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(54) Title: A METHOD AND APPARATUS FOR TESTING CHRONIC AND ACUTE SKIN INFLAMMATION TREATMENTS

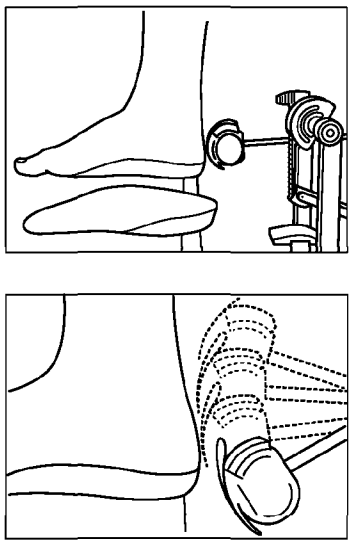

Fig. 1(a)

(57) Abstract: The present invention is directed to a load application mechanism for use in a method for testing the efficacy of a preparation or dressing or other suitable product for the prevention of skin inflammation wherein the mechanism is used to generate a force or pressure, in combination with friction and shear, which leads to skin inflammation and comprises a contact means for rubbing against the skin of a participant and a means for controlling the rate at which the contact means contact a participant's skin.

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A method and apparatus for testing chronic and acute skin inflammation treatments

The present invention is directed to a method for determining the efficiency of prevention, protection or therapeutic treatments of skin inflammation resulting from an excess or chronic load or pressure and apparatus for use in such a method.

The skin on the foot is susceptible to developing a range of mechanical dermatoses as a consequence of repetitive loads during physical activity. Friction blisters, calluses and corns (hereinafter referred to as FCC) present in people of all ages and occur during either high levels of activity and/ or use of ill-fitting footwear and hosiery. Friction blisters (most commonly occurring on the heel), and calluses and corns (most commonly occurring on the forefoot and toes) are not trivial injuries, they can be painful, restrict normal foot function and place the lower limb at increased risk of infection. Altered gait is a common strategy adopted to reduce pressure (and pain) in the area of the FCC. This results in altered lower limb biomechanics and may increase risk of secondary injuries during periods of extended or intensive exercise.

The primary physical response of the skin to acute friction is the separation of intra-epidermal layers, at the level of the *S. Spinosum,* followed by a physiological response of acute inflammation, and with time this area is infiltrated with fluid thus forming a blister. The clinical signs of acute inflammation are: redness, swelling, pain, heat, and disturbed function, which are all closely related to an increase in perfusion to the area. This increased blood flow leads to an increase in temperature of the affected area. Increased temperature is a cardinal sign of foot blisters due to the localized response to mechanical stress and damage to the epidermis.

The same theory is applied to the lower level combined friction and compression loads where the effects of these intermittent loads do not produce acute trauma to

the skin but cause a degree of inflammation in the base of the skin that encourages hyperkeratosis and therefore the formation of calluses and corns.

Changes in skin temperature can therefore be used as an indicator of the early stages of FCC formation, and hence be used in assessing the efficacy of prevention, protection and therapeutic treatments.

The aim of this invention is to provide a mechanism to generate the correct level of trauma leading to skin inflammation in a controlled manner, and provide a means to test the efficacy of various interventions for treatment, prevention, or protection - for example, using skin temperature changes as an indicator of inflammation and the onset of FCC formation.

According to a first aspect of the invention there is provided a Load Application Mechanism (LAM) for use in a method for testing the efficacy of a preparation or dressing or other suitable product for the prevention of skin inflammation wherein the mechanism is used to generate a force or pressure, in combination with friction and shear, which leads to skin inflammation and comprises a contact means for rubbing against the skin of a participant and a means for controlling the rate at which the contact means contacts a participant's skin.

The contact means can be made of any material that is capable of increasing friction and compression causing mild or superficial trauma on the surface of the skin. Typically, the material is selected from any material that is used to form the upper portion of a shoe, such as rubber, leather, synthetic textiles, or any material that is used to form a sock or hosiery textile such as cotton, wool, nylon or polyester. A preferred material is rubber, which has a relatively high coefficient of friction when in contact with the skin.

The contact means is provided with a convex shape in such a way that the angle of contact between the surface of the contact means and the skin of a participant is less than 90 degrees. Typically the angle is between 30 and 60 degrees. The contact means also has provision for applying compression combined with shear to the skin.

The vertical displacement of the contact means ranges from 10mm to 30mm, and is typically 15mm.

The contact means will typically exert a pressure on the skin of a user of up to 490kPa. A typical pressure range is between 50 and 90 kPa for friction blister creation and 320 and 490 kPa for corn and callus formation. Incorporated within the contact means are 3 dimensional load sensors cells which are able to quantify load application values to the skin. These loads represent those experienced during walking and running.

The contact means is secured to an adjacent housing which includes the means for controlling the rate at which the contact means makes contact with the skin of a participant. This housing can either be manually controlled or could enable programmed automated movement of the contact means.

The LAM operates at speeds ranging between 30 and 240 passes/minute. Typically the speed for blister creation ranges from 30 to 120 passes/min and for corn and callus creation the range is 60 to 240 passes per minute. Each pass represents the contact means passing in one direction against the skin of a participant.

The LAM is able to operate under various rubbing profiles: principally a two-directional linear or curved (e.g. up-and-down) rubbing motion, as well as a uni-

directional linear rubbing (e.g. an upwards-only, or downwards-only contact passes) option, generally in a circular or elliptical motion.

The LAM is used in different time cycles in order to create the desired trauma. For blister creation, which is an acute trauma, the load application is semi-continuous until the end point is reached, whereby the end point could be a specific temperature increase, change in skin colour, early signs of damage, signs of blister, and so on. Typically, this occurs within minutes for the average foot. For corn and callus formation, which are longer-term trauma exposure, the load application is intermittent over a longer period of time in controlled cycles. Thus corns and calluses are formed over days of lower-level loading rather than minutes.

The load applicator can be used to test the efficacy of prevention treatments on any suitable part of the body. Preferred parts are the heel and the plantar surface of the foot.

According to a second aspect of the present invention there is provided a method of testing the efficiency of trauma protection and/ or prevention treatments comprising causing partial or full trauma and an increase in skin temperature using the load application mechanism described in the first aspect, applying a protection or further preventative treatment thereto and continuing with the load application to measure the effect of the protection or prevention treatment on rate of increase in skin temperature or trauma.

In the first and second aspects of the present invention, changes in the biophysical properties of the skin with time can be measured using skin hydration meters, elastometry and surface texture imaging of the skin under magnification. Differences in the nature of the skin in response to trauma can be identified. The skin temperature is measured using Infrared thermography, which is widely used to monitor thermal changes in skin pathologies, such as: malignancies, inflammation,

infection, vascular defects, dermatological, and rheumatic disorders. In the case of the foot, plantar temperature has been used as a marker for inflammation in diabetes. The advantages of thermal imaging methods are that they are non-invasive, non-contact and do not restrict data collection to one site because data can be captured across a wide surface area synchronously. It thus offers excellent opportunity to observe thermal changes due to friction, compression and shear at sites on the foot and monitor changes in foot inflammation status over time.

Typically, the thermography method measures a change in temperature over time. In the case of acute trauma (or blister formation), this is typically of up to 5.0 ± 2.5 ºC at point of blister creation.

The measures of significant changes in hydration, elasticity and surface texture (compared to normal skin) are typically: 6 AU, 0.4mm (displacement) and 3 AU respectively, when measured with a Corneometer® Curometer® and Viscioscan® (Courage and Khazaka, Germany).

According to a third aspect of the present invention there is provided a method of determining the efficiency of treatments for healing or reducing mild or superficial skin trauma comprising causing trauma and an increase in skin temperature using the load application mechanism described in the first aspect, applying a healing treatment thereto and measuring the effect of the treatment of a participant's skin post-trauma.

Embodiments of the present invention will now be described, by way of example only, will now be described with reference to the accompanying Figures in which:

Figures 1 (a) - (c) illustrate embodiments of the device of the first aspect of the present invention and how they can be used;

Figure 2 illustrates the mean temperature change (± standard deviation, SD) from baseline at test and control sites at point of trauma formation, 0.5, 1.5 and 5.5 hours post-trauma formation;

Figure 3 illustrates the relationship between temperature readings taken from a thermal imaging camera and a contact thermometer at test and control sites;

Figure 4 illustrates the effect of pre-hydration of the foot on the rate of change of temperature from baseline by comparing the hydrated foot and the non hydrated foot;

Figure 5 illustrates the average change in temperature from baseline in response to load application over time for the test and control site hydrated and non-hydrated groups;

Figure 6 shows the duration (in minutes) taken to get to an end-point for both the hydrated group and non-hydrated group;

Figure 7 shows the relationship between rate of change in temperature from baseline and skin surface hydration;

Figure 8 shows the relationship between rate of change in temperature from baseline and skin elasticity;

Figure 9 shows the difference between the product and non-product foot within the same intervention group where a) represents the powder group, b) represents the film former group and c) represents the antiperspirant group. The 'product foot' is described as the foot onto which the product was used, and the 'non-product foot' is described as the foot onto which no product was used.

Figure 10 illustrates the emerging trends in the effect of the three preventative products on the rate of change in temperature for both the product and non-product foot (rate of change in temperature is taken as a surrogate for rate of inflammation)

Figure 11 illustrates the difference between the rate of change of temperature from baseline between the three intervention groups.

A combined friction and compression load was applied to the posterior heel of 30 volunteers. The test in Example 1 was conducted in the context of generating blisters, and not corns and callus. Temperatures at the test (friction) and a control sites were recorded using a contact thermometer and an infrared thermal imaging camera. Temperature readings were taken during and 5.5 hours post-blister formation. In this example the product could be applied onto the skin prior to loading or after loading as per the first and third aspect, but in this particular case no product was used.

Instrumentation

Thermal imaging camera: FLIR™ SC620 Thermal Camera (FLIR Systems Inc., West Malling, UK): pixel resolution 80 x 80, temperature range 0°C to +250°C, accuracy ± 0.2ºC. Supporting software: Therm CAM™ Quick Report Version 1.1.

Infrared contact thermometer: (Brannan Thermometers, Cumbria, UK): Temperature range: -22 - 80ºC, accuracy ± 0.2ºC.

Load application mechanism (LAM): The LAM comprised a spring operated rotating load applicator with a curved anterior surface (Figure 1) and a strip (60 mm x 30 mm x 0.9 mm) of textured rubber material (Ironman Rubber Covering, Black, OB2090, Algeos UK Ltd., Liverpool, UK) providing an interface with the skin. This covering had a rough upper surface, creating friction between the device and skin. The rubber strip was cleaned with hard surface alcohol disinfectant prior to use and a new piece of material was used for each participant.

The device was secured to a platform adjacent to the participant's feet and positioned such that the load applicator aligned with the back of the heel (Figure. 1a). Two shoe inserts were used to standardise foot position.

The vertical displacement of the LAM was mechanically limited to 15 mm. This range was determined from a pilot study using slow motion high speed video analysis to determine the displacement of the heel relative to the back of a shoe at heel strike. The downward and upward displacement of the LAM was operated manually.

The devices shown in Figures 1 (b) and 1(c) operate in an elliptical manner contacting the skin in one direction (either up or down).

Measurement protocol

All test procedures were conducted in the same room and data collected from each participant between 8am and 4pm on the same day. Temperature and humidity on the day varied no more than 2.3 ºC and 7%.

The participants removed all footwear and hosiery and remained seated on a chair in the test room for 15 minutes, allowing for acclimatisation of the exposed skin to the environmental conditions before standing on the test platform.

The load applicator was positioned such that when in maximum contact with the heel the pressure was 70kPa (7N/ cm^2), measured using a pressure switch. Pilot work conducted during the design of the LAM identified this as an appropriate level of pressure to encourage blister creation without abrading skin or de-roofing the blister. The thermal imaging camera was then positioned 0.5 m from the back of the heel and at an angle of 45º to the long axis of the foot (heel to second toe axis). Baseline temperatures and skin surface hydration were recorded at test and control skin sites.

The load applicator was operated manually at a rate of 120 passes/ min (60 upwards and 60 downwards rubbing contact passes), where one pass represents the LAM passing against the skin once This rate was set to replicate fast walking (approximately 120 steps per minute). The load was applied in this manner continuously for 2 minutes, followed by a 1 minute period during which the investigator recorded thermal image and contact thermometer temperatures. The skin was also visually inspected for any signs of tissue damage. For the purpose of recording the data, the 2 + 1 minutes was called one “load-rest cycle”.

Load-rest cycles were repeated until the early signs of blister formation were observed, which were the appearance of: 1) a blanched area of skin within the erythematous, affected area of skin; and 2) a visible pleat of epidermis lifted from the underlying dermis. The load application was terminated on the initial appearance of the blister. The temperature readings were then recorded every 3 minutes for 30 minutes whilst the participant remained standing. Thereafter, data was collected every hour for 5 hours. After the initial 30 minutes post blister participants were allowed to leave the test room but asked to wear footwear that placed no pressure on the area of the blister (e.g. open back sandals).

The data is described in three stages representing three different time periods of observed blister formation. Stage 1: onset of external load application to the time of the initial appearance of a blister (the number of temperature readings recorded depended on the number of load-rest cycles needed to initiate a blister); Stage 2: 30 minutes post - blister creation (this phase comprised 10 temperature readings recorded at 3 minute intervals) and Stage 3: 5 hours after the 30 minute post-blister period (5 temperature readings recorded at 1 hour intervals).

Ultrasound imaging (20MHz ultrasound probe, Dermascan C®, Cortex Technology, Denmark) was used to confirm the formation of a true blister.

Temperatures at the test and control sites were expressed as mean ± SD. Normality assumptions were tested by an examination of the residual plots and the Shapiro-Wilk test of normality. The Q – Q plots depicted a skewed distribution of data and the Shapiro Wilk test indicated that the distribution of temperatures departed significantly from normality ($p = 0.001$ and $p = 0.001$, respectively). Therefore, non – parametric tests were used. Spearman's correlation coefficient was used to test for relationships between thermal imaging and contact thermography, and Mann – Whitney U was used to test for differences in temperature over time ($p \leq 0.05$). Statistical analyses were carried out in SPSS 16.

Results

Observations made of skin during blister creation and progression

The development of all the blisters created in this study followed a consistent pattern in terms of clinical signs and reported symptoms from the participants. The clinical signs were: redness initially, followed by blanching of the skin, and finally the appearance of a small pleat of epidermis that then filled with fluid during Stage 3. Not all blister sites remained red in colour throughout the 5.5 hours. In some cases there was no visible redness noted, in particular during Stage 3. All participants described a similar sequence of sensations during the load application. These were: an initial 'rub' sensation on the skin, followed by a 'stinging' sensation which then subsided until a 'sharp' pain was felt. This final sensation related to the initiation of the blister.

Changes in skin temperature during blister creation

Figure 2 and Table 1 represent the temperature data at: baseline, the end of Stages 1, 2 and 3 and at the beginning of Stage 3 for both the test and control sites.

Time point	Test site temperatures [ºC] n = 30			Control site temperatures [ºC] n = 30		
	Minimum	Maximum	Mean ± SD	Minimum	Maximum	Mean ± SD
Baseline	22.8	31.2	26.7 ± 2.2	28.9	34.9	31.9 ± 1.4
Initial blister formation	26.3	36.7	32.3 ± 2.2	28.9	34.3	31.6 ± 1.3
30min post-blister	23.4	35.1	29.2 ± 3.3	28.8	34.9	31.7 ± 1.6
1½ hr post-blister	24.2	33.7	29.8 ± 2.7	28.8	34.0	31.1 ± 1.7
5½ hr post-blister	21.3	33.0	27.8 ± 2.6	27.6	33.5	31.0 ± 1.5

Table 1: Temperature ranges at baseline, at the end of each stage of data collection data and at the beginning of Stage 3.

Control sites: The temperatures at the control sites remained relatively constant throughout all three stages of the experiment (mean change in temperature from baseline ± SD: -0.3 ± 1.4ºC, $p>0.05$).

Test sites: The number of load-rest cycles required to cause blistering ranged from 2 to 16 cycles (mean ± SD: 6 ± 4 cycles). In terms of time of load application (although separated by 1 minute rest intervals every 2 minutes) the minimum loading time required to initiate blistering was 4min and the maximum loading time 32min (mean ± SD: 12.8 ± 9.8min). Twenty-three participants (77%) blistered within the first 18 min of load application (i.e. 6 load-rest cycles).

The mean change from baseline to the point of blister formation was 5.0 ± 2.5 ºC. ($p <0.001$). The mean temperatures at the test site decreased significantly at the 30 minute post blister time point compared to the temperatures at the onset of blistering (mean difference 3.1ºC $p< 0.001$). However, these temperatures were still significantly greater (mean difference 2.5 ºC, $p = 0.003$) than baseline temperatures.

The temperatures remained relatively constant over the one hour period after the initial 30 minutes post blister (i.e. 90 minutes post blister) ($p = 0.506$) and then decreased significantly with time over the five our period post blister ($p = 0.06$ when comparing the mean temperatures at 90 minutes and 5.5hours). At the end of the data collection period the mean temperature at the test site was 1.1ºC above the mean baseline temperature ($p = 0.067$).

Other observations: Although temperatures remained relatively constant at the control sites, a temperature increase (with time) was noted on the area of skin between the test and control sites in all participants. Closer inspection of the thermal images revealed common trends relating to this temperature increase. For some participants during the 30 minutes post blister creation there was an area located between the medial malleolus and test sites that demonstrated an increase in skin temperature. This persisted until the end of the data collection period (5.5 hours post blister formation).

Analysis of relationship between the Thermal Imaging Temperature (TT) and Contact Temperature (CT) data

There was a strong positive correlation between TT and CT readings at both the test and control sites (Figure 3, $r = 0.853$ and $r = 0.774$, respectively).

This data obtained describe how changes in foot skin temperature can be quantified non–invasively during the formation of friction heel blisters. It is believed that increased skin temperature is a surrogate measure of the inflammatory response in the skin.

The design of the LAM provided the appropriate amount of compression and friction to the skin to generate friction blisters that had the expected blister anatomy (confirmed using ultrasound imaging). This study has provided a description of how skin temperature changes as friction is applied, a blister is created and as healing begins. The scale of changes and consistency across participants suggests that

temperature would be a suitable measure of how risk factors (e.g. skin hydration) and prevention or treatment strategies might interfere with underlying risk of blister.

Example 2

In this example, the effect of pre-hydrating the skin on the rate of blister creation was investigated by applying combined friction and compression load to the posterior heel of 20 healthy participants using the mechanical device of the first aspect.

Instrumentation

The instrumentation used for the second example is the same as described in Example 1, with the following additions:

- *Skin hydration measurement*: Corneometer® 825 CM (Courage and Khazaka, Colne, Germany) mounted on a MPA 5 multi-probe adapter.
- *Skin elasticity measurement*: Cutomete® 575 (Courage and Khazaka, Colne, Germany)

Measurement Protocol

The test procedure was conducted as per Example 1, with the following exception:

- Baseline skin physiological properties (hydration and elasticity) were measured after the participants were acclimatised to the room conditions
- The skin of one randomly allocated foot of each of the 20 participants was hydrated by soaking the foot in water after baseline measurements and prior to compression and shear load using the LAM. Hydration measurements were taken after the hydration process, but before load application to quantify the immediate changes.
- The compression and shear load was applied to either of the following end-points, whichever occurred first: a) until a change of a maximum of 3^{o}C was evident using thermography, b) until the skin showed early signs of damage or c) until signs of blister formation were observed.
- The contact profile was modified such that the skin was contacted by the rubber contact means in one direction (upwards) only. This was done following additional work highlighting that during in-shoe walking, the shoe has a tendency to rub the heel at the heel strike part of the gait cycle only.

- The contact means was operated at a rate of 30 passes/min, whereby a pass is defined as a contact point rub.

Results

All statistical analyses were conducted as per Example 1. The rate of change of temperature of the skin in the hydrated foot group was significantly greater than that of the non-hydrated foot group (p=0.001). This is illustrated in Figure 4. It was found that the hydrated foot tended to reach an end-point faster than the control, non-hydrated foot as shown in Figure 5 and Figure 6. From Figure 6, it can be seen that 95% of the hydrated group reached an end-point after 10minutes, but only 75% of the control group reached an end-point over the same period of time. A positive correlation is present between rate of change of temperature in response to load and skin surface hydration (r=0.52) shown in Figure 7, and a very weak negative correlation is seen between skin elasticity and rate of change of temperature (r= -0.166) in response to load application seen in Figure 8.

The data illustrate that modifying the skin properties prior to application of the compression and friction load influences the rate of inflammation and risk of blister creation. An advantage of the present invention, as demonstrated by Example 2 is that there is a method and apparatus to study and quantify physiological skin changes during the preventative treatment of the early stage formation of a foot blister.

Example 3

In Example 3 illustrating the use of the invention, the efficacy of three potentially preventative treatments on the rate of blister creation was investigated in a limited size pilot study by applying combined friction and compression load to the posterior heel of 30 healthy participants using the mechanical device of the first aspect. 10 participants were used for each product type.

Instrumentation

The instrumentation used for the second example is the same as described in Example 2, with the exception that the Cutometer® was not used.

Measurement Protocol

The test procedure was conducted as per Example 2, with the following exceptions:

- Skin elasticity was not measured at baseline
- The skin of one randomly allocated foot of each of the 30 participants was pre-treated with either one of: a) an absorbing talc powder, b) a film forming protective layer or c) generic antiperspirant, after baseline measurements and prior to compression and shear load using the LAM. Hydration measurements were taken after application of the preventative treatments, but before load application to quantify the immediate changes.

Results

The Kolmogorov Smirnov test for normality was conducted and the data was found to be normally distributed. Parametric statistical tests were used for this set of data. Paired T-tests were conducted to compare the differences between the product feet and non-product feet of each product category (powder, n=10, film-former, n=10 and antiperspirant, n=10). No significant difference in rate of change of temperature was observed between the treated and untreated feet for each product group (powder, p=0.912; film-former, p=0.611; antiperspirants, p=0.811). This is shown in Figure 9. However, Figure 10 illustrates some emerging trends that indicate that the treated feet had a lower rate of change in temperature (hence of inflammation) than the untreated control. As this was a limited size pilot study, a larger number of participants may be required to validate this trend.

A One-way ANOVA test was carried out to determine if there was a significant difference between the test site of the product foot of the three intervention groups. The result indicated that there is no significant difference in rate of change in temperature between the three intervention groups (p=0.982). This is illustrated in Figure 11.

When the overall change in temperature from baseline to the end-point for participants in their sub-groups was compared, it was found that the antiperspirant

group had a significant difference in the increase in temperature compared to the non-product foot group (p-0.028). No significant differences were found for the other two product groups. This illustrates how the LAM is able to demonstrate differences in product efficacy.

The data generated from Examples 1-3 illustrate how the invention can be used to assess the efficacy of potentially preventative or therapeutic treatments in the context of blister formation, as detailed in the first and second aspect of the invention. Although the studies conducted so far are primarily based on acute inflammation (i.e. the formation or prevention of blister formation on the foot), the principles apply in the context of chronic, lower level and longer-exposure inflammation.

Further modifications and improvements can be made without departing from the scope of the invention described herein.

CLAIMS:

1. A load application mechanism for use in a method for testing the efficacy of a preparation or dressing or other suitable product for the prevention of skin inflammation wherein the mechanism is used to generate a force or pressure, in combination with friction and shear, which leads to skin inflammation and comprises a contact means for rubbing against the skin of a participant and a means for controlling the rate at which the contact means contact a participant's skin.

2. A load application mechanism as claimed in Claim 1 wherein the contact means can be made of any material that is capable of increasing friction and compression and causing mild or superficial trauma on the surface of the skin.

3. A load application mechanism as claimed in Claim 2 wherein the material is selected from any material that is used to form the upper portion of a shoe, such as rubber, leather, synthetic textiles, or any material that is used to form a sock or hosiery textile such as cotton, wool, nylon or polyester.

4. A load application mechanism as claimed in Claim 2 or Claim 3 wherein the material is rubber.

5. A load application mechanism as claimed in any of the preceding Claims wherein the contact means is provided with a convex shape in such a way that the angle of contact between the surface of the contact means and the skin of a participant is less than 90 degrees.

6. A load application mechanism as claimed in Claim 5 wherein the angle is between 30 and 60 degrees.

7. A load application mechanism as claimed in any of the preceding Claims wherein the vertical displacement of the contact means ranges from 10mm to 30mm.

8. A load application mechanism as claimed in Claim 7 wherein the vertical displacement is 15mm.

9. A load application mechanism as claimed in any of the preceding Claims wherein said contact means will exerts a pressure on the skin of a user of up to 90kPa for blister creation and 490kPa for corn and callus creation.

10. A load application mechanism as claimed in Claim 9 wherein the pressure range is between 50 and 90kPa for blister creation and 320 and 490 kPa for corn and callus creation.

11. A load application mechanism as claimed in any of the preceding Claims wherein the contact means is secured to an adjacent housing which includes the means for controlling the rate at which the contact means makes contact with the skin of a participant.

12. A load application mechanism as claimed in any of the preceding Claims wherein the load application mechanism typically operates at a speed between 30 and 120 passes per minute for blister creation and 60 and 240 per minute for corn and callus creation

13. A load application mechanism as claimed in Claim 12 wherein the speed of the device up to 240 passes/min.

14. A load application mechanism as claimed in any of the preceding Claims wherein the load application mechanism is able to operate under various rubbing profiles.

15. A load application mechanism as claimed in Claim 14 wherein the load application mechanism acts in a two-directional linear or curved rubbing motion

16. A load application mechanism as claimed in Claim 14 wherein the load application mechanism acts in a uni-directional rubbing.

17. A load application mechanism as claimed in Claim 14 wherein the load application mechanism acts in a circular or elliptical motion.

18. A load application mechanism as claimed in any of the preceding Claims wherein the load applicator is used to test the efficacy of treatments on any suitable part of the body.

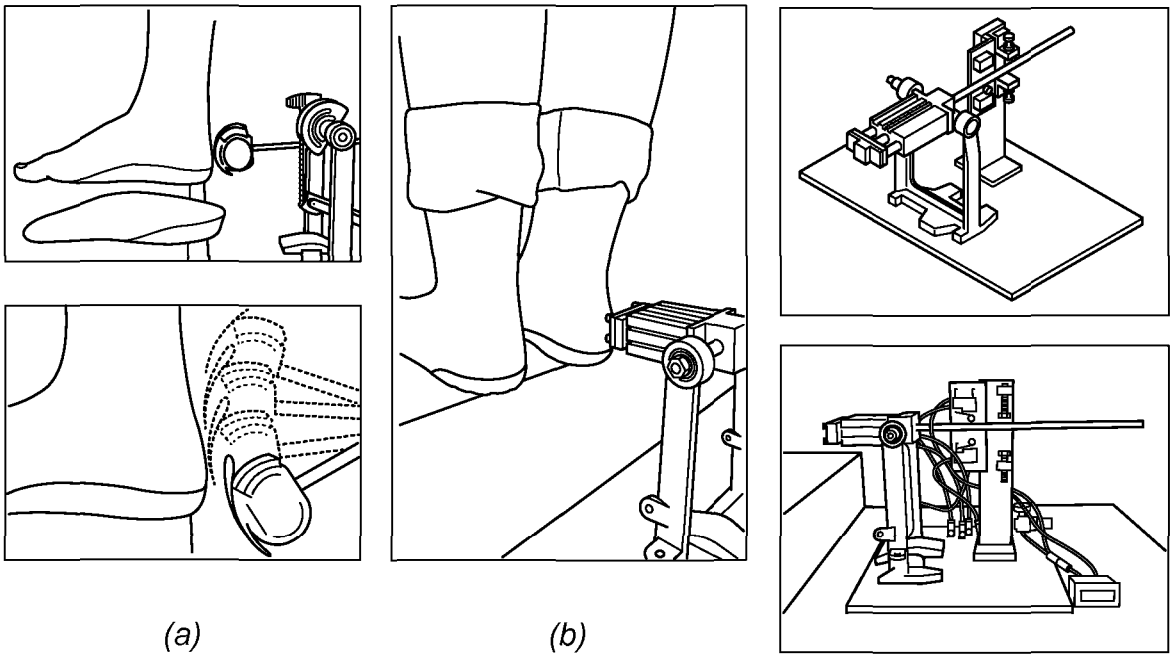
19. A load application mechanism as claimed in Claim 18 wherein the load applicator is used to test the efficacy of treatments on heel and the plantar surface of the foot.

20. A method of testing the efficiency of trauma protection or prevention treatments comprising causing partial or full trauma and an increase in skin temperature using the load application mechanism as claimed in any of Claims 1 - 19, applying a protection or further preventative treatment thereto and continuing with the load application to measure the effect of the protection or prevention treatment on rate of increase in skin temperature or trauma.

21. A method of testing the efficiency of trauma protection or prevention treatments as claimed in Claim 20 wherein the skin temperature is measured using Infrared thermography.

22. A method of testing the efficiency of trauma prevention or protection treatments as claimed in Claim 20 or Claim 21 wherein for acute trauma such as blister formation, the method measures a change in temperature over time of up to 5.0 ± 2.5 ºC at point of blister creation.

23. A method of determining the efficiency of treatments for healing or reducing mild or superficial skin trauma comprising causing trauma and an increase in skin temperature using the load application mechanism described in the in any of Claims 1 – 19.



(a) (b) (c)

Fig. 1

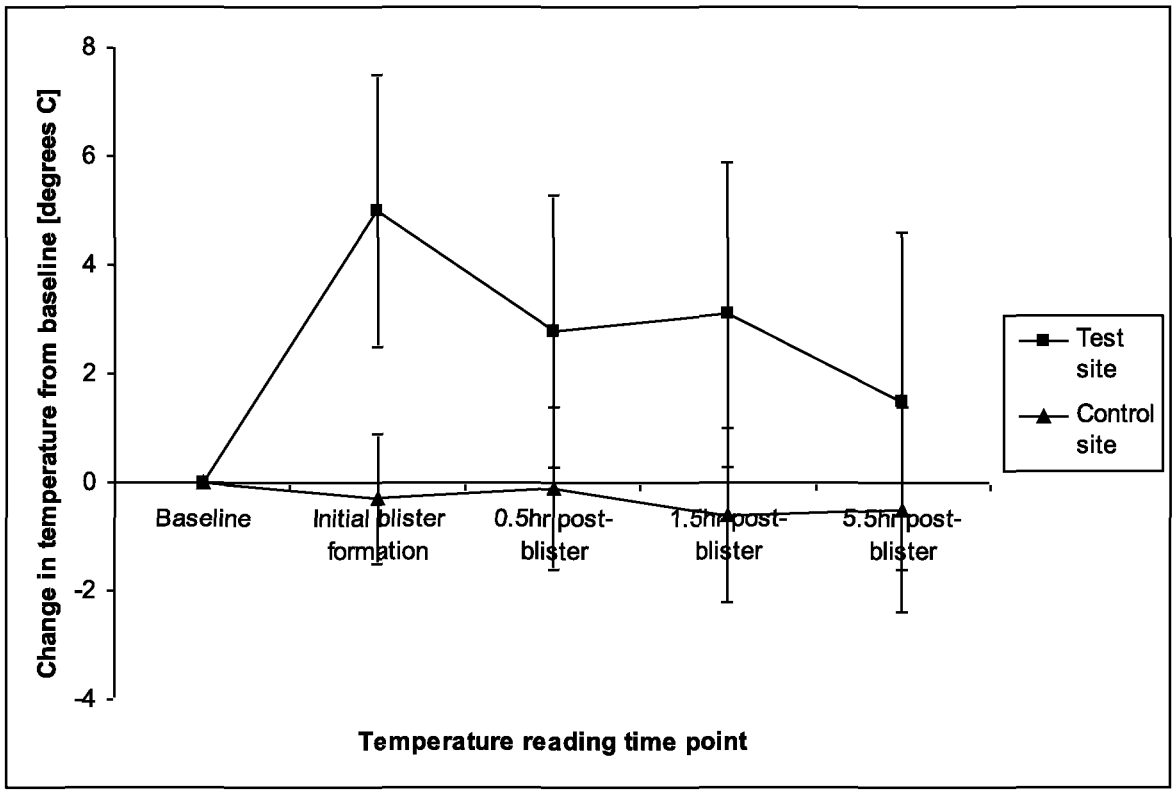

8
6
4
2
0
-2
-4
Change in temperature from baseline [degrees C]
Baseline
Initial blister formation
0.5hr post-blister
1.5hr post-blister
5.5hr post-blister
Temperature reading time point
Test site
Control site

Fig. 2

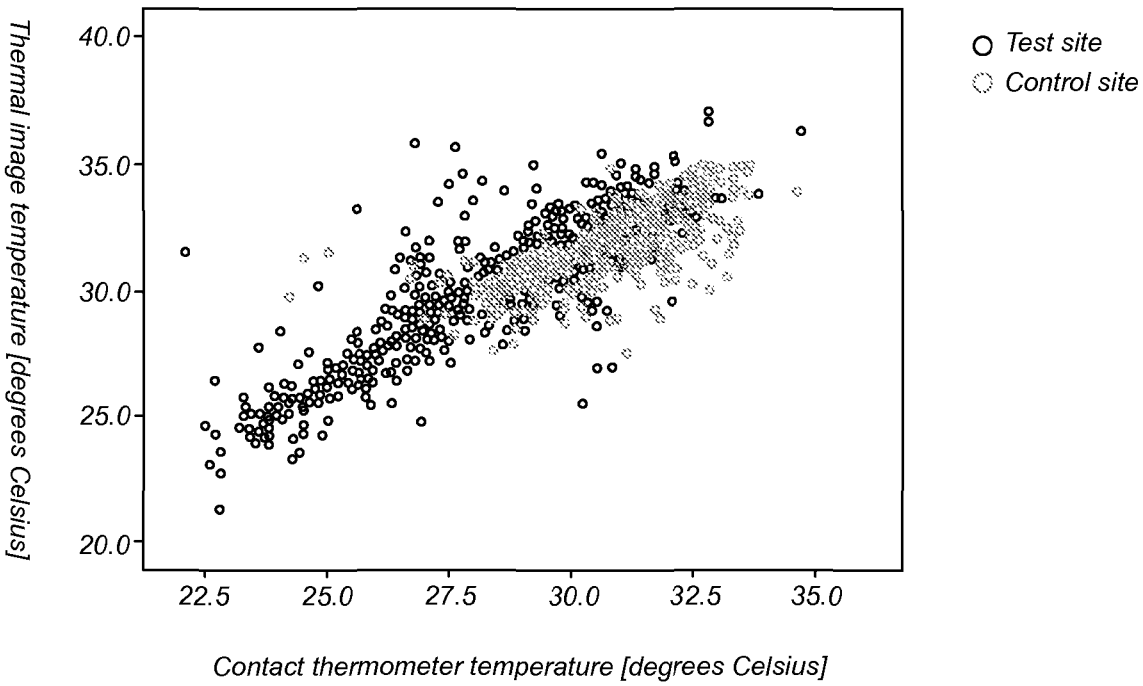

Thermal image temperature [degrees Celsius]
40.0
35.0
30.0
25.0
20.0
22.5
25.0
27.5
30.0
32.5
35.0
Contact thermometer temperature [degrees Celsius]
Test site
Control site

Fig. 3

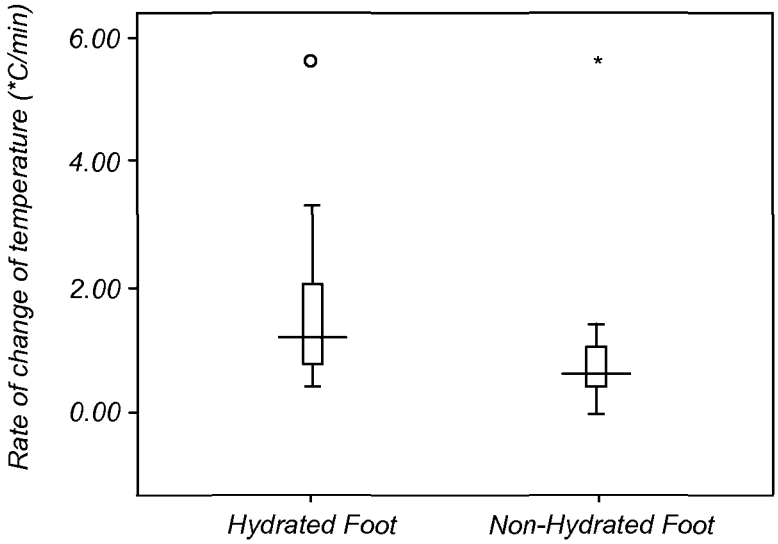

Rate of change of temperature (°C/min)
6.00
4.00
2.00
0.00
Hydrated Foot
Non-Hydrated Foot

Fig. 4

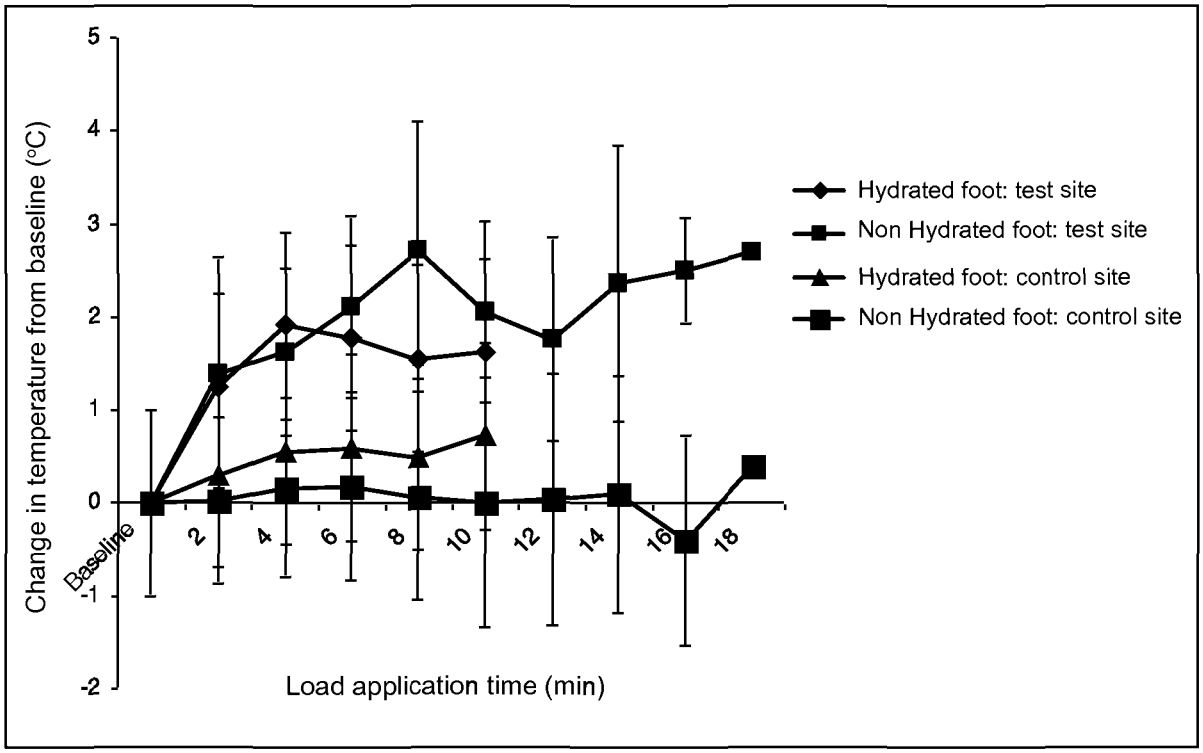

Change in temperature from baseline (°C)
5
4
3
2
1
0
-1
-2
Baseline
2
4
6
8
10
12
14
16
18
Load application time (min)
Hydrated foot: test site
Non Hydrated foot: test site
Hydrated foot: control site
Non Hydrated foot: control site

Fig. 5

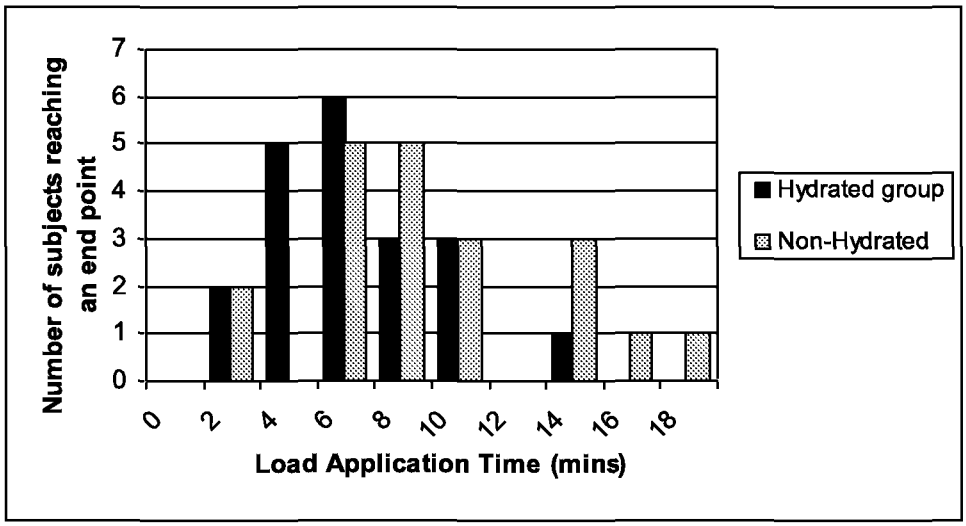

Number of subjects reaching an end point
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
18
Load Application Time (mins)
Hydrated group
Non-Hydrated

Fig. 6

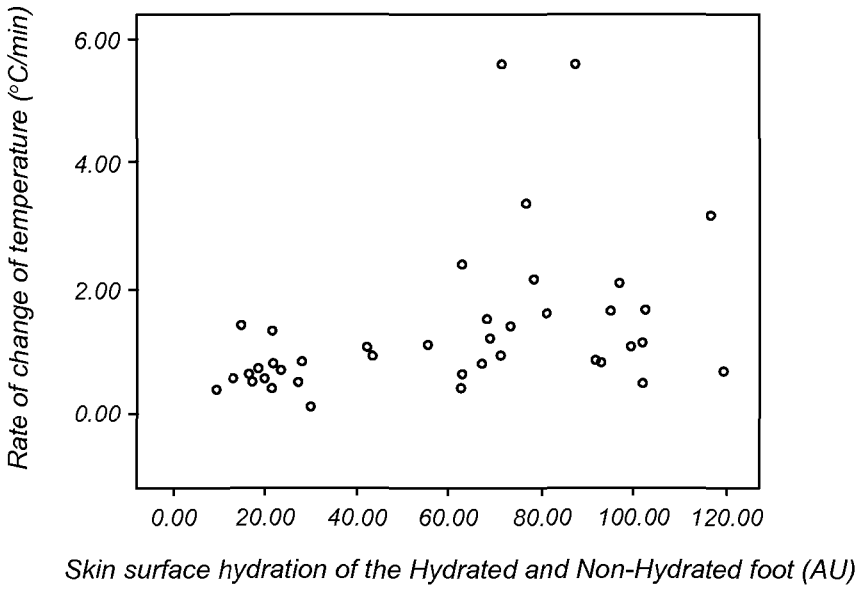

Rate of change of temperature (°C/min)
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Skin surface hydration of the Hydrated and Non-Hydrated foot (AU)

Fig. 7

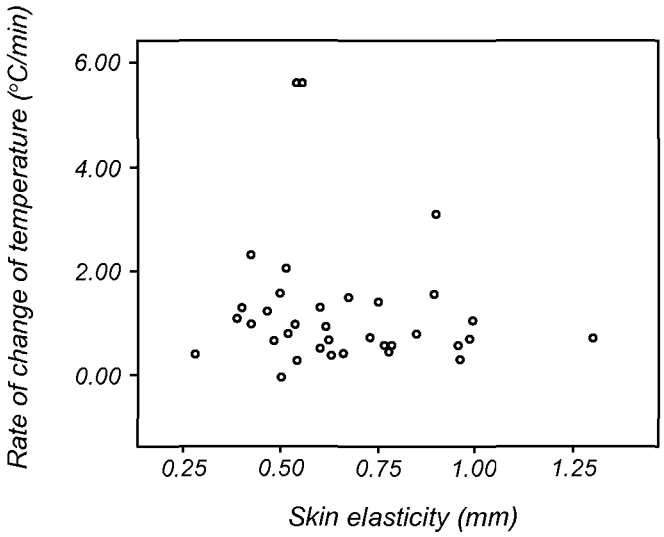
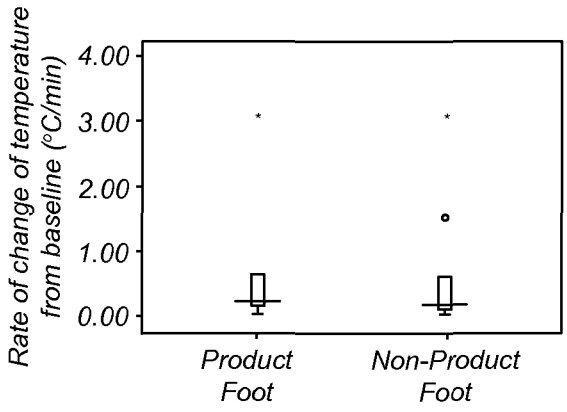
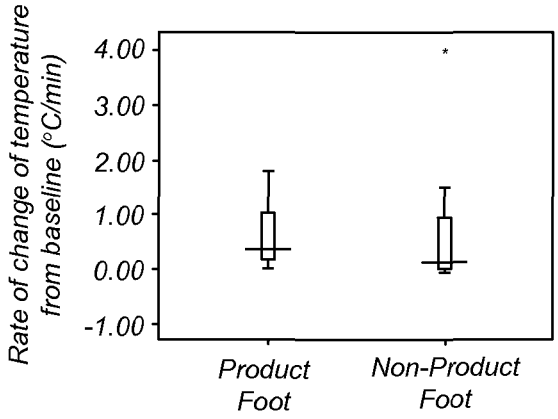

Rate of change of temperature (°C/min)
6.00
4.00
2.00
0.00
0.25
0.50
0.75
1.00
1.25
Skin elasticity (mm)

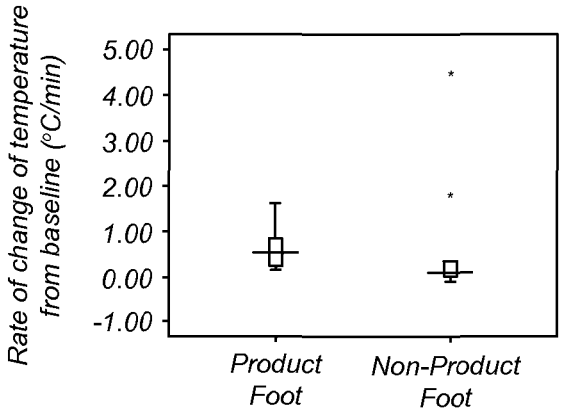
Fig. 8



(a) Powder



(b) Film forming



(c) Antiperspirant

Fig. 9

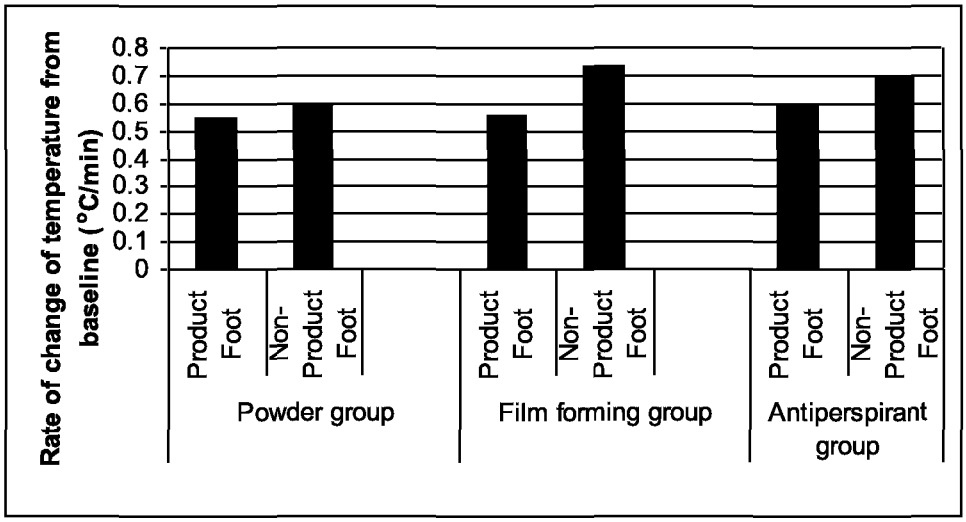

Rate of change of temperature from baseline (°C/min)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Product Foot
Non-Product Foot
Product Foot
Non-Product Foot
Product Foot
Non-Product Foot
Powder group
Film forming group
Antiperspirant group

Fig. 10

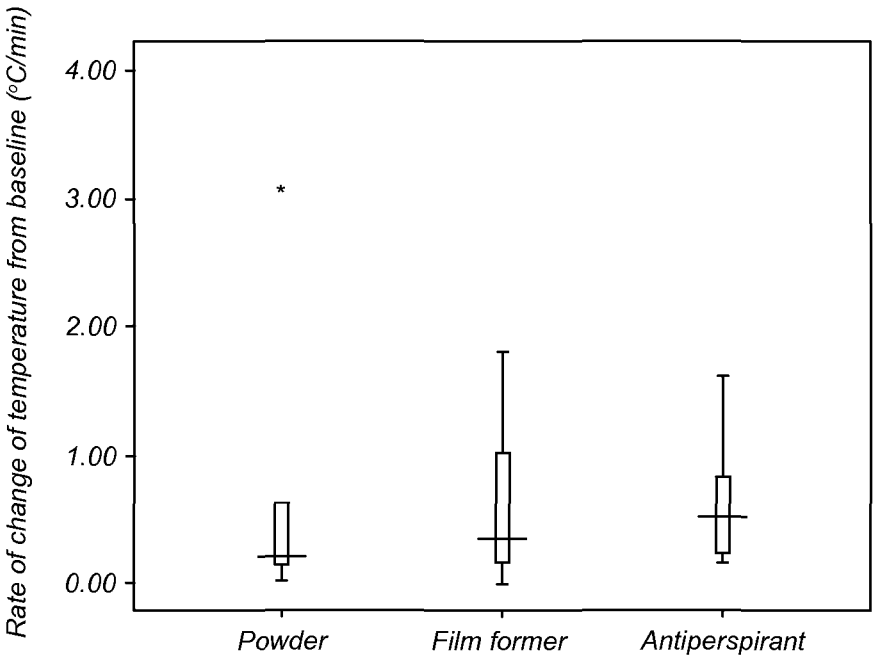

Rate of change of temperature from baseline (°C/min)
4.00
3.00
2.00
1.00
0.00
*
Powder
Film former
Antiperspirant

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050830

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/01
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/101621 A1 (SEVENTH SENSE BIOSYSTEMS INC [US]; BERNSTEIN HOWARD [US]; CHICKERING D) 10 September 2010 (2010-09-10) page 14, line 19 - page 31, line 16 -----	1,20,23
X,P	FARINA HASHMI ET AL: "The formation of friction blisters on the foot: the development of a laboratory-based blister creation model", SKIN RESEARCH AND TECHNOLOGY, vol. 19, no. 1, 14 August 2012 (2012-08-14), pages e479-e489, XP055065763, ISSN: 0909-752X, DOI: 10.1111/j.1600-0846.2012.00669.x the whole document -----	1-23

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2013	20/06/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hooper, Martin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050830

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010101621 A1	10-09-2010	CN 102405015 A	04-04-2012
		CN 102405018 A	04-04-2012
		EP 2408369 A1	25-01-2012
		EP 2408372 A1	25-01-2012
		JP 2012519051 A	23-08-2012
		JP 2012519052 A	23-08-2012
		US 2010256465 A1	07-10-2010
		US 2010256524 A1	07-10-2010
		US 2011009847 A1	13-01-2011
		WO 2010101620 A2	10-09-2010
		WO 2010101621 A1	10-09-2010
		WO 2010101626 A1	10-09-2010

专利名称(译)	一种用于测试慢性和急性皮肤炎症治疗的方法和设备		
公开(公告)号	EP2836108A1	公开(公告)日	2015-02-18
申请号	EP2013717819	申请日	2013-03-28
[标]申请(专利权)人(译)	LRC产品有限公司		
申请(专利权)人(译)	LRC制品有限公司		
当前申请(专利权)人(译)	LRC制品有限公司		
[标]发明人	BUSBY PAUL FORGHANY SAEED HASHMI FARINA KIRKHAM SUZANNE NESTER CHRISTOPHER J RICHARDS BARRY S WRIGHT CIARAN		
发明人	BUSBY, PAUL FORGHANY, SAEED HASHMI, FARINA KIRKHAM, SUZANNE NESTER, CHRISTOPHER J RICHARDS, BARRY S WRIGHT, CIARAN		
IPC分类号	A61B5/00 A61B5/01		
CPC分类号	A61B5/0057 A61B5/015 A61B5/445 A61B5/4848 A61B5/6829		
优先权	2012005646 2012-03-30 GB		
外部链接	Espacenet		

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