



Concomitant Bacterial Isolation in Patients with Tinea Pedis: A Comparative Study of Diabetic and Non-diabetic Patients

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Abstract

Background: Athlete's foot is a prevalent superficial fungal infection that disturbs the skin's natural equilibrium, encouraging bacterial growth and infection.

Objective: To elucidate the prevalence and distribution of bacteria isolated concurrently from individuals with athlete's foot, contrast bacterial isolation trends between diabetic and non-diabetic individuals, and analyze the antibiotic resistance profiles of predominant bacterial isolates.

Methodology: A comparative cross-sectional study involved 100 participant (50 people with diabetes and 50 healthy individuals) diagnosed with tinea pedis through potassium hydroxide. Bacterial isolates were recognized using the VITEK® 2 Compact System. Antimicrobial susceptibility testing was conducted utilizing the Kirby-Bauer disk diffusion technique.

Results: Bacterial isolates were found in 82.0% of patients with diabetes and 68.0% of patients without diabetes, although the differences lacked statistical significance ($\chi^2= 2.61$, $p=0.106$). Diabetic individuals experienced a markedly higher occurrence of chronic foot wounds. In patients with diabetes, *Staphylococcus hemolyticus* and *Staphylococcus aureus* were the predominant isolates, whereas coagulase-negative staphylococci were often found in non-diabetic individuals. Gram-negative bacteria like *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were found more often in patients with diabetes. Among the primary staphylococcal isolates, penicillin resistance was the highest, whereas vancomycin and linezolid exhibited great effectiveness. *Pseudomonas aeruginosa* demonstrated the greatest sensitivity to amikacin, followed by ceftazidime, tobramycin, and finally meropenem. Diabetic individuals displayed a wider variety of Gram-negative bacteria and a notably higher rate of *Staphylococcus* isolation.

Conclusion: The significance of culture-based diagnosis and antibiotic susceptibility testing prior to starting antibiotic therapy was underscored by the significant penicillin resistance.

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Keywords: Tinea pedis, Diabetes, Foot care, Bacterial coinfection, Bacterial species

1. Introduction

Dermatophytes like *Trichophyton rubrum* and *Trichophyton interdigitalis* are the primary cause of athlete's foot (tinea pedis), a superficial fungal infection that affects the skin of the feet, particularly in the spaces between the toes. It is one of the most widespread skin conditions in the world. It is most common in humid settings, among individuals who don't take care of their feet, and among those who wear shoes for extended periods (Rajagopalan *et al.*, 2018) ^[1]. Even while athlete's foot is frequently minor and goes away on its own, it can cause major problems if left untreated. (Akkus *et al.* 2016) ^[2]. Opportunistic bacteria can

enter through erosions and disruption to the skin's barrier function between the toes, which may result in secondary bacterial infections such as cellulitis, lymphangitis, and in extreme situations, osteomyelitis. Thus, it is clinically significant to test for bacterial infections linked to fungal infections of the feet. (Khalifa *et al.* 2023) [3]. Among the most prevalent skin conditions are fungal infections. Up to 30% of diabetics are thought to have skin disorders, with athlete's foot being one of the main causes. Additionally, because fungal infections cause skin fissures and openings for pathogens to enter, they may be a sign of major bacterial problems in diabetics (Alhammadi *et al.* 2023) [4].

Additionally, epidemiological research has demonstrated a robust correlation between diabetes and a higher risk of athlete's foot and associated infections. For instance, cross-sectional studies conducted on a variety of groups have shown that individuals with diabetes are more vulnerable to fungal foot infections than people without the disease. In addition to impairing quality of life, these infections also play a role in the development of diabetic foot problems, which continue to be a leading cause of illness globally (Ababneh *et al.* 2024) [5]. Recent findings indicate that the microbial ecosystem of tinea pedis is more intricate than just the existence of dermatophytes. Damage to the skin barrier between the toes, excessive moisture, fissures, and localized dampness can encourage bacterial survival or proliferation. A recent extensive retrospective analysis employing various molecular tests indicated that bacteria were concurrently identified in a considerable percentage of foot samples infected with dermatophytes, reinforcing the idea of a "dermatophyte community" in which fungi and bacteria coexist within afflicted skin. *Staphylococcus aureus* and *Pseudomonas aeruginosa* were the most frequently found bacteria, especially abundant in samples collected from the interdigital area (Gupta *et al.* 2025) [6]. Comprehensive microbiological investigations to define bacterial isolates linked to athlete's foot are still desperately needed, especially in underdeveloped nations, despite the clinical significance of fungal and bacterial co-infections in diabetes patients. Improving treatment plans and avoiding consequences need an understanding of the range of bacterial infections and their patterns of antibiotic resistance (Macdonald *et al.* 2021) [7].

It is essential to recognize that athlete's foot in diabetic individuals should not be viewed solely as a skin issue. Although existing guidelines for diabetic foot care emphasize prevention and prompt treatment of foot issues, recent studies indicate that athlete's foot may occur alongside bacterial infections, possibly fostering a setting that leads to complications. Consequently, recognizing the bacteria linked to ongoing fungal lesions and assessing their antibiotic resistance patterns will offer clinically important insights for local infection management approaches and effective antibiotic application (Arnold, M. J. 2025) [8]. According to recent research, tinea pedis is not just a superficial fungal infection but frequently incorporates bacterial colonization, particularly in diabetes individuals with persistent lesions. Though understanding of fungal-bacterial interactions in foot infections is growing, there is still a scarcity of specific comparative data on the bacteria linked to tinea pedis in both diabetic and non-diabetic people, especially in the Middle East. Additionally, a significant amount of research targets tinea pedis or stable diabetic foot ulcers, with comparatively

limited investigation into bacteria directly obtained from tinea pedis lesions prior to the development of more serious diabetic foot issues (Alhammadi *et al.* 2023) [4]. Wherever there is a disruption of the skin barrier by dermatophyte, the subsequent bacterial invasion becomes easier, giving rise to a disease referred to as "dermatophytosis." The predominant bacterial strain responsible for tinea pedis, based on past microbiological studies, is *Staphylococcus aureus*, followed by coagulase-negative staphylococci, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Escherichia coli*, *Klebsiella pneumoniae*, and other Gram-negative bacteria, including Enterobacteriaceae. Full microbiological investigations, including the identification of bacteria and the determination of antibiotic sensitivity, are critical in patients with chronic tinea pedis, as the presence of these organisms worsens the local inflammation and interferes with the healing process. Thus, the present research focuses on understanding the frequency of bacterial infections caused by athlete's foot among diabetic and non-diabetics and the nature of such bacteria.

2. Methodology

2.1. Study Design and Study Setting

The current study employed a comparative cross-sectional design to investigate bacterial infection associated with athlete's foot between diabetic and non-diabetic individuals.

2.2. Study Setting and Sample Collection

Clinical samples were collected from outpatients visiting dermatology outpatient departments in hospitals, private clinics, and dermatology private practices.

2.3. Clinical Assessment and Verification of Tinea Pedis

Each individual was diagnosed by a dermatologist as being affected by tinea pedis. This was confirmed through direct microscopic examination using potassium hydroxide (KOH) solution. Those patients who were clinically diagnosed for tinea pedis and whose diagnosis was confirmed by KOH examination were considered in this study. Cotton swabs collected from the affected skin areas were tested for any signs of bacteria after fungal infection had been confirmed. Identification of the bacterial strains was carried out using the VITEK® 2 Compact system.

2.4. Clinical Assessment and Verification of Tinea Pedis

Data regarding clinical and demographics such as age, gender, diabetic status, duration of infection, type of footwear worn, foot hygiene and recent antibiotic intake was collected using structured questionnaires. Patients with and without diabetes were examined in terms of the distribution of bacterial species and the frequency of concurrent bacterial infections. The associations between diabetes, clinical and demographic characteristics, and concurrent bacterial infections were assessed statistically. Statistical significance was defined as a p-value of less than 0.05.

2.5. Testing for Antimicrobial Susceptibility

The Kirby-Bauer disk diffusion technique on Müller-Hinton agar was used to test for antibiotic susceptibility in compliance with the Clinical Laboratory Standards Institute's recommendations (CLSI M100, current edition). Prior to inoculation, the concentration of the bacterial suspension was

brought to the McFarland turbidity criterion of 0.5. According to CLSI recommendations, strains were categorized as sensitive, or resistant based on the width of the zone of inhibition after being incubated at $35\pm 2^{\circ}\text{C}$ for 18–24 hours (Rai *et al.* 2024). Antibacterial activity against penicillin, cefoxitin, erythromycin, clindamycin, gentamicin, ciprofloxacin, trimethoprim/sulfamethoxazole, doxycycline, linezolid, and vancomycin was assessed in gram-positive bacterial isolates (*Staphylococcus*). Piperacillin/tazobactam, ceftazidime, cefepime, gentamicin, amikacin, ciprofloxacin, imipenem, meropenem, and were evaluated against negative isolates.

3. Result

3.1. Demographic and Initial Clinical Features

One hundred patients with tinea pedis participated in this study. Fifty patients were diabetic and fifty patients were not diabetic. Below is a summary of the demographic, clinical, and behavioral characteristics of both groups. (**Table 1**) displays the research participants' baseline clinical features and demographics. Patients with diabetes had a greater prevalence of hypertension ($\chi^2 = 6.828$, $\text{df} = 1$, $p = 0.009$) and were substantially older than non-diabetic patients ($\chi^2 = 20.050$, $\text{df} = 3$, $p < 0.001$). On the other hand, sex, smoking status, and obesity did not significantly differ between the two groups ($p > 0.05$).

Table 1: Demographic and baseline clinical characteristics of diabetic and non-diabetic patients with tinea pedis.

Variable	Category	Non-diabetic n (%)	Diabetic n (%)	χ^2	P-value
Age group (years)	30-40	11(22.0)	5 (10.0)	20.050	< 0.001
	41-50	13(26.0)	7 (14.0)		
	51-60	11(22.0)	33(66.0)		
	61-70	15 (30.0)	5 (10.0)		
Sex	Male/Female	38(76.0) 12(24.0)	31(62.0) 19 (38.0)	2.291	0.130
Smoking	Yes/ No	26(52.0) 24 (48.0)	24(48.0) 26(52.0)	0.160	0.689
Obesity	Yes/ No	11(22.0) 39(78.0)	12(24.0) 38(76.0)	0.056	0.812
History of hypertension	Yes/ No	21(42.0) 29 (58.0)	34(68.0) 16(32.0)	6.828	0.009

3.2. Clinical Characteristics of Tinea Pedis

The clinical features of athlete's foot are given in (**Table 2**). The primary clinical symptom in both diabetes and non-diabetic patients was interdigital lesions, and the location of lesions did not change statistically significantly between the two groups (Fisher's exact test, $p = 0.095$). However, there was a significant difference in the duration of foot lesions

based on the diabetes status ($\chi^2 = 13.152$, $\text{df} = 2$, $p = 0.001$), with diabetic individuals more likely to have chronic lesions (6 months or longer). Additionally, non-diabetic patients were considerably more likely than diabetes patients to have used public swimming pools in the past ($\chi^2 = 8.575$, $\text{df} = 1$, $p = 0.003$).

Table 2: Clinical characteristics of *Tinea pedis* among diabetic and non-diabetic patients

Variable	Category	Non-diabetic (n=50) n (%)	Diabetic (n=50) n (%)	Test	p-value
Location of Tinea pedis lesion	Interdigital	48(96.0)	41(82.0)	Fisher–Freeman–Halton exact test	*0.095
	Plantar surface	1(2.0)	2(4.0)		
	Lateral sites of foot	1 (2.0)	1 (2.0)		
	Heel	0(0.0)	3(6.0)		
	Multiple sites	0 (0.0)	3(6.0)		
Duration of foot lesion	< 1 month	5(10)	10 (20)	$\chi^2 = 13.152$ ($\text{df} = 2$)	0.001
	1–6 months	31(62.0)	13(26.0)		
	> 6 months	14(28)	27(54.0)		
Use of public swimming pools	Yes	14 (28.0)	3 (6.0)	$\chi^2 = 8.575$ ($\text{df} = 1$)	0.003
	No	36(72)	47(94.0)		

*p-values marked with an asterisk were obtained using Fisher's exact test.

3.3. Characteristics Related to Diabetes

The features of patients with diabetes are compiled in (Table 3). The majority of patients (58.0%) had no idea what kind of diabetes they had, although 22.0% had type 1 diabetes and

20.0% had type 2 diabetes. Oral hypoglycemic medications were the most prevalent treatment (50.0%), followed by insulin therapy (42.0%). About half of the patients (48.0%) had been diagnosed with diabetes for five to ten years.

Table 3: Diabetes-related characteristics of diabetic patients

Variable	Category	n	%
Type of diabetes	Type 1	11	22
	Type 2	10	20
	Unknown	29	58
Duration of diabetes (years)	<5	9	18
	5–10	24	48
	>10	17	34
Current treatment	Oral hypoglycemic agents	25	50%
	Insulin	21	42%
	Both insulin and oral agents	3	6%
	None	1	2%

Table 4: Footwear and foot hygiene practices among diabetic and non-diabetic patients

Variable	Category	Non-diabetic (n=50) n (%)	Diabetic (n=50) n (%)	Test	p-value
Footwear Type	Open shoes	7 (14.0)	27 (54.0)	$\chi^2 = 20.132$	<0.001
	Closed shoes	17 (34.0)	11 (22.0)		
	Sports shoes	26 (52.0)	11 (22.0)		
	Safety work shoes	0 (0.0)	1 (2.0)		
Shoe Duration	>4 hours	3 (6.0)	9 (18.0)	$\chi^2 = 12.167$	0.002
	4–8 hours	28 (56.0)	36 (72.0)		
	<8 hours	19 (38.0)	5 (10.0)		
Sock Change	Daily	12 (24.0)	24 (48.0)	Fisher–Freeman–Halton exact test	*0.005
	Every 2-3 days	0 (0.00)	3 (6.0)		
	Irregular	38 (76.0)	23 (46.0)		
Sock Type	Cotton	14 (28.0)	19 (38.0)	$\chi^2 = 1.139$	0.566
	Synthetic	12 (24.0)	10 (20.0)		
	Mixed	24 (48.0)	21 (42.0)		
Drying feet after washing	Yes	4 (8.0)	16 (32.0)	$\chi^2 = 9.000$	0.003
	No	46 (92.0)	34 (68.0)		
Walking bare foot	Yes	5 (10.0)	0 (0.0)	Fisher–Freeman–Halton exact test	*0.022
	No	45 (90.0)	50 (100.0)		
Foot Wash	Once daily	1 (2.0)	1 (2.0)	Fisher–Freeman–Halton exact test	*0.213
	Twice daily	0 (0.0)	3 (6.0)		
	Irregular	49 (98.0)	46 (92.0)		

*p-values marked with an asterisk were obtained using Fisher's exact test.

3.4. Shoe Options and Foot Care Habits

(Table 5) provides a summary of footwear and foot hygiene procedures. Footwear type ($\chi^2 = 20.132$, $df = 3$, $p < 0.001$), daily shoe-wearing duration ($\chi^2 = 12.167$, $df = 2$, $p = 0.002$), sock-changing frequency ($\chi^2 = 10.689$, $df = 2$, $p = 0.005$), drying feet after washing ($\chi^2 = 9.000$, $df = 1$, $p = 0.003$), and

walking barefoot ($\chi^2 = 5.263$, $df = 1$, $P = 0.022$) all showed significant differences between diabetic and non-diabetic patients. However, neither the kind of socks ($p = 0.566$) nor the frequency of foot washing ($p = 0.213$) showed any significant

Table 5: Bacterial co-isolation among diabetic and non-diabetic patients with tinea pedis

Bacterial co-isolation	Diabetic (n=50) n (%)	Non-diabetic (n=50) n (%)	χ^2	p-value
Yes	41 (82.0)	34 (68.0)	2.61	0.106
No	9 (18.0)	16 (32.0)		

3.5. Incidence of Bacterial Co-isolation

The frequency of bacterial co-isolations in athlete's foot patients is displayed in (Table 6). individuals with diabetes had higher rates of bacterial co-isolations (82.0% vs. 68.0%)

than individuals without the disease. Nevertheless, the difference ($\chi^2 = 2.61$, $df = 1$, $P = 0.106$) was not statistically significant.

Table 6: Distribution of bacterial species isolated from diabetic and non-diabetic patients with Tinea pedis

Bacterial species	Group	Diabetic (n= 50*) n (%)	Non-diabetic (n= 50*) n (%)
<i>Staphylococcus aureus</i>	Gram-positive cocci	37 (74.0)	5 (10.0)
<i>Staphylococcus haemolyticus</i>	Gram-positive cocci	46 (92)	7 (14.0)
<i>Staphylococcus simulans</i>	Gram-positive cocci	1 (2.0)	11 (22.0)
<i>Staphylococcus arlettae</i>	Gram-positive cocci	0 (0.0)	13 (26.0)
<i>Staphylococcus equorum</i>	Gram-positive cocci	0 (0.0)	13 (26.0)
<i>Staphylococcus hominis</i> subsp. <i>hominis</i>	Gram-positive cocci	2 (4.0)	15 (30.0)
<i>Staphylococcus cohnii</i> subsp. <i>cohnii</i>	Gram-positive cocci	0 (0.0)	9 (18.0)
<i>Staphylococcus saprophyticus</i>	Gram-positive cocci	1 (2.0)	13 (26.0)
<i>Staphylococcus warneri</i>	Gram-positive cocci	2 (4.0)	9 (18.0)
<i>Enterococcus faecalis</i>	Gram-positive cocci	5 (10.0)	1 (2.0)
<i>Alloicoccus otitidis</i>	Gram-positive cocci	0 (0.0)	1 (2.0)
<i>Pseudomonas aeruginosa</i>	Gram-negative bacilli	8 (16.0)	2 (4.0)
<i>Proteus mirabilis</i>	Gram-negative bacilli	3 (6.0)	2 (4.0)
<i>Escherichia coli</i>	Gram-negative bacilli	6 (12.0)	0 (0.0)
<i>Klebsiella pneumoniae</i>	Gram-negative bacilli	12(24.0)	2 (4.0)
<i>Enterobacter cloacae</i>	Gram-negative bacilli	2 (4.0)	0 (0.0)
<i>Acinetobacter baumannii</i>	Gram-negative bacilli	1 (2.0)	1 (2.0)
<i>Morganella morganii</i>	Gram-negative bacilli	10(20) (20.0)	0 (0.0)

Note: Percentages were calculated using the total number of patients in each group (n = 50). Because more than one bacterial isolate could be recovered from the same patient, the cumulative percentages exceed 100%.

3.6. Distribution of Bacterial Species Obtained from Tinea Pedis

The distribution of bacterial isolates from tinea pedis in individuals with and without diabetes is shown in (Table 7). In both groups, Gram-positive staphylococci predominated. Hemolytic staphylococci (46 strains, 92.0%) and *Staphylococcus aureus* (37 strains, 74.0%) were the most common isolates in diabetic individuals. Conversely, human

staphylococci (15 strains, 30.0%), *Staphylococcus aureus*, *Staphylococcus equorum*, and saprophytic staphylococci (13 strains, 26.0%) were the most prevalent coagulase-negative staphylococci in non-diabetic individuals. Gram-negative bacteria were seldom obtained from non-diabetic patients, whereas *Klebsiella pneumoniae* (12 strains, 24.0%) and *Pseudomonas aeruginosa* (8 strains, 16.0%) were the most commonly isolated strains from diabetes patients.

Table 7: Antimicrobial susceptibility patterns of *Staphylococcus aureus* and *Staphylococcus haemolyticus* isolates recovered from patients with Tinea pedis

Antibiotic	<i>Staphylococcus aureus</i> Sensitive n (%)	<i>Staphylococcus aureus</i> Resistant n (%)	<i>Staphylococcus haemolyticus</i> Sensitive n (%)	<i>Staphylococcus haemolyticus</i> Resistant n (%)
Penicillin	2(4.8)	40(95.2)	2(3.7)	51(96.2)
Cefoxitin	31(73.8)	11(26.2)	24(45.3)	29(54.7)
Erythromycin	19(45.2)	23(54.8)	19(35.8)	34(64.2)
Clindamycin	27(64.2)	15(35.8)	31(58.5)	22(41.5)
Gentamicin	32(76.2)	10(23.8)	43(81.1)	10(18.9)
Ciprofloxacin	25(59.5)	17(40.5)	41(77.4)	12(22.6)
Doxycycline	38(90.4)	4(9.6)	43(81.1)	10(18.9)
Trimethoprim-sulfamethoxazole	34 (81.0)	8(19.0)	39(73.6)	14(26.4)
Linezolid	40(95.2)	2(4.8)	53(100.0)	0(0.0)
Vancomycin	42(100.0)	0(0.0)	53(100.0)	0(0.0)

Table 8: Antimicrobial susceptibility patterns of *pseudomonas aeruginosa* isolates recovered from patients with Tinea pedis

Antibiotic	Sensitive n (%)	Resistant n (%)
Piperacillin-Tazobactam	8(80.0)	2(20.0)
Ceftazidime	9(90.0)	1(10.0)
Cefepime	8(80.0)	2(20.0)
Gentamicin	7(70.0)	3(30.0)
Tobramycin	9(90.0)	1(10.0)
Amikacin	10(100.0)	0(0.0)
Ciprofloxacin	7(70.0)	3(30.0)
Imipenem	8(80.0)	2(20.0)
Meropenem	9(90.0)	1 (10.0)

3.7. Antimicrobial Resistance Profiles of *Staphylococcus aureus* and *Staphylococcus haemolyticus*

The antibiotic susceptibility patterns of the main Gram-positive (*Staphylococcus aureus* and *Staphylococcus hemolyticus*) and Gram-negative (*Pseudomonas aeruginosa*) isolates are included in Tables 7 and 8. Vancomycin was completely effective against both *Staphylococcus* species,

although Linezolid was especially effective against hemolytic *Staphylococcus* (100%). Penicillin, on the other hand, had the highest rate of resistance in both *Staphylococcus* species. Gentamicin, doxycycline, and trimethoprim/sulfamethoxazole were also shown to be very susceptible, although cefoxitin, erythromycin, clindamycin, and ciprofloxacin demonstrated differing degrees of

effectiveness, especially against hemolytic *Staphylococcus*. Amikacin had 100% effectiveness against *Pseudomonas aeruginosa* isolates, but ceftazidime, tobramycin, and meropenem shown high susceptibility rates (90%). Gentamicin and ciprofloxacin had very low susceptibility rates (70%), but piperacillin/tazobactam, cefepime, and imipenem all displayed 80% susceptibility.

4. Discussion

According to this study, the bulk of diabetes athlete's foot cases were concentrated in the 51–60 age range, and individuals with the condition were much older than non-diabetic patients. This is caused by biological factors because aging increases susceptibility to fungal dermatophytosis and prolongs the survival time of fungi by reducing peripheral circulation, impairing skin barrier function, and delaying epidermal cell regeneration, among other things. Peripheral neuropathy and vascular insufficiency aggravate these age-related alterations in diabetic patients, fostering an environment that is conducive to persistent foot infections. This finding is in line with Ogawa *et al.*'s (Ogawa *et al.* 2024) [11] extensive epidemiological investigation, which found diabetes and advanced age to be independent risk factors for athlete's foot. In a similar vein, a recent analysis by Leung *et al.* (Leung *et al.* 2018) [12] highlighted that one of the main risk factors for fungal dermatophytosis is advanced age.

Patients with diabetes are more likely than those without the disease to have hypertension. Although hypertension does not directly cause tinea pedis, it frequently coexists with diabetes as a component of the metabolic syndrome and exacerbates peripheral vascular dysfunction. Increased vulnerability to secondary bacterial infections, delayed tissue repair, prolonged fungal infections, and impaired local immune response are all consequences of reduced blood supply to tissues. Studies assessing diabetic foot issues, where hypertension is often linked to diabetic vascular complications, have revealed similar findings. Contrary to what we found, a number of epidemiological studies on tinea pedis have found that diabetes, not hypertension, is a significant independent risk factor. This suggests that hypertension may not be the only factor but may have an indirect impact due to its effects on blood vessels. (Fan *et al.* 2024) [13]. On the other hand, there were no discernible variations in sex, smoking, or obesity between individuals with and without diabetes. The lack of a sex difference is in line with several epidemiological studies that demonstrate that factors connected to diabetes, the body's immunity, and local environmental circumstances have a greater impact on the occurrence of athlete's foot than sex. Similarly, the lack of a correlation with smoking may indicate that fungal skin infections are complex, with diabetes, humidity, closed shoes, and hygiene practices having a bigger influence than smoking. Our results show that obesity may be a risk factor for patients with diabetic athlete's foot, in contrast to current research. This discrepancy might result from variances in the research population, sample size, ethnicity, definition of obesity, and lifestyle and environmental factors in various geographical areas (Alhammadi *et al.* 2023) [4].

The main clinical symptom in both diabetic and non-diabetic individuals was interdigital mycosis, and the location of infection did not differ statistically significantly between the two groups. This is a natural outcome since the interdigital spaces, with their warmth, wetness, friction, and inadequate ventilation, create the perfect milieu for the growth of skin

fungus. Regardless of whether diabetes is present or not, these variables encourage the formation of skin fungus. Clinical evaluations and epidemiological research have regularly found similar results, and interdigital mycosis is thought to be the most prevalent sign of athlete's foot globally (Leung *et al.* 2023) [15]. In comparison to those without diabetes, diabetic patients suffer from a much longer duration of illness along with an increased incidence of recurrence of chronic lesions (more than six months duration), despite the presence of the same lesion sites. There are several conditions, including peripheral neuropathy, impaired wound healing ability, compromised immunity, and microvascular complications of diabetes, which are believed to cause such a prolonged course of illness. All these conditions impair the body's ability to fight off the infection, leading to disease recurrence and persistence (Nigam, 2017) [16]. In addition, continuous disruption in the integrity of the skin makes one susceptible to further bacterial colonization, making chronic lesions very significant for our case. Our case involves bacterial colonization, which is the main focus of our study. The same outcomes have been observed in diabetic patients, and if left untreated, tinea pedis commonly turns chronic, complicating issues in diabetic feet (Leung *et al.* 2023) [15].

Moreover, a substantially larger number of people without diabetes have had the experience of swimming in the public pools, according to the findings from the research. Since fungus spores feed on moist conditions and spread in individuals with vulnerability by means of direct contact with the skin, the public pools, showers, and changing rooms are perfect places for the transmission of the dermatophytes. This is consistent with previous research that had found swimming pools and public baths to be one of the major environmental factors causing athlete's foot. However, the low prevalence of the usage of pools among diabetics opens the doors for the influence of other factors, such as those relating to diabetes, on the condition. (Leung *et al.* 2023) [15]. The persistence of athlete's foot may be influenced by the length of diabetes, since almost half of diabetic individuals have had the disease for five to ten years. Chronic foot infections and subsequent bacterial colonization are made more likely by peripheral neuropathy, microvascular dysfunction, and impaired immune function, all of which are linked to long-term diabetes. The length of diabetes is a major risk factor for diabetic foot infections, according to current assessments and worldwide recommendations (Senneville *et al.* 2023) [17].

Diabetic and non-diabetic people had significantly different footwear and foot care practices. Certain preventative foot care practices, such as changing socks regularly, completely drying feet after bathing, and refraining from going barefoot, were observed to be more adhered to by diabetic patients. These steps are advised by current worldwide standards to lessen the persistence of athlete's foot and related infections (Leung *et al.* 2023) [15]. However, foot care may not be able to totally avoid fungal infections in diabetic individuals since diabetes-related microvascular damage and impaired immune function are important variables that raise the risk of infection (Bus *et al.* 2024) [18]. *Staphylococcus* species are the main bacterial isolates linked to athlete's foot, according to this study, and *Staphylococcus aureus* is more common in diabetic individuals. This conclusion is in line with previous research showing that *Staphylococcus aureus* is a significant pathogen in diabetes patients' feet because immune system failure, hyperglycemia, and compromised skin barrier function all encourage bacterial adherence and

persistence (Liu *et al.* 2019)^[19].

Patients with diabetes are more likely than those without to have gram-negative bacteria identified from them, including *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Morganella morganii*. This result is in line with a previous comprehensive analysis that found that long-term fungal infections, tissue degradation, neuropathy, and repetitive antibiotic exposure provide an ideal habitat for opportunistic Gram-negative organisms in diabetes patients' feet (Qu *et al.* 2024). The idea of multimicrobial foot infections is supported by the observation in this investigation that dermatophytes coexist with bacterial pathogens. According to recent molecular biological research, patients with athlete's foot frequently have bacterial colonization, especially by *Pseudomonas aeruginosa* and *Staphylococcus aureus*. This colonization may worsen clinical outcomes, cause persistent inflammation, and delay healing, especially in diabetic patients (Gupta *et al.* 2025)^[6]. Penicillin exhibited the highest rate of resistance in antimicrobial susceptibility tests, although vancomycin and linezolid retained good effectiveness against both *Staphylococcus aureus* and *Staphylococcus haemolyticus*. These findings are in line with recent reports showing that the production of β -lactamase (blaZ) enzymes in *Staphylococcus* and the acquisition of the *mecA* gene encoding modified penicillin-binding protein (PBP2a) in methicillin-resistant strains are the main mechanisms of β -lactam resistance. Glycopeptides and oxazolidinones, on the other hand, typically retained better effectiveness against isolates that were Gram-positive (Elbehiry *et al.*, 2026; ECDC, 2024)^[24]. *Pseudomonas aeruginosa* exhibited limited susceptibility to ciprofloxacin and gentamicin, but high susceptibility to ceftazidime, meropenem, and tobramycin among Gram-negative isolates. These results are in line with recent studies showing that aminoglycosides and certain anti-*Pseudomonas* β -lactam antagonists are effective against susceptible isolates, while resistance in *Pseudomonas aeruginosa* is primarily linked to overexpression of the efflux pump (MexAB-OprM), purine loss (OprD), and mutations affecting fluoroquinolone targets (Carrara *et al.*, 2024; Bassetti *et al.*, 2024)^[25, 26]. *Staphylococcus haemolyticus* was less susceptible to cefoxitin and erythromycin than *Staphylococcus aureus*, indicating its well-known capacity to accumulate mobile resistance determinants and serve as a significant reservoir of antibiotic resistance genes in clinical settings. However, both *Staphylococcus* species demonstrated similar susceptibility to vancomycin and linezolid. Recent genomic investigations of coagulase-negative staphylococci have progressively shown this trait (O'Keefe *et al.*, 2024). *Staphylococcus aureus* and *S. haemolyticus* isolates are more numerous than those found in most earlier tinea studies. Although *S. haemolyticus* has always been thought of as a coagulase-negative opportunistic staphylococcus, new research indicates that it is an important source of antibiotic resistance genes and has a remarkable capacity to persist by creating biofilms on injured skin surfaces. Coagulase-negative staphylococci may be more important than previously believed in bacterial infections linked to persistent tinea, especially in diabetic individuals, as evidenced by the frequent isolation of *S. haemolyticus* with *Staphylococcus aureus*. These findings call for more molecular biological research to clarify the pathogenicity and resistance factors of these isolates (Jiménez-Velásquez *et al.* 2024)^[28].

5. Conclusion

This study showed that tinea patients, especially those with diabetes, frequently get secondary bacterial infections. *Klebsiella pneumoniae* was the most common Gram-negative bacterium among the isolated bacteria, which were mostly *Staphylococcus* species, particularly *Staphylococcus aureus* and hemolytic *Staphylococcus*. Vancomycin, linezolid, and amikacin were shown to be effective treatment choices against the dominating pathogens based on observed antibiotic susceptibility patterns. The significance of culture-based diagnosis and antibiotic susceptibility testing prior to starting antibiotic therapy was underscored by the significant penicillin resistance. These findings imply that in order to lessen recurring infections and avoid diabetic foot problems, early diagnosis, proper foot care, and cautious antibiotic usage are essential.

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