

Human nail dust and precipitating antibodies to *Trichophyton rubrum* in chiropodists

R. R. DAVIES, M. A. GANDERTON* and M. A. SAVAGE

*Department of Bacteriology, St Mary's Hospital Medical School, and *Allergy Department, St Mary's Hospital, London*

(Received 14 January 1982; accepted for publication 29 May 1982)

Summary

The toe-nail dust produced in chiropodial practice causes allergic hypersensitivity and *Trichophyton rubrum* is the most common fungal cause of nail dystrophy. Use of drills and burrs to reduce the thickness of hyperkeratotic nails generates dust and chiropodists develop precipitins to *T. rubrum*. A survey into the prevalence of these antibodies in 11.2% of state-registered chiropodists is described and 14% of the profession estimated to have antibodies to *T. rubrum*. In response to a questionnaire 49% stated that toe-nail dust troubled them; complaints of nasal and eye symptoms were 72 and 41% respectively. In 384 chiropodists ventilatory function was tested with a vitalograph. Restrictive lung disease appears to be more common in chiropodists than other sedentary workers.

Introduction

In chiropodial practice the extensive use of drills and burrs to reduce the thickness of grossly thickened toe-nails, produces significant quantities of human nail dust. A single chiropodist may produce up to 3 g of human nail dust during his working day and although large particles settle quickly to the floor and, nowadays, most drills are fitted with dust extractors, varying amounts of the dust become airborne to be inhaled or impacted on to the conjunctivae. Allergic hypersensitivity to human nail dust presenting with conjunctivitis, eczema of the eyelids, rhinitis and asthma has been described by Davies and Ganderton (1975) and immediate hypersensitivity demonstrated by the application of an aqueous extract of nail dust to the conjunctiva and by prick test in the skin.

Fungal infection is a common cause of hyperkeratosis of the nails and *Trichophyton rubrum* is the dermatophyte most commonly isolated from the nails of patients attending skin clinics in hospitals. The discovery by Davies and Ganderton (1975) that a number of apparently uninfected chiropodists in London had precipitating

Correspondence: Dr R. R. Davies, Bacteriology Department, St Mary's Hospital Medical School, London W2 1PG.

antibodies to *T. rubrum* suggested the antibodies were developed in response to the inhalation of airborne antigens of the fungus. Viable *T. rubrum* has been recovered from the air, both when infected nails were being burred and under relatively still air conditions in a clinic at a school of chiropody where every drill is fitted with a dust extractor. Furthermore, it was also found that out of nine chiropodists with precipitins to *T. rubrum*, whilst eight had been in practice for more than 10 years, only one had practised for less than 10 years.

Thirty years ago, *T. rubrum* appears to have been less frequent in its occurrence (Duncan, 1945; Carlier, 1954) and in patients infected with this dermatophyte the antibody response appears to be variable and precipitins an uncommon finding.

In view of these observations a survey into the incidence of precipitating antibodies to *T. rubrum* in state-registered chiropodists (The Council for Professions Supplementary to Medicine) and the possible effects of these antibodies and nail-dust inhalation has been undertaken.

Materials and methods

At various meetings, chiropodists were asked to complete a questionnaire, volunteer a blood sample and undertake simple tests of respiratory function. Between 1975–1979 we were welcomed visitors to eleven meetings of the Society of Chiropodists, viz. the Annual Conventions at Chelsea, Bristol and Durham, 1-day Conferences in Glasgow and Llandrindod Wells, and meetings of the society at Merseyside, S.E. Essex, Manchester and District, London District, Welsh and Midlands Area Branches. We also attended meetings organized by Area Chiropodists in Aylesbury, Preston Hall (Kent) and Worcester.

Prior to each meeting the local organizer was notified of our essential requirements, a place where the chiropodists could assemble in a social setting, chairs, a table for the phlebotomists, suitable surfaces and an electricity supply for the vitalographs. Disposable 10 ml syringes, needles, 'Sterets', dressings, labelled bottles for the blood samples, questionnaire forms, Vitalograph spirometers and charts (Vitalograph Ltd, U.K.), cardboard mouthpieces and separate containers for used syringes, needles and mouthpieces were taken to the meeting. Suitable arrangements were made for all blood contaminated needles and syringes to be either incinerated, taken to a local hospital, or returned to our own laboratory for safe disposal.

Blood was not taken from any chiropodist who gave either a history of recent hepatitis or of a previous blood sample having been found to contain the viral hepatitis B antigen (Australia antigen).

Serum samples were examined for precipitins to *T. rubrum* antigens by counter current-immunoelectrophoresis (CIE) in a manner similar to that of Culliford (1964), and was for 2 hr at 20 v/cm in 0.1% agarose in a veronal buffer of pH 8.2 with wells of 3 mm diameter, 6 mm apart edge to edge. The antigens employed were prepared from 3-week-old pellicles of *T. rubrum* grown at 25°C. The mycelial mat was smashed in an MSK Braun mill (F.T. Scientific Instruments Ltd, U.K.), and after centrifugation the supernate was dialysed against running tap water overnight before freeze-drying. The cytoplasmic enriched extract was reconstituted for use at 30 g/l.

Nail-dust antigens were prepared from a collection of dust donated by the Chelsea School of Chiropody. The nail dust was extracted in distilled water containing 0.4% phenol for eight days. The extract was filtered, dialysed against running tap water and then freeze-dried for use at 30 g/l.

Serum samples from chiropodists with precipitating antibodies to *T. rubrum* and an antiserum from rabbits immunized with *T. rubrum* cytoplasmic antigen were absorbed as follows. A suspension of spores and mycelium was added to 1 ml of the serum and after 3 hr at room temperature centrifuged. The supernate was removed and the process repeated. Serum samples were similarly absorbed with human nail dust and the spores and mycelium of *T. mentagrophytes*.

An antiserum to *T. rubrum* was prepared in NZ white rabbits by subcutaneous injection of cytoplasmic antigen in Freund's complete adjuvant; 10 mg of the antigen being given on three occasions at 4-day intervals.

In tests of respiratory function, a Vitalograph spirometer was used with the subject standing. First the vital capacity (VC) was measured, then the maximum volume of air expired in 1 sec (FEV₁) and the forced vital capacity (FVC) was determined. Each measurement was compared with the normal value from the Vitalograph nomogram for persons of the same sex, height and age. The results for each chiropodist were expressed as normal, obstructive, restrictive or as combined obstructive/restrictive ventilatory disease by reference to a Vitalograph Predictor.

Results

Number of chiropodists

During the period of the survey, the number of chiropodists on the register increased from 4976 in 1976, to 5116 in June 1979. Of 660 chiropodists (12.9% of the number registered in 1979) who returned questionnaires, five were rejected from the final analysis for having only a name and address.

Affect of nail dust

The question 'Does nail dust affect you?' was answered by 635 state-registered chiropodists and twenty final-year students. A total of 299 (46.9%) replied they were not affected; fourteen of those stating the dust affected them, gave no further details, to leave 322 (49.3%) giving a positive reply and clearly stating whether or not the dust affected their eyes, nose, throat or chest, either alone or in combinations. Seventeen of the total failed to give their ages; the mean age of the 305 who reported they were adversely affected by nail-dust was 40 years, that for the 299 who considered they were not affected was 44 years and the ages ranged from 21 to 77 years.

Of the 322 chiropodists who complained of ill effects, nasal symptoms were reported by 230 (72%) with sneezing, itching and blocking in this diminishing order of frequency being described as the most common reactions. Eye symptoms were noted by 131 (40.7%), with itching, soreness, watering and burning being reported in diminishing order of frequency. The number of chiropodists reporting an effect on the chest or throat were eighty-two (24.9%) and seventy-six (23.6%) respectively.

Assuming the 12.9% sample studied is representative of the profession in the U.K., it may be calculated that there are about 2500 chiropodists who are troubled by the dust generated when toe-nails are burred and drilled, whilst about 2400 consider they are not affected. Furthermore, in addition to the state-registered chiropodists there is probably an equal number in private practice who are not registered.

*Antibodies to *T. rubrum**

When serum samples from chiropodists with precipitins to *T. rubrum* were absorbed with the spores and mycelium of the fungus, the precipitin response was lost. However,

Table 1. Incidence of precipitating antibodies to *T. rubrum* in the sera of chiropodists

Years in practice	Number with antibodies	Number without antibodies	Percentage with antibodies
0-5	10	108	8.3
6-10	17	84	16.8
11-15	13	62	17.3
16 or more	41	242	16.9

the absorption of sera with nail dust had no effect on the development of precipitating antibodies when the sera were tested against *T. rubrum*. In the preliminary survey an antigenic preparation from *T. mentagrophytes* did not react with human serum samples with precipitating antibody to *T. rubrum*. However, a very weak precipitin response was observed between *T. mentagrophytes* and rabbit antisera to *T. rubrum*.

A total of 577 volunteered blood samples and as a pilot study had shown those in practice for more than 10 years were more likely to have antibodies than those whose duration of exposure was shorter, the results are grouped as in Table 1.

When tested within 48 h of collection, 14% of all serum samples contained precipitating antibodies to *T. rubrum*. In chiropodists with five or less years in practice 8% had antibodies, whereas about 17% of those with a greater number of years in practice had antibodies.

A study of 100 serum samples collected from control subjects who were not mycologically examined but were assumed not to have infections with *T. rubrum* and from 100 patients with proven *T. rubrum* infections showed an incidence of precipitating antibodies to this fungus as 4 and 9% respectively. It was also found that in one patient with chronic onychomycosis due to *T. rubrum* of 30 years standing, there were occasions when precipitins could be detected and other occasions when they were not.

Ventilatory Function

Although studies of ventilatory function were not undertaken when the survey commenced, 398 chiropodists were tested and only fourteen failed to complete a questionnaire with all the details necessary for evaluation. Of 200 reporting nail-dust troubled them and 184 that it did not, the numbers with abnormality of ventilatory function were twenty-four (12.9%) and twenty-five (14.5%) respectively. The results of the 384 chiropodists were compared with those in a group of 250 office workers. The ages of the chiropodists ranged from 20 to 77 years with a mean age of 39.4 years (s.d. = 13.8) whilst that of the controls ranged from 17 to 67 with a mean of 36.5 years (s.d. = 14). The two groups differed significantly by age in the Mann-Whitney test with $P < 0.0036$. The chiropodists are older than some of the office employees when they commence work, and some of the self-employed continue to practice after normal retirement age. We were unable to find a better matched group of controls.

Among chiropodists, twelve (3%) had a purely restrictive, and thirty-seven (9.6%) an obstructive or combined obstructive with restrictive defect of ventilatory function (Table 2). In the control group, one person (0.4%) showed a restrictive, and

Table 2. Number of chiropodists with defective ventilatory function and precipitating antibodies to *T. rubrum*

	Obstructive	Restrictive	Restrictive/obstructive
Ventilatory defect (n)	26	12	11
Precipitin test + ve	4	0	1
Precipitin test - ve	21	12	9
Not done	1	0	1

Out of the total number of 384 persons performing these tests, 200 said nail dust affected them and 184 reported it did not. Of the 200 dust affected chiropodists twenty-four were abnormal; of the 184 chiropodists who were unaffected by the dust twenty-five were abnormal.

twenty-eight (11.2%) an obstructive or obstructive/restrictive defect. A comparison of the numbers of persons with obstructive and obstructive/restrictive defects of ventilatory function in the two groups showed $\chi^2=0.38$, 1 d.f., this is not significant. Combining chiropodists and controls there were thirteen persons with a restrictive defect of ventilatory function. Using the binomial approximation to Fisher's exact test it was shown that the probability of at least twelve out of the thirteen persons with a restrictive defect being chiropodists was $P<0.0136$, which is significant.

A total of 608 chiropodists answered questions on their smoking habits; 31% smoked and very few smoked more than fifteen cigarettes a day. In nail-dust-affected chiropodists, 30.7% smoked and amongst the chiropodists with a ventilatory defect sixteen (32.6%) smoked and thirty-three (68.4%) did not.

Ventilatory Function and Precipitins to T. rubrum

The numbers of chiropodists with defects of ventilatory function and the presence or absence of precipitins to *T. rubrum* is given in Table 2. No chiropodist with a purely restrictive defect had a positive precipitin test.

Allergic History

The question 'Have you suffered from summer hay fever?' was answered by 608 chiropodists and 129 (21%) replied that they had. When grouped into 319 stating that they were affected by nail dust and 251 who were not, ninety-one (29%) of the nail-dust-affected group and thirty-eight (13%) of the untroubled group gave a subjective report of having had hay fever. With $\chi^2=21.45$, 1 d.f., and $P<0.001$, the greater number reporting hay fever in the dust-affected group was highly significant.

In reply to the question 'Have you ever had an allergy?' 307 of the nail-dust-affected group completed the questionnaire with satisfactory details and 145 (47%) reported an allergy. In 290 chiropodists unaffected by nail dust, eighty-six (30%) reported an allergy. With $\chi^2=19.42$, 1 d.f., and $P<0.001$ the differences between the numbers reporting a history of an allergy in the two groups is highly significant.

Discussion and conclusions

In a group of 557 chiropodists, which comprised an 11.2% sample of those state registered in 1979, 17% of those in practice for 5 years or more had precipitating

antibodies to *T. rubrum*. By comparison, blood samples from 100 patients with proven *T. rubrum* infections showed only nine with precipitins to this fungus. Moreover, as only 8% of the chiropodists in practice for less than 5 years had antibodies, the number with precipitins is related to exposure or length of time in practice. Although a mycological examination of each chiropodist was not possible under the conditions of the survey, chiropodists are taught the clinical signs of tinea pedis and onychomycosis, and when questioned none reported a dermatophyte infection. *Trichophyton rubrum* is the most common fungal cause of nail dystrophy and it is most likely that the precipitating antibodies are developed through inhalation of the dust generated when infected nails are reduced with electric drills. Precipitating antibodies may develop from exposure to viable or non-viable mycelium and non-viable mycelium is a common occurrence in *T. rubrum* infected nails. However, viable *T. rubrum* has been trapped from the air of a chiropody clinic where every drill handset was fitted with a suction dust extractor and the relative amounts of viable and non-viable *T. rubrum* antigen becoming airborne have yet to be investigated. The fungus grows at blood heat, it was little known in Britain 30 years ago and the possibility of transient lung infection cannot be completely discounted. Furthermore, during the survey, although the possibility of an examination of blood samples for specific immune complexes was not foreseen, nail dust was found to activate complement by the alternative pathway (unpublished data).

None of the chiropodists with restrictive lung disease had precipitins and the numbers of chiropodists with an obstructive or a combined obstructive/restrictive defect of ventilatory function did not differ from those in the control group. For many chiropodists, human nail dust is, at the very least, a troublesome irritant and in atopic chiropodists it is immunogenic and a cause of immediate hypersensitivity. There are no commercially available prick test solutions of human nail-dust and prick skin tests were not carried out.

Pepys (1969) reports that in the hypersensitivity diseases of the lungs, precipitating antibodies may play a direct role in some cases of 'late onset' asthma by means of cytotoxic (type II) or Arthus (type III) hypersensitivity reactions. Kawai *et al.* (1973) concluded that the presence of precipitating antibodies against organic dusts cannot be considered as evidence of pulmonary disease and we have not shown the *T. rubrum* precipitins to be harmful.

Chiropody is a small profession and in order to increase the numbers studied, investigations are now being extended with podiatrists in the U.S.A. In the U.S.A. very few podiatrists use drills fitted with dust extractors and there, preliminary studies have shown 24% of the podiatrists examined have precipitins to *T. rubrum* (C. Abramson, pers. comm.). Since these studies began, the numbers of chiropodists using drills fitted with dust extractors has steadily increased. It is estimated that between 80 and 90% of the hand sets now sold are fitted with dust extraction. However, the efficiency of the extractors might well be improved (Pugh & Skone, 1972; Davies & Savage, 1980) and so long as nails are drilled or burred with electric drills, the dust exposure will be continued.

Acknowledgments

We wish to thank Drs R.C. Spencer, A. Chaudhuri, R. Dowd and M. Bennett who on different occasions assisted with phlebotomy and vitalography, Dr A.W. Frankland for advice on the questionnaire, Dr Yvonne Clayton for serum samples and Mr R.

Newson for advice with computing and statistics. We thank the volunteers from the clerical staff of London Transport and from the administrative and clerical staff of the N.W. and S.W. Thames Regional Health Authorities for undergoing tests of ventilatory function. Finally, we express our gratitude to Mr P.J. Read for facilities at the Chelsea School of Chiropody, to the chiropodists for their enthusiastic co-operation and to the Joint Standing Research Committee of St Mary's Hospital for the financial support which made this survey possible. An application to the Licensing Authority, Medicines Division, Department of Health and Social Security by M.A.G. for a clinical trials exemption certificate to use extracts made in our own laboratories for skin testing was neither granted nor denied during the period of the survey.

References

- CARRIER, G.I.M. (1954) An eight year survey of the ringworm flora in Birmingham. *Journal of Hygiene*, **52**, 264.
- CULLIFORD, B.J. (1964) Precipitin reactions in forensic problems. *Nature*, **201**, 1092.
- DAVIES, R.R. & GANDERTON, M.A. (1975) Allergic hazards in chiropody. *The Chiropodist*, **30**, 89.
- DAVIES, R.R. & SAVAGE, M.A. (1980) Dust extracting drills. *The Chiropodist*, **35**, 4.
- DUNCAN, J.T. (1945) A survey of fungous diseases in Great Britain. Results from the first eighteen months. *British Medical Journal*, *ii*, 715.
- KAWAI, T., SALVAGGIO, J., ARQUEMBOURG, P. & MARSH, D. (1973) Precipitating antibodies against organic dust antigens in human sera by counterimmunoelectrophoresis. *Chest*, **64**, 420.
- PEPYS, J. (1969) Hypersensitivity diseases of the lungs due to fungi and organic dusts. *Monographs in Allergy*, Vol. 4, Karger, Basel.
- PUGH, J. & SKONE, J.F. (1972) The health of the chiropodist in a developing community service. *The Chiropodist*, **27**, 53.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.