

# Marching in the Army: Common Cutaneous Disorders of the Feet

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**T**o trample or to march is the characteristic walk of military personnel, whether they are assigned to ordinary training in the camp, in performing a maneuver, or heading for war. The feet and the legs are the most vulnerable parts of the soldier's body. They are used, exhausted, and overstrained during marching. Army veterans are prepared to engage in combat with the enemy, but they are also subjected to many events. The soldier is exposed to a variety of environmental and climatic hazards, including sun, heat, humidity, rain, cold, dry weather, and sand storms, which could cause dermatologic problems.

Military personnel during their career suffer from many cutaneous disorders of the feet and their legs, not to mention other parts of the body. They are also exposed to unfamiliar hazardous infective agents. In addition, there might be a higher incidence of several skin problems of the feet than civilians might experience. Environmental and climatic factors can also affect the feet badly. Exposure to cold and heat and marching through streams and rivers, into muddy land, over snow, through the desert, and up mountain trails and down into valleys all take their toll. The net result leads to hot, sweaty feet, which are easily macerated, ulcerated, and secondarily infected.

## Contact Dermatitis to Military Boots

Military boots protect the feet against injuries and climatic changes, especially excessive exposure to cold. On the other hand, they might favor the development of many kinds of dermatoses (Fig 1). Contact dermatitis from heavy, occlusive footwear is not an uncommon problem in military personnel. Subacute and chronic contact dermatitis involving the lower part of one or both legs and both feet are common. The pattern of dermatitis depends on whether the sensitizer is present in the upper part of the boot, which is a common site for contact dermatitis; it accounts for 60% of cases.<sup>1</sup> The



**Figure 1.** Contact dermatitis of the leg and foot from military boots. Note that the dermatitis on the legs corresponds to the lining of the boot.

dermatitis most often starts over the dorsal surface of the big toes and spreads to the back of the feet or to the other toes. The interdigital spaces are usually spared. The heels are rarely affected, but if this happens, it is usually secondary to contact with the heel cap. The weight-bearing areas of the soles are also affected, in addition to the calves.<sup>2</sup>

Most patients present with either erythematous, papular, and vesicular lesions or patches of chronic eczematization, lichenification, and hyperpigmentation. Army personnel suffering from boot dermatitis often have dermatitis elsewhere on the body. Heat and hyperhidrosis contribute to the contact dermatitis. The differential diagnosis includes dyshidrosis, which can be a minor problem in hot climates, recently developed psoriasis, or even atopic dermatitis, which may have escaped the notice of the induction physician.

The main sensitizers causing boot dermatitis includes rubber accelerators, leather, glues, or dyes.<sup>3</sup> The allergens must traverse the socks before becoming available to the skin for absorption and leading to subsequent dermatitis.<sup>4</sup> The marching and the warmth generated accelerate the leaching of the chemicals from the boots. Allergens may be retained in socks even after being washed and boiled<sup>5</sup>; however, white socks do not prevent contact dermatitis to the boots.

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The most common sensitizer of leather is potassium dichromate, whereas the leading culprit for rubber is mercaptobenzthiazole (MBT). The allergens in adhesive latex are thiram and MBT. The dyeing substance contains the sensitizer chromate or glutaraldehyde. The plastic glue sensitizer is *p-tert*-butylphenol formaldehyde resin, and the linings of boots include phenols or organic mercury compounds as the main sensitizers. Potassium dichromate and nickel sulfate were commonly demonstrated as the contactants in patch tests of patients with boot dermatitis.<sup>6</sup>

Military boots in general are made of different materials, depending on the manufacturer and the military stipulations. The chemical analysis of a military boot made in Romania, for example, showed the following components<sup>7</sup>: chromic oxide (3.5%), protein (77%), synthetic rubber (18.2%), and nickel (0-2%). PPD and various materials used for dyeing of leather, such as sulfur, potassium hydroxide, ammonium sulfate, arsenic, sodium hyposulfate, formic acid, sodium sulfate, formaldehyde, sodium carbonate and bicarbonate, borax, and mineral oils, were all found in traces. The army boots in most armies are not fully lined with cloth, which explains the frequency of contact dermatitis being mainly in those parts not protected by a cloth lining.

In the management of boot dermatitis, patch testing should be done by using one of the standard series (Trolab) and possibly with samples from various parts of the boot itself. Unfortunately, there may be a high percentage of false-negative reactions. Management of army boot contact dermatitis includes the current topical and systemic medications in addition to the following recommendations:

1. Change in the design of army boots to include less sensitizer.
2. Wearing heavy, long cotton socks to prevent or reduce contact between the skin and leather.
3. Permission to wear civilian leather shoes until the contactant is determined and hypoallergenic boots are obtained.<sup>7</sup> This is usually permitted by a central medical army board.

#### *Foot Reactions to Mechanical Trauma and War Injuries*

A healthy foot, meaning intact skin and a physiologically functioning extremity, is paramount to resist the hostile effects of various mechanical injuries and trauma. Poorly fitting army boots worn on a long march will be a source of excessive friction being tantamount to blister formation. Friction can also cause rupture of small blood vessels, leading to ecchymosis, often without a break in the skin.

**ECCHYMOSIS** Ecchymosis, a localized extravasation of blood into the tissues from ruptured blood vessels, might occur secondary to trauma and the pressure of



**Figure 2.** Ecchymosis of the toes, with black eschar of the third toe.

the boots. Ulceration can subsequently occur. Secondary environmental factors, such as humidity, heat, and sweating, may compound the problem. For example, stiff boots, poorly fitting liners, and heavy synthetic or woolen socks will aggravate an existing problem.<sup>8</sup> Abrasions and friction blisters mainly develop on the soles without the aforementioned problems after a long march (Fig 2).

**CORNS** Corns are localized callosities that occur over the bony prominences of the feet and toes, occurring in susceptible army personnel over large bony prominences that often have a familial history of clavus formation. Excessive friction and abnormal pressure aid in the development of corns. These hyperkeratotic lesions are usually painful and can become secondarily bacterially infected. Deformities of the bones may contribute to plantar clavus formation, especially during extensive marches. Management includes careful paring of the corns and the use of suitable orthotic devices to relieve the cause of the friction. Although verrucae plantaris have a different etiology, treatment is similar. In both, aggressive surgery can lead to permanent scarring, which may be more painful than the original disease.<sup>9</sup>

**WAR INJURIES** War injuries that involve the feet and legs are common. They include bombs and hand-grenade explosions, with their shrapnel and fragments injuring the feet and other parts of the body. Land mines and/or errant bombs dropped on soldiers in the battlefield cause any number of moderate to severe injuries, particularly when the more sophisticated bombs and so-called "smart" weapons are used. The high-pressure explosive cluster bombs, or gas and chemical munitions, create even worse wounds.

Foot injuries can also occur accidentally in the battlefield, secondary to mines or booby traps. Unexpected casualties occur during land mine sweeps by specialized military teams. Most wars of the last century have

left behind millions of mines in battlefields or in “no man’s lands.” The trauma usually causes the loss of one or both feet, and in severe explosions, it might involve both legs, thighs, and abdomen and can lead to severe bleeding, shock, and death.

Chemical and biologic warfare agents could also affect the military. Chemicals can cause severe burns and tissue destruction, whereas biologic warfare might create dreadful problems.

### Foot Reactions to Cold

One of the primary functions of the skin is thermoregulation. The human body can maintain a constant temperature of  $\sim 37^{\circ}\text{C}$  over a range of external temperatures between  $15^{\circ}\text{C}$  and  $54^{\circ}\text{C}$ .<sup>10</sup> Exposure to cold initiates a fall in the body temperature below a certain threshold level as well as the temperature of circulating blood. This drop will be counteracted by the temperature-regulating center in the hypothalamus, which in turn increases sympathetic tone and the reflex arising from cold receptors, resulting in constriction in both arterioles and venules of the skin, leading to heat preservation.

The reactions of the feet to cold depend on the rate of chilling and the rate of rewarming. All vital skin processes are depressed by lowering body temperature. Cold also changes platelet adhesiveness, decreases sympathetic conduction, and depresses the metabolism. There are two types of foot reactions to cold: (1) diseases caused by exposure to cold and (2) abnormal reactions and skin conditions aggravated by cold.

#### *Diseases Caused by Exposure to Cold*

**FROSTBITE** The destructive process of frostbite is due to the actual freezing of the pedal tissues exposed to temperatures below the freezing point ( $-2^{\circ}\text{C}$  to  $-10^{\circ}\text{C}$ ), especially in windy, rainy, and damp weather.<sup>11</sup> It affects the toes as well as the fingers, ears, nose, and cheeks. Frostbite may be a painless process, concluding with paralysis of the feet and gangrenous toes and feet. Tight, constrictive boots and socks, immobility, smoking, and peripheral vascular disease are predisposing factors.

Early symptoms include mild tingling but dull pain or just a burning sensation followed by stiffness, loss of sensation to cold and pain, and a waxy appearance of the feet. Erythema, blistering, and burnlike lesions might appear. On rewarming, burning and paresthesias are again felt. Swelling, blistering, and hemorrhagic spots might occur 1–2 days after rewarming. In 5–10 days, the blister fluid is reabsorbed, and a hard, black eschar forms. In severe cases and after a few weeks, gangrene of the toes or other exposed parts of soft tissues may occur. Sometimes, there is spontaneous amputation of the affected part. At other times, surgical



*Figure 3.* Frostbite affecting the lower part of the leg and the foot.

intervention in the form of debridement of the dead tissue or amputation may be necessary (Fig 3).

Treatment begins with immediate, gradual rewarming in a water bath at  $40\text{--}42^{\circ}\text{C}$ , which may prevent some tissue damage.<sup>12</sup> Other measures include the application of antiseptics and administration of topical and systemic antibiotics to prevent and/or treat secondary infection, analgesics, and prophylactic tetanus toxoid injection. Rest for the affected foot and sterile dressing are also needed.

**IMMERSION FOOT** The bane of World War I was the exposure of feet to cold above the freezing point for a period of few days. Also called trench foot, sea-boat foot, or foxhole foot, the condition is worsened by dampness, wind, high altitude, prolonged immobility, and dependency of the limbs (Fig 4). Smoking and vascular problems predispose and aggravate this condition. A warm-water variety proved extremely troublesome during the Vietnam War.

Four phases have been described in the development of trench foot disease: (1) exposure to cold; (2) a prehyperemic phase, characterized by cold, blue, and numb feet; (3) a hyperemic phase, in which edematous, warm, and painful feet signs and symptoms develop and last for  $\sim 10$  weeks; and (4) the posthyperemic phase, in which the feet become sensitive to cold and the development of hyperhidrosis, lasting a few years.<sup>13</sup> Most personnel heal after 2 weeks. Treatment is usually conservative and includes warming, analgesics, and rest of the foot. Pentoxifylline 400 mg three times daily is

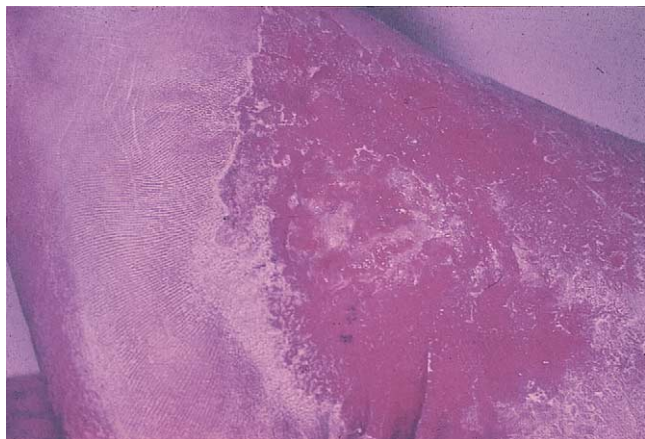


Figure 4. Immersion or trench foot.

helpful. In rare cases, a vasodilator such as oral prostaglandin E1 analgesic is given.<sup>14</sup>

#### *Abnormal Reactions and Skin Conditions Aggravated by Cold*

**PERNIO-CHILBLAINS** With this localized, inflammatory lesion of the foot caused by cold, there is arteriolar and venular constriction, leading to sudden fluid accumulation in the pedal tissues on warming. Aggravating factors include focal sepsis and systemic illness. It is accompanied by erythrocyanosis involving the proximal phalanges of the fingers and toes, heels, lower parts of the legs, thighs, nose, and ears (Figure 5). The clinical picture shows erythematous, edematous, papular lesions, which can blister and ulcerate. There are pruritus, burning sensations, and pain. It usually subsides slowly in 7–14 days. The differential diagnosis includes lupus erythematosus, acrocyanosis, cryoglobulinemia, and peripheral vascular disease. Warming is the main line of therapy, in addition to rest and lubricating cream. Pentoxifylline 400 mg three times daily is helpful.

**ACROCYANOSIS** Acrocyanosis is a persistent, dusty discoloration predominantly of the feet and hands but also



Figure 5. Blistering pernio-chilblains.

of the face. The condition is accentuated by exposure to cold, which lowers the temperature of the affected area, usually leading to excessive sweating and swelling. These changes may be transient after cold exposure, or they may persist in winter or even summer. Acrocyanosis is due to the effect of cold on cutaneous blood vessels, leading to dilation of small vessels and in particular, the those of the subpapillary venous plexus. There is a change in blood viscosity, which has been suggested to play a role in the pathogenesis.<sup>15</sup> The same treatment for chilblains applies here also.

**RAYMOND'S PHENOMENON** It is a paroxysmal pallor and coldness of the extremities, usually precipitated by cold, and often followed by cyanosis. This phenomenon may be associated with trauma, a neurovascular process, occlusive diseases, intoxication, and collagen diseases. Although there is a predisposition for occurrence in women, this condition can affect army personnel as well. Treatment includes gradual rewarming and the use of vasodilators (pentoxifylline 400 mg three times daily), in addition to treatment of the cause.

**COLD URTICARIA** This is a form of physical urticaria characterized by wheals at sites exposed to cooling, usually after rewarming. The commonest type is the acquired idiopathic, which accounts for 90% of the cases of cold urticaria. Wheals appear within minutes after exposure to cold. Cold urticaria may occur in a generalized form that affects the entire body, including the feet, or it may affect the feet only. Cold urticaria of the feet can also occur because of sudden exposure to cold after removal of the boots. It may also occur after immersion of the feet in cold water in susceptible personnel.

The etiology of cold urticaria is not completely known, but histamine is an important factor, in addition to platelet-activating factor 4, prostaglandin D2, kinins, and leukotriene E4.<sup>16</sup> Pressure urticaria is a form of physical urticaria that may affect a soldier's foot because of the pressure of boots in susceptible patients. Treatment is mainly the avoidance of sudden exposure of the feet to a cold climate or immersion of the feet in cold water, in addition to the intake of antihistamines.

#### **Foot Reactions to Heat**

Environmental temperature is an important factor that affects the stratum corneum in a way that makes it brittle and inelastic, especially when the rise in temperature is accompanied by reduced humidity. In the early stages of foot exposure to heat, epidermal atrophy, vasodilatation, and dermal pigmentation occur. Transient erythema, followed by more marked erythema, then appears. Subepidermal blistering due to repeated thermal exposure of the feet during summer also may occur. The caloric action of the skin is due to infrared

radiation (IR), comprising about 40% of solar radiation, with a wavelength range of 0.75–100  $\mu\text{m}$ . IR causes intense vasodilatation, including an immediate erythema and increased cutaneous temperature.<sup>17</sup> By reflex mechanism, the eccrine glands produce sweat that is delivered to the skin surface and permit thermoregulation.

**ERYTHEMA AB IGNE** This is a reticular, telangiectatic, and pigmented dermatosis resulting from either repeated or prolonged exposure to IR insufficient to produce a burn or contact heating, such as from hot water bottles or hot pads. The condition affects the legs and upper parts of the feet more commonly in women. Erythema ab igne results in a reticulated erythema and hyperpigmentation with telangiectasia. The result of this condition is a picture of brown pigmentation, scaling, and atrophy.<sup>18</sup> Erythema ab igne might undergo malignant transformation, mainly to squamous cell carcinoma.<sup>19</sup> Preventive measures are the only effective lines of treatment.

**SOLAR URTICARIA** Direct exposure of the feet to sunlight leads to urticaria in this uncommon condition. Multiple erythematous wheals appear 5–10 minutes after taking off the boots and the exposure of feet to sunlight. The erythematous eruption accompanied by pruritus persists for 1–2 hours. It is due to mast cell degranulation and the release of histamine, in addition to the role of eosinophilic and neutrophilic chemotactic mechanisms.

**HEAT URTICARIA** It is a rare condition caused by the direct effect of climatic heat, warmth, or hot water on the feet.<sup>20</sup> Heat urticaria is an immediate type of reaction that produces wheals at the site of contact to heat within a few minutes. Precipitating factors include exposure to hot water, hot car brakes (especially among vehicle drivers), fireplaces, and sun. Edema, numbness, and pruritus occur. Treatment consists of cooling of the affected parts and use of antipruritics.

**ERYTHERMALGIA (ERYTHROMELALGIA)** It is a paroxysmal attack of erythema, heat, and burning pain of one or more extremities. Erythralgia is precipitated by heat or dependency of the legs and is relieved by cold and elevation of the affected limb. The feet and legs become warm, appear red and congested, and are sensitive to touch. The attacks may last minutes to hours, with a temperature range between 32°C and 36°C. The commonest form is primary idiopathic, which occurs mainly in young women, with a symmetric and bilateral involvement of the legs and feet.<sup>21</sup> The condition responds well to aspirin in a single dose of 650 mg.

## Infections of the Feet

Both the palms and soles are the only skin surfaces of the body that are devoid of hair or apocrine and sebaceous glands but replete with numerous, large, eccrine



Figure 6. Fungal infection of the foot.

glands. Thus, the soles are subject to profuse sweating. Hyperhidrosis increases especially during warmer periods and particularly after a long foot march. Perspiration predisposes and favors the growth of both fungal and bacterial infections.<sup>22</sup> In general, fungal infections are more common in the military than in others. Contrary to what many veterans of World War II, the Korean conflict, or the Vietnam War may believe, not every scaling, red eruption is due to a dermatophyte. Although exotic organisms can afflict military personnel, most infections are due to mundane bacteria or fungi.

### Fungal Infections

**TINEA PEDIS** Athlete's foot is most commonly due to *Trichophyton rubrum*, *T. interdigitale*, and *Epidermophyton floccosum*. Combined infection with two or three species does occur, as does secondary bacterial infection. The wearing of occlusive boots, with the long-standing, build-up of perspiration, moisture, and heat within the boots, are strong predisposing factors for the development of fungal infection (Fig 6).<sup>23</sup>

Maceration of the toe-cleft skin, especially between the fourth and fifth toes, augments this condition. Tinea pedis may also be transmitted within the regiment camp from swimming pools, sports and entertainment centers (including the sauna, Jacuzzi, and steam room), and shower rooms and bathrooms shared by many. Secondary bacterial infection can occur and aggravate the condition.

There are three main clinical varieties of tinea pedis:

1. Intertriginous is the most common form and is characterized by maceration followed by soggy between the toes, usually beginning in the fourth interdigital space. It becomes pruritic and spreads toward the sole and sides of the foot, becoming vesicular, scaly, and painful.
2. Squamous-hyperkeratotic is a diffuse, plantar scaling of the soles and sides of the foot and heel, and it

has a well-defined border. A form of this type is the one hand–two feet disease due to *T. rubrum*.

3. Acute vesiculobullous is the least frequently occurring variety and is characterized by deep-seated vesiculopustules or bullae, which when broken, erode into scaly patches. It usually affects the soles.

The course of infection depends on the presence of a warm and humid climate and the prolonged wearing of boots. It is compounded by the development of superimposed contact dermatitis or bacterial infection. The differential diagnoses include pure hyperhidrosis, pustular psoriasis, and candidosis. Treatment of the acute stage includes soaks with Burow's solution (1:40) or potassium permanganate (1:10,000). Topical antifungal agents or systemic terbinafine (250 mg daily for 3–6 weeks) or itraconazole (100 mg twice daily for 3–6 weeks) are also helpful.

**ONYCHOMYCOSIS** While dystrophy and heaping up of the toenails initially is only of cosmetic concern, once the thickness of the nail impinges on the shoe or is pressed into the flesh, pain and discomfort ensue. This creates a true disability, contrary to the thoughts of many American medical insurance companies.<sup>24</sup> Treatment is not by avulsion. Terbinafine (250 mg daily for 3 months) or itraconazole (100 mg twice daily for 7 days, repeated in 4 and 8 weeks) is the treatment of choice.

#### *Verruca Plantaris*

Plantar warts are caused by any number of the types of human papilloma virus. The thickened area of the sole may be aggravated by the wearing of boots and extended periods of marching. Treatment involves destruction of the affected tissue, and the morbidity of the therapy should be considered (ie, how much down time will there be?). But in widespread verrucae, cryotherapy with liquid nitrogen is the treatment of choice. Laser is also another option in resistant cases. Generally, application of a keratolytic will suffice.<sup>25</sup>

#### **Nail Deformities and Disorders**

A great many nail deformities are the result of trauma that may affect the nails in many ways. Occasional trauma or repeated friction and minor injuries lead to the following deformities<sup>26</sup>:

1. Subungual hematoma is the commonest injury to nails, especially in veterans during training and running or caused by kicking. Hemorrhage produces severe pain and if not treated, may lead to the shedding of the nail. Making a small puncture hole through the nail plate with an electrocautery needle or with an ordinary needle can relieve the hematoma pressure.
2. Onycholysis, onychorrhexis, and onychomadesis. A permanent, longitudinal split of the nails results

from any acute trauma that severs the matrix of the nail. Dystrophic nails may be more prone to additional injury. The same trauma might cause permanent ridges or bands of pigmentation. The treatment of choice is removal of the nail plate with subsequent suturing of the separated parts of the matrix.

3. Onychocryptosis. Ill-fitting boots that inflict minor trauma and incorrect cutting of the lateral edges of the nail can lead to ingrown nails. Coupled with hyperhidrosis and heavy exercising or long marches, onychocryptosis will contribute to a painful nail condition, particularly of the large toe. Warm water soaks and topical antimicrobials are helpful initially, but surgical intervention is usually required.
4. Onychogryphosis. The large toenails are usually affected. The nails become thick, curved, and extremely hard to cut. The problem is magnified by trauma from wearing boots.

#### **Conclusions**

The feet are considered the most targetable parts of a soldier's body during peace and war. They carry the soldier to battle and bear the body weight. The feet are vulnerable by their exposure to environmental hazards, climatologic changes, prolonged standing, long marching, contact with mines in the battlefield, and affliction with different dermatoses secondary to the wearing of boots.

We hope that this chapter will remind dermatologists and other health care personnel about the different cutaneous problems that affect military personnel during war and peace.

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