THE EFFECTS OF VARIOUS LAUNDRY TEMPERATURES, OBSERVATION POINTS, AND DETERGENT CONCENTRATIONS ON THE SURVIVAL OF TRICHOPHYTON MENTAGROPHYTES ON MILITARY SOCK FABRIC

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INTRODUCTION

Disability from skin diseases among American troops in Vietnam engaged in combat in warm wet areas is often the greatest medical cause of non-effectiveness. The most common infection is produced by the dermatophyte Trichophyton mentagrophytes. This parasitic fungus produces the clinical conditions of tinea pedis, (athlete's foot), and ringworm (Blank et al., 1969).

Tinea pedis is not a problem in countries whose inhabitants are habitually barefooted, however hot and damp the climate or poverty-stricken the people. This fact is well attested in Southeast Asia. Only the combat troops who wear socks and boots are affected by the fungus. This disease is also a problem in the United States with its high living standards. The people of the United States and the combat soldiers in Southeast Asia bare their feet in swimming, showers, communal ablutions, or wade through swamps, pick up a fungal inoculum, and then carefully incubate the organism in the ideal environment provided by the shoes and socks they wear (English, 1969). Thus the purpose of this research is to study the effects of home laundry procedures on the growth and survival of Trichophyton mentagrophytes which has been inoculated on military sock material.

In the United States, there is a strong school of thought holding that almost everyone carries the causal fungi on symptom-free feet, and the clinical lesions only flare up when some change in the host's resistance allows the fungi to proliferate (Fosenthal et al., 1956). However, other American workers (George, 1960) support the view most commonly held in this country and elsewhere, that the disease is infectious and that, though a few people are carriers of the causal fungi, the vast majority are either free

of the organism or else have frank lesions of the skin or nails. The majority of published reports support the theory of exogenous infection (English, 1969).

Accepting that cross-infection is the most important cause of tinea pedis, means of reducing this cross-infection need to be studied. Since the most common source of infection appears to be fragments of skin or nails shed from an infected person, an uninfected person could become infected or reinfected by wearing socks which, because of improper laundry procedures, have become contaminated with the virulent organism Trichophyton mentagrophytes. It has been found by Blank et al. (1969) that much of the laundry in Vietnam is done by native girls in the local streams. The clothing itself may be heavily seeded with spores and may be a source of infection.

The importance of the laundry in disease transference is apparent from research previously done in this area. According to McNeil (1961), the ability or inability of a potentially harmful microorganism to survive and multiply in a textile material could influence foot health and serviceability of the fabric. Conversely, microbial survival could be dependent upon the textile fabric itself. Increasing use of household automatic clothes washers in self-service public installations, the use of cold water detergents in cold water, and shorter washing cycles have all focused the attention of many authorities on the possibility of the spread of diseases among families using these facilities. The American Public Health Association (1960) lists about forty communicable diseases caused by bacteria, viruses or fungi which are capable of being indirectly transmitted through articles freshly soiled be discharges from infected persons (Ridenour, 1950).

That dermatophytic infections are still a major military problem as well as a civilian problem in developed countries, points directions of research in the prevention of dermatophytic infections spread by inadequate

laundry.

Research has shown that viable microorganisms have been recovered and enumerated from test launderings under various conditions, but to this date, little specific investigation has been done on the viability during laundry and the specific state of activity of the dermatophyte Trichophyton mentagrophytes under known conditions.

It is obvious that acquisition of information on the subject is dependent on an effective method for recovering the viable organism from the fabric. Therefore the objectives of the present study are to: (1) experiment with efficient methods of recovery of the specific organism, (2) determine the effect of water temperature and soiling in a home laundry situation upon the specific organism, (3) determine the transference, if any, of the organism during the washing process, (4) and to study the interaction of detergent concentration, water temperature, and agitation time on the specific organism.

KEY WORDS

Completed Wash Cycle - the completion of the washing, spray rinse, deep rinse, and spin drying

Run - the number of repetitions of the procedural sequence for the two detergent concentrations, the three variable preliminary launderings, and the four treatments

Survival of Organism - the presence of the specific test organism Trichophyton mentagrophytes on the culture plates

Swatch - the 12 by 8 inch rectangle of fabric cut from the original knitted tubes (and used for innoculation and laundering).

Samples - the one-inch squares, which are cut from the 12 by 8 inch swatch and are plated to determine growth of the specific organism

Treatment - the particular variable substances applied to the fabric swatches before innoculation or laundering

Observation Period - the point in the laundry sequence (after 2 minutes of agitation, after the completed wash cycle, or after drying) in which samples were cut and plated

REVIEW OF LITERATURE

Introduction

The fate of microorganisms in a laundering operation may depend upon a number of physical and chemical factors such as the nature of the water and the washing agents, the temperature and time schedule, and the concentration of the washing agents.

Trichophyton mentagrophytes

By far the most common type of fungus disease in man is dermatophytosis, a superficial infection of the keratinized epidermis and keratinized epidermal appendages, the severity of which is dependent for the most part upon the location of the lesion and the species of fungus involved (Burrows, 1968). Dermatophytes are the most frequently encountered among fungi parasitizing man. They produce predominantly superficial lesions, affecting skin and its appendages, hair and nails. Botanically the dermatophytes constitute a closely related group within the Fungi imperfecti. The spores formed are all asexual conidia (Paldrok, 1953). The majority of the organisms grow readily on laboratory mediums and also grow on such substrates as cereal grains, shed hairs, horn debris, and sterilized fragments of straw in moist tubes. If protected from dryness, they may live on the wooden floors of shower rooms, dressing rooms, and dressing cabins, and on mats for a considerable time. Furthermore, various dermatophytes have been isolated from soil and air, and it is probable that dermatophytes live a saprophytic existence, that was formerly unrecognized. Some dermatophyte species appear to be so closely adapted to man that they are unable to infect lower animals; human infection is transmitted by contact. But animals such as the cat and dog are natural hosts, and human infection may be acquired from them

(Burrows, 1968).

Trichophyton mentagrophytes forms small spores and occurs in chains inside or outside of hair. In general Trichophyton infections show a characteristic tendency to produce an inflammatory reaction with deep infiltration of the skin (Burrows, 1968). The culture of Trichophyton mentagrophytes varies from a powdery type to a cottony type. The powdery strains are considered to be the causative agents in deeper clinical processes, whereas the cottony strains are limited to more superficial lesions (Paldrok, 1953).

Trichophyton mentagrophytes does not produce an infection of the internal organs; rather the microorganisms introduced tend to become localized in the skin and to develop where it is damaged as by scarification. Growth of the fungus in the skin and hair is more or less equal in all directions, and the lesions produced tend to have a circular form. The clinical conditions produced are termed: tinea pedis (athlete's foot); tinea corporis (ringworm of the body); tinea capitis (ringworm of the scalp); tinea cruris (ringworm of the groin); tinea ungium (ringworm of the nail); and tinea imbricata (a special concentric ring form) (Burrows, 1968).

Skin Infections as a Military Problem

Skin infections among military personnel engaged in operations in tropical climates are an important cause of discomfort and disability. In spite of the advances in antibiotic theropy in recent years, dermatological casualties still represent a large proportion of cases seen on sick call by field medical officers. The drain on man power may exceed that caused by casualties due to enemy action (Taplin et al., 1964).

According to studies done by Blank et al. (1969), disability from skin diseases among American troops in Vietnam engaged in combat in warm wet

areas is often the greatest medical cause of noneffectiveness. Infections are the leading causes of cutaneous disease. The most common infection found to be produced was produced by Trichophyton mentagrophytes.

The statement by a military commander that "the fighting strength of troops, such as those in the Mekong delta region of Vietnam, would almost double by improving prevention and treatment of dermatological disorders" poses a real challenge to the military and to those concerned with dermatology (Blank et al., 1969).

Skin problems are reported as the fourth most common cause of hospitalization in the army. Hospital admission rates alone however, are an inadequate measure of the dermatologic problems because many of the men, although unfit for field duty, are not hospitalized. The following examples of units under prolonged cutaneous stress indicates how prominate the problems can become in the front line combat man. One army combat unit of 450 men had 106 of the men incapacitated for field duty by skin problems in one week in September of 1967, in the Mekong delta region of South Vietnam. In August of 1967, one infantry brigade reported that of 209 men requiring hospitalization, 77 per cent were for "foot infections." In the northern part of the country, around Da Nang, the United State's Marines noted that in August of 1967, of 2800 hospitalizations for all causes, 1150 were for skin diseases. In other months the proportions were one half to one third of this figure. In the Air Force at Cam Rahn Bay, skin diseases also were common, with fungous infections as the most common outpatient complaint (Blank et al., 1969).

The degree of cutaneous disability was found to be variable depending upon the weather, the terrain, and the nature of the military operation. Also important were the availability of clean, dry clothing, facilities for good personal hygiene, and a dry place to sleep at night

(Blank et al., 1969).

The most common form of dermatophytosis was Trichophyton mentagrophytes infection which often extended over much of the body surface. In a mycologic study in the Mekong delta region of Vietnam, of 58 men whose skin was often wet for prolonged periods, fungi were demonstrated in 65 of 91 skin lesions studied. The area of the body involved in 142 examined cases definitely pointed to the feet and lower leg. Sixty-nine of the men showed recognizable fungous infection on the ankles and lower legs, 63 involved the dorsa of the feet and 23 involved between the toes and the soles of the feet (Blank et al., 1969).

Blank et al. (1969) stated that dermatophytic infections are still a major military problem in spite of the antibiotic Griseofulvin, which has been used as the drug of choice in treatment. Unfortunately there has been a serious lag in studies of the epidemiology and prevention of these conditions. Almost no specific measures to prevent the mycologic disease and disability have been applied to this problem. In spite of greater knowledge and better drugs, Trichophyton mentagrophytes continues to account for much of the extremely high rate of disease among combat troops.

Clothing as a Means of Transference

Investigations made by Szathmary (1968) further the findings of Ajello (1956) that the soil is a natural reservoir for human pathogenic fungi. Szathmary (1968a) stated that the dust which settles on clothes renders the clothes spore-bearing as well. The origin of human trichophytosis, in spite of thorough investigation, is not yet completely known. Since trichophytosis continually occurs, the origin of which cannot be otherwise explained, the infection of the clothing as a means of transference of the

organism has to be regarded as suspicious. Szathmary (1968) cited the following cases of infection. A five year old child became infected with dermatosis on her interscapular tract 8 to 10 days after her shirt had fallen on the ground from the clothes line. Most frequently cited are the cases which occur in which the disease was restricted to the neck area. The centers of infection lay in the line of friction caused by the collar of the clothing. Cultures taken from these lesions were often accompanied by organisms found in the soil.

Clinical observations also verify the assumption that fabric may be a reservoir for pathogenic fungi. In the case cited, a six year old boy who used to sumersault on an old carpet, was taken ill with trichophytosis on the top of the head eight days later. The carpet had been used constantly and had been exposed to soiling by dirt (Szathmary, 1968).

It is hard to estimate which fibers of textiles are most suitable for the fungi, setting colonies on clothing, because not only the quality, but the method of manufacturing, the treatment before weaving, as well as the further course of the ready fabric, especially staining, are factors which have an influence on the life of fungi growing on them (Szathmary, 1968b).

Ajello and Getz (1954b) studied 100 pairs of shoes that had been in storage for periods of one to four weeks in a prison storeroom. Scrapings were made of the inner soles of these shoes and plated with agar. Fifteen of the 100 pairs of shoes examined were found to yield cultures of dermatophytes. Trichophyton rubrum was recovered from one pair of shoes, and Trichophyton mentagrophytes was obtained from 14 sets of these shoes. In addition, Trichophyton mentagrophytes was isolated from the tile flooring of shower stalls in the prison.

Although tinea pedis is a minor disease, nevertheless it

frequently is a cause of severe discomfort and disability. The economic burden caused by this disease is considerable as trade figures in the United States reveal. In the United States alone $10,000,000 are expended annually for prescribed medicine to combat tinea pedis. In addition to the above figure, many more millions of dollars that are spent for proprietary and patented medications (Ajello, 1954).

With the demonstration that dermatophytes have been isolated from the environment, it is apparent that any treatment directed solely at the feet is inadequate to control the disease. Topical agents are often impractical for widespread body areas, the required repeated applications may not be feasible, especially under combat conditions in Vietnam because the agents are often quickly washed off under wet conditions (Blank et al., 1969). Dermatophytes may be resistant to the treatment of choice, Criseofulvin by mouth. The problems of obtaining pills under combat conditions, of keeping them dry, and of remembering to take them daily is significant (Blank et al., 1969).

Ajello (1954) stated that effective control measures of Trichophyton mentagrophytes must go beyond the body and must also include eradication of the organism in shoes, clothing, and other inanimate reservoirs in the environment to prevent reinfection.

Importance of Laundry in Disease Transference

There are many different types of organisms of both the saprophytic and pathogenic variety that can be incorporated into clothing. Potentially, many kinds of diseases may be transmitted through the medium of clothing. The viability and state of activity of such organisms are dependent upon a variety of factors. Some of the organisms, adapted to living

in or on the human body, may readily succumb once they leave the body; others may survive and multiply slowly, if at all; still others may adapt themselves completely; some may lie dormant in the spore state also (Ridenour, 1950).

Soil removal is achieved in a washing machine by: (1) mechanical and detergent action which dislodge soil from the fabric, and (2) by flushing and dilution which reduces the concentration of soil in the wash solution. The removal of microorganisms occurs in the same way. Microorganisms attached to soil are lifted from the fabric and are suspended in the wash solution (Marmo, 1969a).

To efficiently remove bacteria from cloth or to prevent redeposition of bacteria on cloth, the organism must be removed by the physidal means of dilution or by chemical treatment of the water resulting in chemical desorption followed by dilution (Marmo, 1969a). This, in effect, is the principle around which a clothes washer is constructed, namely chemical desorption by means of detergents in the wash cycle and additional desorption by dilution in the following rinse cycles. But complete bacteria removal cannot be achieved through detergency and dilution alone. Ridenour (1950) concluded that the task of completely destroying bacteria was the job of heat and chemical additives.

It is true that the destruction of bacteria can be achieved entirely with chemicals rather than with high heat, but there are compelling reasons which favor the latter method: (1) It is less expensive to use heat. Hot water is already available because it is necessary for proper soil removal. (2) It is easy to control the amount of heat. Water temperature can readily be maintained within five degrees Fahrenheit of the desired temperature. (3) Careful supervision is required to insure addition of the proper amount of chemicals. A mistake of twice the desired amount, or one

half, can easily occur. (4) An excess of heat, except for a few special fabrics, will not harm the fabrics. (5) An excess of chemicals can often create undesirable and irreversible changes in the fabric. (6) It is absolutely necessary to neutralize or rinse out certain chemicals which may be potentially harmful to the user (Marmo, 1969c).

In 1969, random samples were taken from 40 home or coin-operated washing machines in the San Fernando Valley, California area. The tests showed that bacteria was never completely eliminated from the washing machines and contaminated succeeding washes. The design of the machines and the use of low water temperatures in short washing cycles were blamed for the problem (The Kansas City Times, 1969).

Ruppert (1950) conducted a limited investigation of clothes washer bacteriology in the field. These studies were confined to gross qualitative analysis of wash water samples. Of forty-six samples examined, the organisms found most often were micrococci. Fungi were noted in seventeen of the samples.

Gilson and Bartfeld (1948) studied the public health aspects of self-service clothes washers. They found that at the relatively low temperatures of hot water used, soap wash and repeated rinsing did not disinfect the clothing; and removal of the wash left the washer bacterially contaminated for the next user. Likewise where higher temperatures were maintained in automatic clothes washers, bacterial flora was equally decreased.

The fact that articles of transmission such as socks, towels, sheets, and other items of wearing apparel are handled by more than one member of the family and are washed with other uncontaminated items in the laundry, reveals the tremendous importance laundry can play in the role of public health. For example, The American Public Health Association stated

that ringworm was possibly transmitted indirectly by articles of wearing apparel or towels or by surfaces contaminated with scales or hair from such lesion (Ridenour, 1950). Examples of bacterial and fungal contamination of clothes and bedding from skin lesions was also cited by McNeil (1961).

Effect of Water Temperature

The temperature of the washing medium in the home depends upon the thermostat setting and capacity of the water heater, and how much hot water has been used for other purposes in the home. Very few homemakers have any conception of what temperature is adequate for cleaning clothes. Although much emphasis in advertising has been put on detergents and washing machines, they cannot do the job alone. Water is the basic ingredient for washing.

Washing temperature is still an important factor in determining the amount of soil removed by detergents, even those sold as cold water agents. Schimpf (1969) reported that water temperature was found to be the most significant variable in bacterial removal and redeposition of microorganisms during the laundry process. Arnold (1938) reported after a year's study of commercial laundries that there appeared to be few sanitary problems connected with laundry practices which utilize high temperatures of 165° to 175°F. He pointed out that low temperature operations of about 100°F. might present bacterial problems. Bacteria grew in deposits within the machine and subsequent washings were contaminated. Galbraith (1960) reported that on most fibers, washing at either 120° or 140°F. would remove more soil than would washing at 100°F. which, in turn removed more soil than washing at 70°F.

Certain changes in our way of life indicate a re-examination of bacteriology and the water temperature used in home laundry. Many home