EFFICACY OF ANTIFUNGAL CREAM *VERSUS* POWDER IN THE TREATMENT OF FUNGAL FOOT SKIN INFECTION AND UNPLEASANT FOOT ODOR AT MEDICAL DEPARTMENT OF THAI NAVAL RATING SCHOOL

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Abstract. Tinea pedis is a common infection among military personnel. We retrospectively reviewed the medical records of patients, clinically diagnosed with tinea pedis at the Thai naval rating school medical department during August – September 2015 to compare the efficacy of treating tinea pedis with clotrimazole cream, clotrimazole powder and a combination of boric acid and salicylic acid in a foot powder (mBS foot powder) among military personnel by evaluating clinical improvement and improvement in foot odor. Patients were followed-up at 1 and 3 months using a Total Tinea Pedis Score (TTPS) and self-assessment ordinal score for foot odor and sweat. A total of 120 subjects were included in the study. Thirty-five, 42 and 43 subjected were treated with clotrimazole cream, clotrimazole powder and mBS foot powder, respectively. All topical antifungal treatments significantly decreased the TTPS, foot odor score and sweat score at 1-month ($p<0.001$, $p<0.001$ and $p=0.039$, respectively). Regarding tinea pedis treatment at 3-month, clotrimazole powder had a significantly higher TTPS reduction than mBS foot powder ($p=0.021$). For sweat reduction, mBS foot powder had a significantly higher sweat reduction score than clotrimazole powder and clotrimazole cream. Clotrimazole cream, clotrimazole powder and mBS foot powder were all effective in treating tinea pedis, reducing sweat and foot odor. Powder preparation may be appropriate for tinea pedis in patients with hyperhidrosis or wearing occlusive foot wear.

Keywords: tinea pedis, clotrimazole powder, mBS foot powder, clotrimazole cream

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INTRODUCTION

Tinea pedis is a common infection in military personnel (Ingordo *et al*, 2000; Selvaag, 2000; Djeridane *et al*, 2007). Skin maceration and itching are the most common presenting symptoms, while

unpleasant foot odor is also reported in many participants (Ongsri *et al*, 2017). The anthropophilic dermatophytes, *Trichophyton rubrum* and *T. interdigitale*, are the most common causative organisms of tinea pedis and are spread via human to human transmission (Stefan and Amit, 2011). There may be differences in the etiological organisms by region; non-dermatophyte organisms are a common cause of tinea pedis in tropical countries (Bunyaratavej *et al*, 2015, 2016). In a study conducted among 788 Thai naval cadets in 2015, 57 (7.2%) had a fungal infection of the feet (54 with tinea pedis and 3 with Candida foot infection); of those with fungal infection of the feet *T. mentagrophytes* was the most common (52.8%), followed by *Epidermophyton floccosum* (13.9%) and *Neoscytalidium dimidiatum* (11.1%) (Ongsri *et al*, 2017).

Early diagnosis and effective treatment of tinea pedis is essential. Contagiousness and insufficient treatment make the condition easily transmitted to others and hard to treat. Misdiagnosed or delay in treatment of tinea pedis causes it to become a reservoir for dermatophyte infections to other parts of the body including tinea corporis, tinea manuum and tinea cruris via autoinoculation.

Standard treatment of tinea pedis is topical antifungals while systemic antifungals are usually reserved for patients with tinea ungium or those recalcitrant to topical antifungal treatment. Topical imidazole and allyamine antifungal creams are widely prescribed for tinea pedis (Cohen *et al*, 2002; Rotta *et al*, 2013; Desomchoke *et al*, 2016). Imidazoles (including clotrimazole and ketoconazole) inhibit the synthesis of ergosterol by selectively inhibiting fungal cytochrome P450 14 α-demethylase enzyme and altering the synthesis of triglycerides and phospholipids while allylamines inhibit the conversion of squalene into squalene-2,3-epoxide. A recent meta-analysis showed no differences in antifungal effects, safety or tolerability among antifungal classes (Rotta *et al*, 2013). Generally topical imidazole had 2 preparations as cream and powder; however, the efficacy of clotrimazole powder in treating tinea pedis has not well been studied.

A mixture of boric and salicylic acid foot powder (mBS foot powder) has been used as a traditional antifungal powder and is widely prescribed for tinea pedis in Thai military troops. However, there are limited studies of its effectiveness.

This study aims to compare the efficacy of 1% clotrimazole cream, 1% clotrimazole powder and mBS foot powder for treating tinea pedis and its effect on foot odor and sweat among Thai military personnel at the Thai naval rating school. The side effects, convenience and satisfaction of use of each of these 3 products were also determined.

MATERIALS AND METHODS

We reviewed the medical records of naval rating cadets clinically diagnosed with tinea pedis who received topical treatment with 1% clotrimazole cream, 1% clotrimazole powder or mBS foot powder at the medical department of Thai naval rating school during August – September 2015. Only subjects who returned for follow-up at 1 and 3 months after onset of treatment were included in this study. Those who were poorly compliant with the prescribed treatment or who received other treatment were excluded from the study. Participants were prescribed topical treatment twice daily for 6 weeks and re-

evaluated at 1 month. Subjects were asked to continue treatment until resolution of tinea pedis or not until 6 weeks then they were re-evaluated again at 3 months after treatment onset. A Total Tinea Pedis Score (TTPS) was used to assess severity of the disease at each visit (Cohen *et al*, 2002). The TTPS score ranged from 0-24 and was based on assessing the plantar and interdigital spaces for erythema and scaling. A lower score represented lower disease severity. The score was evaluated by one treatment-blinded physician at baseline and at each follow-up visit. Subjects were asked to assess changes in their feet odor and sweat before and after treatment. Change in sweat was evaluated by self-assessment using an ordinal score of 0-4 (0 = poor controlled sweat, 4 = markedly well controlled sweat), while change in foot odor was measured by an ordinal score of 0-2 (0 = no smell, 1= weak smell, 2 = strong smell). Subjects were also asked about convenience and satisfaction of use with the prescribed treatment. Convenience and satisfaction of use was rated using an ordinal score of 1-5 (1 = unsatisfied, 5 = very satisfied), (1 = inconvenient, 5 = very convenient).

Treatment efficacy was determined by a decrease in the TTPS over time. Changes in the amount of sweat and foot odor were determined by the differences of the rated ordinal scores before and after treatment.

This retrospective cohort study is approved by institution of Naval medical department ethics committee (RP 046/58).

Statistical analysis

Means, medians, minimums, maximums and percentages were used to describe changes in the amount of sweat, foot odor, satisfaction and convenience of use. Association between categorical variables was analysed with the Fisher's exact test and McNemar-Bowker test. The Kruskal-Wallis test was used to compare the TTPS among tested drugs prescribed at each visit. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using Statistical Package for the Social Sciences for Windows, version 18.0 (IBM, Armonk, NY).

RESULTS

A total of 303 patients were clinically diagnosed with having tinea pedis during August – September 2015. Of these, 120 (39.6%) met inclusion criteria and were included in the study. All 120 subjects were young healthy male naval rating cadets, aged 18-20 years. Of these 120 subjects, 35, 42 and 43 subjects were prescribed 1% clotrimazole cream, 1% clotrimazole powder and mBS foot powder, respectively. The baseline TTPS was significantly higher among subjects prescribed clotrimazole powder than the TTPS for the subjects prescribed clotrimazole cream and mBS foot powder. The TTPS decreased significantly among all study groups at 1 month (p<0.001) and 3 months (p<0.001) after treatment onset. There were no significant differences of TTPS reduction among three medications at 1 month after treatment onset (p=0.055). However, subjects using clotrimazole powder had a significantly higher TTPS reduction than subjects using mBS foot powder (p=0.021), while there was no significant difference in TTPS reduction among subjects using clotrimazole cream compared to clotrimazole powder or mBS foot powder after 3-months treatment (Table 1).

The sweat was reduced significantly among three studied medications at 1 month after treatment (p=0.001). Subjects using mBS foot powder had a significantly higher sweat reduction score than subjects

Table 1
Effectiveness of studied drugs in treating tinea pedis determined by Total Tinea Pedis Score.

	Drug tested			*p*-value
	Clotrimazole cream 1% (*n*=35)	Clotrimazole powder 1% (*n*=42)	mBS foot powder (*n*=43)	
Total Tinea Pedis Score[a]				
Baseline TTPS	7 (1,17)	7.5 (2,18)	6 (1,19)	0.037
Reduced TTPS between baseline -1st months	7 (1,17)	6 (-7,18)	5 (-8,19)	0.055
Reduced TTPS between baseline -3rd months	7 (1,17)	7.5 (2,18)	5 (-7,19)	0.021

[a]Values are given as medians; values in parentheses are minimum and maximum. mBS, mixture of boric and salicylic acid; TTPS, Total Tinea Pedis Score.

Table 2
Effectiveness of studied drugs in sweat reduction determined by subject reported sweat at 1 month after treatment.

	Drug tested			*p*-value
	Clotrimazole cream 1% (*n*=35)	Clotrimazole powder 1% (*n*=42)	mBS foot powder (*n*=43)	
Sweat, *n* (%)				0.01
0 (Poor controlled sweat)	1 (3.2)	1 (2.8)	0 (0)	
1 (minimally controlled swear)	3 (9.7)	0 (0)	3 (7.3)	
2 (partially controlled sweat)	20 (64.5)	22 (61.1)	19 (46.3)	
3 (well controlled sweat)	7 (22.6)	10 (27.8)	12 (29.3)	
4 (markedly well controlled sweat)	0 (0)	3 (8.3)	7 (17.1)	

using clotrimazole powder and clotrimazole cream, respectively (Table 2).

All three topical antifungal agents significantly reduced foot malodor at 1 month after treatment onset, however only clotrimazole cream and mBS foot powder significantly reduced foot malodor at 3 months after treatment (Table 3.). Nonetheless, there were no significant differences between the studied drugs in foot malodor reduction at 1 month (p=0.954) and 3 months (p=0.778) after treatment onset (Table 4).

There were no statistically significant differences in the median satisfaction scores for the use of each drug (p=0.543). However, subjects rated clotrimazole cream and mBS foot powder to be significantly more convenient to use than clotrimazole powder (p=0.021).

Table 3
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	Score at 1 month after treatment onset			*p*-value	Score at 3 months after treatment onset			*p*-value
	0	1	2		0	1	2	
Clotrimazole cream, *n* (%)								
Baseline				0.009				0.015
0	0 (0)	0 (0)	1 (25)		0 (0)	0 (0)	1 (20)	
1	5 (71.4)	13 (54.2)	2 (50)		5 (62.5)	13 (59.1)	2 (40)	
2	2 (28.6)	11 (45.8)	1 (25)		3 (37.5)	9 (40.9)	2 (40)	
Clotrimazole powder, *n* (%)								
Baseline				0.007				0.055
0	0 (0)	3 (10.7)	0 (0)		0 (0)	3 (10)	0 (0)	
1	7 (63.6)	16 (57.1)	1 (33.3)		4 (57.1)	18 (60)	2 (40)	
2	4 (36.4)	9 (32.1)	2 (66.7)		3 (42.9)	9 (30)	3 (60)	
mBS Foot powder, *n* (%)								
Baseline				0.039				0.002
0	0 (0)	1 (3.7)	0 (0)		0 (0)	1 (3.1)	0 (0)	
1	4 (57.1)	13 (48.1)	5 (55.6)		5 (83.3)	13 (46.9)	2 (40)	
2	3 (42.9)	13 (48.1)	4 (44.4)		1 (16.7)	16 (50)	3 (60)	

Foot odor evaluation by questionnaires using an ordinal score of 0-2 (0= no smell, 1 = weak smell, 2 = strong smell) assessed at baseline, 1 and 3 months after treatment onset. [a]*p*-values of the scores at 1 month and 3 months after treatment compare to baseline.

DISCUSSION

There are limited data on the effectiveness of different formulations for treatment of tinea pedis. Topical imidazole creams may be sticky or greasy when applied while wearing socks or occlusive military footwear, resulting in noncompliance with treatment. Antifungal powder is effective in keeping the skin dry due to its hygroscopic properties, which is desirable when treating tinea pedis. Antifungal powder was mainly used in prophylaxis of tinea pedis. Clotrimazole powder has been reported to be effective as an adjuvant therapy to clotrimazole cream in treating and possibly preventing superficial fungal cutaneous infection (Desomchoke *et al*, 2016). One previous study reported the efficacy of 1% flutrimazole and 1% bifonazole powder for treatment of tinea pedis. Global cure rate was 65-70% of patients treated with powder (Pereda *et al*, 2003). Similarly, this study demonstrated that topical antifungal powder provide effective outcome in tinea pedis treatment. However, study about comparing between antifungal cream and powder for tinea pedis treatment was limited. In this study, antifungal cream and powder showed no differences in effectiveness after 1 month treatment, therefore antifungal powder may be another treatment option for tinea pedis.

Table 4
Changes in foot malodor by treatment type and time after treatment onset.

Time after treatment onset	Clotrimazole cream, *n* (%)			Clotrimazole powder, *n* (%)			mBS foot powder, *n* (%)			*p*-value
	Improved	Unchanged	Worsened	Improved	Unchanged	Worsened	Improved	Unchanged	Worsened	
1 month	18 (51.4)	14 (40)	3 (8.6)	20 (47.6)	18 (42.9)	4 (9.5)	20 (46.5)	17 (39.5)	6 (14)	0.954
3 months	17 (48.6)	15 (42.9)	3 (8.6)	16 (38.1)	21 (50)	5 (11.9)	22 (51.2)	18 (41.9)	3 (7)	0.778

Heat and excessive humidity yield a suitable environment for dermatophytes to grow (Leyden and Albert, 1978). This study demonstrated that mBS powder and clotrimazole powder significantly reduced more sweat than cream. Dusting powder showed an advantage over cream preparation in decreasing excessive humidity due to its' hygroscopic properties which absorbs excess moisture in applied surfaces, especially in humid body areas (Albanese *et al*, 1992; Pierard *et al*, 1996). Therefore, antifungal dusting powder may be suitable for treatment of superficial fungal infection in moist areas such as in intertriginous areas or in plantar hyperhidrosis.

Some bacteria such as *Kytococcus sedentarius, Dermatophilus congolensis* and *Corynebacterium* spp lead to foot malodor which can be disturbing and even embarrassing in some patients. From a previous study, foot malodor alone has an impact on quality of life more than foot skin lesion (Ongsri *et al*, 2017). In this study, all three topical antifungal agents were found to significantly be beneficial to reduce foot odor.

In summary, all three topical antifungal agents were found to provide significant effectiveness for tinea pedis treatment, sweat and foot odor reduction at 1 month treatment. Powder showed more sweat reduction than cream. Therefore, powder may be another option for tinea pedis treatment especially in moist areas.

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