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FUNGAL COLONIZATION OF BODY SURFACES OF YOUTHS LIVING IN IKWUANO L.G.A, UMUAHIA, ABIA STATE, NIGERIA

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ABSTRACT
Fungal colonization of human body surfaces increases due to interaction with the environment. This study aimed to isolate, identify, and characterize fungal species colonizing young individuals living in Ikwuano Local Government Area, Abia State, Nigeria. 20 samples were taken from the body surfaces such as the nails, armpit, toe web, hairs, and skin from different communities in Ikwuano LGA using the swab stick soaked with distilled water. The samples were inoculated using the spread plate method, cultured in Sabouraud Dextrose Agar, and incubated at room temperature for 5-7 days. The organisms were characterized and identified as Epidermophyton, Trichophyton, Aspergillus, Microsporum, and Candida spp. Trichophyton had a percentage occurrence of (32%), while the least was observed with Candida (13%). The total fungal count for the samples from various body sites for males ranged from 0.27 x 105 - 0.71 x 105 cfu/ml with the highest fungal load occurring in toe web samples (0.71x105 cfu/ml). The total fungal count for the samples from various body sites for females ranged from 0.21x 105 - 1.01 x 105 cfu/ml with the highest load being observed with the skin samples (1.01x105). Proper hygiene should be encouraged to reduce the rate of fungal colonization.

KEYWORDS: *Colonization, Fungi, Dermatophytes, Body surfaces, Skin*

INTRODUCTION

The study of fungi as animal and human pathogens is called mycology (Emmons 1979). Fungi are eukaryotic, unicellular, or multi-cellular organisms that, because they lack chlorophyll, are dependent upon external food sources. They are ubiquitous in all environments and play a vital role in the Earth's ecology by decomposing organic matter. Familiar fungi include yeasts, rusts, smuts, mushrooms, puffballs, and bracket fungi. Many species of fungi live as commensal organisms in or on the surfaces of the human body. "Mold" is the common term for multicellular fungi that grow as a material of intertwined microscopic filaments (hyphae). Exposure to molds and other fungi and their spores is unavoidable except when the most stringent air filtration, isolation, and environmental sanitation measures are observed, e.g. in organ transplant isolation units.

Fungal colonization is the presence of fungi on the host, with growth and multiplication of the fungi, where there is no interaction between host and organism

(no clinical expression, no immune response). Colonization of human skin with bacterial and fungal communities has been observed for decades, but much remains to be understood about host-fungus interactions at this surface. Nowadays, different fungi including *Malassezia, Cryptococcus, Rhodotorula*, and *Candida* species have been identified as human skin commensals (Andreas *et al.,* 2017).

The skin is home to millions of bacteria, fungi, and viruses that constitute the skin microbiota. Similar to those in our gut, skin microorganisms have essential roles in the protection against invading pathogens, the education of our immune system, and the breakdown of natural products (Grice, 2015). As the largest organ of the human body, the skin is colonized by beneficial microorganisms and serves as a physical barrier to prevent the invasion of pathogens. In circumstances where the barrier is broken or when the balance between commensals and pathogens is disturbed, skin disease or even systemic disease can result. Human skin sites can be categorized by their physiological characteristics, that is, whether they are sebaceous (oily), moist, or dry (Byrd, *et al.,* 2018). The idea that fungi form a kingdom distinct from plants and animals gradually became accepted only after Whittaker's discovery (Flynn, 2009). The word "fungi" is commonly used as a collective term for organisms traditionally studied by mycologists from all three kingdoms (Hawkworth 1991). Structurally, the skin is composed of two distinct layers: the epidermis and dermis. The outermost layer (the epidermis) is composed of layers of differentiated keratinocytes. The top layer, or stratum corneum, is composed of terminally differentiated, enucleated keratinocytes (also known as squames) that are chemically cross-linked to fortify the barrier of the skin (Segre, 2006).

Dermatophytes are a fungal infection that occurs often in the human body and affects the areas of the scalp, skin, and nails of the body. These dermatophytes are closely related to fungi that can invade the keratinized tissues of the above-mentioned areas of the human body (Achterman, *et al.,* 2011.). It includes 3 genera, i.e., *Epidermophyton, Microsporum,* and *Trichophyton*. These fungi colonize in the keratin tissues and are repeatedly restricted to the nonliving cornified layer of the upper cell layer of the tissues. Dermatophytes are also associated with secondary bacterial infections leading to systemic skin infections. According to WHO, the prevalence rate of superficial mycotic infection worldwide is 20%–25% (Grumbt, *et al.,* 2013.). Tinea infections are prevalent globally, but they are common in the tropics and geographical areas with higher humidity, overpopulation, and poor hygienic living conditions. The present study was conducted to isolate and identify dermatophytes from skin, hair, and nail samples of youths (male and female) in Ikwuano L.G.A, Umuahia, Abia, State Nigeria.

MATERIALS AND METHODS

Study Area

Ikwuano is one of the local government areas located in Abia State, southeast Nigeria. It has an area of 281 km^2 and lies between the latitudes 5. 24lN and 5 30lN (5.4093° N) and between the longitudes of 7 32lE and 7 37Le (7.5897° E). Its headquarters is in Isiala Oboro. Ikwuano

consists of four different ancient kingdoms as the name 'Ikwuano' implies. These includes Oboro, Ibere, Ariam/Usaka and Oloko. Ikwuano have over 200, 800 population as the year 2022Ikwuano is in the humid forest zone of Nigeria. The Local Government Area has an average rainfall of 2351 mm, average minimum diurnal temperature of 22.90C and relative humidity range between 80 and 90%. The vegetation of the area is predominantly lowland rainforest, which makes it suitable for growing yam, cassava, maize, cashew, and ginger. This has led to the area becoming the food basket of Abia State. Farming is one of the key economic activities of the Ikwuano people. The area also hosts several markets where a variety of commodities are bought and sold. They include Ahia Ndoro and the Ariam Market.

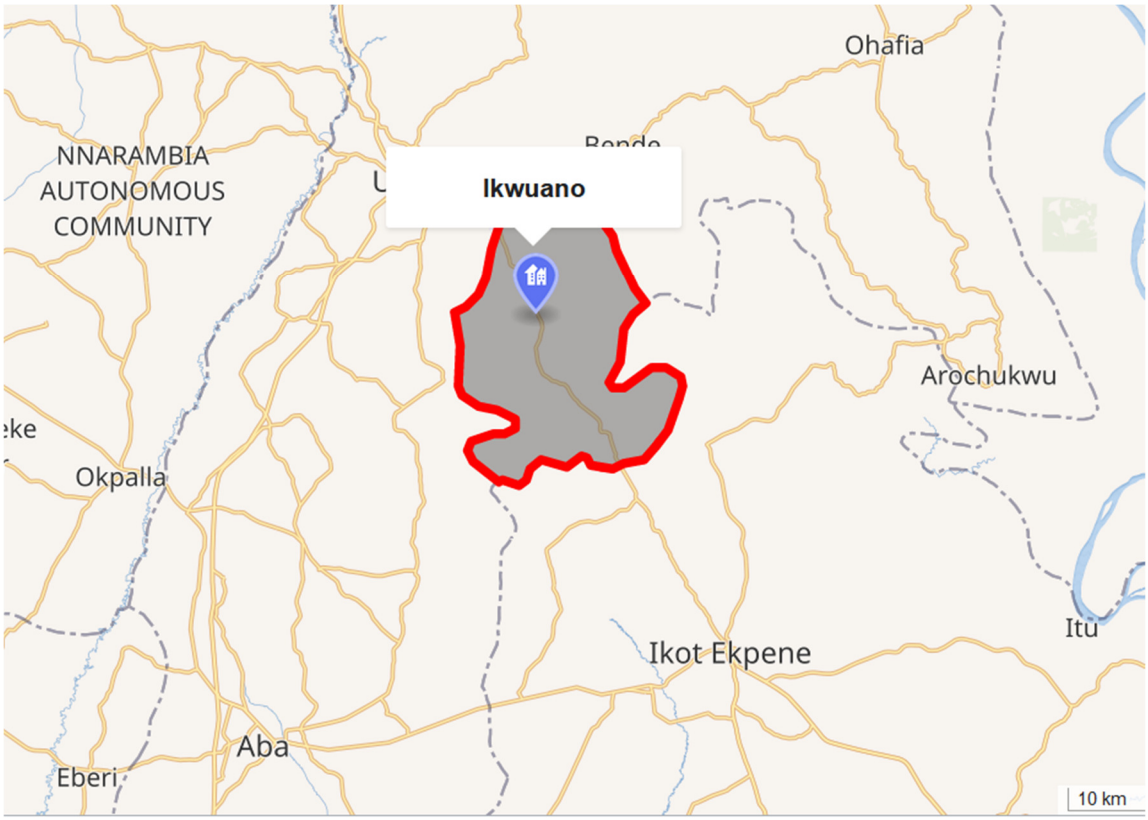

Fig. 1: Map showing the study area (Ikwuano)

Collection of Samples

A total of forty (40) samples were collected from human body surfaces some parts of the human body such as Toe web, nails, hair, and armpit. These samples were collected aseptically using sterile swab sticks moistened with physiological saline. The swab sticks were transferred immediately to the laboratory within one hour of samples collected to prevent drying of the samples for microbiological analysis. All the samples were processed in the laboratory according to the standard microbiological methods under very strict complete aseptic conditions. The swabs were inoculated on appropriate media.

Preparation of Culture Media

The Saboruad Dextrose Agar (SDA) used was prepared according to the manufacturer's instructions for each medium. The required amount of the powdered medium was weighed following the manufacturer's specification and dispensed into glass bottles which were then loosely capped and sterilized by autoclaving at 121^{o}C for 15 minutes. The media were allowed to cool at 45^{o}C before they were aseptically dispensed into sterile plastic Petri dishes.

Inoculation of Culture Media (Culturing the Skin Samples)

The method described by Okoro *et al*. (2012) was used. The swab stick bearing the sample was dipped in a test tube containing 10ml sterile normal saline. Then 10 10-fold serial dilutions were thereafter carried out as described by Nirmala *et al*., (2016).

Isolation of Fungi

From a suitable dilution, 0.1ml of each dilution was uniformly inoculated on the surface of the prepared Saboruad Dextrose Agar plate and spread using a sterile bent rod to maintain an even distribution of the sample in duplicate. Dilutions up to 10^{-5} were carried out and the plates were incubated in an upright position at 30˚C for 3 days. The same procedure was carried out for all the samples. After 48 hours of incubation, the colonies were counted and the number of colonies in each plate was recorded. The different types of colonies were used as inocula to obtain pure cultures by subculturing in SDA (Nirmala *et al*., 2016).

Sub-culturing/Purification of Fungi Isolates

When growth had established, subcultures were prepared using inocula from the different organisms in the cultures plates to obtain a pure culture, this was done by transferring hyphal tips from the colony edge of the cultures to fresh plates of SDA using flame-sterilized blades. After sub-culturing the plates were incubated at 27^{0}C until pure cultures were obtained. The Petri dishes of pure cultures of the test fungi were then sealed with paraffin to prevent contamination. The resulting pure cultures were used for the identification of the fungi isolates with the aid of a compound microscope and identification guides (Sulton, 2000).

Determination of Percentage Occurrence of the Isolates

The occurrence of the fungi species isolated from the test samples was determined as a percentage ratio of their prevalence relative to the total number of samples examined (Onuorah and Obika, 2015). The formula below was used.

$$\% \text{ occurrence} = \frac{\text{No of positive test}}{\text{Total No tested}} \times \frac{100}{1}$$

Data Analysis

Data generated from the experiment were analyzed using the statistical package for Social Science (SPSS) version 25.0. Frequencies and percentages were used to analyze the data derived, and standard deviation and mean squared error of the data were also obtained for the derived data.

RESULTS

The Total Fungal Counts (TFC) of the male samples are shown in Table 1. For the 10 samples collected from the toe web, only 1 sample showed no growth. For the 10 samples of nail, armpit, and skin respectively, there was growth in 5 of the samples and no growth in 5 samples as well. The TFC of toe web samples ranged from 0.27 x 10^5- 0.71 x 10^5 cfu/ml, that of

nail sample ranged from 0.26 x10^5 - 0.55 x 10^5 cfu/ml, hair samples ranged 0.24 x 10^5 - 0.72 x 10^5 cfu/ml, armpit ranged from 0.24 x 10^5 - 0.57 x 10^5 cfu/ml, while that of skin from 0.20 x 10^5 - 0.73 x 10^5. The highest fungal load was recorded with the skin (0.73x10^5), followed by the toe web (0.71x10^5) while the least was recorded with hair (0.24x10^5).

The Total Fungal Count (TFC) of the female samples is shown in Table 2. There was growth in all the samples of toe web collected. For the 10 samples of hair, armpit, and skin, there was growth in 7 of the samples while they were growth in 5 samples of the nail. The TFC of toe web samples ranged from 0.00 x 10^5 - 0.71 x 10^5 cfu/ml, that of nail sample ranged from 0.00 x10^5 - 0.53 x 10^5 cfu/ml, that of hair ranged from 0.00 x 10^5 – 0.72 x 10^5 cfu/ml, that of armpit ranged from 0.00 x 10^5 - 0.57 x 10^5 cfu/ml, that of the skin ranged from 0.21 x 10^5 - 1.03 x 10^5. The highest fungal load was recorded with the skin (1.03x10^5), followed by hair (0.72x10^5), while the least was recorded with the toe web (0.22x10^5).

The fungal identification is shown in Table 3. Based on the colonial characteristics and lactophenol cotton blue (LPCB) staining, they were identified to belong to the genus, *Trichophyton, Epidermophyton, Microsporum, Aspergillus,* and *Candida* species.

Table 4 shows the percentage occurrence of the fungal isolates. As observed from the table *Trichophyton* had the highest percentage 18(32%). It was followed by *Epidermophyton* and *Microsporum* 16(26%) and 15(24%). The last occurrence was observed with *Candida* 9(16%).

As shown in Table 5, the highest number of isolates from male samples was obtained from toeweb (14). It was followed by nail and armpit (13). The least was observed with Hair (9). *Trichophyton* had the highest percentage occurrence (32%), *Epidermophyton* had (26%) occurrence, *Microsporum* (24%), *Aspergillus* (22%) and *Candida* (16%) occurrence.

Table 1: Total Fungal Counts of the body surface of the male

Sample	Toeweb	Nail	Hair	Armpit	Skin	Mean Squared Error	Statistic
Sample 1	0.71 x 10^5	0.42 x 10^5	0.00 x 10^5	0. 27x 10^5	0. 31x 10^5	12.07911	27.00971
Sample 2	0.46 x 10^5	0.39 x 10^5	0.24 x 10^5	0. 00x 10^5	0. 42x 10^5	8.83748	19.76121
Sample 3	0.34 x 10^5	0.26 x 10^5	0.00 x 10^5	0. 00x 10^5	0. 29x 10^5	7.74726	17.32341
Sample 4	0.57 x 10^5	0.00 x 10^5	0.00 x 10^5	0. 33x 10^5	0. 00x 10^5	12.24050	27.37058
Sample 5	0.48 x 10^5	0.00 x 10^5	0.00 x 10^5	0. 41x 10^5	0. 00x 10^5	11.50409	25.72393
Sample 6	0.31 x 10^5	0.00 x 10^5	0.27 x 10^5	0. 00x 10^5	0. 00x 10^5	7.48820	16.74413
Sample 7	0.00 x 10^5	0.53 x 10^5	0.41 x 10^5	0. 00x 10^5	0. 57x 10^5	13.23750	29.59995
Sample 8	0.27 x 10^5	0.44 x 10^5	0.00 x 10^5	0. 00x 10^5	0. 37x 10^5	9.68394	21.65394
Sample 9	0.44 x 10^5	0.00 x 10^5	0.44 x 10^5	0. 31x 10^5	0. 00x 10^5	10.50210	23.48341
Sample 10	0.36 x 10^5	0.00 x 10^5	0.00 x 10^5	0. 34 x 10^5	0. 00x 10^5	9.00800	20.14249
Sample 11	0.59 x 10^5	0.00 x 10^5	0.72 x 10^5	0. 52 x 10^5	0. 61x 10^5	13.24582	29.61856
Sample 12	0.00 x 10^5	0.37 x 10^5	0.47 x 10^5	0. 00 x 10^5	0. 21x 10^5	9.99984	22.36032
Sample 13	0.41 x 10^5	0.32 x 10^5	0.27 x 10^5	0. 24 x 10^5	0. 41x 10^5	3.68249	8.23430
Sample 14	0.00 x 10^5	0.00 x 10^5	0.33 x 10^5	0. 29 x 10^5	0. 36x 10^5	8.48228	18.96696
Sample 15	0.63 x 10^5	0.55 x 10^5	0.36 x 10^5	0. 30 x 10^5	0. 00x 10^5	11.54714	25.82018
Sample 16	0.00 x 10^5	0.32 x 10^5	0.00 x 10^5	0. 00 x 10^5	0. 73x 10^5	15.12146	33.81261
Sample 17	0.31 x 10^5	0.00 x 10^5	0.40 x 10^5	0. 00 x 10^5	0. 00x 10^5	9.25192	20.68793
Sample 18	0.00 x 10^5	0.28 x 10^5	0.31 x 10^5	0. 00 x 10^5	0. 55x 10^5	10.93917	24.46072
Sample 19	0.61 x 10^5	0.33 x 10^5	0.01 x 10^5	0. 57 x 10^5	0. 23x 10^5	11.65453	26.06031
Sample 20	0.37 x 10^5	0.00 x 10^5	0.66 x 10^5	0. 35 x 10^5	0. 33x 10^5	10.98944	24.57314

Table 2: Total Fungal Counts of Body Surface of Female

Sample	Toeweb	Nail	Hair	Armpit	Skin	Mean Squared Error	Statistic
Sample 1	0.71 x10^5	0.42 x10^5	0.33 x10^5	0. 27x10^5	0. 34x10^5	8.16438	18.25612
Sample 2	0.66 x10^5	0.39 x10^5	0.25 x10^5	0. 31x10^5	0. 32x10^5	7.56146	16.90793
Sample 3	0.34 x10^5	0.27 x10^5	0.28 x10^5	0. 00x10^5	0. 00x10^5	7.73302	17.29156
Sample 4	0.47 x10^5	0.00 x10^5	0.00 x10^5	0. 33x10^5	0. 00x10^5	10.54714	23.58413
Sample 5	0.48 x10^5	0.00 x10^5	0.22 x10^5	0. 41x10^5	0. 51x10^5	10.01966	22.40465
Sample 6	0.31 x10^5	0.00 x10^5	0.27 x10^5	0. 00x10^5	0. 21x10^5	6.97598	15.59877
Sample 7	0.30 x10^5	0.53 x10^5	0.41 x10^5	0. 40x10^5	0. 33x10^5	4.18158	9.35031
Sample 8	0.26 x10^5	0.44 x10^5	0.00 x10^5	0. 00x10^5	0. 00x10^5	9.48494	21.20896
Sample 9	0.44 x10^5	0.00 x10^5	0.44 x10^5	0. 31x10^5	0. 44x10^5	8.95644	20.02722
Sample 10	0.36 x10^5	0.00 x10^5	0.00 x10^5	0. 34x10^5	1. 01x10^5	19.36788	43.30789
Sample 11	0.59 x10^5	0.00 x10^5	0.72 x10^5	0. 52x10^5	1.03x10^5	17.21105	38.48507
Sample 12	0.00 x10^5	0.37 x10^5	0.47x 10^5	0. 00x10^5	0. 26x10^5	10.05481	22.48324
Sample 13	0.41 x10^5	0.32 x10^5	0.27 x10^5	0. 21x10^5	0. 00x10^5	7.22443	16.15431
Sample 14	0.00 10^5	0.00 x10^5	0.33 x10^5	0. 29x10^5	0. 00x10^5	8.00070	17.89010
Sample 15	0.63 x10^5	0.45 x10^5	0.36 x10^5	0. 30x10^5	1.01x 10^5	13.41783	30.00319
Sample 16	0.30 x10^5	0.32 x10^5	0.00 x10^5	0. 50x10^5	0. 00x10^5	10.27499	22.97557
Sample 17	0.31 x10^5	0.00 x10^5	0.40 x10^5	0. 00x10^5	0. 00x10^5	9.25192	20.68793
Sample 18	0.00 x10^5	0.28 x10^5	0.31 x10^5	0. 00x10^5	0. 34x10^5	8.03507	17.96697
Sample 19	0.41 x10^5	0.43 x10^5	0.41 x10^5	0. 57x10^5	0. 37x10^5	3.61298	8.07886
Sample 20	0.37 x10^5	0.00 x10^5	0.66x 10^5	0. 35x 0^5	0. 00x10^5	13.15898	29.42436

Table 3: Identification of the fungal isolates

Colonial characteristics	LPCB staining	Fungi
The colony is white and circular	The small and cylindrical shape macroconidia present	*Trichophyton* spp
Greenish and powdery	Club-shaped macroconidia present	*Epidermophyton* spp
Yellowish and powdery	Spindle-shaped microconidia present	*Microsporum* spp
Black and powdery	Conidiophores present	*Aspergillus* spp
Creamy with a smooth texture	Conidia and hyphae present	*Candida* spp

Table 4: Percentage occurrence of isolates

Isolates	**Number of occurrences**	**Percentage occurrence (%)**
Trichophyton	18	32
Epidermophyton	16	26
Microsporum	15	24
Aspergillus	12	22
Candida	9	16
Total	69	100

Table 5: Frequency of occurrence of Isolates about the Body Sites

	Isolate	**Body site (n=10)**					
		Nail	Hair	Armpit	Toe web	Skin	Total (%)
Male	*Epidermophyton*	4	1	3	2	3	26
	Trichophyton	3	4	3	4	2	32
	Aspergillus	2	1	3	3	2	22
	Microsporum	2	2	2	3	2	24
	Candida	2	0	2	2	2	16
	Total (%)	13	9	13	14	11	100
Female	*Epidermphyton*	1	2	2	1	2	14
	Trichophyton	1	1	1	1	2	12
	Aspergillus	1	1	1	1	0	8
	Microsporum	1	1	2	1	2	16
	Candida	0	0	2	1	2	10
	Total (%)	6	5	7	5	8	100

DISCUSSION

Colonization of human skin with bacterial and fungal communities has been observed for decades, but much remains to be understood about host-fungus interactions at this surface. However, this study evaluated the colonization of fungi on human body surfaces of young people in Ikwuano LGA Abia state. Furthermore, the result obtained showed the Total fungal counts of male body surface ranged from 0.27 x 10^5 - 0.71 x 10^5 cfu/ml, for toeweb samples,0.26 x10^5 - 0.55 x 10^5 cfu/ml, for nails samples, 0.24 x 10^5– 0.55 x 10^5 cfu/ml, for hair samples, 0.24 x 10^5 to 0.57 x 10^5 cfu/ml, for armpit samples and 0.20 x 10^5 - 0.73 x 10^5 for the skin samples. The Total Fungal Count of female body surfaces are the toe web samples ranged from 0.00 x 10^5 - 0.71 x 10^5 cfu/ml. The nail sample ranged from 0.00 x10^5 - 0.53 x 10^5 cfu/ml. That of hair 0.00 x 10^5– 0.72 x 10^5 cfu/ml. That of armpit from 0.00 x 10^5 - 0.57 x 10^5 cfu/ml.

That of the skin from 0.21 x 10^5 - 1.03 x 10^5.

These variations in the results could be a result of increased outdoor physical activities and increased sweating, which create a favourable environment for fungal infections, weather change, Geographical distribution, hygienic conditions, and frequent exposure of the body surface to certain environments. In many clinical and epidemiological studies, fungal infections of the skin and scalp represent a relatively common problem, especially in the tropical and subtropical regions of the world where warm and humid climate provides a favourable environment for fungi (Salma *et al*., 2018).

Nowadays, different fungi including *Malassezia*, *Cryptococcus*, *Rhodotorula*, and *Candida* species have been identified as human skin commensals (Andreas *et al*., 2017). The fungal species isolated from this study were *Trichophyton, Epidermophyton, Microsporum, Aspergillus,* and *Candida* species. These results agreed with those of (Uthan Singh *et al*., 2019), who reported that *Microsporum* spp, *Trichophyton* spp*,* and *Epidemophyton* spp were the most common genus of Dermatophytes to be isolated from human body surfaces. According to a certain study by Research wap.com *Aspergillus niger* and *Saccharomyces* spp were the two fungi isolated from an experiment carried out on male and female body surfaces in Osun State Polytechnic Iree. Also, these results were found to conform with the findings of (Sani *et al*., 2020) whose study showed that *Trichophyton spp*, *Microsporum* spp*, Aspergillus* spp*, Epidermophyton* spp*,* and *Candida* spp were the most common fungi isolated from human body surfaces. An epidemiological study demonstrated recovery of *Candida* from the wounds of 8 to 10% of severely burned patients studied (Bruck *et al*. 1972). A Certain study by (Uzeh *et al*. 2012) showed that *Candida* spp. *was* isolated during the assessment of the armpit of some selected university students in Lagos Nigeria.

However, as obtained from this study, *Trichophyton* had the highest percentage of occurrence (32%), followed by *Epidermophyton* (26%) and *Microsporum* (24%). This is similar to what was reported by (Mwaura,2011) on Isolation and Identification of Fungal by dermatological agents among patients attending Thika District Hospital Thika, Kenya, where 62.6% were isolates of *Trichophyton* spp, 24.3% yeast, 2.8% *Epidermophyton* spp., 2.8% *Microsporum* spp. A study explored foot disease in soccer athletes using a culture-dependent approach (Purim *et al*. 2005). The major genera observed in this population of athletes were primarily the dermatophytes, *Trichophyton rubrum* (40%), and *Trichophyton mentagrophytes* (36.4%), whereas *Candida* and other fungi made up the remaining 24%. (Findley *et al* 2013) also observed *Trichophyton* as the only dermatophyte in the fungal survey study and only on the feet of HVs. Genera such as *Microsporum* and *Epidermophyton* were not observed.

The skin fungal diversity is more site-dependent. Sites on the back and head are the most stable with the lowest diversity, whereas the proximal arm sites display intermediate diversity. The foot sites are not very stable, change over time, and are the most diverse, with at least 40 genera colonizing each foot site (Findley *et al*., 2013). A study by Salma *et al.* (2018) showed that the most prevalent isolate both in terms of its percent occurrence and frequency of occurrence in fungal flora of

female hair was *Aspergillus niger*, which some of the isolates were found to be pathogenic to humans. It can cause fatal invasive aspergillosis and pulmonary disease in immunocompromised patients, and they are associated with the production of oxalate crystals in clinical specimens. (Oda *et al*., 2013).

CONCLUSION

This work was centered on the isolation and the Characterization of Fungi isolated from young people in Ikwuano L.G.A Abia state. From the study *Epidermophyton, Trichophyton, Microsporum, Aspergillus,* and *Candida* spp were the organism present in the body surfaces of the study participants. *Trichophyton* had the highest percentage of occurrence followed by *Epidermophyton*. Among the various body sites examined the toe web had the highest fungal load on the male body surface while the skin had the highest fungal load on the female body surfaces examined. The male body surfaces had a more fungal load in comparison with the female body surfaces. The Human body's surface could harbour various species of fungi which if not taken care of can lead to diseases. Proper hygiene is therefore recommended to reduce the rate of colonization hence curbing the incidents of dermatophytosis.

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REFERENCES

Achterman, R. R., Smith, A. R., Oliver, B. G. and White, T. C. (2011). Sequenced dermatophyte strains: Growth rate, conidiation, drug susceptibilities, and virulence in an invertebrate model. *Fungal Genet Biol*., 48: 335–341.

Andreas, K., Burger-Kentischer, A. and Rupp, S. (2017). Interaction of *Candida* species with the Skin. 51(Suppl. 4):2–15. doi: 10.1111/j.1439-0507.2008.01606.x. - DOI - PubMed.

Bruck, H. M., Nash, G., Stein, J. M. and Lindberg, R. B. (1972). Studies on the occurrence and significance of yeasts and fungi in the burn wound. *Ann. Surg.,* 176: 108-110.

Byrd, B. Y. and Segre, J. A. (2018). Dialogue between skin microbiota and immunity. *Science,* 346: 954–959.

Emmons, C. (1979). Medical mycology 2nd edition New York page 53.

Findley, K., Oh, J., Yang, J., Conlan, S., Deming, C., Meyer, J. A., Schoenfeld, D., Nomicos, E. and Park, M. (2013). NIH Intramural Sequencing Centre Comparative Sequencing Program et al. Topographic diversity of fungal and bacterial communities in human skin. *Nature*, 498: 367–370. - PMC - PubMed.

Flynn, P. (2009). Making a Case for the 5th Kingdom, https://www.sciencelearn.org.nz/resources/1439-making-a-case-for-the-5th-kingdom

Grice, E. A. (2015). The intersection of microbiome and host at the skin interface: genomic- and metagenomic-based insights. *Genome Res.,* 25: 1514–1520

Grice, E. A. and Segre, J. A. (2011). The skin microbiome. *Nat. Rev. Microbiol*., 9: 244–53. [PubMed: 21407241].

Grumbt, M., Defaweux, V., Mignon, B., Monod, M., Burmester, A., Wostemeyer, J. and Staib, P. (2011a). Targeted gene deletion and *in vivo* analysis of putative virulence gene function in the pathogenic dermatophyte *Arthroderma benhamiae*. *Eukaryot Cell,* 10: 842–853.

Hawkworth, D. L. (1991). The fungal dimension of biodiversity: Magnitude, significance, and conservation, *Mycological Research*, 95: 641-655. doi:10.1016/S0953-7562(09)80810-1.

Havlickova, B., Czaika, V. A. and Friedrich, M. (2008). Epidemiological trends in skin mycoses worldwide. *Mycoses*, 51(Suppl. 4): 2–15. doi: 10.1111/j.1439-0507.2008.01606.PubMed.

Kong, H. H. and Segre, J. A. (2012). Skin microbiome: looking back to move forward. *J. Invest. Dermatol.* 132, 933–939.

Oda, M., Saraya, T., Wakayama, M., Shibuya, K., Ogawa, Y., Inui, T., Yokoyama, E., Inoue, M., Shimoyamada, H., Fujiwara, M., Ota T., Takizawa, H. and Goto, H. (2013). Calcium oxalate crystal deposition in a patient with Aspergilloma due to *Aspergillus niger. J. Thorac. Dis.* 5(4): E174-E178

Salma *et al,* (2018). Isolation and Identification of microbial and fungal flora from female hair samples in Riyadh Saudi Arabia. *International journal on environment, Agriculture and Biotechnology (IJEAB)*, 13(1): 24561878

Sani, U. D., Ja'afar, S. A., Lurwan, M., Muhammad, S. A. and Muhammad, A. (2020). Isolation and Characterization of Some Fungi Associated with Superficial Fungal Infections. *ARC Journal of Dermatology*, 5(1): 1216.

Segre, J. A. (2006). Epidermal barrier formation and recovery in skin disorders. *J Clin Invest*., 116: 1150–8. [PubMed: 1667075].

Mwaura, E. W. (2011). Isolation and Identification of Fungal by Dermatological Agents among Patients attending Thika District Hospital Thika, Kenya. Pp 63. https://ir-library.ku.ac.ke/handle/123456789/3490…

Nakatsuji, T., Chiang, H. I., Jiang, S. B., Nagarajan, H., Zengler, K. and Gallo, R. L. (2013). The micro-biome extends to subepidermal compartments of normal skin. *Nat Commun*., 4: 1431. [PubMed: 23385576].

Uthansingh, K., Sahu, M. K., Debata, N. K., Behera, D., Panda, K. and Sahu, M. C. (2019). Isolation and identification of fungus associated with skin and nail scalps of patients in a tertiary care teaching hospital. *Apollo Med.,* 16: 16-21.

Uzeh, R. E., Omotayo, E. A., Adesoro, O. O., Ilori, M. O. and Amund, O. O. (2012). Microbial assessment of the armpits of some selected university students in Lagos, Nigeria. *International journal of biological and chemical sciences*. 6(6): 5022-5029.