PAPERS AND ORIGINALS

Control of Tinea Pedis in a Swimming Bath

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Summary

Random samples of the weekly entry of bathers to a swimming pool were examined for tinea pedis and verruca before and at intervals after the supply of individual sachets of foot powder to all bathers.

Over three and a half years the overall incidence of tinea pedis decreased from 8.5% to 2.1%, and in adult males it decreased from 21.5% to 6.9%. The incidence of infection with *Trichophyton mentagrophytes* var. *interdigitale* decreased from 5.3% to 0.5%, and the incidence of infection with *T. rubrum* (1.2%-1.1%) and *Epidermophyton floccosum* (0.9%-0.5%) did not change significantly. The incidence of verruca decreased from 4.8% to 1.2%. Issuing foot powder clearly minimizes the spread of infection and is recommended for general use.

Introduction

About one year after the opening of a new swimming bath in the West of Scotland our help was requested because of the high incidence of foot infections allegedly contracted in these baths. A survey of a 10% random sample of bathers carried out six months later indicated that the overall incidence of tinea pedis was 8.5% and was highest in adult males (21.5%; Gentles and Evans, 1973).

It was decided to try to control the spread of infection, and individual sachets of foot powder* were supplied to all bathers

*Tinaderm, manufactured by Glaxo Laboratories Ltd., Greenford, Middlesex.

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on entry to the baths. Posters were displayed to encourage bathers to use the powder and to instruct them to apply it between and beneath the toes after bathing. We thought that the powder would help to dry the foot and thus restrict the development of any fungal inoculum which might be present. The presence in the powder of tolnaftate, known to be a good therapeutic agent for tinea pedis (Robinson and Raskin, 1965), would also be advantageous. The use of individual sachets though more expensive was preferred since every bather was reminded on each visit to the baths to care for his feet, as well as being provided with the means to do so.

The incidence of verruca, which was also recorded during the initial survey, was found to be 4.8% overall and highest (6.9%) in juveniles. Though the effect of the foot powder on this condition was unknown we felt that the expected improvement in the standard of foot care resulting from its supply would be beneficial.

To monitor the effect of the powder supply it was arranged that surveys would be made at intervals. This paper reports our findings over the period of three and a half years since the supply of foot powder began.

Methods

The issue of foot powder was begun about six months after the initial survey and further surveys were made 18 months later and thereafter at yearly intervals. These were arranged at the same time of year and the same procedures were used as in the initial survey—namely, selection of a 10% random sample of the weekly entry with an electronic counter and collection and processing of specimens (Gentles and Evans, 1973). As before the incidence of verruca was also noted.

The differences in the proportion of infected persons within each age and sex group over the four surveys were tested statistically using methods detailed by Snedecor and Cochran (1967) and by the χ^2 test. Snedecor's and Cochran's method involved application of a variance test for the equality of proportions of infected and non-infected persons within each survey. In those cases showing significant differences in proportions of infections a further test was conducted to detect whether there was a definite downward trend in these proportions with time.

Results

On each occasion about 1% of those drawn in the sample did not appear for examination or refused. The number of individuals interviewed and examined was, therefore, about 9% of the entry except in the second survey when, because of administrative difficulties, it was 7%. The composition of the samples was similar in each survey, with about 3-4% more of the adult entry being examined than of juveniles except in the final survey when the adult sample was lower (table I).

TABLE I—Numbers of Bathers selected and examined in each Period of Study

	1969	1971	1972	1973
No. of juveniles (% of all juveniles)	508 (8.3)	341 (5.8)	467 (7.9)	490 (9.5)
No. of adults (% of all adults)	265 (12.2)	274 (9.9)	313 (11.1)	177 (7.3)
Total (% of all users)	773 (9.3)	615 (7.1)	780 (8.9)	667 (8.8)
No. of refusals (% of all users)	75 (0.9)	93 (1.1)	67 (0.8)	75 (1.0)
Total users	8,291	8,672	8,720	7,553

At each survey sufficient material was obtained from about 50% of all those examined to allow the full laboratory investigation. The number of people from whom no specimen could be obtained, however, increased from 15% in the initial survey to 17%, 27%, and 40% in the last three surveys, with a concomitant reduction in the number of people from whom a specimen sufficient for partial investigation was obtained

TABLE II—Number of Laboratory Investigations performed in each Period of Study

	1969	1971	1972	1973
Culture and microscopy	429 (55.5%)	384 (62.4%)	377 (48.3%)	349 (52.3%)
Culture only	226 (29.2%)	128 (20.8%)	192 (24.6%)	49 (7.4%)
No specimen	118 (15.3%)	103 (16.8%)	211 (27.1%)	269 (40.3%)
Total	773 (100%)	615 (100%)	780 (100%)	667 (100%)

The numbers of bathers examined in each category and the incidence of tinea pedis found by laboratory investigation in each of the surveys is shown in table III. The overall incidence dropped in the four-year period from 8.5% to 2.1%. When figures for male bathers, accounting for over 90% of the infections and the only group with sufficient numbers for valid analysis, were analysed statistically this difference was highly significant ($P < 0.001$). Further statistical analysis confirmed a definite downward trend ($P < 0.001$) in the four-year trial period.

TABLE III

The species of dermatophytes isolated are given in table IV. The number of infections due to *Trichophyton rubrum* remained about the same for each survey (1.1% to 1.3% of

TABLE IV—Species of Dermatophytes Isolated and Their Incidence in Bathers Examined in each Period of Study

	1969	1971	1972	1973
	No. (%) of Isolates	No. (%) of Isolates	No. (%) of Isolates	No. (%) of Isolates
<i>T. mentagrophytes</i>				
var. <i>interdigitale</i>	41 (5.3)	8 (1.3)	7 (0.9)	3 (0.5)
<i>T. rubrum</i>	9 (1.2)	8 (1.3)	10 (1.3)	7 (1.1)
<i>E. floccosum</i>	7 (0.9)	5 (0.8)	1 (0.1)	3 (0.5)
Two species isolated	2 (0.3)	1 (0.2)	0 (0)	0 (0)
Positive on microscopy (no culture)	7 (0.9)	3 (0.5)	1 (0.1)	1 (0.2)
Total	66 (8.5)	25 (4.0)	19 (2.4)	14 (2.1)

the total bathers examined); and those due to *Epidermophyton floccosum* varied only slightly, the incidence in 1969 being 0.9% of those examined compared to 0.5% in 1973. Statistical analysis of the figures for these two species showed that the variation was not significant. The significant reduction was in the incidence *T. mentagrophytes* var. *interdigitale* infections, which fell from 5.3% of those examined in 1969 to 0.5% in the last survey ($P < 0.001$ for males), and again a significant downward trend was confirmed ($P < 0.001$). The change in the infection pattern in adult males is shown in the graph.

Incidence of tinea pedis and of three species of dermatophytes in adult male bathers. T.I. = *T. mentagrophytes* var. *interdigitale*, T.R. = *T. rubrum*, E.F. = *E. floccosum*.

The clinical data obtained were classified according to the most serious symptom seen in each individual and these are presented in table V. While the proportion of individuals with only minor clinical symptoms remained at virtually the same level throughout there was a decrease in the more serious conditions of maceration and fissures in successive surveys (1% in 1973 compared to 10.6% in 1969). A number of individuals who were infected had no lesions and the proportion of the sample in this "carrier" category was 2% in the first survey, falling to 0.3, 0, and 0.5% in 1971, 1972, and 1973 respectively.

TABLE III—Incidence of Tinea Pedis according to Age, Sex, and Period of Study

	1969		1971		1972		1973	
	Number Examined	% Infected	Number Examined	% Infected	Number Examined	% Infected	Number Examined	% Infected
Adult males	205	21.5	230	10.4	249	6.8	116	6.9
Adult females	60	3.3	44	0	64	0	61	1.6
Juvenile males	288	6.3	198	0.5	265	0.4	293	1.4
Juvenile females	220	0.9	143	0	202	0.5	197	0.5
Total	773	8.5	615	4.0	780	2.4	667	2.1

TABLE V—Clinical Appearances of Bathers' Feet in each Period of Study

	Normal		Peeling		Maceration		Fissure	
	No.	%	No.	%	No.	%	No.	%
1969	370	47.9	321	41.5	55	7.1	27	3.5
1971	250	40.7	312	50.7	39	6.3	14	2.3
1972	375	48.1	392	50.3	10	1.3	3	0.4
1973	336	50.4	324	48.6	4	0.6	3	0.5

In the first survey 45.2% (28) of infections in males occurred in those swimming more than once weekly, 43.5% (27) in those swimming weekly, and only 11.3% (7) in those bathing irregularly. In the final survey there was a highly significant reversal; only 8.3% (1) of the infections occurred in those bathing more than once weekly, 41.7% (5) in those bathing weekly, and 50% (6) among those bathing irregularly ($P < 0.001$).

In 1969 and 1973 bathers were asked if they were aware that foot infections could be contracted in communal bathing places and if they took precautions to prevent infection. In 1969 only 60% of adults and 30% of juveniles knew that communal bathing places were a common source of infection and even fewer took precautions (Gentles and Evans, 1973). In 1973 85% of adults and 64% of juveniles said they knew of the possibility of contracting tinea pedis and verrucae in swimming baths, and almost all bathers (94%), regardless of their knowledge of tinea pedis, said they used the supplied powder after bathing though very few took any additional precautions.

The incidence of verruca also dropped considerably between 1969 and 1971 and subsequently remained at a low level among bathers at this swimming pool (table VI). The change in incidence was very significant for juvenile females ($P < 0.001$), and further statistical analysis showed a definite downward trend ($P < 0.001$), and was significant for male juveniles ($P < 0.07$), again with a significant downward trend ($P < 0.05$).

TABLE VI—Incidence of Verruca in Bathers in each Period of Study

	1969		1971		1972		1973	
	No.	%	No.	%	No.	%	No.	%
Male juveniles ..	12	4.1	8	4.0	3	1.1	5	1.7
Female juveniles ..	23	10.9	1	1.4	1	0.5	2	1.0
Adults ..	2	0.8	3	1.1	2	0.6	1	0.6
Total	37	4.8	13	2.1	6	0.8	8	1.2

Discussion

There have been few attempts to control the spread of tinea pedis in communal bathing places, particularly in public swimming baths. This is possibly because of the difficulties involved in this type of investigation. We were fortunate to have the full co-operation of the local administrative and medical authorities, the baths' staff, and the public. As a result the samples drawn were fully representative and only in the last survey was there any variation in composition when the adult sample was lower than in the previous three surveys. Because in the first survey the highest incidence of infection (21.5%) was found in adult males this reduction in the size of the sample was unfortunate. Statistically, however, there is no evidence to suggest that any significant increase in infection occurred within this group during the year between

the last two surveys. Neither were the results likely to have been influenced significantly by the variation in the proportion of the samples not examined mycologically, which probably increased in later surveys because of a general improvement in the condition of the feet. It is not unusual to isolate dermatophytes from "normal" feet (English *et al.*, 1961) and in our surveys the proportions of lesion-free "carriers" were 2, 0.3, 0 and 0.5% of all those examined mycologically. These figures for the total infection rates in our mixed population are comparable with those of other workers (English *et al.*, 1961; Götz and Hantschke, 1965; English *et al.*, 1967), and if translated to take account of the proportion of symptom-free persons from whom a specimen was not obtained (15% in 1969 and 40% in 1973) would give an increased overall incidence of only 0.3% in 1969 and 0.2% in 1973.

The most commonly used procedure aimed at controlling the spread of foot infections in communal bathing places is the foot bath through which the bather is intended to wade before bathing. Critical evaluation of these foot baths has seldom been made, but they are generally believed to have little effect on the spread of foot ringworm (Annan, 1948; English, 1969; Gentles and Holmes, 1957) and this view has been supported by laboratory experiments which showed that the fungal material in skin scales is well protected from disinfectants (Gentles and Dawson, 1956). The other "control" procedure of which we have detailed information concerns the use of foot sprays which release a fine (atomized) spray of an aqueous antiseptic compound to the feet after bathing. Investigations of foot sprays in Britain and Germany indicate that they do not control the spread of tinea pedis (Spencer, 1951; Götz and Hantschke, 1965), and Götz and Hantschke also found that only 10-13% of coal miners used them daily.

Our procedure was designed to try to overcome such defects, firstly, by supplying the antifungal substance in a powder base which would absorb residual moisture on the feet and, secondly, by supplying it in individual sachets. The disadvantages of a central supply unit were thus avoided, and also the bathers were reminded at each visit of the need to care for their feet.

The results over the period of the four surveys indicate that the procedure was remarkably successful. The dramatic drop in the incidence of tinea pedis after 18 months of supply of the foot powder was better than envisaged. Had the original level of infection been contained we should have believed the procedure had merit and deserved further favourable consideration. The continuation of the downward trend in the level of infection in the subsequent years, however, confirms the value of the use of this foot powder as a prophylactic procedure in public swimming baths.

Analysis of the infection rates with various species of dermatophytes, however, shows clearly that in considering the incidence of tinea pedis one must take into consideration the species of fungi involved. *T. mentagrophytes* var. *interdigitale* was responsible for most infections in male bathers (13.2% of adults and 4.2% of juveniles) before introduction of the powder. This incidence was significantly reduced to 0.9% and 0.3% respectively in the final survey, which indicates the efficacy of the powder regimen against this species and confirms the finding of many clinical workers that *T. mentagrophytes* var. *interdigitale* infections are relatively easy to clear. The incidence of infections with *T. rubrum* and *E. floccosum* varied little in these groups during the survey period, which suggests that though the incidence did not decrease the spread of infection was in effect checked.

We believe that the major effect of the foot powder is to prevent establishment of infection, but as our results show it apparently also cures existing infections caused by *T. mentagrophytes* var. *interdigitale*. The chance of curing an infection increases with the frequency of application, and it is not surprising, therefore, to find a reversal of the situation in the initial survey, when those bathing most often had the highest incidence of infection, to that four years later when

only 8.3% of infections occurred among those bathing more than once a week. Since our investigation began Burrell and Nemlich (1970) have reported on the efficacy of tolnaftate powder in treatment as well as prophylaxis of tinea pedis under strictly controlled conditions in a closed community. Unfortunately, they did not indicate the species of dermatophytes responsible for the infections within their group of patients and therefore we do not know if any differential effect of the powder according to dermatophyte was evident.

The effect of the powder on verruca is not known and the reduction in the incidence of this disease may be attributed to a number of factors, the exact or relative effect of any one of which is impossible to assess. The publicity about foot infections which resulted from the initial survey and the subsequent issue of the foot powder emphasized the role of swimming baths in the spread of all foot infections. As a result school parties were more carefully screened for verrucae before coming to the baths, and the pattern of infection changed from the highest incidence occurring in girls in school sessions in 1969 to the highest incidence occurring in boys in 1971 and in boys at free-swimming sessions in 1972. In the final survey no cases of verruca were found in children attending during school swimming sessions. The bath staff also instituted occasional checks on children at free-swimming sessions to try to persuade those with verrucae to stay away from the baths until treated and cleared of infection. To what extent the reduction in the incidence was influenced by the drying effect of the powder and the constant reminder of the need for foot care resulting from its supply is uncertain, but their effect cannot be entirely discounted.

Foot infections are mainly contracted at communal bathing places and will become of increasing importance as these facilities are extended. The chairman of the National Sports Council has said, "In 1969 there were only 10 indoor sports centres, but in 1973 there were 100 with another 200 in planning" (Bannister, 1973). In Scotland also there has been a very considerable increase in the number of swimming baths and sports centres, and plans exist for further expansion to virtually double the present number within the next few years (Muir, 1973). With the increasing availability and use of such facilities it is reasonable to assume that, unless some measure of control is provided, the level of infection in the population at large will rise, thus in time providing a higher initial inoculum within new establishments and consequently increasing the exposure to and rate of spread of infection. Moreover, a change in the relative importance of the species of dermatophytes is not unlikely. During 1973 we investigated unselected representative samples of young competitive swimmers and sportsmen. In both groups the incidence of infection was about 35% and the proportion of *T. rubrum* to *T. mentagrophytes* var. *interdigitale* was 2:1. In contrast most infections in the general population are at present caused by *T. mentagrophytes* var. *interdigitale* (English and Gibson, 1959; English and Turvey, 1968).

Clearly a large proportion of the general population do not appreciate the risks of communal bathing until they suffer the discomfort of infection (Gentles and Evans, 1973). Publicity is greatly needed to inform all users of communal bathing facilities that they are constantly being exposed to infection and that each individual must protect himself. In addition, the public should be informed which protective procedures are likely to be effective and which—for example, foot baths—are not.

Our investigations have shown that the issue to bathers of individual sachets of foot powder will control the spread of tinea pedis. The acceptability of the procedure is clearly shown by the fact that only 6% of bathers said they never applied the powder as directed. Since this result was obtained after three and a half years of supply it can be assumed that the regularity of use is unlikely to decrease with time and, moreover, that there are no unacceptable aspects associated with the regular or long term use of the powder.

The cost of the foot powder relative to the overall running costs of swimming baths or the increase in entry charge necessary to cover the cost of a sachet of powder is small. It is hoped that the procedure will be adopted for more general use.

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