"Sunlight is said to be the best of disinfectants"*: The Efficacy of Sun Exposure for Reducing Fungal Contamination in Used Clothes

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ABSTRACT: **Background:** Tinea pedis is a common chronic skin disease; the role of contaminated clothes as a possible source of infection or re-infection has not been fully understood. The ability of ultraviolet light to inactivate microorganisms has long been known and UV is used in many applications.
Objectives: To evaluate the effectivity of sun exposure in reducing fungal contamination in used clothes.
Methods: Fifty-two contaminated socks proven by fungal culture from patients with tinea pedis were studied. The samples were divided into two groups: group A underwent sun exposure for 3 consecutive days and group B remained indoors. At the end of each day fungal cultures of the samples were performed.
Results: Overall, there was an increase in the percentage of negative cultures with time. The change was significantly higher in socks that were left in the sun (chi-square for linear trend = 37.449, $P < 0.0001$).
Conclusions: Sun exposure of contaminated clothes was effective in lowering the contamination rate. This finding enhances the current trends of energy saving and environmental protection, which recommend low temperature laundry.

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KEY WORDS: fungal contamination, tinea pedis, ultraviolet

One of the major issues of tinea pedis, a common skin disease, is its chronic course and relapses [1]. The possible role of contaminated socks in the infection and re-infection of this disease has not been fully examined and only a few studies have been published on this aspect [2-4]. In this study we evaluate the efficacy of sun exposure in reducing fungal contamination in socks.

* Louis Brandeis, Associate Justice of the U.S. Supreme Court, 1913

MATERIALS AND METHODS

The study was conducted in Tel Aviv, a city on the coast of Israel, in mid-June 2012. Fifty-two contaminated socks proven by fungal culture from patients with tinea pedis were studied. From each sock two samples were taken and divided into two groups: group A underwent sun exposure for 3 consecutive days, while group B remained indoors. At the end of each day fungal cultures of the samples were performed. For fungal identification, a small sample from the contaminated socks was cultured on Sabouraud's dextrose agar (Novamed®, Jerusalem, Israel), which contains chloramphenicol or streptomycin and penicillin to prevent contamination. Fungal identification was made on the basis of morphologic characteristics [5].

STATISTICAL ANALYSIS

Data on culture results from skin samples and nails were presented in basic descriptive (prevalence) tables. For univariate analysis, *t*-tests were used to compare the means of the continuous variables (e.g., age). To assess the distribution of categorical parameters (i.e., gender, clinical skin involvement, hyperhidrosis, etc.), chi-square tests were used. Chi-square for linear trend was used to compare the increase in the percentage of negative sock cultures kept in the sun vs. no sun with time. Coded data were analyzed using SPSS (Chicago, IL, USA) for Windows software, Version 12.

RESULTS

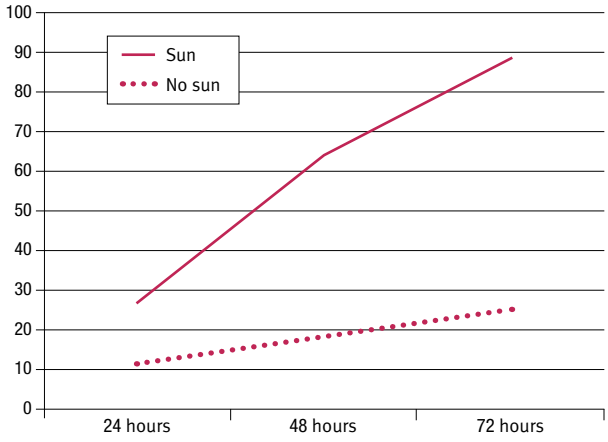
Based on the meteorological data provided by the Israel Meteorological Service, in mid-June 2012 in Tel Aviv the average maximal temperature was 28.2°C and the average maximal direct sun radiation 0.3074 KJ/cm^2.

Our study included 52 patients. Their average age was 41.8 years, 53.8% were males and 46.2% were females. Most of our patients (94.2%) did not suffer from hyperhidrosis. All the patients had a positive skin culture [Table 1]. Most of the

Table 1. Skin culture

Pathogen	Frequency	%
Trichophyton rubrum	37	71.2
Scopulariopsis brevicaulis	1	1.9
T. mentagrophytes	7	13.5
T. rubrum and Aspergillus	3	5.8
Aspergillus and *T. mentagrophytes*	1	1.9
T. rubrum and *Scopulariopsis brevicaulis*	2	3.8
Hendersonula toruloidea	1	1.9
Total	52	100.0

Figure 1. Percentage of pathogen-negative sock cultures with time



Chi-square for linear trend = 37.449, $P < 0.0001$

patients wore cotton socks (67.3%); the rest wore nylon socks. There were no statistically significant differences between the sock fabric and the patients' gender, age, hyperhidrosis, or nail involvement (onychomycosis). However, onychomycosis was more common among those who wore nylon compared to cotton socks (86.7% vs. 60%) and almost reached statistical significance ($P = 0.64$). Hyperhidrosis was significantly more common in younger patients (mean age 29.3 vs. 42.5 years, $P = 0.020$). Overall, there was an increase in the percentage of negative sock cultures with time. The difference was significantly higher in socks that were kept in the sun (chi-square for linear trend = 37.449, $P < 0.0001$) [Figure 1].

DISCUSSION

Louis Brandeis, Associate Justice of the U.S. Supreme Court, seems to have been right when he commented in 1913: "Sunlight is said to be the best of disinfectants." The inactivation of microorganisms by ultraviolet light has long been recognized and this modality is used in numerous applications. It is also known that the sterilization efficiency of UV systems depends on different parameters such as wavelength range and microbial concentration [6-8]. A wavelength of 200 to 300 nm that corresponds to peak absorption of DNA is effective, and the absorption of UV light by the DNA molecule causes the death of microorganisms. This process is necessary for sterilization to take place [9].

In the present study we showed that sun exposure reduced fungal contamination of infected socks. The role of domestic laundry in the disinfection of socks was previously evaluated [2-4]. The domestic laundry process is a synergistic process of temperature, rinse water, and detergent. Ossowski and Duchmann [2] found that *Trichophyton rubrum* was eliminated with a washing temperature of 30°C. Regardless of the textiles and detergents used, reliable decontamination was achieved only by laundering at 60°C. In another study, Hammer et al. [3] evaluated the infection risk of dermatophytes in domestic laundry processes. They conducted experiments transferring *T. rubrum* and *Candida albicans* from contaminated textiles to sterile textiles. Laundry was washed at two temperatures: 30°/60°C. *C. albicans* did not survive any of the tests. *T. rubrum* was found after washing at 30°C, indicating the risk potential of dermatophyte infections in the home. Up to 16% of the initial fungus load was detected in the rinse water. Washing at 60°C, however, eliminated both *T. rubrum* and *C. albicans*. The current trends of energy-saving and environmental protection recommend low temperature laundering. However, as mentioned above, it is necessary to use high temperatures to disinfect socks completely.

It was established in the early 1890s that UV radiation (particularly UVC with a wavelength range of 250–280 nm) is highly germicidal. Only recently was the topical use of germicidal UVC radiation found to be an acceptable and effective therapy for infected nails [10]. It is known that UVC does not reach Earth because of the ozone layer. Several studies have demonstrated that UVB also has an inhibitory effect on dermatophytes [11] and Candida [12]. Although the mechanism of action of UV remains elusive, it is possible that irradiation induces a change in the environment leading to the death of fungal elements. It is well known that darkness and humidity promote fungal proliferation. Sun exposure has an antifungal effect by diminishing these factors.

Our study demonstrated that sun exposure of clothes reduces fungal contamination, obviating the need for high temperature laundering and promoting energy-saving. Today, domestic washing machines incorporate an ultraviolet device designed to reduce microbial contamination as well as promote energy-saving [13].

UV = ultraviolet
UVC = ultraviolet C

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