

Hand eczema in metalworker trainees – an analysis of risk factors

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The present study, as part of PROMETES (Swiss Prospective Metal Worker Eczema Study), was performed to examine risk factors for the development of occupational hand dermatitis in metalworker trainees. Since this disease is very common, a high standard of preventive measures is necessary, especially for persons with an endogenous disposition for the development of eczema, e.g., atopics. Within the cohort of 201 healthy young men, 47 (23%) showed at least mild signs of hand eczema at 1 point of the 2.5 year observation period. Various occupational and domestic exposures, skin protection behaviour, regeneration time, and smoking habits, as well as atopic disposition, were studied with regard to their influence on the skin condition of the metalworker trainees. By multivariate analysis, we determined 3 important risk factors for the development of hand eczema in the cohort. (i) We showed once more the important influence of an atopic disposition as a major risk factor for occupational contact dermatitis. (ii) Furthermore, the results suggest that, apart from chemical irritants, mechanical factors should not be underestimated in their role as irritants to the epidermal barrier. (iii) Additionally, an insufficient amount of skin recovery time seems to support a cumulative sub-irritant effect on the skin, which may lead to irritant contact dermatitis.

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Contact dermatitis in metalworkers is common. There are a number of publications showing the pathogenic effect of metalworking fluids, components of which are considered to be both potent irritants as well as sensitizers (1–5). Metalworkers are also exposed to a number of other chemical irritants, such as cleaning detergents, solvents, and degreasers. Metal chips or dust causing micro-trauma to the skin, as well as pressure and friction, may damage the barrier function of the skin and pave the way for the impact of irritants and allergens. To prevent metalworker's dermatitis, it is therefore essential to minimize contact exposure. Although this can be expected to a certain degree from increased automation of metalworking operations, there still remains a considerable proportion of manual work in this occupation. The principal concept of the prevention of contact dermatitis is based on individual skin hygiene, care and protection. Frequent cleaning of the skin with water and mild detergents, application of barrier

creams, and regular use of skin-care products are the most important measures to keep the skin healthy in the long run.

The aim of the present study was to examine the importance of different occupational exposures as risk factors for the development of contact dermatitis in a cohort of metalworker trainees at 24 metalworking factories. We further studied domestic exposure, skin-care behaviour of the trainees and its development during the observed period, the role of recovery time as another protection factor, and the influence of cigarette smoking on the occurrence of hand eczema. The role of atopic skin diathesis as an endogenous risk factor has been published elsewhere (6).

Materials and Methods

Study design

A prospective cohort study was performed to observe the development of hand eczema in metal-

worker trainees and to identify related risk factors. 201 healthy young volunteers were followed up over 2.5 years from the beginning of their apprenticeship. They represented the entire new workforce of 24 small- and medium-sized metalworking factories in Switzerland. We excluded the only 2 female participants to provide a homogeneous study population regarding age and sex. Another 2 persons were excluded because of signs of pre-existing hand dermatitis.

Examination of skin status

At the beginning of their apprenticeship, each participant was questioned about previous skin problems. The current skin status was examined carefully by a dermatologically-trained occupational physician. Signs and symptoms indicating an atopic skin diathesis were studied. During 2.5 years, we carried out repeated control examinations at 6-monthly intervals to detect skin changes as early as possible.

Observed independent variables

We studied those variables that we considered to be possible risk factors or modifiers for the development of hand eczema in metalworker trainees.

(a) Risk exposure assessment in the working environment

To collect precise and objective information on the multiple exposure factors for each individual, a special skin exposure assessment was designed. Thus, a checklist for job rating with regard to the most important risk factors for skin irritation in the metalworking industry was created. For each single job of training (e.g., drilling, lathe), the workshop instructor gave information on whether and how frequently (i.e., daily, weekly) the trainee would have contact with water- or oil-based metalworking fluids, cleaning agents with and without solvents, metal dust and mechanical factors such as friction and pressure. To obtain information on the individual job activities of each metalworking trainee, a job diary, containing a list of all factory-specific job facilities was created. The participants were asked to note the number of hours spent weekly at the different jobs, days of absence and the weekly number of days of theoretical teaching. The workshop management supervised this to achieve high compliance and quality in the assessment.

By compiling checklists and diaries, we were able to semiquantitatively calculate the individual exposure time to the single risk factors for each trainee during 5 6-month evaluation periods (5).

(b) Risk exposure in the domestic environment

To determine skin hazard factors in the domestic environment, we asked about the approximately weekly number of hours spent on activities such as gardening, cleaning, baby care, do-it-yourself, or car maintenance.

(c) Skin hygiene and protection

All persons were questioned regularly about the frequency of cleaning their hands during the workday and the use of barrier creams and skin care products. We summarized these parameters arbitrarily by giving marks, i.e., "good", "sufficient" and "insufficient" care and protection behaviour.

(d) Smoking habits

We were also interested in whether and to what extent our participants smoked cigarettes.

(e) Atopic skin diathesis

History and presence of atopic major and minor signs and symptoms were studied. Since we were able to show, in a previous study, that history of flexural eczema plays an important rôle as a risk factor for occupational hand dermatitis in our study cohort, we included this variable in the multivariate analysis (6).

Outcome variable

The outcome variable of interest was the presence of an at least early stage of visible hand dermatitis at the time of evaluation according to the examining physician. A participant was considered to be a "case" if 1 or more of the following conditions were satisfied at any part of at least 1 hand: erythema and scaling, vesicles, excoriation, papules, exudation.

Statistical analysis

The aim was to follow the participants of our cohort up to the point where skin damage occurred for the 1st time. We calculated the average daily occupational and domestic exposure, weekly time spent on theoretical classes, quality of skin protection, and smoking behaviour until the diagnosis of dermatitis was primarily made and within the preceding 0.5-year period at which the skin change was observed by our physician for the 1st time. We created a control group of 3× the size of the disease group by randomly selecting 3 unaffected par-

Table 1. Incidence of hand eczema (HE) in a cohort of metalworker trainees

Evaluation period (0.5-year intervals)	1	2	3	4	5	Σ
no. participants	201	198	193	193	190	
HE incidence per period (absolute)	18	10	10	5	4	47
HE incidence per period (relative)	9%	6%	6%	3%	3%	23%

participants for each case, with the same duration of exposure (nested case-control design).

Differences between means were determined using the Mann-Whitney *U*-test and significance established at the 0.05 level. Results with $p \leq 0.1$ were considered as a "trend". Backward logistic regression was performed as a multivariate analysis, using SPSS computer software.

Results

During a period of 2.5 years of training, 47 (23%) young men developed clinical signs of at least an early stage of hand eczema. The 0.5-year period incidences of the conducted follow-ups are shown in Table 1. The observed skin changes were mainly mild. 15 of the affected persons subjectively reported a possible or likely relationship between skin condition and work. 8 persons sought medical care, and 2 had absence from work for this reason. Only 1 person gave up training due to severe hand dermatitis, and 15 trainees resigned from the work due to reasons unrelated to skin disease.

To estimate the average exposure profile during the 5 observation periods, we calculated the mean number of hours spent on jobs with exposure to the irritants of interest, and expressed this as hours per day rather than the summarized number of hours per whole evaluation period (Fig. 1). Metalworker trainees are intensively exposed to metalworking fluids of both the water- and oil-based types. It is conspicuous that there is a much higher exposure to mechanical work causing friction and pressure, as well as to metal dust, within the first 6 months of training than in any of the following periods. The same was found for the use of oil-based metalworking fluids.

We calculated the average number of hours a trainee spent on jobs with the potential hazards over a working day up to the point where skin damage was examined for the 1st time. By comparing the group of diseased with the healthy control group, there was a statistically significant difference found between these groups regarding exposure to pressure and friction. No significant difference was found for any of the other ex-

posures (Fig. 2). With regard to the average daily exposure time during the period immediately before the examination of skin changes in the diseased and parallel control group, only exposure to mechanical irritants such as friction and pressure were significantly increased in the diseased population compared to persons without skin problems (Fig. 3). Performing the same comparisons for the exposure to domestic hazards, we did not find any significant difference.

The study of skin hygiene, skin care and protection behaviour suggested a very slight improvement over the observed time (Fig. 4). However, there was no significant difference between the average skin-care behaviour of the affected and the control group up to the occurrence of skin disease. In the immediately preceding period, we found sig-

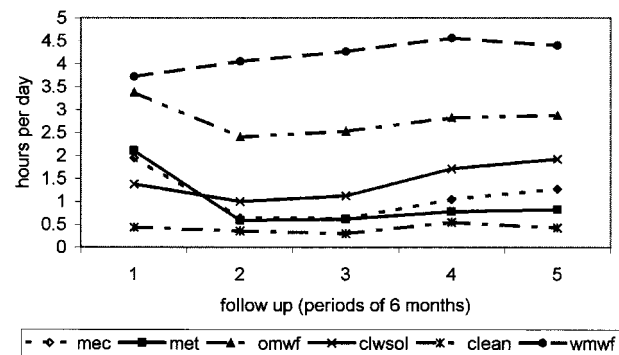


Fig. 1. Average daily exposure to irritants per workday during the observed 6-month periods (mwf: water-based metalworking fluid, omwf: oil-based metalworking fluid, mec: mechanical irritation, met: metal dust, clwsol: cleaner containing solvents, clean: cleaner without solvents).

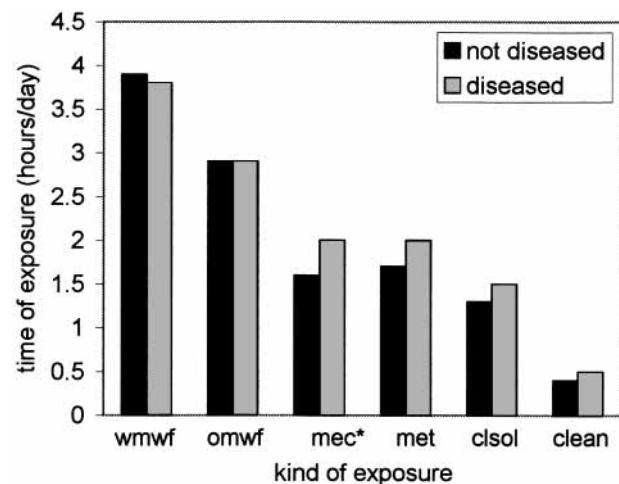


Fig. 2. Hours of exposure per day up to the point where hand eczema first occurred (wmwf: water-based metalworking fluid, omwf: oil-based metalworking fluid, mec: mechanical irritation, met: metal dust, csol: cleaner containing solvents, clean: cleaner without solvents); * $p < 0.05$.

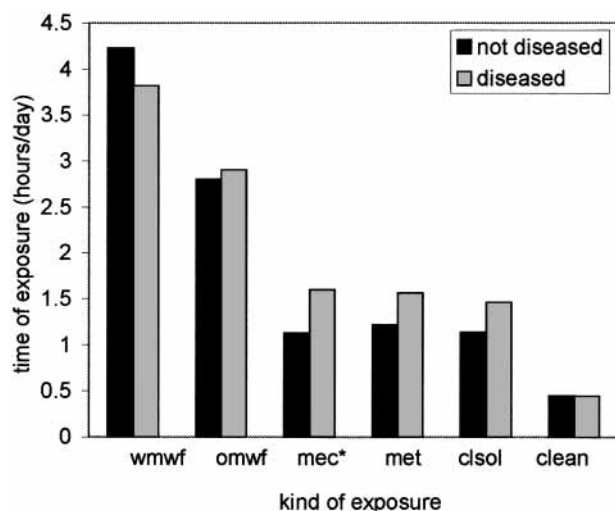


Fig. 3. Hours of exposure per day within the period where hand eczema first occurred (wmwf: water-based metalworking fluid, omwf: oil-based metalworking fluid, mec: mechanical irritation, met: metal dust, clsol: cleaner containing solvents, clean: cleaner without solvents), * $p < 0.05$.

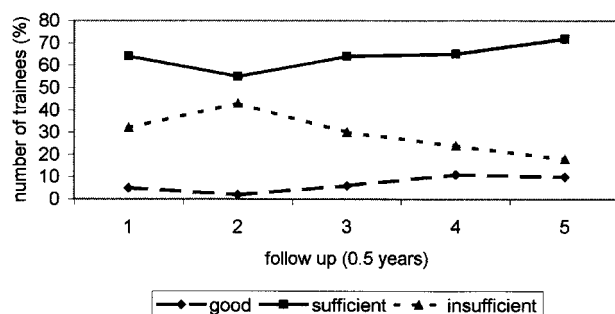


Fig. 4. Quality of skin hygiene and protection during the observed periods.

nificantly better skin care ($p = 0.04$) in those trainees who developed hand eczema than in those who did not.

To investigate the rôle of recovery time as a protective factor against the cumulative subclinical effect of irritants, we compared the average number of days per week spent on theoretical classes by trainees with and without signs of eczema in the

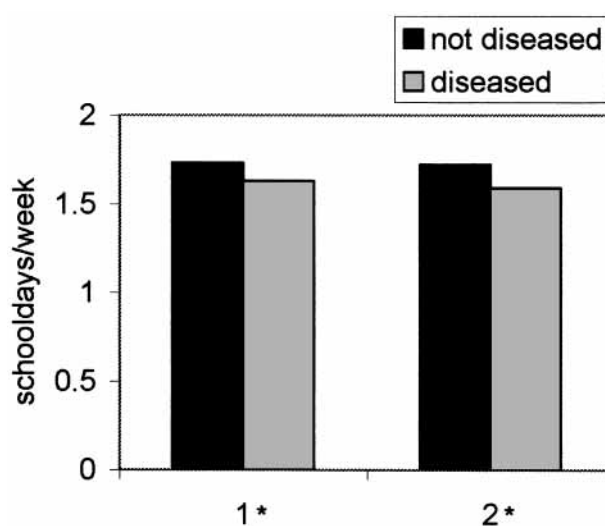


Fig. 5. Average number of school days per week; 1: until diagnosis; 2: within period when hand eczema first occurred. * $p \leq 0.05$.

period where the disease occurred and over the whole period until the disease occurred. In both tests, the affected persons had significantly less recovery time than did their healthy colleagues (Fig. 5).

The number of cigarettes a trainee smoked per day did not show a significant difference between diseased and not diseased.

Finally, we performed a multivariate analysis to observe the influence of the mentioned variables in relation to each other. All exposure factors mentioned above, domestic exposure, number of theoretical classes per week, cigarette smoking, and history of flexural eczema as a disposition factor were forced into the regression model. Since we were aware of a high amount of collinearity between some of the occupational exposures, we performed a backward analysis excluding those variables with a p -value of more than 0.1. Adjusted for all others, we found 3 variables which seem to have an important influence on the development of hand eczema in our cohort (Table 2). Again, we performed the analysis for the total time until skin disease

Table 2. Backwards logistic regression model; initially all observed variables were forced into the model; variables with $p > 0.1$ were excluded in the analyzing process; the 3 most important factors, if adjusted for all others, remained in the model

Variable	Odds ratio ¹	95% CI ¹	Odds ratio ²	95% CI ²
flexural eczema in history (yes)	9.09**	1.51–54.81	11.97**	1.12–127.97
days of theoretical classes (≤ 1.5)	2.64**	1.23–5.67	2.81**	1.20–6.56
mechanical work (h/day)	1.35*	0.98–1.86		
contact with solvents (h/day)			1.44*	0.99–2.08

¹ Variables calculated up to the point where hand eczema was first diagnosed.

² Variables calculated for the 0.5-year follow-up period when hand eczema was first diagnosed.

** $p < 0.05$; * $p \leq 0.1$ ("trend").

occurred and for the period immediately preceding diagnosis.

Discussion

Using the occupational exposure assessment described has enabled us to study semiquantitatively the individual occupational irritancy exposure in metalworker trainees in different metalworking factories. Since enterprises with a small number of employees doing a wide spectrum of different jobs are very common, this kind of assessment seems to be of practical value because it requires little time or expenditure, but is objective. Occupational exposure measures obtained by interview are always biased due to subjective judgement of exposure intensity, dependent on related skin damage.

Comparing the incidences of each observed follow-up period, we found a higher early occurrence of signs of skin damage and a decreasing number of new "cases" during the further evaluation period. As shown in Fig. 1, there is heavy exposure to mechanical hazards, such as pressure, friction, and metal dust, as well as to oil-based metalworking fluids within the 1st months of apprenticeship. During this time, the trainees are mainly involved in manual jobs at the workbench, becoming acquainted to the work environment yet insufficiently skilled to operate machines. The sudden intensive demands on the barrier function of the skin contribute to its early decompensation in persons with sensitive skin conditions. As we described recently, one should also pay attention to an allergic component, e.g., nickel sensitivity, if early skin reactions occur (6).

The decrease in new cases despite ongoing exposure may represent a hardening effect and has been observed in other studies. Goh et al. (2) found new machinists to be most susceptible to cutting fluids during their 1st weeks after starting work. Thereafter, workers appeared to develop tolerance, since the number of newly diseased decreased during the following observation time.

Heavy exposure to water-based cutting fluids did not constitute an increased risk for developing hand dermatitis. As shown in Figs. 2, 3, there was a high mean daily exposure time of approximately 4 h in both diseased and healthy trainees. As part of PROMETES, Wigger-Alberti et al. (7) studied 3 different water-based cutting fluids and compared their irritant effect, which was not dependent on the duration of exposure to but on the irritant potential of the cutting fluid itself (7).

In our study, mechanical work was a significant risk exposure if corrected for all others. This means that, on top of generally heavy exposure to various chemical substances, pressure and friction

promote the development of hand eczema by injuring the horny layer, especially on predisposed skin as in persons with an atopic skin diathesis. As recently shown, the atopy score as proposed by Diepgen et al. (8) does not, but the history of flexural eczema does, significantly indicate a higher risk for development of occupational contact dermatitis (6). Krbek & Schäfer (9) found an above-average incidence of contact dermatitis in those machinists who worked at machines with short running periods and did mechanical work in between, such as smoothing sharp cutting edges of the workpiece. Within the phase of such manual work, the cutting fluid the workers were exposed to during previous machine operating was drying on the skin surface, reaching a higher and thus irritant concentration. Workers with considerably more intensive contact with cutting fluids, without them being able to dry on the skin, did not show as many skin problems.

Regarding our results, the rôle of the number of theoretical classes per week should not be underestimated as an important protection factor. A sufficient amount of recovery time seems to inhibit a cumulative subclinical effect on the skin, which otherwise leads to irritant contact dermatitis.

Skin hygiene, skin care, and protection appeared to be of rather mediocre quality within our study population, although there is a very slight trend to the better along the overall observed time period. Still, at the end of our study only $1/10$ of our trainees earned the mark "good", while $1/5$ still had "insufficient" care and protection behaviour. The significantly better skin care of the affected persons, in the very period where skin damage initially occurred, is in accordance to Funke et al. (10), who also found better skin-care behaviour among those persons who had developed hand eczema and were now alarmed by this. There is still a need for educational work concerning the importance of skin care and protection, if caring about one's own skin is not taken seriously until the 1st signs of damage occur.

Since only $1/3$ of diseased persons subjectively considered a relation between work and hand dermatitis, other factors such as domestic exposure to skin-hazardous substances and activities may be responsible in individual cases. However, our analysis did not demonstrate a difference between persons with and without hand eczema concerning their leisure time activities. Similarly, although a few studies discuss a positive correlation between the development of hand eczema and the extent of cigarette smoking (11,12), we did not find this relationship in our cohort of metalworker trainees.

In conclusion, our results suggest that, apart from chemical irritants, mechanical factors should not be underestimated in their role as irritants to

the epidermal barrier. The study shows once more the important influence of an atopic disposition as a risk factor for the development of occupational contact dermatitis. Of practical use might be the fact that a sufficient amount of recovery time seems to play a considerable protective rôle against irritant skin diseases. Attention should be paid to a sophisticated skin hygiene and protection plan, including thorough information about risk factors and their effects on the skin.

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