DANISH MEDICAL JOURNAL

Original Article

Rental shoes are not a source of tinea pedis

Tanja Roehmer Wriedt[1], Kristoffer Nagy Skaastrup[1], Adeline Held Everland[1], Karen Marie Thyssen Astvad[2], Maiken Cavling Arendrup[2, 3, 4], Viktoria Sigsgaard [1], Gregor Borut Ernst Jemec[1, 4] & Ditte Marie Lindhardt Saunte [1, 2, 4, 5]

1) Department of Dermatology, Zealand University Hospital, Roskilde, 2) Unit of Mycology, Statens Serum Institut, 3) Department of Clinical Microbiology, Copenhagen University Hospital – Rigshospitalet, 4) Department of Clinical Medicine, University of Copenhagen, 5) Department of Dermatology and Allergy, Copenhagen University Hospital – Herlev and Gentofte Hospital, Gentofte, Denmark

Dan Med J 2025;72(9):A03250148. doi: 10.61409/A03250148

ABSTRACT

INTRODUCTION. Tinea pedis is a common disease that affects up to 70% of adults during a lifetime. Most cases are caused by *Trichophyton species*. Worldwide, terbinafine resistance among dermatophytes is rising, which is concerning as terbinafine is the first-line treatment. Due to concerns regarding potential epidemics, this study was conducted to investigate whether rental climbing and bowling shoes are a source of societal spread.

METHODS. A sampling was conducted on 103 pairs of rental climbing shoes and 102 pairs of bowling shoes across four climbing clubs and four bowling clubs, utilising a previously published swabbing technique and culturing. Positive cultures were identified by microscopy and internal transcribed spacer sequencing. Additionally, a questionnaire was completed regarding shoe material and disinfection method.

RESULTS. No dermatophytes were detected on any of the rental shoes. All bowling clubs and one climbing club employed fungicidal cleaning methods.

CONCLUSION. Rental climbing and bowling shoes are unlikely to present an immediate risk for the societal transmission of dermatophytes.

FUNDING. The Royal Hofbundtmager Age Bang Foundation is acknowledged for funding the laboratory work (number 9622-3439).

TRIAL REGISTRATION. The local committee of research ethics (Region Zealand, Denmark, EMN-2021-01399) waived ethical approval.

Tinea pedis is a common disease with an adult lifetime occurrence of up to 70%. Most cases are caused by *Trichophyton* species, especially *T. rubrum,* and concomitant tinea unguium can evolve from the infection [1]. The prevalence of tinea pedis is especially high among miners (72.9%) and European marathon runners (31.0%) [1]. To the best of our knowledge, no population-based study has determined the prevalence of tinea pedis in Denmark. However, Svejgaard et al. reported a prevalence of 6.2% in newly enlisted Danish military recruits [2]. In comparison, the prevalence in the neighbouring Swedish population was estimated to 4.4% [3]. General risk factors for tinea pedis are increasing age, male gender, environmental factors (e.g. high temperatures and humidity), use of public bathing facilities, performing sports activities (e.g. swimming) and wearing second-hand and/or occlusive shoes [1, 4]. Furthermore, the rising terbinafine resistance, which is the first-line treatment of tinea pedis [5], is a concern, especially as it may cause epidemics when transferred to other persons [6]. We have previously addressed the problem by examining how to eliminate terbinafine-susceptible and

resistant *Trichophyton* species inoculated on socks [7]. The methods which efficaciously eradicated the fungi were washing at 60 °C or soaking the socks in a quaternary ammonium compound solution for 24 hours [7].

This study aimed to investigate the risk of societal transmission of dermatophytes causing tinea pedis in rental climbing shoes and bowling shoes. These shoe types were selected due to their occlusive nature, which can contribute to the development of a humid and warm environment. Additionally, they are available for rental and are repeatedly used by multiple customers.

Moreover, climbing shoes are worn without socks, which may further increase the risk of dermatophyte transmission.

Methods

Sampling

Fungal sampling was performed at four climbing and bowling clubs in the Capital Region, Copenhagen, and Region Zealand, Denmark, using a previously described swab technique [8, 9]. A sampling of 102 pairs of shoes per sport was based on a sample size calculation using Epitools with the following assumptions: a confidence interval and sensitivity of 95%, a specificity of 90%, a desired precision of 8% and a 4% prevalence of tinea pedis. Assuming that the United Kingdom and Denmark share shoe sizes, the average European shoe size is 42.5 for men and 39.0 for women [10]. Therefore, the sampled shoes included the most prevalent shoe sizes used in the Danish population (sizes 36-46) and were included according to 80% of a normal distribution.

Sampling was performed from the apical part of the pair of shoes corresponding to a 5 × 5 cm area using a sterile cotton swab moistened with sterile distilled water [8, 9] and inoculated onto Sabouraud agar supplemented with chloramphenicol and cycloheximide (SAB+C+C) (SSI Diagnostica, Hillerød, Danmark). Minimisation of contamination was ensured by placing the plates in separate plastic bags. Additionally, a written questionnaire was administered to gather information on the origin, material, frequency of use and cleaning methods of the rental shoes (**Table 1**).

TABLE 1 Data obtained by questionnaire from the club employee(s) regarding shoe material, disinfection methods and rental frequency and the microbiological findings.

	Climbing shoes					Bowling shoes				
	club					club				
	A	B	C	D	total	A	B	C	D	total
Shoe material										
Insole	Rubber	Rubber	Rubber	Rubber	Rubber	-	-	-	-	-
Vamp	Synthetic material	Microfibre, polyurethane or polycotton	Synthetic material, leather, polyurethane, or suede	Suede	-	-	-	-	-	-
Whole shoe	-	-	-	-	-	Leather	Leather	Leather	Leather	Leather
Do you clean your rental shoes?	Yes	No	Yes	Yes	3/4 yes	Yes	Yes	Yes	Yes	Yes
Cleaning method	Washed in washing machine at 40°C after use	None	Sporadic with soap water	Spray with 70% ethanol from Lomax		Bowltech Shoe Spray after every use[a]	Bowltech Shoe Spray after every use[a]	Bowltech Shoe Spray after every use[a]	Bowltech Shoe Spray after every use[a]	Bowltech Shoe Spray after every use[a]
How often are the rental shoes worn?	1 × daily	2 × a year	1 × weekly	1 × weekly	-	-	-	-	-	-
Pairs of shoes sampled, n	25	27	31	20	103	20	30	27	25	102
Dermatophytes, n	0	0	0	0	0	0	0	0	0	0

a) Contains perfume and < 5% of non-ionic surfactants, didecyldimonium chloride and isopropyl alcohol.

Analysis/laboratory techniques

The SAB+C+C agar plates were incubated at 25 °C for four weeks [11], and positive cultures were examined by macroscopic and microscopic examination by imprinting colony material to tape and transferring it to a microscope slide stained with lactophenol blue. Plates that grew only bacteria and/or yeasts were excluded from further analysis. All moulds suspected to be dermatophytes were planned to be internal transcribed spacer sequenced [11, 12]. The occurrence of other yeasts and moulds was not assessed due to the selective agar plates used.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics

Participation was voluntary, and the collected data were anonymised before analysis. The participating climbing and bowling clubs could request the full test results.

Trial registration: Ethical approval was waived by the local committee of research ethics (EMN-2021-01399).

Results

Four climbing clubs and four bowling clubs (designated as clubs A-D) were included in this study. A total of 103 pairs of climbing shoes and 102 pairs of bowling shoes were selected for sampling (Table 1). Due to differences in the rental shoe inventory between the clubs, the number of rental shoes available for sampling varied from 20 to 31 per club. No dermatophyte isolates were detected in any of the 103 pairs of climbing shoes or 102 pairs of bowling shoes.

All clubs completed the questionnaires, and the corresponding results are presented in Table 1.

Discussion

All bowling clubs and one climbing club (club D) employed fungicidal disinfection methods for shoe cleaning.

No dermatophytes were cultured from any of the sampled shoes. Given that dermatophytes have previously been isolated from footwear [13], these findings suggest that the disinfection protocols implemented by the climbing and bowling clubs may be sufficient to prevent transmission of tinea pedis.

However, the study has limitations, including a relatively small sample size, voluntary club participation, which may have favoured clubs with a high standard for shoe disinfection, and the fact that the study was conducted just after the COVID-19 pandemic, when social transmission might have been low due to lockdown periods.

One could argue that conditions were not optimal for the dermatophytes outside keratinised tissue. However, it has previously been shown that dermatophytes spores can survive in hair and dermal scales for several months to years; thus, fomites can be an important source [14].

Another possible explanation for the absence of positive findings is that climbers and bowlers may have a lower prevalence of tinea pedis and tinea ungvium than the general population. This could be attributed to the necessity of maintaining healthy feet to perform their sports effectively, as symptoms such as itching and stinging could impede athletic performance.

To our knowledge, no studies quantify the prevalence of tinea pedis and tinea ungvium among climbers or bowlers, even though they meet several risk factors (e.g., use with bare feet, closed shoes, warm and humid environment) for developing tinea pedis [15] and subsequently tinea ungvium [16, 17]. The seasons might also influence this study. About 75% of the samples were collected during autumn and winter, whereas a study found that fungal infections of the feet were most prevalent in spring [4].

This study conducted an examination of samples via culture. Studies have shown that examination of dermatophytosis in skin samples via PCR has a higher sensitivity than traditional culture [18, 19]. The efficacy of PCR detection on fomites such as footwear remains uncertain. However, the use of molecular detection may have influenced the results. Consequently, samples that were potentially PCR-positive may have yielded false negatives because culturing was used as the detection method.

Conclusion

This study did not detect any dermatophytes in the 103 pairs of rental climbing shoes and 102 pairs of bowling shoes analysed. Consequently, rental climbing shoes and bowling shoes seem unlikely to pose an immediate risk for societal transmission of dermatophytes. However, continued screening of rental footwear for fungal elements is recommended to prevent potential transmission and maintain hygienic standards in shared environments such as bathing and swimming facilities. Additionally, individuals are advised to take preventive measures to maintain foot health, including wearing slippers in areas where others walk barefoot, to reduce the risk of tinea pedis.

Correspondence *Ditte Marie Lindhardt Saunte*. E-mail: ditte.marie.saunt@regionh.dk

Accepted 15 May 2025

Published 26 August 2025

Conflicts of interest MCA reports financial support from or interest in Amplyx, Basilea, Cidara, F2G, Gilead, Mundipharma and Scynexis, Astellas, Shionogi, Chiesi, MSD, SEGES and EUCAST-AFST. GBEJ reports financial support from or interest in AbbVie, Moomælake, Novartis, UCB and Union Therape. DMLS reports financial support from or interest in AbbVie, Janssen, Sanofi, LeoPharma, Norvartis, Jamjoom Pharma and UCB. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. These are available together with the article at ugeskriftet.dk/dmj

Acknowledgements The authors thank Désiré Mageme Nahimana and Birgit Brandt for their excellent laboratory assistance

References can be found with the article at ugeskriftet.dk/dmj

Cite this as Dan Med J 2025;72(9):A03250148

doi 10.61409/A03250148

REFERENCES

1. Ilkit M, Durdu M. Tinea pedis: the etiology and global epidemiology of a common fungal infection. Crit Rev Microbiol. 2015;41(3):374-388. https://doi.org/10.3109/1040841X.2013.856853
2. Svejgaard E, Christophersen J, Jelsdorf HM. Tinea pedis and erythrasma in Danish recruits: clinical signs, prevalence, incidence, and correlation to atopy. J Am Acad Dermatol. 1986;14(6):993-999. https://doi.org/10.1016/S0190-9622(86)70122-9
3. Drakensjö IT, Chryssanthou E. Epidemiology of dermatophyte infections in Stockholm, Sweden: a retrospective study from 2005-2009. Med Mycol. 2011;49(5):484-488. https://doi.org/10.3109/13693786.2010.540045
4. Toukabri N, Dhieb C, Euch DE, et al. Prevalence, etiology, and risk factors of tinea pedis and tinea unguium in Tunisia. Can J Infect Dis Med Microbiol. 2017;2017:6835725. https://doi.org/10.1155/2017/6835725
5. Gupta AK, Venkataraman M. Antifungal resistance in superficial mycoses. J Dermatolog Treat. 2022;33(4):1888-1895. https://doi.org/10.1080/09546634.2021.1942421
6. Jabet A, Normand AC, Brun S, et al. Trichophyton indotineae, from epidemiology to therapeutic. J Mycol Med. 2023;33(3):101383. https://doi.org/10.1016/j.mycmed.2023.101383
7. Skaastrup KN, Astvad KMT, Arendrup MC, et al. Disinfection trials with terbinafine-susceptible and terbinafine-resistant dermatophytes. Mycoses. 2022;65(7):741-746. https://doi.org/10.1111/myc.13468
8. Kromann CB, Graversgaard C, Riis PT, et al. Dermatophyte prevalence in tools of 43 hairdressing salons in Copenhagen. Acta Derm Venereol. 2016;96(6):846-847. https://doi.org/10.2340/00015555-2388
9. Uslu H, Uyanik M, Ayyildiz A. Mycological examination of the barbers' tools about sources of fungal infections. Mycoses.

2008;51(5):447-450. https://doi.org/10.1111/j.1439-0507.2007.01482.x

10. Shoe Zone blog. The biggest (and smallest) feet in the UK and Ireland revealed. www.shoezone.com/Blog/shoe-knew-it-the-biggest-and-smallest-feet-in-the-uk-and-ireland-revealed (Nov 2023)
11. Astvad KMT, Hare RK, Jørgensen KM, et al. Increasing terbinafine resistance in Danish Trichophyton isolates 2019-2020. J Fungi (Basel). 2022;8(2):150. https://doi.org/10.3390/jof8020150
12. Jørgensen KM, Astvad KMT, Hare RK, Arendrup MC. EUCAST susceptibility testing of isavuconazole: MIC data for contemporary clinical mold and yeast isolates. Antimicrob Agents Chemother. 2019;63(6):e00073-19. https://doi.org/10.1128/AAC.00073-19
13. Ajello L, Getz ME. Recovery of dermatophytes from shoes and shower stalls. J Invest Dermatol. 1954;22(1):17-21;discussion 21-24. https://doi.org/10.1038/jid.1954.5
14. Raugi G, Nguyen TU. 22 - Superficial dermatophyte infections of the skin. In: Jong EC, Stevens DL, eds. Netter's infectious diseases. W.B. Saunders, 2012:102-109. https://doi.org/10.1016/B978-1-4377-0126-5.00022-7
15. Sasagawa Y. Internal environment of footwear is a risk factor for tinea pedis. J Dermatol. 2019;46(11):940-946. https://doi.org/10.1111/1346-8138.15060
16. Lipner SR, Scher RK. Onychomycosis: clinical overview and diagnosis. J Am Acad Dermatol. 2019;80(4):835-851. https://doi.org/10.1016/j.jaad.2018.03.062
17. Tosti A, Elewski BE. Onychomycosis: practical approaches to minimize relapse and recurrence. Skin Appendage Disord. 2016;2(1-2):83-87. https://doi.org/10.1159/000448056
18. Wisselink GJ, van Zanten E, Kooistra-Smid AMD. Trapped in keratin: a comparison of dermatophyte detection in nail, skin and hair samples directly from clinical samples using culture and real-time PCR. J Microbiol Methods. 2011;85(1):62-66. https://doi.org/10.1016/j.mimet.2011.01.023
19. Jacobson LS, McIntyre L, Mykusz J. Comparison of real-time PCR with fungal culture for the diagnosis of Microsporum canis dermatophytosis in shelter cats: a field study. J Feline Med Surg. 2018;20(2):103-107. https://doi.org/10.1177/1098612X17695899

