunnel syndrome
(B) Occupational overuse syndrome
(C) Non-specific forearm pain
(D) Pronator syndrome
(E) Tennis elbow

2. The following is correct with respect to the community prevalence of self reported forearm pain

(A) 0.1%
(B) 1%
(C) 10%
(D) 50%
(E) None of these

3. From longitudinal community based studies the following factors are found to be risks for the development of forearm pain:

(A) Sitting on a chair that is too high or too low
(B) Repetitive movements of the arm or wrist
(C) High levels of psychological distress
(D) Keyboard use for more than 60 minutes daily
(E) Low degree of job autonomy

4. The following pathophysiological changes have been detected in people with non-specific upper limb pain:

(A) Small rise in muscle enzymes after submaximal lifting tasks
(B) Inflammatory changes in muscle biopsy specimens
(C) Reduced mobility of the median nerve in the carpal tunnel
(D) Raised levels of anaerobic metabolites suggesting ischaemia
(E) Abnormal autonomic sensory responses

5. In non-specific upper limb pain there is some evidence from controlled intervention studies for the effectiveness of:

(A) Ergonomic review of the patient's workstation
(B) Multidisciplinary rehabilitation
(C) Physiotherapy
(D) Electromyography biofeedback
(E) Corticosteroid injections

ANSWERS

1. (A) F, (B) F, (C) T, (D) F, (E) F; 2. (A) F, (B) F, (C) T, (D) F, (E) F; 3. (A) F, (B) T, (C) T, (D) F, (E) T; 4. (A) T, (B) F, (C) T, (D) F, (E) T; 5. (A) F, (B) T, (C) F, (D) T, (E) F.

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