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The effect of topical anti blister products on the risk of friction blister formation on the foot

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ABSTRACT

Introduction: Foot blisters are a common injury, which can impact on activity and lead to infection. Increased skin surface hydration has been identified as a risk factor for blister formation, indicating that a reduction in hydration could reduce the risk of blister.
Method: Thirty healthy adults were randomised into 3 groups, each receiving a preventative foot blister treatment (2Toms® Blister Shield®; Flexitol® Blistop and Boots Anti–Perspirant Foot Spray). Cycles of compression and shear loads where applied to heel skin using a mechanism driven by compressed air. Temperature changes were measured during load application using a thermal imaging camera (FLIR Systems Inc. and Therm CAM™ Quick Report). Near surface hydration of the skin was measured using a Corneometer® (C & K, Germany).
Results: There was no significant difference in the rate of temperature change of the skin between the three groups compared to not using products ($p = 0.767$, $p = 0.767$, $p = 0.515$) or when comparing each product ($p = 0.551$). There was a significant decrease in near surface skin hydration, compared to baseline, after the application of powder (−8.53 AU, $p = 0.01$). There was no significant difference in hydration after the application of film former and antiperspirant (−1.47 AU, $p = 0.26$; −1.00 AU, $p = 0.80$, respectively).
Conclusion: With the application of external load we found no significant difference in the effect of the three products on temperature change. The powder product demonstrated an effect on reducing the risk of blister. It is postulated that powder may have a barrier effect.

1. Introduction

Friction blisters are a common injury [1,2] of the hands and feet which can be encountered by anyone, although athletes [3] and military staff [4] are at particular risk. On the foot these lesions can be painful and gait adaptations, adopted to offload the painful site, can lead to lower limb problems and affect performance [5]. Blisters have a high risk of rupturing due to the fragile blister roof, predisposing the resultant wound to the risk of infection [6]. Such an injury can be considered to be trivial by many, however it can have serious implications if not managed effectively. This justifies the pursuit of effective blister prevention measures.

Skin surface hydration has been identified as a key risk factor in friction blister development [7–9]. The coefficient of friction of skin generally increases with increased moisture due to increased surface resistance [10–12]. The alterations in surface resistance, of palmar skin in particular, are complex and comprise a combination of viscous shearing effects; absorption of water by the skin and capillary adhesion effects [10,13–15]. In addition, the plasticizing effect of water on keratin causes the stratum corneum to become less stiff and more deformable therefore increasing the area of contact and increasing friction [16–18]. Indeed, using a laboratory based model of blister formation, the authors have already demonstrated that greater skin hydration is associated with greater risk of foot blisters [11].

Skin hydration is altered by environmental humidity [19],

Abbreviations: LAM, Load application mechanism; N, Newtons.

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perspiration and topical preparations [17,20,21]. For example, foot sweat which is unable to wick away from the skin surface causes the skin to become moist and thereby increases the risk of blister. Measures that reduce skin surface hydration could therefore aid blister prevention and use of powders [22,23], antiperspirants [24–26] and socks [27–29] have been investigated in this context. Research studies testing the effects of sock type found that the risk of blistering was reduced by 12% with the use of acrylic compared to cotton socks [27]. In this study the participants who wore acrylic socks had drier foot skin (and socks) after exercise compared to those who wore cotton socks [28]. Another study reported that a wool polyester blend sock had the lowest blister incidence during the first 6 weeks of basic military training [29]. Man-made fibres, such as acrylic and polyester allow moisture to be drawn away from the foot. This is also referred to as a 'wicking effect' [5].

Powders are applied to the skin in order to absorb moisture and to keep foot skin as dry as possible during activity [30,31]. The therapeutic use of powder in friction blister management has only been suggested and not fully tested in the literature, although it is known that when powder absorbs moisture (either from the skin or the environment) the coefficient of friction on the skin surface increases [31].

Aluminium-based antiperspirants, which aim to block the sweat glands, have been used to prevent excessive perspiration of foot skin [21,32]. Knapik et al. (1998) found that the risk of blister formation was reduced by 12% with the use of an antiperspirant and the lowest incidence of blisters was seen after 3 days of antiperspirant use [26]. Darrigrand et al. (1992) found that sweat accumulation was reduced by 50% and there was a marked reduction in hot spots and blisters with the use of an antiperspirant [21]. However, these two studies also observed a degree of skin irritation caused by antiperspirants [25,26].

Film formers produce transparent, water resistant protective covers for the skin. Several film former products claim to prevent blisters but there is no published research that supports these proposed effects. The mechanisms of action are purported to reduce skin surface friction and reduce the accumulation of sweat. However, there is no published research quantifying this reduction.

In previous studies product efficacy has been defined by the change in blister incidence after physical activity. This tells us about the real world impact of the product but prevents us from studying the precise circumstances that exist when friction blisters develop. 'Real world' outcomes also prevent us from investigating the effect of any single factor on blister formation because the in shoe environment is highly variable and difficult to control. Measures such as time to blister formation; inflammatory response of the skin to shear loads prior to blister formation; the loads required to create blisters and measurement of skin hydration as a covariate related to risk of blister may be more revealing. Research studies which tested blister prevention products, compared the effect of a product versus no product as a control, which tells us little of the comparative efficacy of the various approaches (e.g. powders, antiperspirants, film formers) which have different mechanisms of action.

The current study aimed to test the effect of three products on near surface skin hydration (i.e. moisture content using a measure of capacitance) and the subsequent risk of blister formation using a laboratory based model of blister formation. We have previously employed thermography as a sensitive, reliable measure for tracking blister development and to identify temperature changes at the point of blister formation [11,33]. This approach enables the effects of interventions and any role of skin hydration in these effects to be studied more sensitively than in previous studies.

2. Materials and methods

A convenience sample of 30 healthy individuals aged 18 years and over were recruited from staff and students at the University of Salford, UK. All participants were free of self-reported skin disorders, diseases affecting vascular and neurological systems, systemic diseases, and musculoskeletal disorders of the foot and ankle. Participants also confirmed they had not used anti-inflammatory medication, pain-killing medication, steroids and immunosuppressant medication 48 h prior to data collection. Participants were also asked to discontinue the use of all foot products e.g. creams and sprays, before data collection. Foot sensation and vascular supply were tested using standard podiatric assessment techniques [34] and found to be normal in all cases. Participants were randomised to receive one of the three interventions. Written informed consent was obtained from all participants. Ethical approval was obtained from the Research Ethics Panel at the University of Salford.

2.1. Instrumentation

Near surface hydration (10–20 microns depth) was measured using a Corneometer® 825 CM (Courage and Khazaka, Colne, Germany) mounted on a MPA 5 multi-probe adapter. Skin temperature was measured using infrared thermography (FLIR Systems Inc, West Malling, UK) with a temperature range from 0 °C to 250 °C, accuracy ±0.2 °C. Data were processed using Therm CAM™ Quick Report Version 1.1 software (FLIR Systems Inc, West Malling, UK).

2.2. Description of load application mechanism (LAM)

The LAM (Fig. 1a and b) used in this study comprised of a loading head and a lever arm which was displaced manually. The loading head has a curved anterior surface with a strip of textured rubber material (Ironman Rubber Covering, Black, OB2090, Algeos UK Ltd., Liverpool, UK) providing an interface with the skin (Fig. 1c and d). The rough upper surface of the rubber creates friction between the device and skin. A new piece of rubber was used for each participant. The maximum contact pressure applied to the posterior aspect of the heel by the LAM was 15N for each participant. This was measured using a load sensor (ELF System, Tekscan) placed between the heel and the load applicator head prior to commencing the loading sequence. Once the appropriate force was detected, the position of the foot and LAM were fixed using strapping and bolts (respectively) after which the load sensor was removed.

The head of the LAM moves elliptically so that periods of contact and non-contact between the LAM head and the skin occur, mimicking the contact sequence between the heel and shoe during walking, i.e. an upward contact period followed by a downward non-contact period. A compressed air system was used to move the loading head forwards and backwards whilst the researcher manually displaced the head upwards and downwards to achieve the elliptical motion at a rate of one cycle every 2 s (30 contact passes/min) using a metronome.

2.3. Skin sites tested

Skin measurements were taken from two sites: 1) the posterior aspect of the heel (test site), and 2) below the medial malleolus (control site) (Fig. 1d). Only the test site was loaded.

2.4. Interventions

Three commercially available anti - blister treatments were tested: 2Toms® Blister Shield® (powder comprising