

Dermatological conditions of aquatic athletes

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conditions commonly seen in swimmers. This review provides an update on water dermatoses and discusses newly described conditions such as allergic contact dermatitis to chemical ingredients like potassium peroxymonosulfate in pool water. In order to organize water related skin conditions, we have divided the skin conditions into a number of categories. The categories described include infectious and organism-related dermatoses, irritant and allergic dermatoses, and sun-induced dermatoses. The vast majority of skin conditions involving the water athlete result from chemicals and bacteria in the differing aquatic environments. When considering the effects of swimming on the skin, it is also useful to differentiate between exposure to freshwater (lakes, ponds and swimming pools) and exposure to saltwater. The risk of melanoma amongst swimmers is increased, and the use of SPF 30 or greater sunscreen and protective clothing is highly recommended. Swimmers should be reminded to generously apply sunscreen and be instructed on proper sunscreen usage. This review will serve as a guide for dermatologists, athletes, coaches, and other medical professionals in recognition and treatment of these conditions. We also intend for this review to provide dermatologist with a basic framework for the diagnosis and treatment of a few rarely described dermatological conditions in swimmers.

Key words: Aquatics; Dermatitis; Athletes; Practice Gaps; Freshwater dermatitis

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Core tip: Athletes who spend a significant amount of time in the water are subject to a wide array of diseases that include bacterial and fungal infections. These athletes are often exposed to undesirable environments with excessive humidity, heat, cold, wind, and sunlight. These factors may aggravate or cause different skin conditions that require a dermatologist who has specific knowledge of rare aquatic dermatoses.

Abstract

Numerous manuscripts have described dermatologic

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CONDITIONS RELATED TO IMPAIRED SKIN BARRIER AS A RESULT OF CONTACT WITH WATER

Excessive dryness (swimmer's xerosis) is one of the most common conditions seen in water athletes. It is caused by sebum dilution with water, osmotic effect, and stripping off the stratum corneum. Taking long showers with scrubs and soaps after activity also precipitates the problem. Although easy to diagnose, swimmer's xerosis should be differentiated from swimmer's itch and urticaria^[1-5]. Preventative measures include decreasing shower duration and applying ointment based moisturizing preparations before and after pool activities^[4].

Aquagenic acne occurs due to the rebound effect of sebum over-production after continuously washing off the oils from the skin surface. It may present as an acute exacerbation of a preexisting condition or as a new onset disorder. Other mechanisms include the effect of chlorinated compounds in pool water, occlusion of the sebaceous glands by denuded epidermis, and use of comedogenic moisturizing creams and sunscreens. Aquagenic acne typically presents as common acne and should be treated accordingly. Topical or systemic agents can be used depending on level of severity, but it should be noted that some topical agents may cause additional irritation. Specifically, isotretinoin, commonly used for severe acne treatment, may interfere with performance and cause neuromuscular symptoms and myalgias^[6,7].

CONTACT DERMATITIS

Allergic contact dermatitis

Some evidence suggests that swimmers may be more prone to allergic reaction than non-swimmers since swimmers have a higher incidence of positive skin prick tests, asthma, allergic rhinoconjunctivitis, and bronchial hyperactivity^[8-12]. Increased allergy rates may be partly explained by the use of chlorinated or brominated disinfectants in swimming pools that may increase sensitization to other allergens^[13].

Disinfectants may cause allergic contact dermatitis ("pool water dermatitis"). Compounds proven to cause pool water dermatitis include gaseous chlorine, sodium and lithium hypochloride, 1-bromo-3-chloro-5,5-dimethylhydantoin (BCDMH), potassium peroxydisulfate, and aluminum chlorohydrate^[14-17]. Brominated compounds were previously thought to provide an alternative to chlorine, but have shown an increased potential to cause irritant contact dermatitis. BCDMH is a component that slowly releases bromine and chlorine and is believed to be the causative



Figure 1 Allergic contact dermatitis to new swim wear.

agent of an outbreak of swimming pool contact dermatitis in the United Kingdom^[18-20]. Initially, only negative patch tests to BCDMH were seen, and it was believed to be a solely irritant dermatitis. However, positive patch tests for BCDMH were later reported^[16]. It was also proposed that certain individuals may develop an allergic contact dermatitis because of the chlorine, released from BCDMH, but test were negative for BCDMH itself^[21].

Allergic contact dermatitis can also be caused by certain clothing and equipment swimmers use (Figure 1). Early reports described reactions to the components of resins (thioureas, benzothiazole, dithiocarbamate and formaldehyde) in goggles, scuba masks, nose clips, earplugs, fins, fin straps, and swimsuits^[22-29]. Allergic contact dermatitis to dodecyl diaminoethyl glycine, a diving suit disinfectant, has also been described^[30]. Raccoon-like depigmentation was described from use of neoprene goggles in a child, but the etiology (toxic or allergic) was not confirmed^[31].

Irritant contact dermatitis

Irritant contact dermatitis in athletes usually develops as a result of chronic friction (Figure 2). Use of caps and goggles that press tightly against the skin may lead to purpura formation^[4]. A specific irritant dermatitis known as "pool toes" and "pool palms" is caused by friction of the feet and palms against the pool's rough cement bottom^[32-34]. Another form of irritant dermatitis in males is "shoulder dermatitis", which is caused by rubbing an unshaven chin against the shoulder while performing the crawl stroke^[35]. In surfers, nodules may develop in the pretibial area due to continuous friction with the surf board^[35]. These irritant dermatoses usually resolve spontaneously with cessation of the offending activity, but persistent nodules can be treated with topical keratolytics and intralesional corticosteroids.

SKIN INFECTIONS

Athletes who spend a significant amount of time in the water are subject to a wide array of bacterial and fungal infections. Excessive maceration, dryness, and changes in the skin microflora contribute to the development of

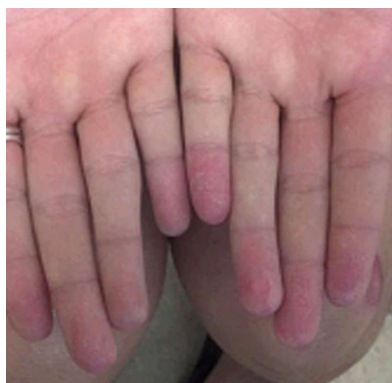


Figure 2 Fingertips that desquamate from the friction of the contact with the sides of the pool.

the skin infections. Additionally, the risk of disease is increasing because of pool overcrowding and common use of showers and towels.

Bacterial infections

Pseudomonas aeruginosa is able to survive in high temperate water and causes several skin conditions including hot tube folliculitis, otitis externa, and hot foot syndrome. Outbreaks of *Pseudomonas* infections may arise from contact with contaminated water^[36-38]. Current studies show that *Pseudomonas* contamination is common in pools and even more so in hot tubs since they are difficult to clean^[39]. To decrease the rate of infection, chloride concentration of the water should be monitored daily. Athletes, especially those who train intensely for a prolonged period of time, are prone to the colonization of the ear canal by *Pseudomonas*^[40].

Hot tub folliculitis presents as a disseminated itchy pustular rash that appears within two days of water exposure. It is prone to localize in the intertriginous areas and may also be seen in a bathing suit distribution. Hot tub folliculitis (Figure 3) is usually a self-limited condition, but systemic symptoms such as low-grade fever, lymphadenopathy, headache and malaise may be rarely seen. It can also be accompanied by other *Pseudomonas* infections including otitis, conjunctivitis, mastitis, and urinary tract infections^[41]. *Pseudomonas* folliculitis may also develop under the suit that has led to the aptly suited description of “diving suit folliculitis”^[42,43].

Pseudomonas is the most frequently implicated pathogen in the development of otitis externa. Swimmers are five times more likely to develop otitis externa than non-swimmers^[44]. Otitis externa presents with pain limited to the external auditory canal, but the ear appears erythematous and swollen with variable discharge (Figure 4). Prophylaxis is generally achieved through proper cleaning and drying of the ear canal in addition to avoidance of excessive moisture in and around the canal. Acidification with a topical solution of 2% acetic acid combined with hydrocortisone for inflammation is effective treatment, although most physicians will also prescribe combination steroid/antibiotic drops. Another dermatoses known as hot foot syndrome has been described as a subcutaneous



Figure 3 Buttock folliculitis.

eruption on the soles of children swimming in the same pool^[38,45]. In both reports *Pseudomonas* was isolated from the swimming pool, but a causative relationship (isolation from the skin lesion) was only performed in one child, leaving debates about the etiology of the condition^[46,47].

Swimmers also show increased rates of skin colonization by *Staphylococcus* and *Streptococcus*^[40]. Bikini bottom is a deep folliculitis of the buttocks that is caused by *Streptococcus* or *Staphylococcus aureus*. It is the result of wearing tight fitting bikinis for prolonged periods of time and presents as firm nodules that manifest along the inferior gluteal crease^[48]. Prevention is aimed at early removal of the swimsuit, while treatment consists of oral antibiotics based on sensitivities.

Recent European and American studies have shown that most swimming pools and showers are contaminated with *Mycobacteria*^[49-52]. Although not necessarily symptomatic, these bacteria can cause granulomatous disease of the lungs and skin^[53]. *Mycobacterium marinum* (*M. marinum*) is ubiquitous in pools, aquariums, freshwater, and saltwater. Since its discovery in Sweden, multiple outbreaks of *M. marinum* outbreaks have been described throughout the world^[54-56]. It also causes so-called “fish tank” or “swimming pool” granuloma which has a predilection for the dorsum of the hands, fingers, and elbows, especially when skin trauma or open wounds are present^[57]. The predilection for the extremities is due to inhibition of growth of *M. marinum* at 37 °C so the organisms tends to infect the cooler parts of the body including the extremities^[57]. The granuloma usually presents as a solitary, erythematous papule or nodule and may be mistaken for sporotrichosis or leishmaniasis^[58,59]. Disseminated infection is rare, although a case of disseminated *Mycobacterium* that presented as erythema nodosum was previously described in a 12-year-old girl^[60]. Histopathology of skin lesions reveal typical tuberculoid granulomas in only 60% of cases, while the other 40% display non-specific inflammation with neutrophils^[61]. Frequently, superficial biopsies fail to show specific changes, but granulomas may be seen in the subcutaneous tissue or synovium. Paucity of microorganisms is the characteristic feature of *M. marinum* infections, and the identification of the microorganism is a challenge. Culture and polymerase chain reactions may also be



Figure 4 *Pseudomonal* infection of external ear canal.

useful for identifying microorganisms^[62,63]. Localized lesions of swimming pool granuloma are self-limited and resolve with scar formation. Patients can be treated with clarithromycin, minocycline and trimethoprim-sulfamethoxazole; multidrug therapy with ethambutol and rifampin is needed if disseminated disease is present^[57]. Although rare in immunocompetent individuals, other mycobacteria, mainly *M. chelonae* and *M. fortuitum* may also cause cutaneous granulomas.

Fungal infections

Several studies have shown that swimming pools are contaminated with dermatophytes, which increases the risk of infection^[64]. Prolonged contact with water causes increased susceptibility to fungal infections, and Kamihama *et al*^[65] found that 63.6% of swimmers are dermatophyte carriers. However, the incidence of tinea pedis among aquatic athletes is not well studied, but early reports have found that it may be up to 10%^[52,66]. *Trichophyton mentagrophytes* accounts for up to 85% of infections and has been isolated from swimming pool decks and locker room floors^[65,66]. Tinea pedis (Figure 5) should be differentiated from pitted keratolysis, caused by *Corynebacteria*, which presents with the small punched-out depressions and an unpleasant smell. Tinea can be prevented by proper foot hygiene and patient education. Initial treatment involves topical antifungals twice daily for one to two months, but systemic antifungal agents may be used if refractory disease is present.

Viral infections

Swimmers and those who use common showers have a greater incidence of plantar warts (Figure 6) and molluscum contagiosum, although the exact incidence in athletes is unknown^[67-69]. Liquid nitrogen, curettage, and salicylic acid are helpful for removal of the lesion. There is not enough evidence to confirm that covering warts helps prevent spread^[70].

HAIR CONDITIONS

Aquatic athletes are prone to develop specific hair conditions. Green hair discoloration, often seen in light-



Figure 5 Tinea pedis on the foot of a swimmer.



Figure 6 Plantar warts on the foot of a swimmer.

haired athletes, is an effect of bleach and copper ion deposition that are used to kill algae^[71]. Seborrheic keratosis may also undergo green color change along with the hair due to copper ion deposition^[72]. Wetting the hair prior to chlorinated water exposure, prompt bathing after exposure, and use of a copper chelating shampoo may mitigate this problem. Hair discoloration coexisting with nail plate damage has also been described in Japanese swimmers and was considered to be a result of cuticle damage due to water friction and hypochlorous acid penetration^[73].

FRESHWATER DERMATITIS

Athletes who swim in marine water may be exposed to conditions transmitted by sea and river microorganisms. Jellyfish, anemones, sponges, corals and rarely Coelenterates (Cnidaria) are known to cause dermatitis and infection if traumatized (Figure 7). Dermatitis can also develop after contact with fish (jellyfish, stingray, weeverfish, stonefish), cones, or sea snakes (Hydrophiidae) due to their venomous toxin (Figure 8). Exposure may result in blistering and skin necrosis along with systemic symptoms, including respiratory muscle paralysis.

Another dermatitis, known as “seabather’s eruption”, is a pruritic eruption that appears under the bathing suit. It is caused by contact with swimming stages of the thimble jellyfish, *Linuche unguiculata*, and it is seen in Florida, the



Figure 7 Coral reef dermatitis that became infected secondary to trauma.



Figure 10 Squamous cell carcinoma on dorsal forearm.



Figure 8 Jellyfish sting on patella.



Figure 11 Squamous cell carcinoma on helix of ear.



Figure 9 Basal cell carcinoma on superior aspect of ear of swimmer.

Caribbean and Brazil. Cercarial dermatitis (swimmers' itch) develops after penetration of *Shistosoma's* larvae through human skin. The exact species of *Shistosomas* that cause the eruption, their animal hosts, and distribution is still under investigation^[74]. The condition is usually self-limited and presents as pruritic papules on exposed body surface areas, usually sparing the bathing suit region.

Onchocerciasis (river blindness) is caused by the filaria *Onchocerca volvulus*. Acquisition of the disease may occur after swimming in the Middle East, Africa or Latin America. Skin changes in onchocerciasis include nodule formation in the area of penetration, a pruritic rash,

lichenification, vitiligo-like changes, and atrophy after microfilaria migration. Early detection and treatment of filaria with ivermectin helps prevent river blindness.

ENVIRONMENT-RELATED CONDITIONS

Outdoor athletes are often exposed to undesirable environmental conditions such as excessive humidity, heat, cold, wind, and sunlight that may aggravate or cause different skin conditions. Sun exposure in athletes may be extreme and can lead to a higher risk of basal cell carcinoma (Figure 9), squamous cell carcinoma (Figures 10 and 11), and melanoma (Figure 12). Moehrle^[75] has found that burns were seen in triathletes despite of use of SPF 25+ sunscreens. However, data regarding the incidence of skin cancers in aquatic athletes is limited to several early studies. In 1992, a screening of surfers demonstrated an increased incidence of basal cell carcinomas in surfers, despite of their young age^[76]. Nelemans *et al*^[77] have shown that the odds of melanoma risk were higher in swimmers, but he contributed it largely to the chlorination of the water in swimming pools.

Use of SPF 30 or greater sunscreen and protective clothing is highly recommended to athletes^[78,79]. When counseling swimmers on sunscreen usage, one should advise use of a sunscreen that contains SPF 30 or greater, is water resistant, and provides broad spectrum UVA



Figure 12 Melanoma on the leg.

and UVB coverage. Swimmers should also be told to generously apply the sunscreen to all bare skin before going outdoors since it can take up to 15 min for skin to absorb sunscreen. Finally, they must be counseled to reapply sunscreen immediately after swimming or every two hours, whichever is sooner.

CONCLUSION

Aquatic athletes present a unique set of challenges for the dermatologist. It is important to educate athletes, parents, and coaches in an attempt to prevent short and long term dermatological sequela.

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