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Occupational rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry

by ILKKA KUORINKA, M.D., and PAAVO KOSKINEN¹

KUORINKA, I. and KOSKINEN, P. Occupational rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry. *Scand. j. work environ. & health* 5 (1979): suppl. 3, 39—47. The prevalence of occupational rheumatic diseases and the relation of the diseases to some specific work load factors were investigated. Ninety-three workers from a light mechanical industry were given a clinical, epidemiologic examination. General work methods were analyzed, and cycle time, mode of control, and the number of pieces handled/time unit were registered. The prevalence of tension neck was 61.3 % and that of muscle-tendon syndrome 18.3 %. The prevalences of other ailments were insignificant. The number of muscle-tendon symptoms correlated with the number of pieces handled. No other work load factors displayed a statistically significant relationship to the diseases. Tension neck had no relation to the weight/height index.

Key words: job analysis, muscle-tendon syndrome, occupational rheumatic diseases, tension neck, work stress.

Rheumatic occupational diseases of the neck and upper limbs are common in jobs involving manual tasks (4). An example of this situation is the occurrence of the tendomuscular syndrome in more than 50 % and tension neck in more than 40 % of the cases examined in another study (7). In this article we have used the common name "occupational rheumatic diseases" to cover several illnesses characterized by pain and/or pathological changes in the connective tissue and muscles. The terminology and problems of the diagnosis are dealt with in the reviews (5, 6, 11) in this supplement.

The possible etiology and pathological mechanisms are by no means clear. The mechanisms between occupational stress

and strain are still obscure, although as early as 1927 Obolenskaja and Goljanitzki (10) pointed out the role of mechanical load and identified the variety of workers' movements related to tenosynovitis. The pathological phenomena seem to have many causal factors, mechanical strain appearing to be the most evident. Mechanical trauma may be caused by rapid, repetitive movement, the use of force in extreme positions, the use of force by unaccustomed workers, etc. The acceptance of the theory of mechanical trauma as a causative agent does not lead to definitive guides for prevention because mechanical overstrain can occur in many different ways during work.

Mechanical overstrain is however not the only causal factor proposed. Gray and Gottler (2) found that many of their cases of tenosynovitis had positive serologic

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findings of rheumatoid arthritis. Maeda (8) emphasized the role of mental stress in the occurrence of the cervicobrachial syndrome.

In this report we present the results of a study on the prevalence of neck and upper limb rheumatic diseases in workers of a light mechanical industry. The characteristics of the work load factors are related to the symptoms and diseases.

SUBJECTS AND METHODS

Subjects

The subjects were factory workers performing manual operations in the scissor making process. Ninety of the manual workers were women and three were men. The mean age was 32.3 years (SD 11.7), and the mean length of employment 3.7 years (SD 4.3).

Temporary workers and those having had recent trauma were excluded.

Altogether 115 employees were involved in manual activities. From this group, a total of 102 persons were examined. Of the remaining group five were on sick leave and eight chose not to be examined for reasons of their own. Only one of the five on sick leave was out of work due to an occupational rheumatic disease.

There was a ten-month interval between the work history and production data collection and the clinical investigation; thus final results have been reported only for the 93 people who were able to take part in both phases.

Clinical, epidemiologic examination method

The method used for the clinical examination in this study has been described in detail elsewhere (12). On the whole, a physiotherapist made a systematized examination and interviewed the subject. She asked the examinee questions about his or her work history, previous general ill-

nesses, history of diseases of the musculoskeletal system, and other general information such as weight and height.

The physical examination of the subjects took place according to a scheme including test movements, palpation, and inspection. The physiotherapist had to determine whether certain signs existed or not, and which were the results of the test movements. She did not try to reach a clinical diagnosis. The diagnosis itself was made after the examination with a set of predetermined criteria (12). In problem cases a team of orthopedic and physiatric specialists handled the results. This method was employed to diminish the subjective component of a clinical diagnosis and to ascertain the comparability of the different materials.

In table 1 we have compared materials from this and another study. The comparison is estimated to be reliable because the method used was the same and the interreliability of the physiotherapists performing the examination was measured.

The agreement between the physiotherapists was the following: hand grip force 0.91 (Yule's modified coefficient of contingency); palpable hardenings and/or aching tender points in the neck 0.73–0.83 (Yule's modified coefficient of contingency); palpable hardenings on the tendons in the wrist 0.73–0.88 (Yule's modified coefficient of contingency).

Analysis of the work

The job analysis consisted of two parts. In the first, the work history of the previous year was collected from the production and salary payment forms. The following details were collected: individual workhours per workplace and task; the number of different products passing through each working station, calculated from the production statistics. In the second part, the work methods for each station and product were analyzed. This analysis yielded a description of the standard work methods for each type of work station. The stations were also classified into categories according to the dominance of inspection or manipulation of the scissors and according to the length of the cycle.

Details of the job analysis

Work history. The enterprise records the number of pieces handled and hours worked for each worker daily. Payment is then determined on the basis of these reports. The information on the forms is entered into automatic data handling registers. From these registers the total number of hours worked and the absences recorded for each worker during 1977 were retrieved.

Despite all the care taken to avoid errors, there were conflicting data. Therefore, for the additional analysis of the work history and load, only those cases for which 80 % or more of the hours could be cross-checked were allowed to remain in the study. The total number of cases meeting this criterion was 76.

Analysis of work methods. We analyzed the work of a few workers in each station. A videotape and observations were used as a basis for the method of analysis. From this analysis we determined the standard method, which, thus, does not take into account individual differences. According to this method of analysis we estimated the characteristics for each workplace, as well as the total number of pieces handled per year.

We analyzed the work movements also for the deviation of the wrist joints. A deviation of more than 20° from a basic anatomic position was the basis for calculation. The time the joint was in such

a position during each work cycle (one work piece) was multiplied by the number of pieces handled per hour. This, in turn, was multiplied by the number of hours spent at the task preceding, and at the time of, the clinical examination. This procedure yielded an index used to describe the load on the wrist joint caused by work in a deviated position (I_{dev}).

RESULTS

Occurrence of occupational rheumatic disorders of the neck and upper limbs in scissor making

The symptoms were concentrated in two anatomic regions, namely, the neck and wrists. Other symptoms and symptom complexes were rare. The overall prevalence of the tension neck syndrome was 61 %, and that of the muscle-tendon syndrome 18 %. In this study muscle-tendon syndrome refers to various affections of the tendomuscular apparatus, as described in another article (7). In table 1 the number of persons having tension neck or muscle-tendon syndrome is indicated. The prevalences are compared to the material presented in another article (7).

The other neck and upper limb affections in manual workers were three cases of cervical syndromes, two of humeral

Table 1. Occurrence of neck and upper limb rheumatic diseases in scissor makers and two comparable groups.

Neck and/or upper limb disease	Occupational groups		
	Scissor makers	Shop and factory workers ^a	
	Manual workers (N = 93) (%)	Shop assistants (N = 143) (%)	Factory workers (N = 163) (%)
Tension neck	61.3	27.8	37.5
Muscle-tendon syndrome	18.3	13.5	55.9
Other neck and/or upper limb affections	4.3	0.6	19.0

^a Figures from Luopajarvi et al. (7).

tendinitis, and one other shoulder region ailment.

The diseases seemed to accumulate in the same individuals. The 17 manual workers with muscle-tendon syndrome also had tension neck. One person had muscle-tension syndrome in three locations, while the others had it in one location only.

The persons with muscle-tendon syndrome were all right-handed. Four of them had affections in the left hand, one had it in both hands, and the remaining 12 were affected in the dominating hand. Most affections were on the extensor side of the hand.

As is shown in table 2, there was no clear relationship between age and either tension neck or muscle-tension syndrome.

The other affections of the musculoskeletal system showed a definite trend towards increasing with increasing age ($\chi^2 = 10.47$; $p < 0.01$).

Work load characteristics and the occurrence of neck and upper limb affections

Tasks and their characteristics. The main characteristics of the different tasks are shown in table 3. No big differences were found between the tasks, but those that did occur can, however, be grouped according to (a) cycle time, (b) mode of control (manual task, inspection), and (c) number of pieces handled (mean values).

A wide individual variation existed for the performance of each task. The work method, according to which the cycle times and the number of pieces handled were recorded, is a standard one, i.e., we recorded methods from each workplace for one to ten workers and the typical course of the task was generalized for all workers at the same workplace. As a result, individual variations have not been accounted for.

Table 2. The number of neck and/or upper limb cases in four age groups. The number of "other musculoskeletal affections" are based on the subjects' histories. The percentages for each category of illness refer to total number of cases.

Age group (years)	Affection				Cases of illnesses (Total N = 108)	Number of subjects (Total N = 93)
	Tension neck (N = 57) (%)	Muscle- tendon syndrome (N = 17) (%)	Other upper limb affections (N = 4) (%)	Other mus- culoskeletal affections (N = 30 ^a) (%)		
≤ 20	58.3	25.0	0.0	16.7	12	14
21 — 30	63.9	13.9	0.0	22.2	36	37
31 — 40	50.0	18.8	0.0	31.2	16	15
≥ 41	43.2	13.6	9.1	34.1	44	27

^a Reported by the examinee.

Table 3. Characteristics of the different tasks in scissor making.

Description	Dominating characteristic	Cycle time (s)	Number of pieces handled/h
1. Grinding the edges of the tool	Manipulation	2.0—2.4	605
2. Plastifying the handle	Manipulation	18.2—26.1	250
3. Riveting two pieces together	Manipulation	7.3—13.4	180
4. Adjusting the rivet	Inspection/ manipulation	9.1	240
5. Grinding the ends and ring	Manipulation	3.8—9.5	190
6. Simple inspection	Inspection	10.3	150
7. Complete inspection	Inspection	variable	
8. Stamping, washing, drying	Manipulation	2.7—4.3	390

The work load varied with each task. The physical load, in terms of energy consumption, was estimated to be low. We used cycle time and the total number of pieces handled during the day or throughout the investigation year as parameters for work load. The total number of pieces handled in a year reflected the general long-term stress of the job. The cycle time did not always depict the true speed in work movements. The number of fast, elementary movements was considerably higher in short-cycle tasks than in long-cycle ones however. The mode of control of the material (inspection or manual operations) combined some of the mental and physical load factors of the work.

Task characteristics and work load of the diseased and healthy workers

The variables of the task characteristics used were cycle time and inspection/manipulation dichotomy. The tasks were classified as short-cycled, cycle time between 2.0–9.5 s (tasks 1, 4, 5, and 8 in table 3), or long-cycled, cycle time between 7.3–26.1 s (tasks 2, 3, 6, and 7 in table 3).

If the subjects did more than one task during the investigation year, the last task, as reported by the subject, was used as the basis for classification.

Table 4 presents the number of persons with tension neck and muscle-tendon syndrome in short- and long-cycle tasks. No significant differences were found between the diseased and nondiseased workers doing short- and long-cycle tasks.

Table 5 shows the number of persons with tension neck and muscle-tendon syndrome in manipulation- and inspection-type tasks. Tasks 4, 6, and 7 are classified as inspection tasks, while tasks 1, 2, 3, 5, and 8 are considered to be manipulative. The last task reported by the subject formed the basis for this classification. The tension neck cases tended to be slightly less common in the inspection tasks, but the difference was not significant (table 5).

Wrist joint deviation and its relation to the symptoms. The index (I_{dev}) describing the deviation load of the wrist joint was compared to the number of signs found in

the clinical examination. A linear correlative analysis was employed for the comparison. There was no correlation between the number of signs in the wrist and the I_{dev} ($r_{right\ hand} -0.16$, $r_{left\ hand} -0.06$).

Total work load during the investigation year. The total work load was described by the number of pieces handled during one year. The relation of the work load to muscle-tendon syndrome was studied in a case-referent setting. Twelve persons with muscle-tendon syndrome, whose work histories were known, formed the cases. The referents were age-matched (± 1 year) persons from the same occupational group, but without the disease. Their total number was 36. The mean number of pieces handled by the cases was 310,500 per year and by the referents 263,000 per year. Although the workers with muscle tendon

Table 4. Number of tension neck or muscle-tendon syndrome cases in short- and long-cycle tasks. (Total number of subjects = 93)

Disease	Short-cycle tasks (N = 48) (%)	Long-cycle tasks (N = 63) (%)	Total (N)
Tension neck	58.3	46.0	57
Muscle-tendon syndrome ^a	22.9	15.9	21
No neck or upper limb disease	18.8	38.1	33
Total	100.0	100.0	111

^a Includes four other upper limb affections.

Table 5. Number of tension neck or muscle-tendon syndrome cases in the inspection and manipulation tasks. (Total number of subjects = 93)

Disease	Inspection tasks (N = 43) (%)	Manipulation tasks (N = 68) (%)	Total (N)
Tension neck	44.2	55.9	57
Muscle-tendon syndrome ^a	20.9	17.6	21
No neck or upper limb disease	34.9	26.5	33
Total	100.0	100.0	111

^a Includes four other upper limb affections

syndrome had handled more pieces during the investigation year than those without, the difference was not quite significant.

The groups were then divided into three classes according to the number of pieces handled during one year, and the number of objective signs in the wrists and arms was noted for each group. The results are shown in table 6. The number of symptoms increased in both groups according to the number of the pieces handled. As expected, the number of symptoms in the muscle-tendon syndrome cases was greater than that of the referents in all classes. For the cases the rise in the number of symptoms seemed to be steeper.

Individual disposition. In this study we controlled one constitutional factor by calculating the Quetelet index (weight/height²) (1). The quotient was 22.5 and 23.8 for those with and those without muscle-tendon syndrome, respectively. For the tension neck and nontension neck groups the figures were 23.3 and 24.0, respectively. As a result there were no differences between the groups, and the hypothesis of this aspect of constitution being a predispositional factor did not gain support.

DISCUSSION

Confounding factors

The work load was estimated from, among other things, the cycle time. The same job can be done, however, with different speeds and different work-rest schedules, depending partly on the psychomotor skill

of the worker. These differences affect the work, but cannot easily be controlled in a study.

Degenerative diseases of the musculoskeletal system usually increase with advancing age. Therefore it is to be assumed that age is a confounding factor even for neck and upper limb diseases. According to the results of the present study, however, this assumption does not hold true. The cases of muscle-tendon syndrome and tension neck were not overrepresented in the older age groups, whereas other musculoskeletal diseases (table 2) tended to increase with age.

One confounding factor could be the length of employment. Among our subjects the age and length of employment correlated; thus its effect should not differ from that of age. The age structures of the different groups compared in the analysis did not differ significantly from each other.

Inflammatory musculoskeletal diseases might also be confounding factors. Gray and Gottler (2) reported an increased number of cases of tenosynovitis in rheumatoid arthritis patients. As a precaution, known seropositive rheumatic affections were to be excluded from the study, but none were reported by the examinee. Serological tests of the subjects were not made.

The selection (both self-selection and selection by foremen) of workers for tasks which seem to suit them best plays an important role as a modifier of work load. The foremen tend to place newcomers in the simpler manipulative tasks and promote other workers, according to proved skill, to inspection tasks. On the other hand, the workers may express their willingness to stay in a job they want. The

Table 6. Number of signs of muscle-tendon syndrome found in groups having handled different numbers of pieces per year.

	Number of pieces handled per year								
	< 200,000			200,000—300,000			> 300,000		
	Number of subjects	Number of symptoms		Number of subjects	Number of symptoms		Number of subjects	Number of symptoms	
		Mean	SD		Mean	SD		Mean	SD
Muscle-tendon syndrome	3	11.0	4.4	5	14.6	6.4	4	19.0	5.6
No muscle-tendon syndrome	9	3.3	3.0	18	3.9	3.9	9	4.6	6.0

latter might happen on the basis of subjective work strain or for social reasons. This selection tends to balance the work load and workers' skill and aptitude, which in turn makes the effect of work load factors less evident. Thus such selection dilutes the effect of specific work load when compared to a situation in which no such adaptive mechanism exists.

The most important effect modifier was work outside the factory. Extra work, work at home, and hobbies, where added to the work load in the factory, can affect the occurrence of illness. In our earlier, unpublished questionnaire pertaining to such activities outside of the factory, the results did not indicate any correlations between illness and these activities. This aspect seems to extend beyond the controllable scope of the study, and its effects can only be assumed.

If a task were the same in all work stations of the same type, then skill and individual capacities would be the most potent effect modifiers. None of these could be controlled in the study, but subjective judgements revealed large differences in the skills of different workers.

Occupational rheumatic diseases

The prevalence of occupational rheumatic diseases is not easily compared from one study to another because the diagnostic criteria are rarely identical. The results of this study are directly comparable with those of Luopajarvi et al. (7) however because the method and criteria are the same and the interreliability between observers (physiotherapists) was tested and found to be satisfactory.

The prevalence of tension neck in scissor making was 61.3 %. Among packers and shop assistants the prevalence was 37.5 and 27.8 %, respectively. In part the difference might be due to the differences between the observers (lower test-retest correlations).

Maeda, in his review on occupational cervicobrachial disorders (8), placed the overall frequency of these disorders in the manufacturing industry at about 10,000 patients per 6.1 million workers in 1970 and 1971, one-fifth of the workers complaining of local fatigue. The criteria for occupational cervicobrachial disorders are

not directly comparable to tension neck in this paper however.

The tasks linked to occupational cervicobrachial disorders in Maeda's review were, among others, keyboard operations, writing, packing different goods, assembly-line work, etc. The same elements of work load can be found in Maeda's review as in our study.

The muscle-tendon syndrome prevalences for the three occupations compared were the following: scissor makers 18.3 %, shop assistants 13.5 %, and packers 55.9 %. Among the scissor makers, the disorder was somewhat more common than among the shop assistants, whereas among packers it was more than twofold compared to the shop assistants. Both packing and scissor making are factory jobs, the difference being in the incentive level and, according to subjective judgements, in the differences in workplace layout.

Of Well's 100 industrial soft-tissue syndrome cases, 22 % were tendinitis (14). The patients were from factories in light industry.

The differences between the work movements involved in scissor making and packing have not been analyzed in detail nor have any self-evident differences been found.

The general characteristics of the work load in scissor making showed no definite relation to the diseases found. Fast, repetitive movements (short-cycle time) were not related to muscle-tendon syndrome or tension neck, nor were the two main types of tasks, namely, manipulation and inspection, related to illness. There was, however, a slight trend towards tension neck being more common in manipulation-type tasks. The differences were not statistically significant however. The low correlation between work load parameters and the neck and upper limb affections is probably partly due to insensitivity in the recording of the work method. Individual recording of work methods might yield more information than a recording method on the group level.

The total work load measured for the number of pieces handled in one year seems to be a measure that is positively correlated to illness at the symptom level. The number of symptoms of tendinitis increased as the number of pieces handled

per year increased. The size of the material limited further analysis, which might have answered the question of whether "an acceptable load" level can be found at which symptoms become minimized.

It had been our hypothesis that working with the hands in a deviated wrist joint position would be deleterious to tendons/tendon sheets. This hypothesis did not gain support in this investigation. An additional analysis of the material suggests that grasping with the fingers wide open might be a more strenuous position and might be related to tendon/tendon sheet injuries. This possibility must still be investigated.

Individual disposition towards tendinitis or other neck or upper limb affections is often promoted as a main causal factor. Very few facts have been presented supporting this claim.

Welch (13) reported a vibration test that showed good results in predicting proneness to tenosynovitis. The vascular reaction is, according to Hettinger (3), pathological in tenosynovitis-prone persons; thus the exposure to vibration leads to abnormal behavior of the hand temperature. We have not succeeded in reproducing Welch's experiment.

Mittelmeyer (9) found that neck tension tended to be more common in persons having a pycnic constitution, while the Quetelet index for weight/height did not show any differences between diseased or healthy groups.

Conclusions

In this study we have concentrated on the relation of work load to symptoms and signs in the neck and upper limbs. The study took place in a factory producing scissors, where the workers performed successive tasks, from grinding the cast to finishing the product.

In another study (7) we found a high prevalence of the tension neck and muscle-tendon syndromes (tendinitis/tenosynovitis) in factory workers (packers) — the prevalence in the reference group (shop assistants) was definitely lower. In the present study the prevalence of tension neck was higher than in shop assistants and packers, but the prevalence of the muscle-tendon syndrome was inbetween that of the other groups.

These differences in prevalences gave rise to an investigation of the role of work load factors in detail. We used production statistics as a source of information and employed work study methods for recording the work load variables.

The load involved in work movements was described from work cycle time and an index related to wrist deviation during work movements. The tasks were divided into two categories according to their character — manipulation and inspection tasks. In manipulative tasks the worker's movements are, in most cases, fast and fairly stereotyped. In inspection tasks the worker finishes the product and tests the function of the scissors, also small reparations are made. The inspection tasks seem to contain decision making and a sensorimotor work load, as well as the use of muscle force in some parts of the task. The manipulation tasks mainly contain a sensorimotor load, which seems to be fairly elevated in some tasks.

The total work load was estimated from the total number of pieces produced by the worker during one year.

The work load factors mentioned have been related to the number of tension neck and muscle-tendon syndrome cases and the total number of symptoms. The work load factors cycle time and manipulation-inspection did not show a statistically significant relation to the diseases although tension neck tended to be more common in the manipulative tasks. The total work load (total number of pieces handled) correlated with the number of symptoms both for subjects defined as "ill" and for those classified as "not ill."

The following two main conclusions were drawn:

1. Disorders of the neck and upper limbs seem to be common in manual tasks.
2. No single work load factor has yet been found which could be related to the disorders and symptoms studied although we have not been able to test all of the hypotheses. We consider wide grasping grips, the use of force, and some individual factors of disposition to be worth additional investigation.

In this study we found that the number of symptoms increased as the number of

work pieces handled per year increased. This finding might lead to a pessimistic conclusion, i.e., that the more one works, the more ill one gets. It remains to be investigated whether this holds true for other types of subjects and work.

The interesting question arises of whether there is a work load threshold below which no symptoms occur.

Until we attain more knowledge on the role of single work load factors, our message for prevention should be: all possible means — ergonomic, organizational and environmental — should be used to alleviate the work load of manual (repetitive) tasks.

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