Sweat and Skin Fungal Infections: High-Impact Sport Comparing Women

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الملخص

إن المشاركات في الرياضات التي تتطلب مجهودًا بدنيًا عاليًا معرضات لخطر الإصابة بعدوى فطريات الجلد بسبب عدد من الأسباب بما في ذلك التعرق المتكرر، ورطوبة الجلد لفترات طويلة، واستخدام الأسطح المشتركة. تؤثر هذه العدوى؛ مثل فطريات الجلد، وداء المبيضات، والعدوى المرتبطة بالملاسيزيا على أداء الرياضيين ونوعية حياتهم. وعلى وجه التحديد، تهدف الدراسة إلى تحديد حدوث وأنواع وأسباب العدوى الفطرية الجلدية المحتملة بين الرياضات التي تتطلب مجهودًا بدنيًا عاليًا لدى الإناث وأكثر الطرق فعالية لمنع حدوثها. أجريت دراسة مقطعية مقارنة مع ١٠٠ مشاركة، مقسمة إلى مجموعتين: ٥٠ امرأة من الرياضيات و٥٠ امرأة من غير الرياضيات (مجموعة التحكم). تم الحصول على المعلومات باستخدام الاستبيانات وقوائم المراجعة، بالإضافة إلى التقييم السريري والمسحات الميكروبيولوجية للجلد والأظافر. وشملت الملاحظات الإضافية معدل التعرق وقلوية الجلد ومستوى تلوث مرافق التمرين المستخدمة.

كان من الجدير بالملاحظة مرة أخرى، كما هو متوقع، أن ٤٠% من الرياضيين الذين خضعوا للدراسة وجدوا إيجابيين للإصابة بالآفات الفطرية مقارنة بـ ١٥% من غير الرياضيين. وكانت العدوى الطفيلية الأكثر شيوعًا هي سعفة القدم بنسبة ٢٥% وسعفة الفخذ بنسبة ١٥% وداء المبيضات بنسبة ١٠% وسعفة المبرقشة بنسبة ٨%. وكان لدى الرياضيين معدل تعرق أكثر كثافة (٤٢٥ ± ٩٠ مل/ساعة) ودرجة حموضة الجلد المنخفضة (٥,٢ ± ٠,٥) مما كان مناسبًا لنمو الفطريات. التحديات البيئية الرئيسية الرطوبة العالية أثناء التدريب ٦٥ ± ١٠ والمعدات الملوثة ٨٥٠ ± ١٢٠ وحدة تشكيل مستعمرة/سم². وشملت الإجراءات الأخرى التي ساهمت في مخاطر الإصابة تدابير مثل تأخير الاستحمام خاصة بعد التمرين.

الكلمات المفتاحية : العرق، العدوى الفطرية، الرياضة، آفة الجلد.

Abstract

__Female participants in HI sports are at a higher risk for skin mycosis infection due to a number of reasons including frequent sweating, prolonged skin dampness, and usage of shared surfaces. These infections; such as dermatophytosis, candidiasis, and *Malassezia* related infections affect the performance of athletes and their quality of life. Specifically, the study purports to determine the occurrence, types and likely causes of skin fungal infections among the female high impact sports and the most efficient ways of preventing the same. A comparative cross-sectional study was conducted with 100 participants, divided into two groups: 50 women of athletes and 50 women of non-athletes (control). Information was obtained using questionnaires and checklists, plus clinical assessment and microbiological swabs of the skin and nails. Additional observations included sweat rate, skin alkalinity and level of contamination of the exercise facilities employed.

___It was again, as expected, noteworthy that 40% of athletes under the study were found positive for fungal lesions compared with 15% of the non-athletes. The frequently found parasitic infections were *Tinea pedis* 25% and *Tinea cruris* 15%, Candidiasis 10% and *Tinea versicolor* 8%. Athletes had denser sweat rate (425 ± 90 mL/hour) and lower skin pH (5.2 ± 0.5) which were favorable to fungal growth. Major environmental challenges High humidity during training 65±10 and contaminated equipment 850±120 CFU/cm². Other procedures which contributed towards the infection risks included such measures as delayed showering particularly after exercising.

Keywords : Sweat, Fungal Infections, Sport, Skin lesion.

Introduction

People who engage in high-impact aerobic exercises most likely to sweat and experience prolonged skin moisture exposure to sportst item either directly or indirectly making them prone to fungal infections. Female sport participants should be researched because of physiological, and environmental factors which they experience. Skin fungal infections due to efficacy sweating, moisture and contact with the athletic wear and equipment shared with other athletes are potential high risks faced by women athletes participating in high-intensity sports. Vivid aspects *Tinea pedis* (athlete's foot) and *Tinea cruris* (jock itch) are the two most frequent dermatophyte infections identified in athletes (Turner *et al.*, 2021). These infections occur in warm and moist conditions normally promoted by tight fabrics such as synthetic sportswear and duration of athletic activities. Furthermore *Candida albicans* that is the yeast that causes candidiasis often infect areas that causes inflammation often where there is friction or moisture such as the groins or under the breasts especially among female athletes that involve themselves in activities such as running and gymnastics (Smith *et al.*, 2020). Tinea versicolor, due to *Malassezia* species, results in skin color changes and is owing to sweat and heat commonly observed at the back and shoulders (Jones & Lee, 2019). Some of the risk factors detected include the use of non-porous fabrics, failure to shower immediately after exercising, and sharing of equipment or showers known to have been contaminated by the fungus. It is therefore clear that those facilities and amenities that are shared, for instance gym locker rooms and showers pose high risk of fungal transmission. Inadequate skin drying or improper application of antifungal powders are additional points

that foster development of these infections (Davis *et al.*, 2022). Onychomycosis, commonly known as nail fungus, is also very predominant in athletes, the incidence of onychomycosis arises from nail trauma and the use of trapped shoes during training (Brown *et al.*, 2022). To reduce these risks researchers suggest that a two-pronged approach is useful in the process of preventing them. Some of them are the use of sweat-and moisture resistant fabrics in clothing; this calls for washing of sports equipment frequently and lastly, it entails drying of the skin soon after being soaked (Taylor *et al.*, 2021; Harris *et al.*, 2021). Moreover, protective antifungal preventive actions, including powdery and cream preparations, have had positive results in protecting patients from being infected by fungi. However, the present literature has a gender gap as it relates to fungal infection of female athletes and thus requires more focused study to promote better dermatology among females athletes.

Aim of the study

The purpose of this dissertation was to establish the frequency, varieties and factors that lead to development of skin fungal infection among women who participate in high-intensity activities.

Materials and methods

Study Design

This study shall utilize a cross-sectional comparative research design in order to determine the status and correlates of skin fungal infections and measures of prevention amongst high impact exercising women and non-exercising women. The participants in the study will be recruited with a statistical power that increases representativeness and credibility by covering fifty participants in each group, making it one hundred in all.

Group A (athletes)

Female 18-35 years with induced and spontaneous high-impact exercise training program for the last six months and at least three sessions per week with each session not less than an hour.

Group B (Non-athletes)

Group B will be women aged 18-35 years who are sedentary or physically inactive, recruited from the community as comparators to Women in Group A, by age and Socioeconomic status.

Inclusion criteria

The target population included, women only, within the age of 18-35 years. They have never had most chronic skin conditions other than fungal ones and disease such as eczema or psoriasis. Patients' willingness to give informed consent.

Exclusion criteria

History of taking antifungal agents in the preceding 3 months. Immunosuppressive diseases or medicines, for instance corticosteroids.

Questionnaire

This structured questionnaire will elicit information in the areas of demographic data (age, BMI, economic status). Type of sport, how often, and how long the patient involved in sports activities. Showering practices and use of antifungal powders etc. Textiles and apparels (inclined to choose products made of this type of cloth or that type of fabric). Design and availability of public amenities (gym, shower).

Clinical examination

The dermatologists will then coherently perform a broad standard assessment to analyze external signs of manifestations of fungal related diseases. Any specific part of the body such as the foot, groin, back, nails will have to be observed for inflammation, scaliness and possible color changes.

Sweat rate measurement (athletes only)

They were to be determined gravimetrically after the standard training bouts to compare with the levels of infection.

Calculate each athletes sweat rate (sweat rate=pre-exercise body weight-post- exercise body weight +fluid intake –urine volume/ exercise time in hours

Data analysis

Binarized values and the corresponding percentages of fungal infection. Standard deviations and means for the typically measured variables such as the sweat rates. Two sample t-tests for continuing variables (e.g., infection rates between athletes and non-athletes). Independent samples t-test or U-test for interval or ratio level variables. As for evaluating the odds ratio between sweat production and hygiene practices and the risk of fungal infection logistic regression is used with a prevalence of 26%.

Ethical considerations

Potential participants will find out the reason for the study; what will be done and not be done; and measures that will be taken to ensure that anonymity of the participants is protected. In this case written consent will be obtained. Any information about a person will be collected anonymously, and will be stored securely and confidentially. Individuals who developed fungal infections during the study will be referred to see a dermatologist and be educated about prevention measure.

Parameters for the study

A. Demographic parameters

1. **Age:** Gender of participants: percentages of males and females in the sample age of participants: range of years of the participants.
2. **Body Mass Index (BMI):** In order to determine if weight or body composition is an effective predictor of susceptibility to infections.

3. **Socioeconomic Status:** As a possible reason for the conduct of hygiene practices and methods as well as for access to preventive measures.

B. Physical activity parameters

1. **Training frequency:** Total training sessions in a week, training frequency.
2. **Duration of training:** duration of each session in terms of hours.
3. **Intensity of training:** not high intensity, moderate intensity, or low intensity, which can affect the quantities of the sweat.

C. Personal care and lifestyle characteristics

1. **Showering practices:** can greatly benefit from recommendations concerning the duration and time of showering after exercise.
2. **Use of antifungal products:** Substances in the form of powders, cream or soaps taken as preventative measures.
3. **Clothing materials:** perception of breathability on fabrics versus synthetic fabrics.
4. **Use of community facilities:** how often the Juvenile has crossed path with the virus; instances of going to the gym, showering, using the locker room or shared equipment.

D. Sweat and skin parameters

1. **Sweat production rate:** generally determined during the exercise phase (for instance through gravimetric measurement).
2. **Skin moisture retention:** assessment of skin's moisture loss immediately after the training session by utensils such as corneometers.

3. **Skin pH levels:** To assess whether the change of pH are more suitable for fungal growth.

E. **Clinical parameters**

1. **Presence of fungal infections**
2. **Observable symptoms:** for this reason, the client may notice erythema, desquamation, itching, or color changes on the skin. Location: Feet, groin, nails, or other body part.
3. **Recurrence history:** fungal infections in the past.

F. **Environmental parameters**

1. **Humidity and temperature of training environment:** Expressed in training spaces because these factors affect the growth of fungi.
2. **Shared equipment contamination:** Preliminary testing of communal sporting apparatus to determine fungal load.

G. **Outcome parameters**

1. **Prevalence of fungal infections:** comparison of number of positive cases in athletes and those within the population.
2. **Risk factors:** the nature of relationship between sweating, cleanliness and illness levels.
3. **Preventive effectiveness:** Assessing measures of personal hygienical practices, such as products employed by participants (antifungal remedies).

H. **Rationale for parameters:** These parameters were selected with an aim of achieving a comprehensive concept of the whole issue of fungal infections. this include:

1. **Some topic areas include (biological aspects):** fungal species and sweat production).
2. **Hygiene and dressing forms part of the behavior aspects** as far as disease and illness are concerned.
3. **Training conditions that was factors that exist in the external environment** affecting the training process.
4. **Patient care/service related associations** (infection rates and intensity).

I. Detection of fungi by microscopy

Diagnosis of fungal infection in *Tinea Pedis*, *Tinea Cruris*, Candidiasis and *Tinea Versicolor* entail using a microscope to examine clinical samples for fungal particles. The process often employs the KOH preparation technique to solubilize keratin and increase the conspicuousness of fungal structures.

***Tinea Pedis* and *Tinea Cruris*:** Skin scaling includes samples that were taken from the affected skin. Microscopic examination reveals that dermatophytes were branching, septate hyaline hyphae which may be arthroconidiating. The KOH preparation enhances visibility of these structures contrasting against the debris of dead cells.

Candidiasis: sputum or mucosal or cutaneous biopsy specimens were studied. *Candida* species are unicellular oval budding yeast form, pseudohyphal form, or true hyphal form depending on the place and the stage of infection seen on light microscopy.

Tinea Versicolor: Tissue samples from mucosal surfaces of scale-afflicted skin were stained and minutely observed. In KOH, *Malassezia* become

slipper like form and form a typical “spaghetti and meatballs” in which spaghetti are short hyphae and meatballs are spherical yeast cells.

Results

In table (1), they have tried to identify the variation that exists in group A which was the athlete group and group B which was non-athlete group. The two groups were thus of similar age and BMI, in an attempt to reduce influence from these parameters. It was also evident that, the trained athletes undertake their training sessions more frequently and for a longer duration than non-athletes who did not undergo regular training; 5.2 sessions/week, and 1.8 hours/session, respectively. Regarding exposure to fungal risk factors 72% of athletes practice high-intensity activities and thereby have higher sweat rates. Essential, in brisk trawling for lengthy periods that they practice in a bid to enhance performance, athletes produces more sweat and rub the skin frequently. These conditions predispose the patient to develop fungal infections as fungi grow best in warm and moist conditions High-intensity sports produce sweating, use of occlusive clothing and skin damages that can favor fungal growth.

Table (1): Features of the Population and Their Level of Physical Activity

Parameter	Athletes (Group A)	Non-Athletes (Group B)
Age (mean ± SD)	28.3 ± 4.2	27.9 ± 3.9
BMI (mean ± SD)	23.5 ± 2.8	24.1 ± 3.2
Training frequency (sessions/week)	5.2 ± 1.1	0
Training duration (hours/session)	1.8 ± 0.4	0
Training intensity (%)	High: 72, Moderate: 28	N/A

Table (2) demonstrates differences in hygiene habits and clothing choices between the two groups, in our survey, 85% of athletes take shower after exercising, while the 15% who did not take shower directly after exercising have a higher risk given longer exposure to sweat. Some areas of concern were identified; major one being that only 40 percent of athletes use antifungal products. Players prefer comfortable clothing fabric such as breathable fabric being used by 65% of the athletes, through reduces moisture retention. High usage (75%) among athletes exposes them to fungal infections that may be from infected surfaces. A person takes a shower less frequently or not at all the sweat and moisture on the skin surface create the right conditions for the development of fungi. They failed to that athletes who did not pay much attention to personal hygiene were likely to get affected. The relatively small proportion of athletes who reported using antifungal products could mean one of two things; they were unaware of the potential problem or did not regard it as very serious,

thereby leaving their skin open to infection. Non-breathable, synthetic fabrics tend to hold water and heat thus they create conducive environment for fungi. But of course, athletes who wear breathable fabrics opt for less of this risk though they do not totally shy away from it. Shared showers and locker rooms which can be utilized frequently by athletes compromise body surfaces and greatly facilitate fungal infection.

Table (2): Personal Care and Way of Life

Parameter	Athletes (Group A)	Non-Athletes (Group B)
Showering post-exercise (%)	85	N/A
Use of antifungal products (%)	40	15
Breathable clothing usage (%)	65	N/A
Use of communal facilities (%)	75	N/A

The supported by the findings presented in table (3) depicting the prevalence of fungal infections were Athletes (40%) have a significantly higher prevalence compared to non-athletes (15%), which pointed that physical activity as well as sweating is a risk factor. The most frequent infection in these athletes was *Tinea Pedis* at 25% because of the use of occlusive shoes for long periods and showering with other athletes. *Tinea*

Cruris and Candidiasis infections were more frequent in athletes because the skin in the groin and folds were subjected to friction and moisture. *Tinea Versicolor* infections were somewhat more common among athletes (8%) than non-athletes (2%) and were likely to be magnified by sweating and heat.

Perspiring and rubbing their skin, athletes constantly expose themselves to injuries and infections with fungi that non-athletes were less like to come across. Wearing of occlusive footwear for long periods results in accumulation of moisture suitable for growth of fungi. Locker rooms, a part of public or shared spaces, also add to the spread of the highly contagious fungal infection. Groin area and under the breasts were folds where the skin remains moist and constantly rubbed during exercise and therefore it will only take a few hours for the area to become infected by the fungus. Due to the warmer as well as humid weather during training session it leads to the activation of *Malassezia* which causes skin discoloration.

Table (3): Clinical and Microbiological Observations

Parameter	Athletes (Group A)	Non-Athletes (Group B)
Prevalence of fungal infections (%)	40	15
Tinea Pedis (%)	25	10
Tinea Cruris (%)	15	5
Candidiasis (%)	10	2
Tinea Versicolor (%)	8	2

Table (4), was gave the comparison of the environmental factors and the performance outcomes related to the development of fungal infections, Athletes produce much more sweat; (425 ± 90 mL per hour) thus promoting the growth of fungus. The study has found that the skin pH of athletes was (5.0 ± 0.5) than non-athletes group with skin pH of (5.5 ± 0.4) and this skin acidity makes them more prone to fungal infections. Fungi thrive in training environments that were characterized by high humidity (65 ± 10%). The contamination level of the shared equipment (850 ± 120 CFU/cm²) in athletes environment sources was identified as another major influence to fungal exposure. High impact sports tend to cause sweating and thus makes the skin to become moist. This moisture, if not attended to in a relatively short time, becomes a health promoting environment for fungal development. The drop of pH in athletes might be caused by sweat and rubbing that decrease oily skin layer and allow fungal penetration. High humidity environment favours the existence of fungal spores and exposes learners to it throughout their training. Treadmills, machines, barbell, and bench facilities in gyms harbor contaminated fungal spores. These surfaces are often contacted by athletes and poor washing practices put the athletes in touch with fungi.

Table (4): Ecological and resultant metrics

Parameter	Athletes (Group A)	Non-Athletes (Group B)
Sweat Production (mL/hour, mean ± SD)	425 ± 90	N/A
Skin pH (mean ± SD)	5.0 ± 0.5	5.5 ± 0.4
Humidity in Training Area (%)	65 ± 10	N/A
Shared Equipment Contamination (CFU/cm²)	850 ± 120	N/A

Discussion

This study, therefore, establishes there was a higher proportion of women in high impact sports to be affected by fungal infections than their non-sporting peers. This result demonstrate the complexity of the process of development of fungal infections which can be influenced by physiological, environmental and behavioural factors. Since athletes 41 sweat a lot, chafe a lot and often share facilities, they live in a perfect habitat for fungal growth and spread. These outcomes support other scholarly works showing that athletes are in the primary risk category for dermatophyte infections, including *Tinea pedis* and *Tinea cruris* (Turner *et al.*, 2021; Ameen, 2010), the most common infections reported among the athletes were *Tinea pedis* 25% and *Tinea cruris* 15%, Candidiasis 10% and *Tinea versicolor* 8%. This might be so because *Tinea pedis* commonly occurs in this population perhaps due to the continued use of occlusive footwear that retains moisture and heat in support of fungal proliferation. This finding is in

harmony with Adam *et al.*, (2014) saying that dermatophytes were the most predominant in infections among athletes.

Similarly, Candidiasis as a complication of immunosuppression was more superficial, affecting areas that were easily exposed to friction and moisture accumulation, such as the groin and the inframammary folds, indicating that skin folds promote candidal proliferation. The athlete population has slightly higher *Tinea versicolor* incidence rates than the non-athlete group due to the effects of heat and sweating for *Malassezia* growth as observed by Jones and Lee indicating that sweating was a significant catalytic factor for *Malassezia*, and thus *Tinesa versicolor* (Jones & Lee, 2019).

The study also enumerated some risk factors that were found to explain increased infection risks among the related subjects in general; athletes in particular. Daily sweating rate, determined to be 425 ml/hour overall with 90 ml/hour varying within and between subjects especially in athletes, was identified. Sweating itself causes moisture which if not controlled favors fungal growth if not properly supervised. Also, the lower skin acidosis noted in athletes at 5.0 ± 0.5than the non-athletes at 5.5 ±0.4 might weaken skin barrier and increase potentiality to fungal infestation. Such results were in agreement with earlier studies that associated sweat and pH shifts with fungal development (Leyden *et al.*, 1987).

Hypothesized causal factors that were evident from the observed results were also an account of environmental factors. Some significant sources of fungal exposures included; high level of relative humidity in training areas (65±10%) and contaminated training equipment (850± 120CFU/CM²). These results call into the question the need to frequently clean shared

amenities as Harris *et al*., (2021) has it. In addition, synthetic wears which holds water or moisture increases the chances of fungi. Those wearing comfortable sportswear that enables good sweating protection from bacterial and fungal mostly caught fewer diseases (Anderson *et al*., 2020).

Proper hygiene measures were also other main reasons that linked were responsible for high infection rates, 85 percent of the athletes indicated that showering after exercise was the norm, 15 percent of the time, athletes leave sweat and moisture on the skin. Delays in practices of washing, along with failure to dry the body adequately, create an environment well suited to the growth of fungi. These observations were similar to Davis *et al*., (2022) where the authors pointed to the importance of early hygiene to avoid skin infections.

This work also sets a basis to establish more precise preventive measures to minimize the occurrences of fungal infections for the female athletes. Prevention should involve further education of the fungal risks inherent from signing a sweat-drenched towel and a proper way of hygiene by reminding participants to wash their body immediately after practice. Powder and creams used for antifungal prophylaxis has been effective in high risk patients, therefore, athletes diagnosed with recurrent infections should be administered for this purpose (Aly and Maibach, 1977). Furthermore, people need to practice adequate gargling and face mask wearing because fungal presence was often observed in gyms (Harris *et al*., 2021), the wearing of breathable and moisture resistant sporting apparels should be promoted so that sweating and skin damage may be allowed (Taylor *et al*., 2021).

Conclusions

The findings of this work showed that, the crossection of women in high intensity physical activity have higher levels of fungal infections than non-physically active women. This study clearly showed that conditions like *Tinea pedis*, *Tinea cruris*, Candidiasis, and *Tinea versicolor* have pathological relationships with physiological factors like sucring, lowered skin pH and sustained moisture. Pother contributory factors include, high levels of humidity in training environment and cross-contamination of shared sporting equipment. The problem was then compounded by behavioral factors include, delaying the practice of post-exercise showering.

Recommendations:

The study argues that specific prevention measures should be taken to mitigate the risks, these include; counseling athletes on hygiene measures, use of dry, and light-colored laundry to minimize microbial growth and production of the fungi, and constant disinfection of common areas and equipments. Even though antifungal agents applied topically in the form of powders and creams significantly reduce the incidence of recurrent infections, except in patients with immune deficiencies, they are best utilized as antifungal prophylaxis.

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Conflicts of interest

There are no conflicts of interest.

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