ORIGINAL ARTICLE

Active epidemiological surveillance of musculoskeletal disorders in a shoe factory

Y Roquelaure, J Mariel, S Fanello, J-C Boissière, H Chiron, C Dano, D Bureau, D Penneau-Fontbonne

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See end of article for authors' affiliations

Correspondence to: Dr Y Roquelaure, Centre de consultation de pathologie professionnelle (Center for Occupational Health and Ergonomics), Centre Hospitalier Universitaire (University Hospital), F-49033 Angers Cedex, France; yvroquelaure@chu-angers.fr

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Aims: (1) To evaluate an active method of surveillance of musculoskeletal disorders (MSDs). (2) To compare different criteria for deciding whether or not a work situation could be considered at high risk of MSDs in a large, modern shoe factory.
Methods: A total of 253 blue collar workers were interviewed and examined by the same physician in 1996; 191 of them were re-examined in 1997. Risk factors of MSDs were assessed for each worker by standardised job site work analysis. Prevalence and incidence rates of carpal tunnel syndrome, rotator cuff syndrome, and tension neck syndrome were calculated for each of the nine main types of work situation. Different criteria used to assess situations with high risk of MSDs were compared.
Results: On the basis of prevalence data, three types of work situation were detected to be at high risk of MSDs: cutting, sewing, and assembly preparation. The three types of work situations identified on the basis of incidence data (sewing preparation, mechanised assembling, and finishing) were different from those identified by prevalence data. At least one recognised risk factor for MSDs was identified for all groups of work situations. The ergonomic risk could be considered as serious for the four types of work situation having the highest ergonomic scores (sewing, assembly preparation, pasting, and cutting).
Conclusion: The results of the health surveillance method depend largely on the definition of the criteria used to define the risk of MSDs. The criteria based on incidence data are more valid than those based on prevalence data. Health and risk factor surveillance must be combined to predict the risk of MSDs in the company. However, exposure assessment plays a greater role in determining the priorities for ergonomic intervention.

Work related upper limb musculoskeletal disorders (WMSDs) are a heterogeneous group of disorders which include peripheral nerve entrapments, muscle disorders, tendinitis and tenosynovitis, and vascular disorders. The work environment and performance of work contribute significantly to the development of such disorders.[1 2] As in other industrial countries, workers' compensation (WC) claims for WMSDs in France are increasing in a wide range of occupational groups.[3] As the risk of musculoskeletal disorders (MSDs) is high in the shoe industry, a surveillance programme for MSDs was implemented to identify and reduce work related risk factors in a large shoe factory.

Surveillance is defined as the ongoing systematic collection, analysis, and interpretation of health and exposure data in the process of describing and monitoring a health event.[2] The main objective of the surveillance of MSDs is to determine the need for action and to plan, implement and evaluate ergonomic intervention and programmes.[2 4] Different systems are available for routine analysis of health and exposure to risk factors. Passive surveillance using WC and sickness data is easy to implement, even in small sized industries.[2 4–6] Active surveillance involves a workplace specific system to identify MSDs and their risk factors. Two levels are available for active surveillance of both health and risk factors.[2] The first level (level 1) uses questionnaires and checklists, which provide a quick assessment of the situation. The second level (level 2) uses physical examinations and in depth job analysis by trained health care providers. According to a previous study in the shoe industry,[7] the level 1 active surveillance of MSDs based on a questionnaire about pain or musculoskeletal symptoms is insufficient to identify cases of MSD with any precision. In France, level 2 active MSD surveillance could easily be implemented because each worker undergoes a compulsory medical examination each year. However, few ergonomists or trained workers are available to conduct the surveillance of risk factors in the workplace. A modified version of the model of surveillance of MSDs and their risk factors proposed by Hagberg *et al* was used in this study to take into account the features of the French occupational health system.[2] The surveillance programme combines a level 2 active medical surveillance and level 1 active surveillance of the risk factors. The company's occupational physician conducted the medical surveillance and two trained ergonomists performed the level 1 active surveillance of the risk factors for each worker.

The principal aim of the study was to assess this strategy of active surveillance of MSDs; the second aim was to compare different criteria for deciding whether or not a work situation could be considered at high risk of MSDs. This paper focuses mainly on the methodological aspects of the surveillance of MSDs.

METHODS

Subjects

A large, modern, mechanised shoe factory in which epidemiological studies on MSDs had previously been conducted was selected for this study.[7 8] Six of the 12 production units of this shoe factory, employing about 2000 wage earners, were randomly selected and 20% of the blue collar workers for each

Abbreviations: CDI, concise index; CTS, carpal tunnel syndrome; IR, incidence rate; MSD, musculoskeletal disorder; PR, prevalence rate; WC, workers' compensation; WMSD, work related upper limb musculoskeletal disorder

Table 1 Description of samples, 1996 and 1997

	1996	1997
Production units*	6	5
Total workers*	253	191
Female*	158 (62%)	117 (61%)
Age (years)†	40.2 (7.3)	41.1 (7.4)
BMI (kg/m^2)†	24.3 (4.4)	24.4 (4.4)
Years of service (years)†	20.3 (4.4)	21.2 (4.3)
Years at work situation (years)†	15.0 (9.7)	16.9 (9.8)

*N (%); †mean (SD).

production unit were randomly selected using the payroll rosters. Two hundred and fifty three of the 1250 blue collar workers were thus randomly included in the study in 1996. About 10% of these workers had refused to answer a questionnaire about working conditions in 1996 and were not followed up in 1997. Moreover, because of the decrease in activity of one production unit as a result of the economic crisis, only five of the six production units were included in the study in 1997. For that reason, only 191 out of the 253 workers examined in 1996 were re-examined by the same physician during a 12 month period in 1997. Table 1 reports sociodemographic data.

Definition of health outcome

All the workers were interviewed during the 12 month period and examined using the same procedure by the same company occupational physician experienced in assessment of MSDs. The clinical procedure consisted of three stages. The worker was first asked about pain and symptoms (tingling, burning, numbness, stiffness, lack of mobility, etc) in one or both of the upper limbs during the previous 12 months and the previous week. In the next stage, the minimal examination procedure consisted of testing mobility and sensitivity to pressure of the neck, shoulders, elbows, and wrists, followed by the sensitivity evaluation and provocation tests for carpal tunnel syndrome (CTS) (Phalen's and Tinel's tests) for each side. Finally, in cases of pain or symptoms in one of the regions of the upper limbs, the physical examination was extended by specific testing for tension neck syndrome, rotator cuff syndrome, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, radial tunnel syndrome, Guyon's canal syndrome, and hand–wrist tendinitis. The relevant tests were standardised using clinical textbooks.[9 10] MSDs were considered to have been diagnosed if the results of any one of the three clinical procedures was positive.

This paper mainly reports the results regarding CTS, rotator cuff syndrome, tension neck syndrome, and cubital tunnel syndrome, because the prevalence of the other MSDs was too low (see table 2). The surveillance definitions of these disorders were as follows:

- The definition for CTS was nearly the same as the surveillance definition of the NIOSH[11]—that is, (1) presence of one or more of the symptoms suggestive of CTS (paresthesias, pain, or numbness affecting at least part of the median nerve distribution of the hand(s)), and (2) presence of objective findings in affected hand(s) or wrist(s), including either (a) Tinel's sign, positive Phalen's test, or diminished or absent sensation to pin prick in the median nerve distribution, or (b) slowing of sensory and/or motor conduction velocities (<40 m/s) in the median nerve at the wrist level.
- The definition for rotator cuff syndrome was: (1) intermittent pain in the shoulder or in the deltoid region worsened by active elevation movement of the arm; and/or (2) tenderness over the humeral head; and (3) presence of at least one of the following signs: painful arc on active arm elevation, resisted shoulder abduction, external rotation, or internal rotation.
- The definition for tension neck syndrome was: (1) pain in the shoulder or neck; and (2) tenderness over the descending part of the trapezius muscle.
- The definition for cubital tunnel syndrome was: (1) intermittent paresthesias distal to the elbow in the ulnar distribution of the forearm and the hand; and (2) positive Tinel's sign; and/or (3) slowing of the sensory and/or motor conduction velocities (<40 m/s) in the ulnar nerve at the elbow level.

The definitions used to diagnosed lateral and medial epicondylitis, radial tunnel syndrome, Guyon's canal syndrome, and hand–wrist tendinitis were those defined by Pujol.[10]

Exposure measurements

The work situations of the six production units of the large shoe factory were classified into nine main types of work situation according to a previous study in the French shoe industry.[7] The job titles of these groups of work situation were: cutting (21 workers in 1996); preparation of the leather, including supplying pieces of leather (sewing preparation) (23 workers); sewing (67 workers); assembly preparation (12 workers); mechanised assembling, including carding (26 workers); manual assembling (24 workers); pasting (13 workers); and finishing, including checking (27 workers) and packing tasks (19 workers).

Risk factors for MSDs were assessed for each worker by standardised job site work analysis. The work analysis was

Table 2 Prevalent cases of MSDs in 1996 and 1997 and incident cases of MSDs in 1997

	Prevalent cases and PR in 1996		Prevalent cases and PR in 1997		Incident cases and IR in 1997	
MSDs	N*	PR (95% CI)	N†	PR (95% CI)	N‡	IR (95% CI)
Tension neck syndrome	19	7.5 (4.2 to 10.8)	8	4.2 (1.3 to 7.1)	7	3.7 (1.0 to 6.4)
Rotator cuff syndrome	20	7.9 (4.5 to 11.3)	18	9.5 (8.1 to 10.7)	12	6.3 (2.9 to 9.8)
Medial epicondylitis	0	0 (–)	1	0.5 (0 to 1.5)	0	0 (–)
Lateral epicondylitis	5	2.0 (0.3 to 3.7)	6	3.1 (0.6 to 5.6)	4	2.1 (0.1 to 4.1)
Cubital tunnel syndrome	10	5.2 (2.1 to 8.3)	8	4.2 (1.4 to 7.0)	5	2.6 (0.4 to 4.9)
Radial tunnel syndrome	1	0.4 (0.0 to 0.8)	2	1.0 (0 to 2.4)	2	1.0 (0 to 2.4)
Carpal tunnel syndrome	46	18.2 (13.3 to 23.0)	42	22.0 (15.9 to 28.0)	23	12.0 (7.3 to 16.7)
Guyon's canal syndrome	1	0.4 (0.0 to 0.8)	1	0.5 (0 to 1.5)	1	0.5 (0 to 1.5)
Hand–wrist tendinitis	6	2.4 (1.4 to 3.4)	6	3.1 (0.6 to 5.6)	6	3.1 (0.6 to 5.6)
≥1 MSD§	88	34.8 (28.8 to 40.8)	72	37.7 (27.3 to 48.1)	35	18.3 (12.7 to 23.9)
≥2 MSD§	21	8.3 (4.8 to 11.8)	16	8.4 (4.4 to 12.4)	7	3.7 (1.5 to 5.9)

N, number of cases; PR, prevalence rate; IR incidence rate.
*Total number of workers = 253; †total number of workers = 191; ‡number of new cases without MSD examined in 1996/100 person years. §One (or two) or more of the nine MSDs under review (i.e. tension neck syndrome, rotator cuff syndrome, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, radial tunnel syndrome, carpal tunnel syndrome, Guyon's canal syndrome, and hand–wrist tendinitis).

performed by direct observation and questioning by two specially trained assessors unaware of the medical status of individual workers. A modified version of the checklist proposed by Keyserling *et al* was used for this.[12] When the workers had two or more work situations, analysis was performed on the most frequent work situation. Job rotation between different work situations was recorded. Eighteen risk factors belonging to five classes of ergonomic factors were taken into account by the checklist:

- Repetitiveness (work cycle <30 sec; repetition of the same motions/exertions during more than half of the work cycle)
- Local mechanical contact stress (finger; palm; elbow; armpit)
- Forceful manual exertion (weight over 4.5 kg, 2.7 kg, 1 kg; slipping object or tool; pressing or pushing with the thumb, wearing gloves)
- Awkward upper extremity posture (pinch grip; wrist deviation; twisting of the forearm; reaching down and behind the torso; use of elbow above mid torso level)
- Hand tool usage (vibration exposure; cold; finger trigger motion, unbalanced or jerky tools or objects).

The response mode was dichotomous ("positive" *v* "negative") for risk factors "repetitiveness" and "local mechanical stress". Ergonomic factors regarding force, posture, equipment, and tools had to be present during more than a third of the working cycle to be considered as "positive". The checklist took into account 18 risk factors for each hand. An ergonomic score for right, left, and both hands was calculated for each work situation as the sum of "positive" risk factors.

Data analysis

The unit of analysis regarding health outcomes was the patient and not each limb. Prevalences of CTS, rotator cuff syndrome, tension neck syndrome, and at least one of the nine MSDs surveyed (tension neck syndrome, rotator cuff syndrome, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, radial tunnel syndrome, CTS, Guyon's canal syndrome, and hand–wrist tendinitis) were calculated for each type of work situation in 1996. The prevalence rates for each of the nine types of work situation were calculated on the basis of the existing cases of MSD during the 12 month period, divided by the total number of workers at the corresponding type of work situation. The incidence rates were calculated as the number of cases of MSD arising during the 12 month period in each of the nine types of work situation, divided by the total number of workers of the corresponding categories who did not have the MSD under review in 1996.

A concise index (CDI) was calculated for the whole sample of workers as the sum of MSDs of each upper limb of each worker, divided by the number of upper limbs exposed to increased risk.[13] In this particular case only, the unit of analysis was not the worker but each upper limb. Thus, the CDI is divided by two if the ergonomic risk factors were detected in both hands.

Different criteria, including Hagberg's criteria,[2] for deciding whether a MSD problem is identified were compared:

- Criteria 1 and 2: the prevalence rate ($PR_{(1996)}$) of the MSD under review in the type of work situation was high in 1996. Criterion 1: the $PR_{(1996)}$ was considered to be high if there was more than a twofold difference in the $PR_{(1996)}$ for the type of work situation compared to the prevalence for the entire population.[2] Criterion 2: the $PR_{(1996)}$ was considered to be high if the ratio between the $PR_{(1996)}$ in the type of work situation and the $PR_{(1996)}$ for the entire population was over 1.5 (criterion 2).
- Criteria 3 and 4: the incidence rate of the MSD under review in the type of work situation under review was high. The incidence rate ($IR_{(1997)}$) was considered to be high if there was more than 1 per 100 person years) (criterion 3), or if the $IR_{(1997)}$ was more than twice that of the whole sample of the factory (criterion 4).[2]
- Criteria 5 and 6: the exposure to ergonomic risk factors of the type of work situation under review was high. Exposure was considered to be high if at least one risk factor was identified according to the job analysis of the type of work situation under review (criterion 5),[2] or if the ergonomic score of the type of work situation was greater than the median value for the whole sample of the factory (criterion 6).

The χ^2 test and analysis of variance (ANOVA) were used to study the associations between health outcomes and ergonomic factors and to compare the characteristics of the workers, whether they were followed up in 1997 or not. Statistical analysis was performed on the Statistical Package for Social Science software (SPSS for Windows, version 10.0).

RESULTS

The prevalence rates of any MSDs studied were very high in the whole shoe factory in 1996 and 1997 (table 2). More than a third of the blue collar workers were affected by at least one of the nine MSDs under review. The highest prevalence rate in 1996 involved CTS, followed by rotator cuff syndrome, tension neck syndrome, and cubital tunnel syndrome. Rotator cuff syndrome, cubital tunnel syndrome, and CTS were bilateral in 15%, 20%, and 38% of cases, respectively. The incidence rates were very high for all MSDs. The highest incidence rate involved CTS, followed by rotator cuff syndrome, tension neck syndrome, and cubital tunnel syndrome. The prevalence of having at least one MSD in 1996 did not differ between the six production units ($p = 0.381$). Differences between the incidence of having at least one MSD between the five production units surveyed in 1997 were not significant ($p = 0.481$). Lack of difference between production units was also observed for the prevalence and incidence of any MSDs studied.

Table 3 reports the results of the surveillance of health outcomes. According to criterion 1 (PR in the type of work situation $\geq 2 \times$ PR for the whole sample), the prevalence rate for tension neck syndrome was "high" for assembly preparation. The prevalence rate for rotator cuff syndrome was "high" for cutting and assembly preparation. No type of work situation had a "high" prevalence rate of CTS. The same applied to the prevalence rate for having at least one MSD. The use of criterion 2 (PR in the type of work situation $\geq 1.5 \times$ PR for the whole sample) reveals a "high" prevalence rate for tension neck syndrome for sewing. The PR of CTS was "high" for assembly preparation. The same applied to the prevalence rate for having at least one MSD with assembly preparation.

The incidence rate of tension neck syndrome was over 1% (criterion 3) for sewing preparation, sewing, and mechanised and manual assembling. According to criterion 4, the incidence rate of tension neck syndrome was "high" for sewing preparation and mechanised assembling (IR in the type of work situation $\geq 2 \times$ IR for the whole sample). The incidence rate of rotator cuff syndrome was over 1% for all types of work situation except assembly preparation, manual assembling, pasting and packing. The incidence rate of rotator cuff syndrome was "high" (criterion 4) for finishing. The incidence rate of CTS was over 1% for all types of work situation except for sewing preparation, assembly preparation, and packing. The incidence rate of having at least one MSD was over 1% for all types of work situation except assembly preparation and packing. The incidence rate of having at least one MSD was "high" (criterion 4) for mechanised assembling.

Because 62 workers were not followed up in 1997, the possible effect of selection of the workers who were followed up in both years was studied. The workers not followed up in 1997 were slightly older than those who were (41.1 (7.4) years *v*

Table 3 Prevalent cases in 1996 and incident cases in 1997 of tension neck syndrome, rotator cuff syndrome, CTS, and having at least one MSD for the main types of work situation

Types of work situation (number of workers)	MSDs			
	Tension neck syndrome N (%)	Rotator cuff syndrome N (%)	Carpal tunnel syndrome N (%)	⩾1 MSDs¶ N (%)
Cutting				
Prevalent cases (N=21)	1 (4.8)	4 (19.0)*†	2 (4.8)	5 (23.8)
Incident cases (N=19)	0 (0)	1 (5.3)§	3 (15.8)§	4 (21.1)§
Sewing preparation				
Prevalent cases (N=23)	0 (0)	0 (0)	4 (11.4)	4 (11.4)
Incident cases (N=18)	2 (11.1)‡	1 (5.5)	0 (0)	2 (11.1)
Sewing				
Prevalent cases (N=67)	10 (14.9)†	4 (6.0)	15 (22.4)	26 (38.8)
Incident cases (N=52)	2 (3.8)§	2 (3.8)§	7 (13.5)§	8 (15.4)§
Assembly preparation				
Prevalent cases (N=12)	3 (25.0)	3 (25.0)*†	4 (33.3)†	8 (66.7)†
Incident cases (N=8)	0 (0)	0 (0)	0 (0)	0 (0)
Mechanised assembling				
Prevalent cases (N=26)	1 (3.8)	2 (7.7)	5 (19.2)	9 (34.6)
Incident cases (N=18)	2 (11.1)‡§	2 (11.1)‡§	3 (16.7)§	7 (38.9)‡§
Manual assembling				
Prevalent cases (N=24)	1 (4.2)	2 (8.3)	2 (8.3)	5 (20.8)
Incident cases (N=21)	1 (4.8)§	0 (0)	4 (19.0)§	4 (19.0)§
Pasting				
Prevalent cases (N=13)	1 (7.7)	1 (7.7)	2 (15.4)	6 (46.2)
Incident cases (N=9)	0 (0)	0 (0)	2 (22.2)§	1 (11.1)§
Packing				
Prevalent cases (N=19)	0 (0)	1 (5.2)	4 (21.1)	5 (26.3)
Incident cases (N=11)	0 (0)	1 (9.1)§	0 (0)	0 (0)
Finishing				
Prevalent cases (N=27)	2 (7.4)	0 (0)	7 (25.9)	9 (33.3)
Incident cases (N=22)	0 (0)	4 (18.2)‡§	4 (18.2)§	4 (18.2)§
Whole sample				
Prevalent cases (N=253)	19 (7.5)	20 (7.9)	46 (18.2)	88 (34.8)
Incident cases (N=191)	7 (3.7)§	21 (5.2)§	23 (12.0)§	35 (18.3)§

N, number of cases; PR, prevalent rate; IR, incidence rate. Incidence case = number of new cases in 1997 without the MSDs examined in 1996/100 person years. %: percentage of workers per type of work situation suffering from the MSD under review.
*PR in the type of work situation ⩾2 PR for the whole sample. †PR in the type of work situation ⩾1.5 PR for the whole sample. ‡IR in the type of work situation ⩾2 IR for the whole sample. §IR in the type of work situation >1%. ¶One or more of the nine MSDs under review (i.e. tension neck syndrome, rotator cuff syndrome, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, radial tunnel syndrome, carpal tunnel syndrome, Guyon's canal syndrome, and hand–wrist tendinitis).

38.0 (6.5) years; p = 0.003), which suggests possible selection bias. However, the number of years on the job was not higher for the workers not followed up in 1997 (15.1 (10.2) years *v* 14.7 (7.8) years; p = 0.857). The prevalence rate of having at least one MSD was not significantly higher for the workers not followed up in 1997 (35.5% *v* 34.6%; p = 0.510). The same applied to any MSDs studied. Ergonomic scores were higher for the workers who were not followed up in 1997 (8.9 (2.2) *v* 8.0 (2.3); p = 0.013), which suggests higher ergonomic strains, although the proportion of workers for each type of work situation was similar for both groups (p = 0.552).

Table 4 reports the results of the surveillance of work exposure. Most of the workers remained at the same work situation for many years and worked full-time—that is, 1600 hours per year. Few of the 191 workers followed up in both years had a change of work situation (7.8%). Tasks involved both hands for all workers (99%).

Regarding criterion 5, at least one recognised risk factor for MSDs was present for each of the work situations (99.6%). Consequently, an ergonomic risk was identified as being present for all work situations. For most of the work situations the work cycle was under 30 seconds (73%) or else the hand(s) repeated the same motions/exertions for more than half of the work cycle (79%). Thus, if we considered the two factors, repetitiveness was high for 95% of the work situations, whichever the type. However, only 11 workers (5%) had to exert force above 1 kg. Most of them were responsible for packing and packaging the shoes. For most of the workers, the task required at least one of the five awkward postures of the upper limbs to be taken into account. The elbow was above the middle of the thorax during work for 70% of the work situations, especially for pasting and sewing preparation. The task required extreme wrist extension in 38% of the work situations, particularly for manual assembling and sewing. The need for extreme wrist flexion was less frequent (13%), except for manual assembling (24%). Few work situations (3%) required forearm twisting except finishing (11%). Wrist deviation was observed in 38% of the work situations, particularly for sewing. At least one of the four mechanical stresses taken into account by the checklist was present for 71% of the workers, particularly those assigned to cutting, sewing and pasting. No worker wore gloves during work. None used unbalanced or jerky objects, tools, or equipment. The task involved vibrating tools only in manual assembling (25%), mechanical assembling (16%), and preparation of sewing activities (5%). No workers were exposed to cold or blowing cold air. In most cases, both upper limbs were exposed to ergonomic risk factors. The concise index (CDI) of having at least one MSD was 27%. The CDI for rotator cuff syndrome and CTS were 4% and 12%, respectively.

Regarding criterion 6, the mean ergonomic scores for right, left, and both hands were 4.2 (SD 1.2), 4.0 (SD 1.3), and 8.3 (SD 2.3), respectively. The mean ergonomic scores (Es) for both hands, which ranged between 6.5 and 9.1, significantly differed between types of work situation (p < 0.01). The

Table 4 Distribution of the main ergonomic factors and ergonomic scores in the factory

Types of work situations (number of workers)	Ergonomic factors: High repetitiveness N (%)	Force >1 kg N (%)	Elbow above mid torso N (%)	Forearm twisting N (%)	Wrist flexion >45° N (%)	Wrist extension >45° N (%)	Wrist deviation N (%)	Rapid triggering motions N (%)	Mechanical stress ≥1 N (%)	Bilateral ergonomic score ≥8 N (%)
Cutting (21)	21 (100)	0 (0)	16 (76)	0 (0)	0 (0)	4 (19)	4 (19)	4 (19)	18 (86)	14 (67)*
Sewing preparation (22)	20 (91)	0 (0)	18 (82)	0 (0)	2 (9)	5 (23)	5 (23)	1 (5)	11 (50)	13 (59)
Sewing (62)	62 (100)	1 (2)	49 (79)	1 (2)	12 (19)	36 (58)	37 (60)	1 (2)	52 (84)	51 (82)*
Assembly preparation (10)	10 (100)	0 (0)	7 (70)	0 (0)	0 (0)	5 (50)	3 (30)	0 (0)	5 (50)	8 (80)*
Mechanised assembling (25)	24 (96)	1 (4)	15 (60)	2 (8)	3 (12)	10 (40)	7 (28)	0 (0)	19 (76)	14 (56)
Manual assembling (25)	24 (96)	2 (8)	13 (52)	0 (0)	6 (24)	15 (60)	5 (20)	2 (8)	17 (68)	11 (44)
Pasting (10)	10 (100)	0 (0)	10 (100)	0 (0)	1 (10)	2 (20)	2 (20)	3 (30)	8 (80)	8 (80)*
Packing (19)	12 (63)	5 (26)	14 (74)	0 (0)	4 (21)	3 (16)	8 (42)	0 (0)	10 (53)	10 (53)
Finishing (26)	25 (96)	2 (8)	17 (65)	3 (11)	2 (8)	6 (23)	11 (48)	8 (31)	16 (62)	14 (54)
Whole sample (238)	225 (95)	11 (5)	166 (70)	7 (3)	31 (13)	93 (39)	91 (38)	23 (10)	169 (71)	158 (66)

Total number of work situations examined = 238.
*Ergonomic scores over the median value when compared with the ergonomic score for the whole sample.

highest ergonomic scores were observed for assembly preparation (Es = 9.4 (1.7)), sewing (Es = 9.1 (1.8)), pasting (Es = 8.5 (1.4)), sewing preparation (Es = 8.1 (2.1)), and cutting (Es = 8.1 (2.4)). The lowest ergonomic scores were observed for manual assembling (Es = 6.5 (2.5)) and packing (Es = 7.6 (3.5)). Two thirds of the workers had bilateral ergonomic score higher than 8 out of 18. When compared to the median bilateral ergonomic score for the whole sample, the ergonomic score was "particularly high" (criterion 6) for assembly preparation, sewing, cutting, and pasting. These types of work situation were among those associated with the highest prevalence of at least one MSD. However, the mean bilateral ergonomic score was not significantly different between subjects with and without at least one MSD (8.3 (2.2) *v* 8.1 (2.4); p = 0.652). Except for sewing preparation, the bilateral ergonomic scores were in the medium range for the types of work situations with high incidence rates of MSDs—that is, mechanised assembling (Es = 7.8 (2.0)) and finishing (Es = 8.0 (3.2)). The bilateral ergonomic score was not significantly different for the workers with or without incident cases of MSDs in 1997 (8.4 (2.2) *v* 8.1 (2.4); p = 0.306).

The use of different criteria to decide whether or not a type of work situation could be considered at high risk of MSDs gave different results (table 5). Based on a twofold difference in prevalence rates in 1996 (criterion 1), two types of work situation were identified: cutting for rotator cuff syndrome, and assembly preparation for tension neck syndrome and rotator cuff syndrome. If the threshold chosen to consider ratios of prevalence rate as high was reduced to 1.5, three types of work situation were identified: cutting for rotator cuff syndrome, sewing for tension neck syndrome, and assembly preparation for all disorders. Based on a twofold difference in incidence rate (criterion 3), the three types of work situation identified (sewing preparation, mechanised assembling, and finishing) were different from those identified by prevalence data. When incidence rates over 1% (criterion 4) were considered, all types of work situation except assembly preparation and packing were identified as at high risk of MSDs. At least one risk factor (criterion 5) was identified for all the types of work situation. However, the ergonomic risk could be considered as especially high (criterion 6) for four types of work situation: sewing, assembly preparation, pasting, and cutting. These types of work situation had the highest ergonomic scores for both hands.

DISCUSSION

The study includes a comparison of cross sectional and longitudinal estimates of MSDs in a large factory. Possible selection bias of workers could have occurred during the follow up since the workers not followed up in 1997 were older and exposed to higher strains than the others. However, exposure duration was not higher for the workers not followed up in 1997. A change in activity for numerous workers was responsible for the exclusion from the prospective part of the surveillance, which was independent of health status. This is supported by the fact that the prevalence of MSDs was not higher for the workers excluded from the follow up. These workers were not dismissed from the company in 1997 but their tasks had changed for one year. They were in fact given tasks other than the production of shoes, such as sorting and packing clothes. This was mainly a result of decreased activity in the shoe factory resulting from the economic crisis during this period. Consequently, if the healthy worker effect occurred during the follow up, its influence on the results was probably low. Part of the fluctuation in the prevalence rates in work situations might also be a result of the cyclical evolution of most MSDs.[14] Some workers probably used new working strategies that diminished muscular strain, especially in the case of upper limb pain. Workers' coping strategies could also explain the fluctuation in prevalence rates of MSDs in work situations

Table 5 Results of surveillance according to the criteria used to identify types of work situation at high risk of MSDs

High risk types of work situation					
Health assessment criteria				Ergonomic assessment criteria	
1	2	3	4	5	6
$PR_{(1996)}$ in the type of work situation ≥2 $PR_{(1996)}$ in the whole sample • Cutting‡ • Assembly preparation†‡	$PR_{(1996)}$ in the type of work situation ≥1.5 $PR_{(1996)}$ in the whole sample • Cutting‡ • Sewing† • Assembly preparation†‡§¶	$IR_{(1997)}$ in the type of work situation ≥2$IR_{(1997)}$ in the whole sample • Sewing preparation† • Mechanised assembling†¶ • Finishing‡	$IR_{(1997)}$ >1% • Mechanised assembling†‡§¶ • Cutting‡§¶ • Manual assembling†§¶ • Finishing‡§¶ • Sewing†‡§¶ • Sewing preparation†‡¶ • Pasting§¶	At least one ergonomic risk factor* • All work situations	Bilateral ergonomic score over the median score for the whole sample* • Cutting • Sewing • Assembly preparation • Pasting

*Total number of work situations examined = 238. †tension neck syndrome; ‡rotator cuff syndrome; §CTS; ¶one or more of the nine MSDs under review (tension neck syndrome, rotator cuff syndrome, lateral epicondylitis, medial epicondylitis, cubital tunnel syndrome, radial tunnel syndrome, CTS, Guyon's tunnel syndrome, and hand–wrist tendinitis). $PR_{(1996)}$ = prevalence rate in 1996. $IR_{(1997)}$ = incidence rate in 1997.

over time. The small number of workers in each group of work situation increases the variability of such proportional data. This phenomenon might have been greater in 1997 because of the smaller size of the sample of workers. Therefore, the percentage of workers suffering from MSDs in each type of work situation should be treated with caution. The variability of the data might explain the low agreement between prevalence rate and incidence rate for each type of work situation.

Surveillance of MSDs requires routine analysis of health and exposure data. In France, all workers undergo a compulsory annual medical examination by the company's occupational health physician. This feature of the French occupational health system reinforced the choice of level 2 active medical surveillance of MSDs, for which brief health related physical examinations and/or interviews can be used.[2] Physical examination of the workers allows accurate diagnosis but is time consuming. In the present study, physical examinations required about 30–45 minutes for a worker suffering from at least one MSD and 10 minutes for a healthy worker. As a result, only a sample of workers was included in the surveillance programme to limit the workload of the occupational physician. Surveillance definitions were similar to those of two recent consensus conferences.[15 16] The three stage clinical procedure, which allows rapid assessment of health status, is in agreement with the proposal of Ricci and colleagues.[5] According to the high number of MSDs diagnosed, the clinical procedure seems to be efficient. However, the diagnostic value of the procedure could not be assessed because of the lack of a reference method.

Whatever the limits of the method, the study emphasises the importance of systematic health surveillance in this shoe factory. The prevalence and incidence of all disorders were high in the whole plant, which is consistent with previous studies in the shoe and garment industries.[7 17 18] CTS was the most frequent disorder, followed by rotator cuff syndrome, which is consistent with WC claims records and French epidemiological findings.[3] However, the magnitude of the problem was much higher than WC claims, which emphasises the importance of systematic medical surveillance of MSDs. WC records are known to underestimate the prevalence of MSDs because only severe cases are detected.[4] Moreover, in some cases, workers refuse to file a claim for their occupational illness for fear of being dismissed, because of the litigious nature of the WC process.

The choice of the criteria to decide whether or not a type of work situation could be considered at high risk of MSDs has a dramatic effect on the results of the health surveillance. The criterion based on prevalence data (criterion 1 = PR in the type of work situation ≥2 × PR for the whole sample) is not sufficiently sensitive for the detection of work situations at high risk of MSDs. Therefore, the threshold chosen to consider ratios in the prevalence rate as high or not should be decreased to 1.5 for medical surveillance. In a general way, the incidence rate is more valid than the prevalence rate to detect types of work situation with high risk of MSDs since the incidence rate is less affected by the healthy worker effect. Criterion 4 (IR >1%) is effective in identifying the types of work situation with high risk of MSDs. Thus, all types of work situation except manual assembling and pasting could be considered to be at high risk of MSDs in this particular shoe factory. The threshold chosen seems reasonable by comparison with WC claims data in the region of the Pays de la Loire in 1995. Indeed, the compensation data indicate an industry wide incidence rate of 1.02 WC claims per thousand workers. If the IR >1% criterion reveals the need for ergonomic intervention to reduce the risk of MSDs in the shoe factory, this criterion is probably too sensitive to prioritise prevention. The use of the twofold difference in incidence rate criterion (criterion 3) permits identification only of the three types of work situation with the highest risk of MSDs. The cut off value of this incidence rate criterion could be lowered to increase the sensitivity of the method. More simply, the work situations could be ranked from highest to lowest incidence rates of MSDs.

Many checklists have been proposed for the surveillance of MSDs risk factors.[2 19] The checklist used in this study allows rapid and precise screening of ergonomic exposure in the workplace.[12] Checklists were filled out by direct observation of the work situation by two experts, which is probably more accurate than direct questioning of workers by plant employees as proposed by Keyserling and colleagues.[12] The task analysis and exposure assessment of each work situation took about 30 minutes for each worker. The results show a high level of ergonomic strain in all work situations. This explains the high prevalence and incidence of MSDs in almost all types of work situations. Criterion 5 (existence of at least one risk factor in the work situation), which correspond to Hagberg's rule of decision,[2] permits identification of an ergonomic risk of MSDs in all types of work situation. This criterion, which depends on the checklist used, is probably too sensitive to prioritise preventive action in production lines. We have therefore introduced a more restrictive criterion, according to which a type of work situation was considered to have an ergonomic risk if the score was above the median score of the whole company (criterion 6). In this case, the types of work situation identified as at potential high risk corresponded to the types of work situation detected by the medical surveillance based on prevalence data. The lower agreement between ergonomic data and incidence rate was probably caused by year to year

data fluctuations, whereas prevalence data and ergonomic data were collected during the first year of follow up. As the choice of the cut off value of the ergonomic score has a dramatic effect on the result, it might be more effective to rank the types of work situation from highest to lowest scores to assess ergonomic exposure.

From a methodological point of view, the large shoe factory studied is a good example for health surveillance because of the stability of the working population. The results of the health surveillance were therefore easy to link with job titles, and the existing standardised medical files of the company were sufficient for this purpose. However, health data collection was a lengthy process as it took place throughout the two year period. In the case of a large turnover of workers, incidence data would be much more difficult to use. This would be particularly true in some sectors employing numerous temporary workers, such as the cleaning and building sectors. In such cases, it might be easier to use only standardised interviews that allow quicker assessment of the health status than physical examination.[2] Another advantage of simple standardised interviews is that they can be confidently conducted by occupational nurses. In a general way, monitoring of risk factor exposure is more proactive than assessment of MSDs in that it does not require workers to be adversely affected. Moreover, the occurrence of possible selection bias caused by the turnover of the workforce and the coping strategies used by workers argue in favour of exposure surveillance. Consequently, although health and risk factor surveillance must be combined to predict the risk of MSDs in the company, exposure assessment plays a greater role in determining the need for ergonomic intervention. Moreover, in small sized industries, medical surveillance could even be difficult to implement because of sampling fluctuations. In these companies, which represent a large part of the economic sector, it might be more appropriate to concentrate surveillance on ergonomic risk factors rather than medical surveillance.[2] Regardless of the method(s) used, this study emphasizes the importance of systematic surveillance of MSDs.

Surveillance of MSDs and their risk factors in this factory had led to the planning and implementation of ergonomic intervention. The results of health and risk factors surveillance were reported confidentially to decision makers and employees during three special Health and Safety Committee sessions. This committee, which exists in each large plant, participates in the construction of the health and safety programme of the company and can decide on the implementation of any ergonomic intervention. Medical and exposure surveillance had clearly shown that a high risk of MSDs existed in almost all types of work situation. Ergonomic intervention was therefore planned and implemented in the whole factory. The first stage of the intervention process was the implementation of an ergonomic training programme for workers and supervisors in each production unit. In the second stage, a team of consultants conducted an in depth ergonomic diagnosis in a production unit. After this, a wide scale ergonomic intervention programme was implemented to reduce ergonomic hazards in all production units. Intervention has begun in the areas where the highest incidence rates and ergonomic scores were observed. Changes in work organisation and technology have therefore been made in the cutting and shoe assembling sectors, including pasting. However, relatively few changes have been planned in the sewing sector, because a large part of the sewing process has been contracted out. The surveillance of MDSs and their risk factors is presently being continued in the factory in order to evaluate the effectiveness of the ergonomic intervention programme.

Conclusion

Surveillance of adverse outcomes and ergonomic risk factors is important in deciding the most appropriate action for the prevention of MSDs. The decisions based on health surveillance depend largely on the definition of the criteria used to define the risk of MSDs. Criteria based on incidence data are more valid than those based on prevalence data. Health and risk factor surveillance must be combined to predict the risk of MSDs in the company. However, exposure assessment plays a greater role in determining the priorities for ergonomic intervention.

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Authors' affiliations

Y Roquelaure, S Fanello, J C Boissière, H Chiron, C Dano, D Penneau-Fontbonne, Centre de consultation de pathologie professionnelle (Center for Occupational Health and Ergonomics), Centre Hospitalier Universitaire (University Hospital), F-49033 Angers Cedex, France

J Mariel, D Bureau, Service Médical Inter-entreprise de l'Anjou (Occupational Health Service of Anjou), 25, rue Carl Linné, F-49009 Angers, France

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