WORKING FOR A HEALTHY FUTURE

HISTORICAL RESEARCH REPORT

Research Report TM/88/19
1989

Clinical epidemiological study of relations between upper limb soft tissue disorders and repetitive movements at work

English CJ, Maclaren WM, Court – Brown C, Hughes SPF, Porter RW, Wallace WA, Graves RJ, Pethick AJ, Soutar CA

World Health Organisation Collaborating Centre For Occupational Health

RESEARCH CONSULTING SERVICES

Multi-disciplinary specialists in Occupational and Environmental Health and Hygiene

www.iom-world.org

HISTORICAL RESEARCH REPORT
Research Report TM/88/19
1989

Clinical epidemiological study of relations between upper limb soft tissue disorders and repetitive movements at work

English CJ, Maclaren WM, Court – Brown C, Hughes SPF, Porter RW, Wallace WA, Graves RJ, Pethick AJ, Soutar CA

INSTITUTE OF OCCUPATIONAL MEDICINE
Research Avenue North, Riccarton, Edinburgh, EH14 4AP
Tel: +44 (0)870 850 5131 Fax: +44 (0)870 850 5132
e-mail publications@iomhq.org.uk

Report No. TM/88/19
UDC 616.74

CLINICAL EPIDEMIOLOGICAL STUDY OF RELATIONS BETWEEN UPPER LIMB SOFT TISSUE DISORDERS AND REPETITIVE MOVEMENTS AT WORK

CJ English
WM Maclaren
C Court-Brown
SPF Hughes
RW Porter
WA Wallace
RJ Graves
AJ Pethick
CA Soutar

January 1989

Price:
£40.00 (UK)
£45.00 (Overseas)

Report No. TM/88/19
HSE CONTRACT 1/MS/126/585/85

INSTITUTE OF OCCUPATIONAL MEDICINE

CLINICAL EPIDEMIOLOGICAL STUDY OF RELATIONS BETWEEN UPPER LIMB SOFT TISSUE DISORDERS AND REPETITIVE MOVEMENTS AT WORK

by

CJ English, WM Maclaren, C Court-Brown, SPF Hughes, RW Porter, WA Wallace, RJ Graves, AJ Pethick, CA Soutar

FINAL REPORT ON HSE RESEARCH CONTRACT No. 1/MS/126/585/85

Duration of project: 3 years

Institute of Occupational Medicine
8 Roxburgh Place
EDINBURGH
EH8 9SU

Tel: 031 667 5131
Telex: 9312100237=TD G
Fax: 031 667 0136

January 1989

This report is one of a series of Technical Memoranda (TM) published by the Institute of Occupational Medicine. Current and earlier lists of these reports, and of other Institute publications, are available from the Librarian/Information Officer at the address overleaf.

For futher information about the Institute's facilities for research, service/consultancy and teaching, please contact the Librarian/Information Officer in the first instance.

CONTENTS

INSTITUTE OF OCCUPATIONAL MEDICINE

CLINICAL EPIDEMIOLOGICAL STUDY OF RELATIONS BETWEEN UPPER LIMB SOFT TISSUE DISORDERS AND REPETITIVE MOVEMENTS AT WORK

by

English CJ*, Maclaren WM*, Court-Brown C†, Hughes SPF†, Porter RW‡
Wallace WA⊕, Graves RJ*, Pethick AJ*, Soutar CA*

* Institute of Occupational Medicine, Edinburgh.

† University Dept of Orthopaedic Surgery, Princess Margaret Rose Orthopaedic Hospital, Edinburgh.

‡ Dept of Orthopaedics, Doncaster Royal Infirmary, Doncaster.

⊕ Dept of Orthopaedic and Accident Surgery, University Hospital, Queen's Medical Centre, Nottingham.

ABSTRACT

A case-control study of subjects attending orthopaedic clinics has examined the influence of activity at work on risk of upper limb soft tissue disorders. The aims of the study were to determine: what activities are associated with clinically defined upper limb soft tissue disorders; the relative risks of these disorders in different activities at work and elsewhere; what proportion of clinically diagnosed upper limb soft tissue disorders in the community as a whole are attributable to physical activities at work; and what major ergonomic factors can be identified as common to high risk situations. Subjects between the ages of 16 and 65 attending orthopaedic clinics in Doncaster, Edinburgh and Nottingham, in which defined conditions were diagnosed by the participating orthopaedic surgeons, were invited to take part. Diagnostic criteria for the cases included all soft tissue conditions of the upper limb to which repetitive strain may contribute. Controls were subjects attending the same clinics within the same age-range whose clinical diagnoses did not include disease of the upper limb, cervical or thoracic spine. The case:control ratio was 1:2.

Subjects who agreed to participate answered a questionnaire about activities at work during the previous two years. The questionnaire was designed to elicit as much information as possible, within practical constraints, about repetitive movements of the upper limb at work, including detailed interrogation about the direction and range of movements at each joint or group of joints, enquiring additionally about complex movements thought to be relevant to repetitive strain injuries. The questionnaire also asked about frequency of repetition, application of force, spells of activity, total duration of activity, and sustaining fixed postures. Information on use of tools, wet conditions, sports and

hobbies, height and weight was also recorded.

580 cases and 996 controls were studied, representing 96% and 93% respectively of those invited to participate. The diagnoses of the cases included soft tissue conditions affecting the shoulder, elbow, forearm, wrist, thumb, hand and fingers. The two most frequent diagnoses were carpal tunnel syndrome and ganglion; tenosynovitis of the forearm accounted for only 4% of cases; tenovaginitis of the tendons of the thumb (de Quervain's disease) for 5% of cases. The diagnoses of the controls included traumatic, degenerative and inflammatory conditions, mostly of the legs and lower back. Forty percent of controls and 12% of cases attributed their illness to an accident, and 33% of controls and 23% of cases often worked in wet conditions. Women predominated among the cases (70%) and men among the controls (66%). Over four-fifths of both cases and controls had worked in at least one job during the previous two years.

The statistical analysis aimed to identify factors contributing to risk of injury irrespective of recruiting centre, and did not study local differences in these relationships. Jobs statistically significantly over-represented among the cases compared with controls were cleaner, hairdresser, video display unit operator and other keyboard users, butcher, music teacher and machine operator. Jobs over-represented among the controls compared with the cases included miner and policeman. Cases in general were older and shorter than controls. Cases with conditions of the wrist and forearm were heavier than controls (after adjustment for height), and more likely to be female.

Associations between movements performed at work and risk of upper limb soft tissue disorder were demonstrated. Notably, movements which were associated with arm conditions included repeated gripping in the palm with fingers and thumb, related to finger conditions; pinching between thumb and fingers, not in the palm, related to thumb conditions; bending the thumb, related to forearm tenosynovitis; wrist supination/pronation with wrist and forearm conditions; rotating the shoulder with arm raised, related to shoulder conditions.

Rates of movements above the once per minute threshold apparently influenced only risk of thumb conditions in relation to rate of wrist flexion and extension (except for a negative association between rate of rotating the wrist and tenosynovitis of the forearm). Hours spent per day performing movements more frequently than once per minute influenced risk of forearm tenosynovitis in relation to pinching, tapping with the fingers and flexing/extending the wrist; and risk of shoulder conditions in relation to bending the elbow. Some other positive and negative associations between movements of joints anatomically rather distant from the site of disease were demonstrated.

Sustaining a fixed position increased the risks of thumb, wrist and forearm conditions in relation to keeping the thumb bent. Performing movements forcibly did not appear to influence the risks, except for an association between flexing the elbow forcibly and risk of wrist or forearm conditions.

The influence of interactions between movements has not yet been examined.

Sporting activities contributed to risks of thumb and elbow conditions. Hobbies involving use of the arms contributed to risk of wrist and forearm conditions.

Calculation of attributable risks of injury in relation to named occupations indicated that work as a keyboard operator, cleaner, hairdresser and machine operator together account for about 9% of cases of upper limb soft tissue disorders presenting to orthopaedic clinics nationally.

The results suggest that occupation makes a not negligible contribution to the upper limb soft tissue disorders seen at orthopaedic clinics, and that attention should be directed initially towards the modification of work activities to minimise use of the thumb, pronation/supination and flexion/extension of the wrist, and rotation of the shoulder with arm elevated. Further ergonomic and epidemiological studies of high risk occupations would enable these findings to be translated into recommendations for task or machine modification. Studies, similar to that reported here, but based in other areas where different jobs are represented might identify other potentially harmful components of activities at work, and would provide an opportunity to test the stability of the relationships described here. Additional analyses of our data, to study the influence of interactions between movements, and relations between activities and injury specific to recruiting centre, would be desirable.

1. INTRODUCTION

Some soft tissue disorders of the upper limb are suspected of being caused in part by repetitive physical activity. When they are believed to be the result of such activity they may be called "repetitive strain" or "cumulative trauma" injuries. Repetitive strain injuries have been reported in a variety of occupational groups (reviewed in an addendum to this report), but conclusions on the frequency of soft tissue disorders in relation to occupation in general are difficult to reach because of lack of agreement on definitions of the conditions, and because reports have tended to concentrate on selected occupations (Thompson, Rawlings and Harrington, 1987). Attempts to identify specific features of activity at work which predispose to injury have generally been descriptive and anecdotal, and even where detailed analyses of hand and arm movements have been made, potentially damaging components of the task have been identified mostly by intuition based on common sense and experience, rather than objective comparisons with control subjects (Armstrong *et al*, 1982; Putz-Anderson, 1988).

General and soundly based information is needed on which occupations are associated with increased risk of soft tissue disorders, and more specifically on the features of activity at work which are responsible for injury.

Soft tissue disorders to which repetitive activity may contribute include well recognised syndromes such as tenosynovitis, carpal tunnel syndrome, tennis elbow or rotator cuff injuries of the shoulder, and additionally rather ill-defined symptoms in the upper limb (McDermott, 1986; Stone, 1983), which are nevertheless associated with pathological changes (Dennet and Fry, 1988). Each of these syndromes may be the result of non-occupational as well as occupational factors.

We have performed a case-control study of individuals presenting to orthopaedic clinics with defined soft tissue conditions of the upper limb, irrespective of the possible causation. The study aimed to determine: what activities are associated with clinically defined upper limb soft tissue disorders; the relative risks of these disorders in different activities at work and elsewhere; what proportion of clinically diagnosed upper limb soft tissue disorders in the community as a whole are attributable to physical activities at work; and what major ergonomic factors can be identified as common to high-risk situations.

2. METHODS

2.1 Study Centres

The participating orthopaedic surgeons are based in Edinburgh, Doncaster and Harlow Wood near Nottingham. All patients presenting to selected orthopaedic clinics in Edinburgh Royal Infirmary and Princess Margaret Rose Hospital, Doncaster Royal Infirmary, Queen's Medical Centre and Harlow Wood Orthopaedic Hospital, Nottingham were considered for their eligibility for the study. The orthopaedic clinics included hand, fracture and general orthopaedic clinics.

2.2 Subjects

All individuals attending the orthopaedic clinics, aged 16 to 65 years, who satisfied the diagnostic criteria, were invited to participate. Fourteen medical diagnoses were chosen for case definition after a review of the literature and discussions with the participating surgeons. Diagnostic criteria were agreed to ensure consistency. The diagnoses were:-

rotator cuff injury, including partial tear, or rupture, tendinitis or painful arc syndrome

rupture of long head of biceps

shoulder capsulitis - defined as a loss of elevation of at least 30° and a limitation of external rotation to 45° or less

symptomatic acromio-clavicular arthritis

tennis elbow (lateral epicondylitis)

golfer's elbow (medial epicondylitis)

cubital tunnel syndrome

carpal tunnel syndrome

median nerve compression in the forearm

forearm tenosynovitis

de Quervain's disease (tenovaginitis of the abductor pollicis longus and extensor pollicis brevis muscles)

trigger finger or trigger thumb

ganglion

arthritis of the first carpo–metacarpal joint

Controls were defined as individuals within the same age range whose clinical diagnoses did not include disease of the upper limb, cervical or thoracic spine.

2.3 Procedures at Clinics

All patients who, in the opinion of the consultant orthopaedic surgeon, satisfied the clinical diagnostic criteria of case or control were advised of the nature of the study and were invited to take part. Details were recorded of those who declined to participate including their medical diagnosis. A trained interviewer, who was present at all clinics, obtained the signed consent of those who agreed to participate, and then proceeded to administer the questionnaire, being unaware of the case–control status of the individual, wherever this was possible. The interviewer subsequently obtained details of the medical diagnosis from the hospital case notes and recorded this on the questionnaire. This was then forwarded by post to the Institute of Occupational Medicine. Recruitment was planned to take place until about 500 cases and 1000 controls had been recruited.

2.4 Design and Content of Questionnaire

The questionnaire was designed by the research team to be administered by a trained interviewer and to take a maximum of twenty minutes. It was designed to elicit information on the directional components of movements of the upper limb, (irrespective of left or right side), based on simple anatomical and functional descriptions of possible movements, together with supplementary information on repetition and force associated with the movements. The design of the questionnaire took into account present knowledge on the likely ergonomic factors contributing to risk of disease. As far as possible, the questions were intended to obtain information similar to that which a trained observer would obtain by a detailed task analysis, though the constraints of questionnaire design and administration limited the detail which could be investigated. The questions referred only to work performed during the previous two years.

The movements included:–

1. Gripping or holding any object in the palm with fingers and thumb.

2. Holding or pinching an object between fingers and thumb, not in the palm.

3. Repeated tapping movements with the fingers more than once a minute.

4. Apart from gripping movements, moving or bending the thumb repeatedly more than once a minute.

5. Twisting the wrist so that the palm faces up and then down, more than once a minute (pronation/supination).

6. Bending the wrist up and down repeatedly more than once per minute (flexion/extension).

7. Bending the wrist from side to side repeatedly more often than once per minute (ulnar and radial deviation).

8. Rotating the wrist, as if turning a handle, more often than once per minute (rotation).

9. Bending the elbow more often than once a minute (flexion).

10. Raising and lowering the whole arm from shoulder forwards or backwards more often than once a minute (shoulder flexion).

11. Moving the raised outstretched arm from side to side across the body more than once per minute (shoulder rotation with elevated arm).

12. Moving the arm across the body like a pendulum, more than once per minute (adduction/abduction).

13. Keeping the whole arm raised for more than a minute.

14. Keeping the elbow bent, moving the forearm from side to side across the body, more than once per minute (shoulder rotation with elbow flexed).

The requirement for a frequency greater than once per minute was the result of an arbitrary definition of what frequency constitutes "repetitive". If the subject admitted performing any of these movements at work, he or she was asked about frequency, longest period of repetition without interruption, total time spent each day in repeating this movement, whether force was applied, and, where appropriate, the range of the movement, and whether a fixed upper limb posture was ever sustained for more than a minute.

Additionally the questionnaire asked for an occupational history for the previous two years, whether hand tools were used and whether the workplace was cold or wet. The subject was also asked whether he or she took part in any sporting activity as frequently as once per week for a three month period or more, and if yes, which sport(s). Other hobbies or leisure activities were also recorded, together with the average number of hours per week spent driving, left or right handedness, whether the present illness started with an accident, and whether a claim for compensation was being made. Personal details and height and weight were recorded. The questionnaire is appended to this report. It was tested on volunteer subjects for comprehensibility.

2.5 Administration of Questionnaires

The participating orthopaedic consultants each appointed one interviewer for their centre. Two were already in employment with the respective orthopaedic departments, undertaking various tasks on research projects, and one had no previous experience of research work.

They all attended an intensive two-day course of instruction at the Institute of Occupational Medicine, which included lectures and talks on the theory and practice of questionnaire administration by an interviewer, instruction on interviewing technique, by personal demonstration and use of a training tape, and demonstration and practice of the relevant upper limb movements. (The interviewers were trained to demonstrate the movements).

Tape recordings were made of the interviewers administering the questionnaire to correct and improve their technique. They attended an orthopaedic out-patient clinic and administered the questionnaire to patients under the supervision of the project coordinator (CJE). The aims and logistics of the study were clearly outlined together with their role and responsibilities. CJE subsequently visited the three centres and fully explained to all the participating and supporting medical, nursing and clerical staff in the orthopaedic clinics, the aims and logistics of the study. Written details and instructions were provided for clinic staff use. Recruitment to the study commenced immediately after this period of training, and CJE monitored the content of the completed questionnaires and advised the researchers appropriately. In December 1986, six months after commencement of recruitment, CJE visited the three centres and spent half a day observing each of the interviewers administering the questionnaire to patients in the orthopaedic clinics. She found their interviewing techniques to be as originally instructed, with no departure from the text apart from prompting in an agreed manner. The demonstration of the upper limb movements was consistently accurate and clear. It was agreed that the researcher in Doncaster should be relocated to a room within the out-patient clinic area and this had the desired effect of reducing the refusal rate from this centre.

2.6 Analysis

The completed questionnaires were coded and transferred to computer file. Validation programmes and procedures were drawn up and implemented before the analysis commenced.

The analysis was carried out in several stages:-

(1) A general description of cases and controls was obtained, comprising frequency distributions of diagnosis, age, sex, height, weight and other variables of interest, with means and standard deviations for continuous variables, separately for each centre.

(2) The occupational histories of cases and controls were compared to provide a basis for the case selection procedure in the ergonomic study, and also to calculate approximate relative risks of becoming a case in certain occupations, for use in calculating attributable risks.

(3) In subjects employed during the two years before completion of the questionnaire, case–control comparisons of questionnaire responses about activities at work (frequencies or means as appropriate) were made by centre and by case group (cases were allocated into six groups according to the anatomical site of injury). This part of the analysis gave a guide to interpreting the results of the next stage, the logistic regression analysis.

(4) For employed cases and controls, a series of multiple logistic regression analyses were performed using case–control status as the response variable and responses to questionnaire items as explanatory variables. The aim was to discover which movements were most influential in predicting the likelihood of being a case, while allowing for the possible influences of other factors such as age, sex and anthropometric variables.

(5) For all cases and controls, the influence of participation in sporting or other leisure activities upon case probability was examined, both descriptively and by regression methods. For this purpose, a coding system was devised for sports and hobbies, described in Appendix 3.

Details of 2, 3 and 4 are as follows:–

2.6.1 Comparison of cases' and controls' occupational histories

Two frequency distributions were drawn up, one for cases and one for controls, of the jobs done in the two years prior to interview. Where the same job (for example, cleaner/domestic) appeared more than once in the occupational history, it contributed a count of only one to the frequency distribution. The proportion of cases in any particular occupation was then compared to the proportion of controls, the standardized difference in proportions being calculated using a "pooled" estimate of the underlying proportion of subjects in the job category. Thus, taking the results for cleaner/domestics as an example (Table 4):–

proportion of cases who worked as cleaners = $^{46}/_{580}$ = 7.9%
proportion of controls who worked as cleaners = $^{36}/_{996}$ = 3.6%
Difference in proportions = 4.3%

$$\text{Estimated standard error} = \sqrt{\left(\frac{46+36}{580+996}\right)\left(1-\frac{46+36}{580+996}\right)\left(\frac{1}{580}+\frac{1}{996}\right)}$$

$$= 1.2\%$$

Standardized difference = 4.3/1.2 = 3.73

The statistical significance of the difference in proportions may be very roughly assessed by referring the standardized difference to a table of the Normal distribution (when freqencies become small, this procedure will not yield an accurate result).

2.6.2 Comparisons of cases and controls on questionnaire responses

The items in the questionnaire relating to movements (Questions 2 to 15) fell naturally into two categories, those to which the answer can either be Yes or No (dichotomous variables), and those where an assessment of rate or of duration is required (continuous variables). The same form of statistical summary was used for both types of variable; thus, the mean response, the standard error of the mean, and the number of valid responses were obtained for all variables, separately for cases and controls. (For dichotomous variables, the mean response is equal to the percentage of positive responses.) Cases and controls were compared by subtracting means, and the statistical significance of differences was roughly asssessed by referring the standardized difference to tables of the Normal distribution. The same form of analysis was used for questionnaire items other than those relating to movements at work, for example sex, age, height, weight, employment status etc. Case-control differences were calculated (a) for all cases in all three centres, and by centre; and (b) separately for six subgroups of cases in all three centres, and by centre. These extensive tabulations have not been included in the report, but copies are available on request.

It should be noted that the number of valid responses to any particular question depends on whether the question is designed to be asked unconditionally (for example, Question 2), or to be asked only if the response to a previous question has been positive (for example, Question 2(a)).

2.6.3 Multiple logistic regression analyses - relationships between movements at work and the probability of upper limb disease.

The application of multiple logistic regression analysis to case-control data has been described in detail by BRESLOW and DAY (1980); for this study, such analyses were carried out using the GENSTAT statistical program (ALVEY *et al*, 1983).

With such a large set of questionnaire responses to consider in relation to the risk of disease, it was necessary to carry out regression analysis according to a well-defined sequence of steps. It was felt that the procedure described below would give a thorough screening of the data for exposure-disease relationships, and that those of importance would be identified.

Each of the six groups of cases (fingers, thumb, wrist and forearm, elbow, shoulder, ganglia (site unspecified)), was analysed in the same way - ie the same logical sequence was followed in screening variables for their influence on risk.

The sequence contained five steps:-

Step 1. The joint effect upon risk of sex, age, height, weight and handedness (right, left, ambidextrous) was examined first. Two other variables also considered at this stage were "accident status" (whether or not the present injury was attributable, in the subject's judgement, to an accident) and "compensation status" (whether or not the subject was claiming compensation as a result of their injury). This analysis yielded a (different) regression equation for each case group, which was used to adjust estimated effects of upper limb movements obtained in all further analysis.

Step 2. The influence of responses to each of the 14 "question-groups" upon the risk of becoming a case was considered next. Each question-group was considered separately, and adjustments for the possible effects of variables such as age and sex were carried out using the results from step 1, above. This analysis highlighted those question-groups which seemed to discriminate between cases and controls, but took no account of the combined effects of the particular movements involved.

Step 3. Those question-groups which were found to influence risk (significance level 10%) in the analyses of step 2 above were next considered together, using the method of "forward selection" of variables. Because the potential number of variables was so large, this analysis was confined to responses to those questions making up the question-groups which were asked unconditionally - for example, Q5 or Q5(e), but not Q5(a). As a result of this step, the number of influential question-groups to be considered in the next step was reduced. (A significance level of 10% was used in considering whether or not to include effects.)

Step 4. In this step, those influential question-groups identified in Step 3 were analysed jointly. Responses to unconditional questions and also to conditional questions concerning for example, rates, durations and force, were fitted to the case-control data. However, only those conditional questions which had appeared to discriminate between cases and controls in Step 2 were included. Again, the method of forward selection of variables was used. After this step, a tentative regression model could be identified.

Step 5. In the final step, the regression equation obtained from Step 4 was considered together with those conditional responses previously identified in Step 2 as influential, but not so far considered in a forward selection procedure.

The results of this analysis yielded the final regression model. Following these five steps, the resulting regression equation was examined, and terms not significant at the 5% level were omitted.

2.6.4 An example of the model selection process - wrist and forarm cases

Step 1. Variables found to influence the probability of being a case were height, weight, sex and accident status. (Note that a term for "study centre" is always present in the regression model.)

Step 2. Influential question–groups were: 2,3,5,6,7,9,10,11,12 and 15.

Step 3. The method of forward selection was carried out using as potential independent variables, responses to Q2, Q3, Q5, Q5E, Q6, Q7, Q7E, Q10, Q10F, Q11, Q12 and Q15. (Note that Q9 was mistakenly omitted from this step; its effect was examined in Step 5, below.) Jointly, influential question–groups were found to be 3,5,6 and 10.

Step 4. The following forward–selection procedure was carried out: Unconditional questions presented to regression program: Q3, Q5E, Q6, Q10, Q10F. Conditional questions presented to regression program: Q3A, Q3E, Q10D. The tentative model established after this stage is Q3, Q5E, Q6, Q10, Q10D, Q10F.

Step 5. This tentative model was considered together with Q2A, Q7B, Q9, Q9B, Q11D, Q12B and Q15B (Note that Q9 was considered here, having been mistakenly omitted in Step 3). This yielded a final model containing the terms: Q3, Q5E, Q6, Q10, Q10D, Q10F, Q12B, Q15B.

Finally, the effects of Q15B and Q10F were found to be not significant at the 5% level, and these were omitted from the model

It will be observed in Table 12 that a term has been fitted which describes the relative risk of repeated elbow flexion greater than once per minute, ie a term corresponding to Q10. This does not contradict the example given above, since in order to fit conditional questions such as Q10D, the corresponding unconditional question was fitted first, even though it was not itself statistically significant.

2.6.5 Attributable Risks Calculation

The results tabulated in Table 4 suggest that the risk of developing one of the upper limb conditions considered in this study is raised for certain occupations, for example cleaner/domestic or machine operator. However the consequences of this increased risk for the general working population only become apparent when the number of persons actually engaged in the high–risk occupation is considered.

Breslow and Day (1980) describe how to derive an estimate of the proportion of all persons with a given disease in the general population, whose condition may be attributed to a defined exposure. This proportion, usually known as the Attributable Risk, is calculated from two quantities, one of which, the relative risk of the disease in question, is often estimated from case–control data. The other is the proportion of exposed persons in the general population, and an estimate of this may be obtained from a control sample, assuming it is representative of the general population.

In the present study, the term "exposed" refers to any one of four job categories, viz keyboard operators, cleaner/domestics, hairdressers, and machine operators. (See the footnote to Table 22 for the definition of these job catogories.) The "non-exposed" category, which is used as the baseline category for the calculation of relative risk estimates, is defined as any other job, or unemployed (ie not in paid work). The specific case of cleaner/domestics will be used to illustrate the calculations.

Table 22 (a) shows the odds ratio estimate of the risk of cleaner/domestics becoming upper limb cases relative to persons in the "non-exposed" category. This estimate is obtained very simply:

$$\frac{46/470}{36/905} = 2.46$$

If the absolute (but unknown) risk in the "non-exposed" category is denoted by p, then the risk in the "exposed" category (ie cleaner/domestics) is estimated as 2.46 x p. Similarly, the risks for keyboard operators, hairdressers and machine operators may be calculated to be 1.92 x p, 5.78 x p, and 2.03 x p respectively.

Using now the data in the table in Appendix 2, an estimate of the proportion of persons in the general population suffering from at least one of the upper limb disorders considered in this study is given by

$$(0.9253 \times p) + 0.0281 \times 1.92 \times p) + (0.0280 \times 2.46 \times p) +$$
$$(0.0018 \times 5.78 \times p) + (0.0168 \times 2.03 \times p) = 1.0926 \times p.$$

Among cleaner/domestics, the number of cases, expressed as a proportion of the general population, is

$$0.0280 \times 2.46 \times p$$

If there were no excess risk for this occupational group, this proportion would be

$$0.0280 \times p$$

and so the "excess" number of cases among cleaner/domestics is given by

$$0.0280 \times 1.46 \times p.$$

Finally, the Attributable Risk is obtained by expressing this excess number of cases as a fraction of the total number of cases, viz

$$\frac{0.0280 \times 1.46 \times p}{1.0926 \times p}$$

The Attributable Risk estimates for the three other occupational groups are obtained similarly.

It will be noted that the method of calculation described here does not require the estimation, from the case-control data, of proportions of the general population which are "exposed" to particular occupations. Rather, these quantities have been estimated from census data (OPCS, 1986).

2.6.6 Groupings of Occupations, Sports and Hobbies

In view of the very large number of sports and hobbies recorded, nine subgroups were identified based on a subjective assessment of the predominant use of the upper limb, or otherwise, the load on the upper limb, either heavy or light, the repetitive occurrence of upper limb activities, and whether or not the activity required gripping a hand tool or other implement. These subgroups (shown in Appendix 3) were used in the logistic regression analysis when assessing the influence of sports and leisure activities on case-control status.

2.7 Ergonomic Study

2.7.1 The aim of the ergonomic study was to illustrate, by the study of a small number of subjects in jobs associated with high risk of repetitive strain injury, how features of the work likely to be associated with risk of injury may be recognised by comparisons with empirical criteria. The criteria and methods of observation have been described previously (Pethick *et al*, 1987).

2.7.2 Subjects

Subjects in the cleaner/domestic, keyboard user and machine operator occupational groups were invited for study.

All those cases undertaking these jobs who were recruited from the Doncaster and Nottingham clinics were approached by letter. Their consent was sought for agreement to approach their employer so that an ergonomist could visit their workplace to study their working environment. Once this agreement was obtained the local Employment Medical Advisor assisted by approaching the individual's employer to obtain consent for access to their premises.

Forty-six cases were invited to participate and eleven agreed. Ten employers were contacted and six agreed to take part.

2.7.3 Methods

Subjects agreeing to participate were informed of the nature of the study. If the subject had left his employment, management assisted in identifying the tasks which he or she had undertaken and other doing similar tasks were asked other employees to participate. No-one refused.

The assessment included interviewing the worker to determine normal duties, making video recordings of these tasks, and where possible, measurement of the workplace.

The video recording was subsequently analysed in detail. Attention was directed principally towards the movements affecting that part of the upper limb which was known to be injured. The collection of angular data was based on observing the extremes of the postures of wrist, elbow and shoulder. Sustained postures were also noted and quantified. Cycle times, task element times, durations of force applied and rest periods in the cycle were measured. Force and discomfort were not measured in these preliminary studies.

3. RESULTS OF CASE-CONTROL COMPARISONS

3.1 Response and General Information

Two hundred and eighty-two, 139 and 186 potential cases were identified in Edinburgh, Doncaster and Nottingham respectively, and all but 12, 12 and 3 of these agreed to participate. Overall response for the cases was 96%. Four hundred and thirty-nine, 335 and 296 potential controls were identified in the three centres respectively, and all but 21, 46 and 7 participated. Overall response among the controls was 93%.

The diagnoses of the cases are listed in Table 1. Carpal tunnel syndrome and ganglion were the most frequent diagnoses. Table 2 shows the site of diagnosed disease among the controls. Foot, knee and lumbar spine were the most frequent sites of disease. Table 3 shows that women predominated among the cases, and men among the controls. Eighty-four percent of the cases and 81% of the controls had worked in at least one job during the previous two years, and of these, 70% of cases and 80% of controls worked full time, and 6% and 5% were self employed. Eighty-eight percent of cases and 89% of controls were right-handed. Twelve percent of cases and 40% of controls attributed their illness to an accident, and 4% of cases and 9% of controls were claiming compensation. Eighty-four percent of cases and 81% of controls were in employment at the time of the study, and 70% and 80% of these respectively were full time employees. Cases were less likely than controls to engage in sports regularly (35% and 46% respectively), and cases were less likely to work in wet conditions than controls (23% and 33% respectively). Eighty-two percent of cases and 87% of controls said they used tools at work.

3.2 Jobs

Subjects who had worked during the previous two years reported working in a total of 437 job descriptions. Table 4 lists the jobs for which the proportion of cases exceeds the proportion of controls by at least 1.28 times the standard error of the difference (corresponding to a 20% statistical significance, an intentionally wide selection criterion). Table 5 lists the jobs for which the proportion of controls exceeds the cases, by the same selection criteria.

The diagnoses in 32 cases who were keyboard operators (combined category:- secretary etc in Table 4) consisted of nine with thumb conditions (four de Quervain's disease, four trigger thumb and one osteoarthritis of the first metacarpophalangeal joint), five with carpal tunnel syndrome, five with shoulder conditions (three rotator cuff injuries and two shoulder capsulitis), four forearm tenosynovitis, two with tennis elbow and seven with ganglia (three wrist, two fingers and two site unspecified).

3.3 Specific Movements at Work

For comparisons of case-control status with specific movements at work, the cases were grouped as shoulder, elbow, wrist and forearm, finger and thumb cases. Ganglia where the site was not specified formed an additional group. Other ganglia were grouped according to their position. Table 6 shows these groupings.

The analysis was designed to identify factors associated with upper limb conditions when all these centres were considered together, and has not examined or allowed for differences between centres in these relations.

3.3.1 Thumb Conditions

Sixty-nine subjects had conditions affecting the thumb. Table 6 shows the frequencies of individual diagnoses. Fifty-one of these had worked during the previous two years. Thirty-three of the 51 presented in Edinburgh, 5 in Doncaster and 13 in Nottingham. Twenty-five percent of employed cases and 59% of employed controls were men. Ten percent of cases and 43% of controls stated that their illness started with an accident. Cases were on average shorter (164 cm) than controls (172 cm), lighter (67 and 73 kg respectively) and older (46 and 38 years respectively).

Analysis confirmed differences between centres, and the influence of age and height. The analysis indicated which movements influenced risk of thumb conditions. Table 7 shows the observed relations, and Table 8 the results of the logistic regression model.

If a subject held or pinched an object between fingers and thumb, not in the palm, the odds of having a thumb condition were increased approximately four times (odds = $^{P}/_{1-P}$ where P = probability that a subject has a condition). Also, if a subject kept the thumb in a bent position (apart from gripping movements) for more than a minute, the odds of having a thumb condition were increased approximately three times.

Additionally the frequency with which the wrist was bent up and down (flexion/extension) influenced the odds (a factor of 1.4 for each increase of 20 repetitions per minute).

If a subject rotated the wrist repeatedly more than once per minute, the odds of being a case were divided by approximately three.

The jobs of the 30 cases with thumb conditions in Edinburgh who said they pinched an object between finger and thumb included three teacher/lecturers, two typists, two secretaries, two clerks, two medical laboratory technicians and 19 other single named occupations. The jobs of the 10 cases in Edinburgh who said they kept their thumb bent for more than a minute included a typist, cleaner/domestic, joiner, shop assistant, midwife, assembly line worker, medical laboratory technician, sales representative, post office branch manager and bar person. The jobs of the four cases in Doncaster who said they bent their wrists up and down repeatedly more than once a minute included a secretary, an assembly line worker, a cleaner/domestic, and a bar person.

3.3.2 Finger Conditions

Sixty subjects had conditions affecting the fingers. Table 6 shows the frequencies of individual diagnoses. Fifty of these had worked during the previous two years. Thirty-four of the 50 presented in Edinburgh, 5 in Doncaster and 11 in Nottingham. Forty percent of employed cases and 59% of employed controls were men. Five percent of cases and 43% of controls stated that the illness started with an accident. Cases were shorter (167 cm) than controls (172 cm), and older (45 years and 38 years respectively).

Analysis confirmed differences between centres and the influence of accidents and age. The analysis indicated which movements influenced the risk of finger conditions; Table 9 shows the observed frequencies and Table 10 shows the results of the logistic regression model.

If the condition started with an accident, the subject was approximately eight times more likely to be a control than a case. This reflects the fact that of fifty cases only six reported accidents whereas of the 809 controls, 345 reported an accident. Subjects who gripped objects in the palm with fingers and thumb repeatedly more than once per minute were about three times as likely to have a finger condition as those who gripped less frequently than this. Subjects who gripped less frequently than once per minute were less likely to have finger conditions than those those did not grip at all.

The rate of repetition of bending the thumb repeatedly was inversely related to risk of finger conditions.

Some movements of more distant joints of the arm also appeared to influence risk of finger conditions; bending the elbow more than half-way, raising and lowering the whole arm from the shoulder, and moving the forearm from side to side (rotation of the shoulder joint) each appeared to increase risk of having a finger condition rather than being a control.

The largest group of cases with finger conditions who gripped objects repeatedly was in Edinburgh. These 13 subjects included three nurses and ten other single occupations.

3.3.3 Wrist or Forearm Conditions

Two hundred and eighty-five subjects had wrist or forearm conditions. Table 6 shows the individual diagnoses. Two hundred and thirty-three had worked during the previous two years, and, of these, 135 presented in Edinburgh, 39 in Doncaster and 59 in Nottingham; 26% of cases and 59% of controls were male; 8% of cases and 43% of controls stated that their illness started with an accident; cases were shorter (164 cm) than controls (173 cm), (lighter (69 kg) and 73 kg respectively).

Regression analysis showed that sex, age, height, weight and accidents were found to influence case/control status.

Table 11 shows the observed frequencies of selected movements, and Table 12 shows the results of the logistic regression model.

Women were about twice as likely as men to suffer wrist or forearm conditions, and shorter and heavier subjects were at increased risk. Accidents were associated with being a control.

Holding the thumb in a bent position for more than a minute was associated with increased risk (an odds ratio of 1.7), and repeated pronation and supination of the wrist was associated with an odds ratio of 1.38 (though this association did not quite reach statistical significance).

Pinching repeatedly was associated with a reduced risk of wrist and forearm conditions.

Repeated elbow bending more than once a minute with force was significantly associated with increased risk (odds ratio 1.61), compared with bending the elbow without force.

The length of the longest period for which the raised outstretched arm was moved from side to side across the body was positively associated with risk of wrist and forearm conditions.

Twenty-one of the employed cases with wrist and forearm conditions had forearm tenosynovitis. The group was considered too small for detailed statistical analysis, and the observed prevalences have been inspected. Selected variables are illustrated in Table 13. The observations suggest a positive association between tenosynovitis and bending the thumb repeatedly, and negatively with forcefully and repeatedly moving the forearm across the body with elbow bent. Hours per day spent pinching between thumb and forefinger, tapping with the fingers, bending the wrist up and down, and moving the forearm across the body with elbow bent also appeared to be positively associated. These suggestive findings need to be confirmed by study of a larger group.

3.3.4 Elbow Conditions

Forty one subjects had elbow conditions (35 tennis elbow and 6 golfer's elbow). Thirty-four had worked during the previous two years, 11 from Edinburgh, 21 from Doncaster and two from Nottingham. Of the 34, 50% were men and 17.6% said the illness started with an accident. Cases tended to be shorter than controls (167 cm and 172 cm respectively).

After allowing for recruiting centre, only height was found to contribute to risk of elbow conditions (negatively). A difference in height of plus 10 cm was estimated to decrease the risk by a factor of 0.61 (95% confidence intervals 0.42, 0.89). No movements at work could be shown convincingly to influence the risk in this small group.

3.3.5 Shoulder Conditions

Seventy-two subjects had conditions of the shoulder. Specific diagnoses are listed in Table 6. Sixty-nine of them had worked during the previous two years. Of these, eight presented in Edinburgh, 28 in Doncaster and 33 in Nottingham. Sixty-one percent were male. Thirty-one percent of cases and 43% of controls indicated the illness started with an accident. Cases were older (47 yrs) than controls (38 yrs).

Regression analysis showed that age was found to influence risk of shoulder injuries. Table 14 shows the observed frequencies of selected movements, and Table 15 shows the results of the logistic regression model. Moving the raised outstretched arm from side to side across the body increased the risk of shoulder conditions by a factor of 2.3. Some aspects of movements of other joints were also related to risk; the number of hours per day spent bending the elbow repeatedly at work was positively related to risk, as was the rate of rotating the wrist as if turning a handle. Pinching between finger and thumb was negatively associated with risk.

3.3.6 Keyboard Operators

Thirty-two cases and (by chance) 32 controls had worked as secretary/temporary secretary, word processor operator, computer operator, typist/audio typist, clerk/typist or visual display unit operator ("combined category," Table 4). Wrist and forearm (12 cases), thumb (9) and shoulder (5) conditions were the most frequent among the cases. Table 16 shows the observed relations between selected movements of interest and case-control status. Detailed statistical modelling was not performed in view of the small numbers. Movements whose associations with case status (without allowing for other factors) could have occurred by chance less than one time in 20 included gripping in the palm more frequently than once per minute, and (negatively) sustaining this grip for longer than a minute; also to the rate of bending the elbow. Other features whose case-control differences correspond to probabilities less than 1 in 5 are the length of the longest period of pinching between thumb and fingers and number of hours per day spent performing this movement, keeping the thumb bent, flexing and extending the wrist more frequently than once per minute (and the rate per minute of this movement) and bending the elbow repetitively, especially when done with force.

Rate of tapping with the fingers, and hours per day performing these movements was similarly high in cases and controls.

3.3.7 Sports and Hobbies

Sports and hobbies reported by the cases and controls were classified arbitrarily according to whether they involved use of the upper limbs, and whether usage was repetitive at a frequency greater than once per minute, or involved gripping or the use of force. Details of the classification are described in Appendix 4.

For each case group, classified by anatomical site of injury, the influence of sports and hobbies was examined by tabulations and by logistic regression modelling, allowing for the influence of age, height, weight, sex, centre and history of accident, where these variables had been shown to contribute to the risk of being a case.

This process identified contributions of sports to elbow and thumb conditions, and hobbies to wrist and forearm conditions. Table 17 shows the frequencies of elbow cases in relation to sports activities, and Table 18 shows the results of the regression model. Sports involving (a palmar) grip were associated statistically significantly with elbow conditions. Table 19 shows the frequencies of thumb injuries in relation to sports activities. Sports not involving use of the upper limb were associated with a lower frequency of thumb conditions than no sports at all. Use of the upper limb was associated with a higher risk of thumb injury than non-use sports, the risk being higher with sports not involving repetitions as frequently as once per minute than with sports associated with repetitions > 1/min. A similar pattern was discernible for sports involving "heavy activity", and sports involving gripping. The risk was apparently higher for sports requiring "light" activity relative to those requiring "heavy" activity, and also for non-gripping relative to gripping. The zero prevalence in one group caused mathematical difficulties in estimating the relative risks associated with these differences. However the results of likelihood ratio tests suggested among sports participants, there was increased risk among those who used the upper limb ($X^2 = 8.3$, $P < 0.001$), relative to those who did not. The disparity in risk between the heavy and light category was significant at the 10% level.

Table 20 shows the associations of hobbies involving use of the upper limb with wrist and forearm conditions. Table 21 shows the results of the logistic regression. Hobbies involving little or no upper limb activity were associated with least risk. Both not doing a hobby at all, or doing a hobby which involved use of the upper limb, were associated with increased risk of wrist and forearm conditions.

3.4 Estimated Attributable Risks of Upper Limb Conditions in Four Occupations

Table 22(a) shows the numbers of cases and controls who had been employed during two years prior to interview in one of four occupations (keyboard operators, cleaners, hairdressers or machine operators). The table shows the calculated proportion of cases attributable to occupation. In total about 9% of cases attending orthopaedic clinics are estimated to be attributable to these four occupations together. Keyboard operators account for between 2 and 3 percent, and cleaners between 3 and 4 percent of cases.

3.5 Ergonomic Studies

3.5.1 Machine Operator 1

This worker's job was as Computer Numerical Controlled (CNC) Milling machine operator. He was videoed for one hour forty nine minutes.

It was known that this worker had an injury to his left shoulder therefore particular attention was paid to this region when assessing the video record.

The major job or working components identified were setting up the jig in preparation for milling and the milling operation itself. The tasks involved in these activities were analysed in detail.

In fifteen out of the 24 task components recorded, his left arm was elevated at the shoulder, and in most of these some loading was apparent, in some instances helping to support the weight of his upper body.

The ergonomic factors which were primarily influencing his posture were:

(a) the position of the clamps to hold the jig, particularly those at the back which were difficult to get at because of the shape of the jig;

(b) the position of the visual task at the turret in relation to the position of controls on the right side of the machine;

(c) the height of the bench for setting up the drills in the chucks;

(d) the height of the turret, the weight of the chucks and forces required when changing them;

(e) the clarity of various displays, e.g. the drill sizes on their shanks which made him hunch forward to read them.

Further information on the detailed analysis of this subjects tasks is available on request.

3.5.2 Machine Operator 2

This female operator no longer worked at the factory. She had an injury to her left elbow. The factory manufactured clothing and the operations included what could be described as light machining and packing operations. She carried out four jobs; working on the fusing press, the seam press, hook and bar machine, and dispatch. Each of these was studied.

It is likely that amongst the four jobs the one most likely to affect the right elbow was the seam press operation. The posture adopted for the ironing component involved some elevation of the right shoulder and abduction and inward rotation of the shoulder, with flexion of the elbow. Some loading obviously occurred during the ironing cycle, which covered 46 seconds for each pair of trousers. The ergonomic factors which were primarily influencing her posture were: the height of the ironing table and the design of the iron handle.

3.5.3 Machine Operator 3

This man no longer worked at the place where the injury first occurred and it was not possible to observe him at his place of work or others at the works.

However he described and demonstrated his work. The injury was to his right hand. His job was to clean up bars on a sanding machine prior to plating. He stood in front of the machine, picked up the bar with his right hand from a pile of bars on his right and transferred it to his left. He lifted his right elbow and hand up, grasped the bar and pushed it down onto the belt of the sanding machine. It was apparent from his demonstration that the bar would have been pressing into both his palms as he did this operation. He repeated this manoevre eight times for each of 50 to 100 bars.

The ergonomic factors which were primarily influencing his posture were: the height of the machine, and the need to hold the bar lengthwise to push the bar forwards onto the machine, and to grip with his palm as he pushes against the polishing machine.

The next four subjects were observed undertaking their normal duties and are described in less detail than the earlier cases. Domestic cleaner 1 was a case but cleaners 2 and 3 undertook similar work to the case who no longer worked at her stated place of work at the time of interview. The remaining case was a keyboard operator.

3.5.4 Domestic Cleaner 1

This female subject had a ganglion of her right wrist. She worked two hours a day for six days a week as a cleaner in a health centre. Her job consisted of cleaning basins and toilet fittings, washing floors with a mop, polishing floors with a rotary buffer and vacuum cleaning other floors.

The activityy judged most likely to contribute to injury was using the rotary floor buffer. The floor buffer was a rotary disc machine held in both hands in front of the body at just above waist height and swung from side to side. A switch on the right handle had to be held down with the right forefinger to operate the machine. Vibration was transmitted to the handle. The factors which are likely to have contributed to her condition are; a sustained right hand grip, necessary to hold the switch down; repetitive movements from side to side, with the right hand and forearm in a static flexed position; exacerbation by other right handed operations (wiping surfaces, wringing out cloths, depressing the wringer handle on the mop bucket and hoovering the floor.

3.5.5 Domestic Cleaners 2 and 3

Nature of tasks

The original (female) cleaner no longer worked in this job, which consisted of general cleaning duties in a maternity ward. She suffered from carpal tunnel syndrome and tennis elbow. Two other female cleaners, undertaking similar tasks, were recorded. They are treated as one person, even though they carried out certain tasks which were different from each other.

The main tasks are: (1) dry floor mopping/sweeping; (2) floor buffing (as for domestic cleaner 1); (3) wet floor mopping (as previously); (4) cleaning surfaces with wet cloth; (5) changing disposable bag on waste disposal units; (6) vacuum cleaning TV room; (7) wet mopping of door sills and sides.

These tasks were in many ways similar to those described for Cleaner 1, although they were more variable and interspersed with different activities. The nature of the activities performed was such that the dominant hand and arm undertook the majority of the strain of forceful repetitive and static actions. There was therefore a strong potential for, in this case, a right handed person to experience injuries to the right limb.

3.5.6 Keyboard Operator

This female subject was a headmaster's secretary in a school. Her duties consisted of typing, collecting dinner money and general clerical work. She worked mornings only for a total of 16 hours per week during school terms.

Her original medical problem had been a prolapsed intervertebral disc, as a result of which she had been told to change her usual typing chair to an ordinary chair with a cushion fixed to the back rest. After about 2 years she developed problems with both wrists (carpal tunnel syndrome). Recordings were made of her typing, using both the typing chair and the chair with cushion.

During typing with the ordinary chair her seat height was so low that her elbows, at an angle of 60° – 70°, were well below table top height. As a result her wrists were unnaturally angled to reach the typewriter keys. The low seat did mean that she could sit well under the desk, which had a drawer across its centre section restricting access by the thighs.

When she sat in the typing chair, which had an adjustable backrest, its greater seat height prevented her sitting far enough forward to fit her thighs under the desk, a gap of only 105 mm being left between seat and underside of desk. This forced her too far away from the typewriter for comfort and possibly contributed towards her back problem originally.

In summary, this woman's back problem caused her to use a seat unsuitable for typing and the desk was unsuitable owing to the restricted leg room. This was incompatible with a low enough desk top to prevent over-flexion of the wrists required to reach the keys of the typewriter.

3.6 Summary of Results

1. Among a population of subjects attending orthopaedic clinics, the factors influencing whether a subject presented with a soft tissue disorder of the upper limb or a condition of the legs or back have been studied. Five hundred and eighty subjects with upper limb conditions (cases) were studied, and 996 subjects with other conditions (controls).

2. The diagnoses of the cases included soft tissue disorders affecting the shoulder, elbow, forearm, wrist, thumb, hand and finger. The most frequent diagnoses were carpal tunnel syndrome and ganglion. Tenosynovitis of the forearm accounted for only 4% of cases; tenovaginitis of the tendons of the thumb (de Quervain's disease) for 5% of cases.

   The diagnoses of the controls included traumatic, degenerative and inflammatory disease of the feet, legs, hips and lower back. Forty percent of controls and 12% of cases attributed their illness to an accident, and 33% of controls and 23% of cases often worked in wet conditions.

3. Women predominated among the cases (70%) and men among the controls (56%). Over four-fifths of both cases and controls had worked in at least one job during the previous two years.

4. Jobs statistically significantly over-represented among the cases compared with controls were cleaner, hairdresser, VDU operator and other keyboard users, butcher, music teacher and machine operator.

   Jobs over-represented, but not statistically significantly so (0.2 > P > 0.05) included teacher/lecturer, packer, kitchen assistant, checkout operator and bank officer. Jobs done by cases but not controls were educational administrator, animal nurse, potter, taxi driver, graphic artist, woodwork teacher, and community worker.

5. Jobs statistically significantly ($P < 0.05$) over-represented among the controls compared with the cases included miners and policemen.

   Jobs over-represented but not significantly so ($0.2 > P > 0.05$) included labourer, plumber, mechanic, librarian, bricklayer, catering manageress, postman, insurance agent, handyman, marine engineer, electronics engineer, sewing factory examiner, building surveyor, garage manager, prison officer, travel consultant, builder, shop manager and tyre fitter.

6. Cases in general were older and shorter than the controls. Cases with conditions of the wrist and forearm were heavier than controls after adjustment for height, and more likely to be female.

7. Associations between components of movements at work and conditions of the upper limb are summarised in Table 23. Notably, movements associated with diseases included gripping in the palm, with finger conditions; pinching between thumb and fingers, not in the palm, with thumb conditions; bending the thumb with forearm tenosynovitis; wrist supination/pronation with wrist and forearm conditions; rotating the shoulder with arm raised with shoulder conditions.

8. Rate of movements above the once per minute threshold apparently influenced risk of thumb conditions in relation to rate of wrist flexion and extension. Some negative associations between rates of movements and injury were demonstrated, and also positive associations between some movements and anatomically rather distant injuries.

9. Hours spent per day performing movements more than once per minute influenced risk of forearm tenosynovitis in relation to pinching, tapping with the fingers and flexing/extending the wrist; and risk of shoulder conditions in relation to bending the elbow.

10. Sustaining a fixed position increased the risks of thumb, wrist and forearm conditions in relation to keeping the thumb bent.

11. In general, performing movements forcibly did not appear to increase the risks, except for forcibly bending the elbow repetitively.

12. The influence of interactions between movements has not been examined. Nor have differences between centres in relations between work and upper limb conditions been studied.

13. Sporting activities contributed to risk of thumb and elbow conditions. Hobbies involving use of the arms contributed to risk of wrist and forearm conditions.

14. Calculation of attributable risks of injury in relation to named occupations indicated that work as a keyboard operator, cleaner, hairdresser and machine operator together accounts for about 9% of cases of repetitive strain injuries presenting to orthopaedic clinics nationally.

15. Ergonomic case studies of three machine operators, three domestic cleaners and a typist illustrate how a detailed task analysis enables the identification of potentially hazardous components of activities by comparison with accepted criteria, and would permit recommendations for task or machine modification to be made.

4. DISCUSSION

By means of an epidemiological study of a population attending orthopaedic clinics we have been able to study risks of repetitive strain injuries across a wide range of occupations. By concentrating on detailed components of movements and activities at work, it has been possible to identify those components common to risk of illness, when study of whole tasks might not have been able to distinguish which parts of a complex of movements were responsible for risk of injury. Occupations not represented in the catchment areas will not of course have been studied, but it is hoped that jobs associated with risk but not identified in the study may in future be recognised because they include specific risky movements.

The population of cases we studied, those attending orthopaedic clinics, presumably represent those severely affected by their illness, and the results do not necessarily apply to those with transient or less severe symptoms. This selection has the advantage that each case has been diagnosed by an orthopaedic surgeon. The controls, those attending the same clinics, but with conditions mostly of the legs and back, do not necessarily represent the distribution of occupations to be found in the general population, since occupation could also have influenced their health. The relative over-representation of miners, labourers, policemen and some others among controls compared with cases suggests that these jobs predispose to foot, leg or back conditions, rather than protect against repetitive strain injuries of the upper limb. The relatively high proportion of accidents among the controls additionally suggests the main cause of illness in many of these subjects.

Thus the case-control differences indicate the occupational influences which determine whether a person presents to a clinic with a soft tissue condition of the arm as distinct from a condition of the leg or back. Interpretation of these differences in the context of the general population should be cautious. It should also be borne in mind that the study made no attempt to distinguish between diseases which are caused by activities at work and diseases for which medical advice is sought because activities at work cause discomfort or difficulty.

We chose to study occupations during only the two years before interview, accepting that some of the injuries may have commenced earlier, and that subsequent occupations may give little or no guide to the activities in progress when the condition developed (particularly since some subjects might have taken jobs which did not exacerbate symptoms further). In addition some subjects had not worked during the period, possibly partly because of their illness. These difficulties will have tended to obscure real associations between occupation and illness.

In the event, relations between occupation and risks of illness were demonstrated. The cases included excesses of some named occupations, compared with controls. We are aware of other reports of repetitive strain injuries in cleaners, machine operators, packers, butchers and musicians (reviewed by Putz–Anderson, 1988) though not in hairdressers. The identification of these occupations provides some reassurance that our case and control selection criteria do enable occupational influences on upper limb repetitive strain injuries to be studied.

The shorter stature of the cases than the controls might have been a consequence of a relationship between height and risk of having a leg or back injury, particularly since the difference in height was observed almost irrespectively of the anatomical site of the arm injury. A hypothesis that shorter people are disadvantaged at work because of the necessity for unsuitable postures is tenable, but not confirmed by the study.

The wrist and forearm were the commonest site of injury in our series. The commonest diagnoses were carpal tunnel syndrome and ganglion; forearm tenosynovitis represented only 4% of the case diagnoses. The attributable risk calculations (the results of which probably represent maxima, in view of the probable differences between our controls and the general population) suggested that 9% of upper limb soft tissue injuries presenting to orthopaedic clinics can be attributable to working in only four types of job (cleaner, keyboard operator, machine operator and hairdresser). The proportion of cases with occupationally related conditions is presumably even greater than this, if other occupations associated with risk were to be taken into account.

It is improbable that this study will have identified all the components of movements which predispose to risk of severe repetitive strain injuries, partly because only a selection of occupations will have been represented in the study catchment areas, and partly because a questionnaire cannot describe activities in as much detail as some observational methods. Nor have we yet been able to analyse the influence of interactions between movements. Furthermore, the analysis intentionally searched for relations between work activities and risk of injury which were detectable when all three centres were considered together, in order to increase confidence that the demonstrated relationships were general. Differences in these relationships between centres were suggested by the data (see Tables 7, 9, 11 and 14), and study of these might well be informative.

The work has however enabled the identification of components of activities particularly associated with risk of injury, and some activities not obviously associated with risk, so that further research efforts or even preventive action can be directed towards the apparently most harmful features of activities at work.

Movements not shown by this study to be associated with upper limb repetitive strain injury included ulnar or radial deviation of the wrist, abduction or adduction of the shoulder and keeping the arm raised. The results for radial or ulnar deviation of the wrist are consistent with one other study (Kuorinka and Koskinen, 1979), though others have suggested that some of these movements are associated with risk (Kurppa *et al*, 1979; Tichauer, 1976; Armstrong *et al*, 1985; Chaffin, 1973; Hagberg, 1984).

The positive findings include some which suggest possible preventive measures and others which suggest a need for more detailed work. The results suggest that sustained flexion or repeated pinching or gripping with the thumb is hazardous, and, that repetitive tasks should if possible be designed to minimise use of the thumb. Wrist supination/pronation should also if possible be minimised by task and machine redesign. Rate of repeated flexion/extension of the wrist was also associated with increased risk in our study (and in others; Kivi, 1982; Dimburg, 1987; Kurppa, 1979; Armstrong and Chaffin, 1979.) Probably tasks should be designed to minimise any movements at the wrist, but particularly supination/pronation and flexion/extension.

Shoulder rotation with raised arm also appeared to be hazardous, and this is a feature which could be designed out of some jobs. Other poorly controlled observations reviewed by Hagberg (1984), indicate that raising the arm to or above shoulder height is a common feature of risky jobs. Avoidance of rotation of the shoulder with arm elevated may provide a solution if elevation cannot be avoided.

The study provided limited information on the relations between rate of repetition of movements and risk. Our arbitrary choice of a once per minute threshold for repetition has permitted the identification of some hazardous repetitive movements, but other thresholds might also be relevant. Over this threshold, reported rates of repetition of wrist flexion and extension as high as 65 per minute on average, contributed to risk of injury.

Additionally, hours spent per day performing movements did appear to influence risk of tenosynovitis and shoulder conditions. In relation to tenosynovitis, mean hours per day spent pinching, tapping, flexing/extending the wrist, and rotating the shoulder with flexed elbow, ranged from 4.6 to 6.8 hours for cases and from 3.1 to 3.8 hours for the controls, and this might provide a tentative indication that limitation of time spent in these activities to about half, or less, of the working shift, might be beneficial.

The length of the longest spell of an activity was shown to be associated with risk (of wrist and forearm conditions) only for shoulder rotation with raised arm. The mean longest spells so identified were 63 minutes for cases and 46 minutes for controls, but these may apply only to the shoulder, and not to movements of the smaller joints. Force applied more frequently than once per minute was not identified by the study as additionally hazardous, except for forcible flexion of the elbow joint.

Some more detailed analysis of existing data would be desirable, to study the influence of interactions between movements, and relations between activities and injury specific to individual recruiting centres. The results also suggest that more detailed studies of activities in particular occupations might help to define recommended limits for certain movements, or alternative task design. For instance detailed studies of cleaners or keyboard operators, paying particular attention to the hazardous movements identified in this study, might enable recommendations to be made for working practices and job or equipment redesign.

ACKNOWLEDGEMENTS

We thank the Health and Safety Executive for financial support, the subjects who participated in this study, and the invaluable assistance of many colleagues. In particular we should like to thank Professor A Seaton and Dr M Jacobsen for the study design; Mrs A Traynor, Miss J Kemp and Mrs C Elliot for the interviewing and coordination at clinics; Mr N J Barton for additionally recruiting subjects for the study; the nursing staff at the clinics; Ms A Kinnear for the programming and data control; Mr M Muirhead and Ms H Collins for working much overtime on the statistical analysis and Miss A McCarron and Miss A Lobban for typing this report.

REFERENCES

ALVEY NG, BANFIELD CF, BAXTER RI, GOWER JC, KRZANOWSKI WJ, LANE PW, and ten others (1983) Genstat - A general statistical program. Rothamsted Experimental Station.

ARMSTRONG T, BUCHHOLZ B, RADWIN R, TOBEY S, WOOLLEY C. (1985) Analysis and control of upper extremity posture. In: Brown ID, Goldsmith R, Coombes K, Sinclair MA, eds. Ergonomics International 85. Proceedings of the ninth congress of the International Ergonomics Association, 2–6 September 1985, Bournemouth. London: Taylor and Francis: 889–891.

ARMSTRONG TJ, CHAFFIN DB. (1979) Carpal tunnel syndrome and selected personal attributes. Journal of Occupational Medicine; 21: 481–486.

ARMSTRONG TJ, FOULKE JA, JOSEPH BS, GOLDSTEIN SA. (1982) Investigation of cumulative trauma disorders in a poultry processing plant. American Industrial Hygiene Association Journal; 43: 103–116.

BRESLOW NE, DAY NE. (1980) Statistical methods in cancer research. Vol 1 - The analysis of case-control studies. Lyon: International Agency for Research on Cancer.

CHAFFIN DB. (1973) Localized muscle fatigue - definition and measurement. Journal of Occupational Medicine; 15: 346–354.

DENNETT X, FRY HJH. (1988) Overuse syndrome: a muscle biopsy study. Lancet; i: 905–908.

DIMBERG L. (1987) The prevalence and causation of tennis elbow (lateral humeral epicondylitis) in a population of workers in an engineering industry. Ergonomics; 30: 573–579.

HAGBERG M. (1984) Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible pathophysiology. International Archives of Occupational and Environmental Health; 53: 269–278.

KIVI P. (1982) The etiology and conservative treatment of humeral epicondylitis. Scandinavian Journal of Rehabilitation Medicine; 15: 37–41.

KUORINKA I, KOSKINEN P. (1979) Occupational rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry. Scandinavian Journal of Work, Environment and Health; 5(suppl. 3): 39–47.

KURPPA K, WARIS P, ROKKANEN P. (1979) Peritendinitis and tenosynovitis. A review. Scandinavian Journal of Work, Environment and Health; 5(suppl. 3): 19–24.

KURPPA K, WARIS P, ROKKANEN P. (1979) Tennis elbow: lateral elbow pain syndrome. Scandinavian Journal of Work, Environment and Health; 5(suppl. 3): 15-18.

McDERMOTT FT. (1986) Repetition strain injury: a review of current understanding. Medical Journal of Australia; 144: 196-200.

OFFICE OF POPULATION CENSUSES AND SURVEYS. (1986) Occupational Mortality. The Registrar General's Decennial Supplement for Great Britain, 1979-80; 1982-83. Series DS No 6. Part I. Commentary. HMSO.

PETHICK AJ, MABEY MH, GRAVES RJ. (1987) Development of a practical method for workplace redesign to reduce upper limb strain injury. In: Buckle P, ed. Musculoskeletal disorders at work. London: Taylor and Francis: 239-246.

PUTZ-ANDERSON V. (1988) Cumulative trauma disorders. A manual for musculoskeletal diseases of the upper limbs. National Institute for Occupational Safety and Health, Cincinnati, Ohio. London: Taylor and Francis.

STONE WE. (1983) Repetitive strain injuries. Medical Journal of Australia; 2: 617-618.

THOMPSON D, RAWLINGS AJ, HARRINGTON JM. (1987) Repetition strain injuries. In: Harrington JM, ed. Recent advances in occupational health. No. 3. London: Churchill Livingstone: 75-89.

TICHAUER ER. (1966) Some aspects of stress on forearm and hand in industry. Journal of Occupational Medicine; 8: 63-71.

TICHAUER ER. (1976) Biomechanics sustains Occupational Safety and Health. Industrial Engineering; 8: 45-56.

Table 1 Frequency of diagnoses among cases.

Diagnosis	Edinburgh (total 270)	Doncaster (total 127)	Nottingham (total 183)	All (total 580)
Rotator cuff injuries	7	15	26	48
Rupture of longhead of biceps	0	0	2	2
Shoulder capsulitis	1	13	7	21
Acromio-clavicular arthritis	0	1	0	1
Tennis elbow	12	21	2	35
Golfer's elbow	0	4	2	6
Cubital tunnel syndrome	3	0	1	4
Carpal tunnel syndrome	81	31	59	171
Median nerve compression in forearm	0	1	3	4
Forearm tenosynovitis	11	3	10	24
de Quervain's disease	12	6	9	27
Trigger finger/ Trigger thumb	36	8	16	60
Osteoarthritis of 1st carpometacarpal joint	13	2	0	15
Ganglia	94	22	46	162

Table 2 Sites of disease among controls.

Site of Disease	Edinburgh (total 418)	Doncaster (total 289)	Nottingham (total 289)	All (total 996)
Foot	109	75	76	260
Ankle	12	7	37	56
Shin or calf	9	8	35	52
Knee	135	112	80	327
Thigh	16	6	11	33
Hip	26	16	23	65
Pelvis	3	1	1	5
Lumbar spine	108	63	25	196
Abdomen	0	1	0	1
Thorax	0	0	1	1
Head	0	0	0	0

Table 3 Sex distribution of cases and controls.

	Percent female	
	Cases	Controls
Edinburgh	75	47
Doncaster	61	41
Nottingham	69	43
All	70	44

Table 4 Jobs (in descending order of case frequency) for which the proportion of cases exceeded the proportion of controls by at least 1.28 times the standard error of the difference. Assuming no difference in the underlying "true" proportions of cases and controls, differences of this magnitude could have arisen by chance approximately once in five times. Values of the statistic greater than 1.96 indicate differences which could have arisen by chance, approximately, less than one time in twenty.*

Job description	Standardised difference in proportions	No of cases (total 580)	No of controls (total 996)
Cleaner/Domestic	3.72	46	36
Machine operator	1.66	18	18
Teacher/Lecturer	1.61	20	21
Secretary/temp secretary	1.77	17	16
Hairdresser	3.18	12	4
Packer	1.39	9	8
Kitchen assistant	1.28	7	6
Checkout operator	1.86	6	3
Butcher ('s assistant)	2.25	6	2
Bank officer	1.90	5	2
VDU operator	2.27	3	0
Educational administrator	1.85	2	0
Music teacher	1.85	2	0
Piano teacher	1.85	2	0
Animal nurse	1.85	2	0
Potter	1.85	2	0
Taxi driver	1.85	2	0
Graphic artist	1.85	2	0
Clothing machinist	1.31	1	0
Woodwork teacher	1.31	1	0
Community worker	1.31	1	0
Combined categories:			
secretary/temp; word processor operator; clerk/typist; VDU operator	2.24	32	32
machine operator; clothing factory machinist; machinist/cutter-upholsterer; sewinging machinist	1.90	20	19
music teacher; piano teacher	2.62	4	0

* Where the total number of cases and controls in a job category is small, these approximate P values will not be accurate. In such situations, the standardized statistic provides only a very rough indication of statistically significant differences. (In particular, it is uninformative for VDU operators, educational administrators, etc, down to Community workers, in the above table.)

Table 5 Jobs (in descending order of control frequency) for which the proportion of controls exceeded the proportion of cases by at least 1.28 times the standard error of the difference (P<0.2). Values of this statistic greater than 1.96 indicate differences which could have arisen by chance one in twenty times.*

Job Description	Standard difference in proportions	No of controls (total 996)	No of cases (total 580)
Miner (not spec.)	2.23	32	8
Labourer	1.70	22	6
Policeman	2.30	9	0
Plumber	1.60	8	1
Mechanic	1.43	7	1
Librarian	1.71	5	0
Bricklayer	1.71	5	0
Catering manageress	1.71	5	0
Parts man/manager	1.71	5	0
Insurance agent	1.53	4	0
Handyman	1.32	3	0
Engineer (marine)	1.32	3	0
Engineer (electronics)	1.32	3	0
Examiner (sewing factory)	1.32	3	0
Surveyor (building society)	1.32	3	0
Garage manager	1.32	3	0
Prison officer	1.32	3	0
Travel consultant	1.32	3	0
Builder	1.32	3	0
Miner (face)	1.32	3	0
Shop manager	1.32	3	0
Tyre fitter	1.32	3	0

* See caption and footnote to Table 4.

Table 6 diagnoses, diagnostic groupings and frequencies

Diagnosis			Frequency (%)
Rotator cuff injury	}		48(8.3)}
Rupture of long head of biceps	}	Shoulder cases	2(0.3)}
Shoulder capsulitis	}		21(3.6)}
Symptomatic acromio-clavicular arthritis	}		1(0.2)}
		Total	72
Tennis elbow	}	Elbow cases	35(6.0)}
Golfer's Elbow	}		6(1.0)}
		Total	41
Cubital Tunnel Syndrome	}		4(0.7)}
Carpal Tunnel Syndrome	}		171(29.5)}
Median nerve compression-forearm	}	Wrist and forearm cases	4(0.7)}
Forearm tenosynovitis	}		24(4.1)}
Ganglia (wrist)	}		82(14.1)}
		Total	285
Trigger finger	}		36(6.2)}
Ganglia (finger)	}	Finger cases	23(4.0)}
Ganglia (hand)	}		1(0.2)}
		Total	60
De Quervain's Disease	}		27(4.7)}
Osteoarthritis of 1st carpo-metacarpal joint	}	Thumb cases	15(2.6)}
Ganglia (thumb)	}		3(0.5)}
Trigger thumb	}		24(4.1)}
		Total	69
Ganglia (site unknown)			53(9.1)}

Table 7 Thumb conditions: observed frequencies of cases according to performance of selected movements. "Total number" means total number of cases and controls.

		Edinburgh		Doncaster		Nottingham		All	
Movement	Performed	Total Number	% Cases	Total Number	% Cases	Total Number	% Cases	Total Number	% Cases
Q3 Hold or pinch an object between finger and thumb.	Yes	243	12.3	149	3.4	196	5.1	588	7.7
	No	102	2.9	96	0.0	74	4.1	272	2.2
Q5E Keep thumb bent for more than a minute (apart from gripping movements)	Yes	53	18.9	97	2.1	113	5.3	263	6.8
	No	292	7.9	147	2.0	156	4.5	595	5.5
Q9 Rotate wrist as if turning a handle more often than once a minute.	Yes	84	3.6	77	1.3	60	1.7	221	2.3
	No	261	11.5	167	2.4	210	5.7	638	7.2
Q7 Bend wrist up and down repeatedly more than once a minute.	Yes	93	9.7	119	3.4	104	4.6	321	5.6
	No	252	9.5	125	2.4	161	5.0	538	6.1

		Edinburgh		Doncaster		Nottingham		All	
		Mean (SEM)	No.	Mean (SEM)	No.	Mean (SEM)	No.	Mean (SEM)	No.
Q7A Rate of bending wrist up and down repeatedly (per min)	Cases	62.9 (39.6)	9	25.0 (5.0)	2	85.0 (55.2)	5	65.1 (27.3)	16
	Controls	19.4 (2.2)	78	14.5 (2.0)	60	24.4 (3.0)	104	20.3 (1.6)	242

Table 8 Logistic regression model for factors contributing to risk of thumb conditions. Estimated regression coefficients have been expressed on the odds* scale, by taking anti-logs. The quoted parameters give the ratio of the odds of being a case between different risk categories defined by upper limb movements, or (for example) ages or heights. (The parameters quantifying differences in risk between centres are not shown).

Characteristic	Estimated odds ratio		Approximate 95% confidence interval†
Age (years)	Per increase of 5 years:	1.37	(1.18, 1.58)
Height (cms)	Per decrease of 10 cms:	2.23	(1.49, 3.13)
Q3 "Pinch"	Yes v. No:	4.23	(1.67, 10.73)
Q5E "keep thumb bent"	Yes v. No:	3.19	(1.45, 7.00)
Q7 Bend with wrist up and down repeatedly > 1/min	Yes v. No:	0.69	(0.29, 1.65)
Q7A Rate of bending wrist	Per increase of 20 reps/min:	1.40	(1.11, 1.76)
Q9 Rotate wrist more than once per minute	Yes v. No:	0.34	(0.12, 0.94)

* The "odds" of being an upper limb case are related to probability or risk by the equation: odds = prob ÷ (1 - prob).

† Approximate 95% confidence intervals were obtained by anti-logging the quantities: estimated regression coefficients ± 2 standard errors. Where confidence limits do not contain 1.00, the effect is significant at approximately 5%.

Table 9 Finger conditions. Observed frequencies and means of selected movements.

Movement	Performed	Edinburgh Total Number	Edinburgh % Cases	Doncaster Total Number	Doncaster % Cases	Nottingham Total Number	Nottingham % Cases	All Total Number	All % Cases
Q2 Grip or hold any object in palm with finger and thumb	Yes	273	7.3	202	2.5	227	4.8	702	5.1
	No	73	19.2	43	0.0	41	0.0	157	8.9
Q2A Do this (Q2) repeatedly more than once per minute	Yes	116	11.2	105	4.0	113	4.4	334	6.6
	No	156	4.5	96	1.0	113	5.3	365	3.8
Q5 Move or bend thumb repeatedly more than once per minute(apart from gripping movements)	Yes	74	10.8	64	1.6	67	1.5	205	4.9
	No	272	9.6	180	2.2	200	5.0	652	6.1
Q10 Bend elbow repeatedly more than once per minute.	Yes	193	6.2	210	2.9	183	1.6	586	3.7
	No	153	14.4	58	8.6	62	3.2	273	10.6
Q10E3 Bend elbow to more than half way repeatedly more than once per minute	Yes	85	8.2	113	1.8	99	4.0	297	4.4
	No	108	4.6	70	1.4	111	1.8	289	2.8
Q11 Raise and lower whole arm from the shoulder forwards or backwards more than once per minute	Yes	78	9.0	90	3.3	84	3.6	252	5.2
	No	268	10.1	155	1.3	184	4.3	607	6.1
Q11E1 Raise arm as in Q11, but to below shoulder level	Yes	53	1.9	65	1.8	37	5.4	155	2.6
	No	25	24.0	25	8.0	45	2.2	95	9.5
Q15 Keeping elbow bent, move forearm from side to side across the body more than once per minute	Yes	110	13.6	105	3.8	92	3.3	307	7.2
	No	236	8.1	139	0.7	176	4.5	551	5.1

		Edinburgh Mean	(SEM)	No.	Doncaster Mean	(SEM)	No.	Nottingham Mean	(SEM)	No.	All Mean	(SEM)	No.
Q5A Rate of bending thumb (apart from gripping)(per min)	Cases	24.9	(5.9)	8	-	-	0	20.0	-	1	24.3	(5.2)	9
	Controls	49.7	(5.6)	64	25.9	(9.6)	26	33.3	(4.1)	65	38.8	(3.4)	155
Q15A Rate of shoulder rotation (per min)	Cases	6.2	(0.8)	14	14.0	-	1	11.0	(4.9)	3	7.4	(1.1)	18
	Controls	20.0	(3.6)	92	11.2	(1.9)	46	21.0	(2.4)	89	18.6	(1.8)	227

Table 10 Logistic regression model for finger conditions. See caption and footnotes to Table 8.

Characteristic	Estimated odds ratio		Approximate 95% confidence interval
Age (years)	Per increase of 5 years:	1.25	(1.15, 2.10)
Height (cms)	Per decrease of 10 cms:	1.23	(0.82, 1.86)
Accident	Non-accident v. accident:	7.97	(2.81, 22.65)
Q2 Grip in palm (frequency unspecified)	Yes v. No:	0.36	(0.41, 0.96)
Q2A Grip repeatedly > 1/min	Yes v. No:	3.03	(1.23, 7.47)
Q5 Bend thumb repeatedly > 1/min	Yes v. No:	2.23	(0.59, 8.41)
Q5A Rate of bending thumb	Per decrease of 20/min:	2.12	(1.03, 4.35)
Q10 Bend elbow > 1/min	Yes v. No:	0.14	(0.05, 0.41)
Q10E3 Bend elbow more than half-way	Yes v. No:	3.40	(1.08, 10.73)
Q11 Raise and lower whole arm from the shoulder > 1/min	Yes v. No:	4.99	(1.57, 15.82)
Q11E1 Raise arm to below shoulder level	Yes v. No:	0.15	(0.03, 0.68)
Q15 Move forearm from side to side > 1/min	Yes v. No:	7.13	(2.44, 20.86)
Q15A Rate of moving forearm from side to side	Per decrease of 10/min	3.70	(1.44, 9.52)

Table 11 Wrist and forearm cases. Observed frequencies by selected movements, and means of continuous variables.

Movement	Performed	Edinburgh Total Number	Edinburgh % Cases	Doncaster Total Number	Doncaster % Cases	Nottingham Total Number	Nottingham % Cases	All Total Number	All % Cases
Q3 Hold or pinch an object between finger and thumb	Yes	297	28.3	160	10.0	217	14.3	674	19.4
	No	150	34.0	118	18.6	99	28.3	367	27.5
Q5E Keep thumb in a bent position for more than a minute	Yes	73	41.1	109	12.8	134	20.1	316	22.5
	No	374	28.1	156	14.1	181	17.7	711	22.4
Q6 Twist wrist so that palm faces up and then down, more than once per minute	Yes	120	35.8	146	13.7	139	20.9	405	22.7
	No	327	28.1	132	13.6	177	16.9	636	22.0
Q10 Bend elbow more often than once a minute	Yes	271	33.2	210	14.3	253	19.4	734	23.0
	No	176	25.6	68	11.8	63	15.9	307	20.5
Q10D Exert force while bending elbow more than once a minute	Yes	152	32.9	140	13.6	113	15.9	405	21.5
	No	119	33.6	62	14.5	140	22.1	321	24.9
Q12 Move raised out-stretched arm from side to side across body more than once per minute	Yes	84	33.3	61	13.1	57	15.8	202	22.3
	No	363	29.5	216	13.9	259	19.3	838	22.3

		Edinburgh Mean (SEM)	Edinburgh Number	Doncaster Mean (SEM)	Doncaster Number	Nottingham Mean (SEM)	Nottingham Number	All Mean (SEM)	All Number
Q12B Longest period during which this movement (Q12) was repeated without interruption	Cases	75.9 (26.1)	25	75.0 (22.2)	6	17.4 (6.4)	9	62.6 (17.0)	40
	Controls	41.3 (9.7)	55	37.0 (8.7)	49	59.1 (12.9)	48	45.5 (6.1)	152

Table 12 Logistic regression model for conditions of wrist or forearm. See caption and footnotes to Table 8.

Characteristic	Estimated Odds ratio		Approximate 95% confidence interval
Sex	Females v. males:	2.18	(1.29, 3.69)
Accident	Non-accident v. accident:	9.70	(5.37, 17.53)
Height	Per decrease of 10 cms:	2.03	(1.52, 2.71)
Weight	Per increase of 10 kgs:	1.20	(1.03, 1.39)
Q5E Keep thumb bent	Yes v. No:	1.70	(1.12, 2.57)
Q6 Twist wrist repeatedly > 1/min	Yes v. No:	1.38	(0.93, 2.05)
Q3 Pinch > 1/min	Yes v. No:	0.69	(0.48, 1.00)
Q10 Bend elbow > 1/min	Yes v. No:	1.11	(0.69, 1.80)
Q10D Bend elbow > 1/min with force	Yes v. No:	1.61	(1.02, 2.54)
Q12 Moving raised outstretched arm across body > 1/min	Yes v. No:	0.46	(0.26, 0.82)
Q12B Longest period of this movement	Per hour:	1.61	(1.13, 2.30)

Table 13 Observed frequencies and means for 21 subjects with tenosynovitis from all three centres. Detailed statistical analysis was not performed, and these variables were selected because the observed differences between cases and controls (t-test) indicated that the difference could have arisen by chance only 1 in 20 times. These variables are indicated by an asterisk. Some other related variables are included to aid interpretation.

Movement	Performed	Total number		% Cases
Q3 Hold or pinch between fingers and thumb, not in palm > 1/min	Yes	555		2.2
	No	275		3.3
Q4 Tap with fingers > 1/min	Yes	229		3.5
	No	600		2.2
Q5 Bend thumb ≥ 1/min	Yes	205		4.9*
	No	623		1.8
Q7 Bend wrist up and down > 1/min	Yes	313		3.2
	No	516		2.1
Q9 Rotate wrist ≥ 1/min	Yes	222		2.7
	No	607		2.5
Q15 Keeping elbow bent, moving forearm across body ≥ 1/min	Yes	293		2.7
	No	536		2.4
Q15D Make this movement (Q15) with force	Yes	116		0.9*
	No	171		4.1
		Mean	(SEM)	Number
Q3D Hours per day pinching >1/min	Cases	6.8	(0.5)	4*
	Controls	3.4	(0.2)	160
Q4C Hours per day tapping with fingers > 1/min	Cases	4.6	(0.7)	8*
	Controls	3.1	(0.2)	210
Q7C Hours per day bending wrist >1/min	Cases	5.4	(0.7)	10*
	Controls	3.8	(0.2)	290
Q9A Rate of rotating wrist (per min)	Cases	18.5	(5.3)	6*
	Controls	31.3	(2.6)	176
Q15C Hours per day moving forearm across body with elbow bent >1/min	Cases	5.4	(0.8)	8*
	Controls	3.3	(0.2)	269

Table 14 Observed frequencies and means for shoulder cases and controls, by selected movements.

Movement	Performed	Edinburgh Total Number	Edinburgh % Cases	Doncaster Total Number	Doncaster % Cases	Nottingham Total Number	Nottingham % Cases	All Total Number	All % Cases
Q3 Hold or pinch an object between finger and thumb	Yes	215	0.9	159	9.4	206	9.7	580	3.4
	No	105	5.7	108	11.1	84	15.5	297	10.4
Q9 Rotate wrist > 1/min	Yes	83	2.4	78	2.6	64	7.8	225	4.0
	No	237	2.5	188	13.3	226	12.4	651	9.1
Q10 Bend elbow > 1/min	Yes	185	2.2	196	8.2	227	10.1	608	7.1
	No	135	3.0	71	15.5	63	15.9	269	9.3
Q12 Move raised outstretched arm from side to side across the body > 1/min	Yes	59	5.1	60	11.7	57	15.8	176	10.8
	No	261	1.9	206	9.7	233	10.3	700	7.0

Movement		Edinburgh Mean (SEM)	Edinburgh Number	Doncaster Mean (SEM)	Doncaster Number	Nottingham Mean (SEM)	Nottingham Number	All Mean (SEM)	All Number
Q9A Rate of rotating wrist (per minute)	Cases	100.0 -	1	25.0 -	1	58.0 (12.8)	5	59.3 (12.1)	7
	Controls	32.2 (4.6)	80	28.4 (4.2)	37	31.9 (4.1)	59	31.3 (2.6)	176
Q10B Length of longest period of bending elbow repeatedly > 1/min	Cases	52.5 (33.7)	4	41.6 (14.4)	13	54.8 (16.5)	23	50.3 (10.9)	40
	Controls	70.5 (7.1)	181	67.8 (7.9)	144	82.5 (7.0)	203	74.4 (4.2)	528
Q10C Hours per day elbow bent repetitively > 1/min	Cases	5.8 (0.3)	4	4.3 (0.7)	14	5.3 (0.6)	23	5.0 (0.4)	41
	Controls	3.9 (0.2)	181	4.1 (0.2)	166	4.8 (0.2)	204	4.3 (0.1)	551

Table 15. Logistic regression model for conditions of shoulder. See caption and footnotes to Table 8.

Characteristic	Estimated Odds ratio		Approximate 95% confidence interval
Age (years)	Per increase of five years:	1.36	(1.21, 1.53)
Q3 Pinch (freqency undefined)	Yes v. No:	0.51	(0.28, 0.91)
Q9 Rotate wrist > 1/min	Yes v. No:	0.18	(0.04, 0.74)
Q9A Rate of rotating wrist	Per increase of 30 times per min:	2.02	(1.12, 3.65)
Q10 Bend elbow > 1/min	Yes v. No:	0.29	(0.12, 0.71)
Q10B Longest period of elbow bending	Per increase of 1 hour:	0.69	(0.49, 0.97)
Q10C Hours per day this movement repeated	Per increase of 1 hour:	1.22	(1.07, 1.40)
Q12 Move raised outstretched arm from side to side across body	Yes v. No:	2.30	(1.16, 4.54)

Table 16 Keyboard operators:- Observed case-control status associated with selected variables. *0.05 > P > 0.01. |t| values greater than 1.28 correspond to P < 0.2.

Movement	Performed	Number	% Cases	|t|
Q2 Grip in the palm (frequency unspecified)	Yes	32	59	1.5
	No	32	41	
Q2A Grip >1/min	Yes	8	88	2.1*
	No	24	4	
Q2F Sustain grip for over 1 min	Yes	20	45	-2.4*
	No	12	83	
Q3 Pinch (frequency unspecified)	Yes	54	48	-0.7
	No	10	60	
Q3A Pinch >1/min	Yes	7	43	-0.3
	No	47	49	
Q4 Tap >1/min	Yes	63	49	-
	No	1	100	
Q5 Bend thumb >1/min	Yes	56	50	0.0
	No	8	50	
Q5E Keep thumb bent	Yes	19	68	1.9
	No	45	42	
Q7 Flex/extend wrist >1/min	Yes	19	63	1.4
	No	45	44	
Q9 Rotate wrist >1/min	Yes	8	50	0.0
	No	56	50	
Q10 Bend elbow >1/min	Yes	27	59	1.3
	No	37	43	
Q10D Bend elbow with force >1/min	Yes	7	86	1.8
	No	20	50	

	Cases			Controls			|t|
	No.	Mean	(SEM)	No.	Mean	(SEM)	
Q3B Pinch:-rate per min	3	8.3	(3.3)	4	8.8	(3.9)	-0.1
Q3C :longest period (mins)	3	65.7	(38.5)	4	4.0	(2.2)	1.6
Q3D Total hours per day	3	3.7	(1.8)	4	1.0	(0.4)	1.5
Q4A Tap:- rate per min	31	288.9	(24.8)	31	275.0	(20.8)	0.4
Q4B: longest period (mins)	31	92.9	(14.1)	31	84.5	(12.8)	0.4
Q4C Total hours per day	31	5.0	(0.3)	31	5.2	(0.5)	-0.4
Flex/extend wrist Q7A :- rate per min	9	93.9	(46.3)	6	27.3	(11.1)	1.4
Bend elbow Q10A :- rate per min	15	20.1	(4.7)	9	6.0	(2.0)	2.8*

Table 17 Frequencies of elbow conditions according to sporting activities. (N/A means "not applicable").

Sports	UL use	Gripping	Case	Control	Proportion of cases	Repetition >1/min	Case	Control	Proportion of cases
N	N/A	N/A	15	543	2.7%	N/A	{ see across }		
Y	N	N/A	2	130	1.5%	N/A			
	Y	N	5	139	3.5%	N	6	113	5.0%
		Y	19	181	9.5%	Y	18	207	8.0%

Table 18 Logistic regression model for conditions of the elbow in relation to sporting activities. See caption and footnotes to Table 8.

Characteristic	Estimated Odds ratio		Approximate 95% confidence interval
Height	Per decrease of 10 cms:	1.79	(1.22, 2.63)
Sport indicator	Sports activity (non-UL) v. no sports activity:	0.88	(0.18, 4.18)
Upper limb use (for sports participants)	UL use (non-repetitive and non-gripping) v. no UL use:	0.63	(0.09, 4.58)
Gripping (for UL users)	Gripping v. no gripping:	6.04	(1.97, 18.56)
Repetition (> 1/min) (for UL users)	Repetition v. no repetition:	2.37	(0.82, 6.86)

Table 19 Frequencies of thumb conditions according to sporting activities (N/A means "Not applicable").

Sports	UL use	Repetition	Case	Control	%	Heavy	Case	Control	%	Grip	Case	Control	%
N	N/A	N/A	(1) 49	543	8.3	N/A	see across			N/A	see across		
Y	N	N/A	(2) 0	130	0	N/A				N/A			
	Y	N	9	113	7.4	N	(3) 16	212	7.0	N	9	139	6.1
		Y	11	207	5.0	Y	(4) 4	108	3.6	Y	11	181	5.7

Table 20 Frequencies of wrist and forearm conditions according to hobby activities (N/A means "not applicable").

Hobbies?	UL use	Case	Control	Risk (%)
N	N/A	94	346	21.4
Y	N	23	159	12.6
	Y	168	490	25.5

Table 21 Logistic regression model for conditions of the wrist and forearm in relation to hobby activities. See caption and footnotes to Table 8.

Characteristic	Estimated Odds ratio		Approximate 95% confidence interval
Sex	Female v. male:	2.09	(1.32, 3.28)
Height	Per decrease of 10 cms:	1.69	(1.32, 2.16)
Weight	Per increase of 10 kgs:	1.13	(0.99, 1.29)
Accident status	Non-accident v. accident:	7.66	(4.59, 12.70)
Hobby indicator	Hobby activity (non-UL) v. no hobby activity:	0.49	(0.29, 0.85)
Upper limb use (for hobbyists)	UL use v. no UL use:	1.93	(1.16, 3.23)

Table 22 (a) Ratio (listed occupation versus "all other occupations, or unemployed") of the odds of developing one of the upper limb conditions considered in this study.
(b) Estimated proportion of upper limb cases in the general population which may be "attributed" to the listed occupation.

		(a)		(b)
Occupational group*	No. cases	No. controls	Odds ratio	Proportion of cases "attributable" (%)
Keyboard operators	32	32	1.92	2.38
Cleaners	46	36	2.46	3.75
Hairdressers	12	4	5.78	0.80
Machine operators	20	19	2.03	1.58
Sub total	110	91	2.33	9.08†
All other occupations or unemployed	470	905	-	-

† The proportions in this column will in general be additive over mutually exclusive job categories. In this case, the discrepancy is due to the fact that the combined odds ratio is <u>not</u> the mean of the separate odds ratios, weighted by the population proportions of Table A1.

* These groups consist of the following occupations (as given at interview):-
Keyboard operators: secretary/temp; wordprocessor operator; computer operator; typist/audio typist; clerk/typist; VDU operator
Cleaners: cleaner/domestic
Hairdressers: hairdresser
Machine operators: Machine operator - not specified; clothing factory machinist; machinist/cutter - upholstery; sewing machinist.

Table 23 Summary of demonstrated associations between movements and case status. Positive signs indicate positive associations.

Movement	Performed	>1/min	Rate	Longest period	Hrs/day	Force	Sustained > 1 min	Extent of Movement
Grip	-ve fingers	+ fingers						
Pinch		+ thumb - wrist and forearm - shoulder			+ tenosynovitis			
Tap(fingers)					+ tenosynovitis			
Bend thumb		+ tenosynovitis	- fingers				wrist and forearm + thumb	
Wrist pronation/ supination		+ wrist and forearm (not quite significant)						
Wrist flexion/ extension			+ thumb		+ tenosynovitis			
Wrist ulnar/ radial deviation								
Wrist rotation		- shoulder - thumb	+ shoulder - tenosynovitis					
Bend elbow		- fingers			+ shoulder	+ wrist and forearm		+ fingers (more than way V. less than way)
Shoulder flexion		+ fingers						- fingers (below level of shoulder v. above)
Shoulder rotation with raised arm		+ shoulder - wrist and forearm		+ wrist and forearm				
Shoulder adduction/ abduction								
Keep arm raised								
Shoulder rotation with elbow flexed		+ fingers	- fingers		+ tenosynovitis	- tenosynovitis		

APPENDIX 1

The Questionnaire

INSTITUTE OF OCCUPATIONAL MEDICINE — **CONFIDENTIAL**

REPETITIVE STRAIN INJURIES OF THE UPPER LIMB — **QUESTIONNAIRE**

STUDY CENTRE (enter E for Edinburgh, D for Doncaster or N for Nottingham) [ ]

Date of Clinic (enter as day, month, year e.g. 9th July 1986 as 090786)

d	d	m	m	y	y

Day of Clinic (tick appropriate box)

[ ] MON [ ] TUES [ ] WED [ ] THURS [ ] FRI

CODE AT IOM [ ]

Time of Interview (enter as hour and minute according to 24 hour clock e.g. 2.05 p.m. as 1405)

h	h	m	m

Name Of Interviewer ____________________ CODE AT IOM [ ]

Details From Medical Notes :-

Patient's Name ____________________

Hospital Number [| | | | | |]

Examining Doctor ____________________ CODE AT IOM [|]

Complete Medical Diagnosis (tick appropriate box)

1. ____________________ [ ] [ ] [ ] [ ] CODE AT IOM [| |]

Right Left Both Not Appl.

2. ____________________ [ ] [ ] [ ] [ ] CODE AT IOM [| |]

Case/Control status (tick appropriate box - red labels identify Cases white labels identify Controls)

[ ] Case [ ] Control

CODE AT IOM [ ]

Good morning/afternoon.

My name is

Thank you for agreeing to take part in our research which is a study of strains of the arm. I am going to ask you some questions about the hand and arm movements you make while you are at work.

The interview will take about 20 minutes.

Your answers will be strictly confidential.

Have you any questions that you would like to ask me before we begin?

Please will you sign this consent form?

1. I am going to ask you what jobs you have had in the last 2 years either full or part-time, starting with the most recent.
[If none, enter NONE and go straight to question 18]

Rec No.	Name of Employer / Nature of Business		Occupation/Job Title		Dates From (m m y y)	Dates To (m m y y)	Full / Part Time
1							
2							
3							
4							
5							
		WILL BE CODED AT IOM		WILL BE CODED AT IOM			enter F if FULL or P if PART time

I am now going to ask you some detailed questions about the movements of your hands and arms while you are or were at work during the last two years. I will demonstrate these movements to you as we proceed.

The first questions are about your hands and fingers.

2. At work, during the last 2 years, do or did you have to grip or hold any object in your palm with your fingers and thumb? Y/N

[If N, go to question 3]

(a) Do or did you have to grip like this, then release repeatedly, more often than once a minute? Y/N

[If N, go to question 2(f)]

(b) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(c) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(d) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark < 1)

(e) While making this movement do or did you have to exert force? Y/N

(f) Do or did you have to sustain a grip like this for over a minute? Y/N

3. Do or did you have to hold or pinch an object between your fingers and thumb, not in your palm? Y/N

[If N, go to question 4]

(a) Do or did you have to pinch like this, then release repeatedly, more often than once a minute? Y/N

[If N, go to question 3(f)]

(b) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(c) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(d) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(e) While making this movement do or did you have to exert force? Y/N

(f) Do or did you have to sustain a grip like this for over a minute? Y/N

4. Do or did you make repeated tapping movements with your fingers more than once per minute? Y/N

[If N, go to question 4(e)]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you keep your fingers in a bent position for over a minute? Y/N

5. Apart from gripping movements, do or did you move or bend your thumb repeatedly more than once per minute? Y/N

[If N, go to question 5(e)]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you have to keep your thumb in a bent position for more than a minute? Y/N

The next group of questions is about wrist movements.

6. Do or did you have to twist your wrist so that the palm faces up and then down, more than once per minute? Y/N

[If N, go to question 7]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

7. Do or did you bend your wrist up and down repeatedly more than once per minute? Y/N

[If N, go to question 7(e)]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you keep your wrist in a bent position for more than a minute? Y/N

8. Do or did you bend your wrist from side to side repeatedly more often than once per minute? Y/N

[If N, go to question 8(e)]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you keep your wrist in a bent position for more than a minute? Y/N

9. Do or did you rotate your wrist, as if turning a handle, more often than once per minute? Y/N

[If N, go to question 10]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

The next group of questions is about elbow movements

10. Do or did you bend your elbow more often than once a minute? Y/N

[If N, go to question 10(f)]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you usually bend your elbow:

to half way or Y/N

to less than half way or Y/N

to more than half way? Y/N

(f) Do or did you keep your elbow bent for more than one minute? Y/N

The next group of questions is about shoulder and whole arm movements.

11. Do or did you raise and lower your whole arm from the shoulder forwards or backwards more than once a minute? Y/N

[If N, go to question 12]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

(e) Do or did you usually raise your arm like this:

to below shoulder level or Y/N

to shoulder level or Y/N

or above shoulder level? Y/N

12. Do or did you move your raised outstretched arm from side to side across your body more than once per minute? Y/N

[If N, go to question 13]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

13. Do or did you move your arm across your body like a pendulum, more than once per minute? Y/N

[If N, go to question 14]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

14. Do or did you keep your arm raised for more than one minute? Y/N

15. Keeping your elbow bent, do or did you move your forearm from side to side, across your body, more than once per minute? Y/N

[If N, go to question 16]

(a) How many times a minute do or did you repeat this movement? (enter with leading zeros e.g. twice as 002)

h h m m s s

(b) What is or was the longest period during which you kept repeating this movement without interruption? (enter as hours/mins/secs e.g. 9 seconds as 00 00 09)

(c) How many hours per day in total do or did you spend repeating this movement? (enter with leading zero e.g. 5 hours as 05, if less than 1 hour mark <1)

(d) While making this movement do or did you have to exert force? Y/N

16. Do or did you use any hand tools at work? Y/N

[If N, go to question 17]

(a) What do or did you use?

____________________ CODE AT ION

____________________ CODE AT ION

____________________ CODE AT ION

____________________ CODE AT ION

(b) Which of these do or did you use the most? CODE AT ION

____

(c) For how many hours in the day at maximum do or did you use it?
(enter with leading zero e.g. 2 hours as 02)

17. Is or was your workplace often cold? Y/N

(a) Is or was your workplace often wet? Y/N

The next group of questions is not about your work.

18. During the past 2 years have you taken part in any sporting activity as frequently as once per week for a 3 month period or more? Y/N

(If N go to question 19 or
if Y specify and continue)

____________________ CODE AT ION

____________________ CODE AT ION

____________________ CODE AT ION

____________________ CODE AT ION

19. During the last 2 years have you done any other hobbies or leisure activities as frequently as once a week? Y/N

(If N go to question 20 or
if Y specify and continue)

______________________ CODE AT IOM

______________________ CODE AT IOM

______________________ CODE AT IOM

______________________ CODE AT IOM

20. During the last 2 years what is the average number of hours per week that you have driven a car, van or lorry?
(enter with leading zeros e.g. 4 hours as 004)

Finally, I would like to ask you some questions about yourself.

d d m m y y

21. What is your date of birth?
(enter as day, month, year
e.g. 2nd March 1906 as 02 03 06)

22. Record Sex - M (= Male) or F (= Female)
obtained by observation M/F

23. Are you Right or Left handed or Ambidextrous?
(enter R for right, L for left or A for ambidextrous) R/L/A

24. Did your present illness start with an accident? Y/N

25. Are you making a claim for compensation? Y/N

We are now finished the interview.
Thank you very much indeed for your help and cooperation.

HEIGHT (enter patient's height in centimetres e.g. 180)

WEIGHT (enter patient's weight in kilograms e.g. 080)

IOM Ref. MS.7.26
24.07.86

APPENDIX 2

Population (10%) in 1981, within four occupational groups. (Taken from the Registrar General's Decennial Supplement on occupational mortality, 1979-80, 1982-83.)

Occupation group and unit*		Men aged 20-64 (Gt. Britain)	Women aged 20-59 (England and Wales)	Proportion of total population†
049.02	(Typists, shorthand writers, secretaries)	1,244	64,476	2.81%
050	(Office machine operators)	2,516	8,905	
068.03	(Other domestic and school helpers)	794	37,792	
072.02	(Cleaners, window cleaners, chimney sweeps, road sweepers)	10,687	38,460	2.80%‡
074	(Hairdressers, barbers)	684	4,327	0.18%
102.03	(Sewers, embroiderers)	980	12,836	
112.04	(Machine tool operators)	24,025	4,342	1.68%
113.01	(Press, stamping and automatic machine operators)	2,297	1,589	

* As defined in the Decennial Supplement.

† 10% sample in 1981: men aged 20-64 (Gt. Britain) = 1,502,667;
women aged 20-59 (England and Wales) = 1,244,588.

‡ Excludes the 10,687 men listed under occupation 072.02.

APPENDIX 3

Classification of jobs, sports and hobbies.

Jobs, sports and hobbies were allocated to the following categories, according to the perceptions of the project team of the jobs, sports and hobbies of the study subjects. "Repetitive" was defined to be more frequent than once per minute.

Group 1	Major use of upper limbs not required.
Group 2	Upper limbs used extensively; repetitive movements; heavy work; no gripping of hand tool or similar implement.
Group 3	Upper limbs used extensively; repetitive movements; heavy work; gripping of hand tool or similar implement.
Group 4	Upper limbs used extensively; repetitive movements; light work; gripping of hand tool or similar implement.
Group 5	Upper limbs used extensively; repetitive movements; light work; no gripping of hand tool or similar implement.
Group 6	Upper limbs used extensively; no repetitive movements; heavy work; gripping of hand tool or similar implement.
Group 7	Upper limbs used extensively; no repetitive movements; heavy work; no gripping of hand tool or similar implement.
Group 8	Upper limbs used extensively; no repetitive movements; light work; gripping of hand tool or similar implement.
Group 9	Upper limbs used extensively; no repetitive movements; light work; No gripping of hand tool or similar implement.
Group 10	Unclassified

HEAD OFFICE:

Research Avenue North,
Riccarton,
Edinburgh, EH14 4AP,
United Kingdom
Telephone: +44 (0)870 850 5131
Facsimile: +44 (0)870 850 5132

Tapton Park Innovation Centre,
Brimington Road, Tapton,
Chesterfield, Derbyshire, S41 0TZ,
United Kingdom
Telephone: +44 (0)1246 557866
Facsimile: +44 (0)1246 551212

Research House Business Centre,
Fraser Road,
Perivale, Middlesex, UB6 7AQ,
United Kingdom
Telephone: +44 (0)208 537 3491/2
Facsimile: +44 (0)208 537 3493

Brookside Business Park,
Cold Meece,
Stone, Staffs, ST15 0RZ,
United Kingdom
Telephone: +44 (0)1785 764810
Facsimile: +44 (0)1785 764811

Email: iom@iom-world.org