Onychomycosis and Other Superficial Fungal Infections of the Foot in the Elderly: A Pan-European Survey

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Key Words
Onychomycosis • Fungal infections • Epidemiology

Abstract
Background: The escalating ageing population in the western world has led to an increased incidence of superficial fungal infections. The most common infections include onychomycosis, tinea pedis and tinea cruris. With the increasing life expectancy, the prevalence of onychomycosis and other superficial fungal infections is likely to increase further without adequate prevention and treatment. Objective: To study the prevalence of foot mycoses in Europe. Method: The Achilles project represents a survey of 90,085 subjects from 16 European countries. Results: Approximately half of the total screened population had evidence of fungal foot infection, with tinea pedis and onychomycosis affecting one quarter of these individuals. Advancing age showed an unfavourable effect on the prevalence of these infections. Conclusion: As the number of aged people in developed countries continues to increase, skin diseases will constitute a greater pharmaco-economic concern of worldwide healthcare. Better recognition by clinicians and patients of mycotic foot disease will help prevent direct morbidity and further complications.

Introduction
Both old age and chronic exposure to the sun increase the risk of developing some specific skin disorders. Indeed, estimates suggest that 60% of people over 65 years have one or more dermatoses for which they need medical advice or treatment [1]. Among them, onychomycosis is a common infection that can result in significant morbidity. Clean, healthy nails are important in our society and dystrophic nails can be a social impediment and cause significant embarrassment, thereby affecting a patient’s self-esteem. In addition, thickened nails can be painful, interfere with the function of the nail unit, affect the ability to use the hands and fingers and may cause discomfort in walking. Indeed, patients with onychomycosis often report quality of life problems [2, 3]. The prevalence of tinea pedis and onychomycosis has increased steadily since 1950 [4]. The estimated lifetime risk of acquiring a superficial fungal infection is approximately 10–20% [5]. Onychomycosis affects mainly adults, although epidemiological data are limited [3, 6]. Trauma and sport activities are risk factors. Several patient groups also seem to be especially at risk of infection, such as individuals with diabetes, HIV infection, renal disease or psoriasis [7, 8]. Available epidemiological data also indicate that the prevalence of onychomycosis increases with ageing [9]. For example, results from surveys suggest that...
overall the incidence is much higher in adults than in children, afflicting 0.6% of children under the age of 18 years, approximately 10–20% of adults and 15–40% of elderly people [4, 7, 8]. Many older individuals are also unable to cut their thickened onychomycotic nails because of poor vision or arthralgia and rely on others to complete this task. With the increasing life expectancy in the western world, the prevalence of onychomycosis and other superficial fungal infections is likely to increase further without adequate prevention and treatment [10].

An epidemiological study has examined the prevalence of onychomycosis and tinea pedis in 210 elderly subjects presenting altered nails in order to determine their causative agents, incidence and clinical characteristics [9]. Onychomycosis was confirmed microbiologically by the isolation of fungi in 35% of patients, mainly from toenails. In addition, tinea pedis occurred in 25% of the patients. The most frequent clinical characteristics were the thickening, opacity and presence of longitudinal ridging on the surface of the nails. *Trichophyton rubrum* was the most common dermatophyte isolated and *Candida parapsilosis* was dominant among *Candida* spp. Diabetes mellitus was the most prevalent associated disease.

**Achilles Prevalence Survey**

In the Achilles prevalence survey conducted on foot disease, a major objective was to investigate the effect of age on the prevalence of foot diseases in Europe. In the first part of the study, 19,588 subjects from 11 European countries received a free clinical examination of their feet by dermatologists and a mycological examination if a fungal infection was suspected [3, 6]. Overall, 61.3% of persons included in the study were assessed as having a disease of the foot. A logistic analysis model was used to examine the prevalence of foot disease and age. It indicated that the risk of foot disease was approximately 1.77 times higher for men than women. For age, the risk of foot disease increased by approximately 4% for each additional year.

In the recent second phase of the Achilles survey, over 70,497 subjects from 16 different European countries received a free clinical examination of their feet by their general practitioners. This survey revealed that approximately half of the screened population had evidence of fungal foot infection, with tinea pedis and onychomycosis affecting one quarter of these individuals. The most frequent foot diseases were fungal infections, being reported in 40.6% of individuals. The model predicted that the risk of a fungal infection was approximately 1.5 times higher for men than for women. For age, the risk increased approximately 1.1 times with each additional year for both genders. The risk of a fungal infection increased up to a maximum of 75 years (fig. 1). The odds ratios for the prevalence of all foot diseases and fungal foot disease in relation to age group was assessed using a multivariate logistic regression model (table 1). A significantly unfavourable effect of age on the prevalence of foot disease and fungal foot infection was found.
Fig. 2. Distribution of tinea pedis by age.

Fig. 3. Distribution of onychomycosis by age.

Table 1. The prevalence of foot disease (n = 18,313) and fungal foot disease (n = 17,661) depending on age using logistic regression analysis

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Foot Disease odds ratio</th>
<th>95% confidence interval</th>
<th>p value</th>
<th>Fungal foot disease clinical odds ratio</th>
<th>95% confidence interval</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults (18–39 years)</td>
<td>1.15</td>
<td>1.03–1.28</td>
<td>0.014</td>
<td>2.65</td>
<td>2.25–3.13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Middle-aged (40–64 years)</td>
<td>2.30</td>
<td>2.05–2.57</td>
<td>&lt;0.001</td>
<td>6.93</td>
<td>5.87–8.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Elderly (&gt;64 years)</td>
<td>3.10</td>
<td>2.70–3.57</td>
<td>&lt;0.001</td>
<td>7.75</td>
<td>6.47–9.29</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
A clinical diagnosis of tinea pedis was reported in 26.3% of individuals. Again, the prevalence was higher among men than women and increased approximately 9% with each additional year of age, up to a maximum of 68 years (fig. 2). In total, onychomycosis as assessed clinically affected 29.6% of individuals. The risk for men was approximately 1.27 times higher than for women. For both genders, the risk increased approximately 1.13 times with each additional year, reaching a plateau value at 79 years of age (fig. 3). Using a multivariate logistic regression model, the odds ratios for the prevalence of tinea pedis and onychomycosis were estimated in relation to the age group (table 2). Increasing age exhibited a significantly unfavourable effect on the incidence of tinea pedis or onychomycosis. The incidence of simultaneous tinea pedis and onychomycosis also increased with age, with 25.7% of elderly individuals having both types of infection.

The most frequently isolated fungus from nails was *T. rubrum* in all age groups (fig. 4). Although other fungi (*Aspergillus* spp., *Scopulariopsis brevicaulis* and *Candida* spp.) were less common, their prevalence generally increased with age (fig. 4). The frequency of mixed fungal growths from skin or nail samples was also more prevalent among the elderly population. In contrast, the prevalence of *Trichophyton*, *Candida* and *Aspergillus* spp. declined with increasing age in skin lesions involving the feet. Apart from age and gender, other important predisposing factors for increasing the overall risk of fungal infection included diabetes and vascular disease.

### Table 2. Age-specific prevalence of tinea pedis (vs. no tinea pedis) and onychomycosis (vs. no onychomycosis) using logistic regression analysis (data on 17,648 cases)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Tinea pedis (clinical)</th>
<th></th>
<th></th>
<th></th>
<th>Onychomycosis (clinical)</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>odds ratio</td>
<td>95% confidence interval</td>
<td>p value</td>
<td>odds ratio</td>
<td>95% confidence interval</td>
<td>p value</td>
<td></td>
</tr>
<tr>
<td>Adults (18–39 years)</td>
<td>2.38</td>
<td>1.97–2.86</td>
<td>&lt;0.001</td>
<td>3.61</td>
<td>2.75–4.72</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Middle-aged (40–64 years)</td>
<td>4.15</td>
<td>3.45–4.99</td>
<td>&lt;0.001</td>
<td>12.45</td>
<td>5.64–7.40</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Elderly (&gt;64 years)</td>
<td>3.66</td>
<td>2.99–4.47</td>
<td>&lt;0.001</td>
<td>17.94</td>
<td>13.63–23.61</td>
<td>&lt;0.001</td>
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</table>

### Conclusion

Elderly patients are more likely than the general population to have cutaneous diseases due to structural changes, altered immunological response and different environmental influences. Mechanical and functional changes, as well as the reduced immunological capacity of aging skin predispose the elderly to a variety of skin diseases including fungal skin infections. This pan-European Achilles survey was undertaken to gather basic information on the epidemiology of foot diseases in the general population. The results revealed that the most frequent foot diseases were fungal infections, especially onychomycosis and tinea pedis. The prevalence of all foot diseases and particularly fungal infections increased with advancing age. More men as compared with women had fungal infections of the feet. Such findings are in line with a previous study conducted in Britain.
Indeed onychomycosis is often thought to affect about 3% of the general population and up to 5–15% of older people.

The mycological details of the Achilles survey should be taken with caution. Due to the large pan-European involvement, uniformity in mycological sampling is not guaranteed. Following the design of such an epidemiological survey, histology and repeated cultures were not performed. Hence, some false-negative and false-positive data should be expected. However, the large size of the screened population likely minimizes the bias.

The nature of fungal pathogens in nails is a matter of vivid controversy [12–16]. The present data confirm the presence of dermatophytes, yeasts and moulds either singly or in various combinations in altered nails. Whether they are primary pathogens or opportunistic organisms cannot be proven here. Only time-consuming and expensive laboratory investigations can address this quandary [16].

These results indicate that clinicians and patients need to pay more attention to foot disease in order to limit morbidity and further complications. As the number of aged people in developed countries continues to increase, skin diseases may represent an increasing proportion of worldwide healthcare. Clinicians must recognize and treat these processes early in order to avoid complications in this vulnerable population.

References