Physiological and appearance characteristics of skin maceration in elderly women with incontinence

• **Objective:** To identify the physiological and appearance characteristics of skin maceration caused by urine and/or faeces and determine their suitability as risk indicators for incontinence-associated dermatitis.

• **Method:** This cross-sectional, comparative study involved sixty-nine elderly women with urinary and/or faecal incontinence who provided informed consent to participate. Exclusion criteria included serious medical problems, acute illness and the presence of damaged skin on the buttocks. The physiological and appearance characteristics of macerated skin on the buttocks of the patients were examined. Stratum corneum and dermis hydration levels, transepidermal water loss and skin pH were used to assess skin condition. Skin morphology (sulcus cutis) was confirmed using images at x15 magnification. The erythema index and white index were used to evaluate colour in the macerated skin areas.

• **Results:** Forty-four patients exhibited skin maceration. Stratum corneum and dermis hydration levels were significantly greater in the maceration group than in the non-maceration group, as were transepidermal water loss, skin pH and differences in sulcus cutis interval between the buttock of interest and the subumbilical region. Furthermore, differences in the erythema and white indices between these two regions were significantly higher and lower, respectively, in the maceration group than in the non-maceration group.

• **Conclusion:** To our knowledge, this is the first report to note that there are interesting changes not only in the epidermal layer but also in the dermis layer in patients with skin maceration. This finding confirmed that skin maceration caused by incontinence is a severe condition. Moreover, the erythema index was the best index for identifying skin maceration caused by incontinence, indicating that it can be used for precise and easy identification of the condition in clinical practice.

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dermatitis; elderly; faecal incontinence; skin maceration; urinary incontinence

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Continued on page 19

Incontinence is a frequent and bothersome symptom among the elderly. In nursing home residents, the prevalence of urinary and faecal incontinence is estimated to range from 47.4–74.3% and from 40.4–52.1%, respectively.[1-3] Therefore, incontinence-associated dermatitis (IAD) is a common condition among elderly individuals, with an overall reported prevalence of 5.7%–22.8%.[4,5] Symptoms accompanying IAD include discomfort, itching, burning and pain, and these influence the quality of life of patients.[6] Moreover, the estimated total cost of IAD management among nursing home residents is $136.3 million per year in the USA.[7] The economic impact of this health problem is therefore considerable, indicating an urgent need for preventive measures.

With the goal of preventing IAD, we investigated the physiological characteristics of the skin of elderly patients with and without IAD and found that skin hydration was high in areas adjacent to IAD.[5] Empirical estimates also indicated that the areas adjacent to IAD were more likely to be exposed to urine and/or faeces at levels equivalent to the degree of IAD areas; therefore, the areas adjacent to IAD may suffer damage of some kind. Moreover, particularly in females, the skin of the buttocks is excessively hydrated to an extent similar to that observed in the areas adjacent to IAD. This can be due to anatomical reasons, considering that the buttocks region contacts the pads worn by the patient to absorb urine.[8] These findings indicate that excessive skin hydration may be a high-risk condition for IAD development, particularly in female patients with incontinence. In addition, our previous study confirmed that the hydration of glossy skin in elderly patients with incontinence was significantly greater than that of normal skin in elderly patients with continence.[9] Glossy skin is characterised by a shiny appearance and disappearance of skin texture. We therefore considered excessive skin hydration caused by incontinence to be a severe condition that can change the morphological appearance of

the skin. However, in a clinical setting, excessive skin hydration such as that in the areas adjacent to IAD is known as skin maceration, and the condition is thought to be reversible.[10] In other words, it is a normal condition resulting from exposure to urine and/or faeces, which include various irritants, and it is not clinically recognised as a pathological condition requiring treatment.

Skin maceration is defined as the softening and subsequent breakdown of skin. It results from prolonged exposure to moisture and tissue softening caused by soaking until the connective fibres can be teased apart.[11,12] In addition, skin maceration is characterised by a whitened appearance and swelling.[12] The pathophysiology of skin maceration induced by water or normal saline has been demonstrated in several animal and *in vitro* studies. Increased hydration induces large pools of water not only in the intercellular space but also in the corneocytes, causing extensive disruption of the intercellular lipid lamellae in the stratum corneum.[13-16] Furthermore, an *in vitro* study showed that excessive hydration enhances transcutaneous penetration of large biomacromolecules without causing permanent skin damage.[17] Our group also revealed that excessive hydration resulted in transcutaneous penetration of small as well as large biomacromolecules deep into the dermal layer in older rat skin, whereas previous studies reporting structural changes arising from skin maceration focused on the stratum corneum.[18] For example, the molecular weight of trypsin, a digestive enzyme present in faeces, is approximately 23,000 Da. It may penetrate the macerated skin, and because skin tissue is considered vulnerable to the action of digestive enzymes, skin maceration can increase the risk of IAD development.

In a clinical setting, skin maceration in the perineum as well as the buttocks, groin, perianal and gluteal cleft areas is caused by exposure to urine and faeces. However, pure water or normal saline were primarily used in the abovementioned studies. Therefore, details on skin maceration caused by urine and faeces remain unknown. We consider that skin maceration caused by urine and faeces containing irritants may be more severe than that caused by pure water or saline in elderly individuals. Moreover, Warner et al. verified similar changes in skin structure in patients with skin maceration caused by urine and those with skin maceration caused by water; however, they did not consider the influence of faeces or changes in other layers such as the dermal layer, focusing only on structural changes in the stratum corneum.[16] Evaluation of the characteristics of skin maceration, including the appearance and physiological characteristics of both the epidermis and dermis, in elderly individuals with incontinence would clarify the severity of skin maceration caused by urine and/or faeces. This clarification will in turn contribute to the early prevention of IAD. Moreover, identification of characteristics that are most closely related to skin maceration will facilitate more accurate and easy identification of this condition in elderly individuals with incontinence. These characteristics will also have the potential to function as indicators of skin assessment. This study aimed to reveal the physiological and appearance characteristics of skin maceration associated with urine and/or faecal incontinence in the elderly and assess the suitability of these characteristics as potential indicators.

Method

Study design and subjects

This cross-sectional, comparative study was conducted between June 2010 and April 2011 at a long-term medical facility consisting of 10 units in Ishikawa Prefecture, Japan. A complete survey was conducted in 2 of the 10 units. Patients eligible for enrolment included elderly women with severe urinary and/or faecal incontinence who agreed to participate. The severity of incontinence was evaluated using the Incontinence Severity Index, and subjects with 6–8 points were categorised as having severe incontinence.[19] Additionally, all patients with functional incontinence were considered eligible. Functional incontinence was defined as incontinence due to impairment of physical or cognitive functioning. Only women were recruited as study subjects because they have a larger area of skin that comes into contact with urine. Our previous study of elderly women showed that exposure to urine in particular increased skin hydration.[8] Patients with an acute illness and those with damaged skin on the buttocks were excluded. Patients were visually screened for these exclusion criteria by an investigator. This study was approved by the Medical Ethics Committee of Kanazawa University (#266). Written informed consent was obtained from all patients or their family. The possibility that patients would be unnecessarily disturbed during inspection of their skin was fully considered. When abnormal changes were found in a patient during an investigation, the investigation was promptly discontinued.

Definition of skin maceration

Skin maceration was defined as skin that had developed a whitened appearance with swelling.[12] Signs of whitening limited to a hair follicle were also considered to be skin maceration after a consensus on this definition was reached between a dermatologist and our research team. A trained researcher from the Department of Wound Care Management, a dermatologist and a wound/ostomy/continence nurse diagnosed skin maceration on the basis of photographs. A consensus between two of these investigators was required for a diagnosis of skin maceration

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Table 1. Patient characteristics

	Total (n = 69)	No maceration (n = 25)	Maceration (n = 44)	P-value
Age (year)*	90 (86–92)	88 (86–90)	91 (85–94)	0.121
Underlying disease**				0.930
• Cerebrovascular disease	53 (76.8%)	19 (76.0%)	34 (77.3%)	
• Cardiac disease	10 (14.4%)	4 (16.0%)	6 (13.6%)	
• Malignant neoplasm	2 (2.9%)	1 (4.0%)	1 (2.3%)	
• Other disease	4 (5.8%)	1 (4.0%)	3 (6.8%)	
Immobility**	52 (75.4%)	19 (76.0%)	33 (75.0%)	0.926
Paralysis**	46 (66.7%)	16 (64.0%)	30 (68.2%)	0.723
Contracture**	45 (65.2%)	16 (64.0%)	29 (65.9%)	0.873
Body mass index (kg/m^2)*	16.8 (15.4–19.1)	17.3 (15.5–18.6)	16.7 (15.4–19.3)	0.979

*Mann–Whitney U test
**Chi-square test
Number of patients (%) or Median (Inter quartile range)

Table 2. Relationship between skin maceration and urine/faeces exposure

	No maceration (n = 25)	Maceration (n = 44)	P-value
Dual incontinence**	**10** (40.0%)	42 (95.5%)	<0.001
Frequency of changed absorbent pads (times/day)*	**1** (1–3)	3 (3–3)	<0.001
Contact with urine at buttocks**	**6** (24.0%)	36 (81.8%)	<0.001
Contact with faeces at buttocks**	**1** (4.0%)	8 (18.2%)	0.093
Faecal frequency (times/4 days)*	**2** (1–6)	2 (1–4)	0.868
Presence of diarrhoea**	**5** (20.0%)	9 (20.5%)	0.964

*Mann–Whitney U test
**Chi-square test
Number of patients (%) or Median (Inter quartile range)

to be acceptable. Inter-rater reliability was K=0.60 (Fleiss's K), which indicates fair to good reliability.[20] To eliminate bias, different individuals assessed the physiological and appearance characteristics of the skin and diagnosed skin maceration.

Physiological characteristics

We measured the stratum corneum hydration level, which was the amount of water in the surface layer of the skin (stratum corneum: Fig 1) to assess the skin moisturising ability. We also measured the dermis hydration level, which was the amount of water in the dermis layer (Fig 1), to evaluate the effects on the connective tissue layer. The hydration level of the stratum corneum was measured by a capacitive method (Corneometer CM-825®; Courage Khazaka Electronic GmbH, Koln, Germany),[21] whereas that of the dermis was determined by dielectric measurement using an open-ended coaxial probe for layered structures (MoistureMeter D; Delfin Technologies, Kuopio, Finland).[22,23] The two probes were considered appropriate for the measurement of human skin function and had effective measurement depths of 1.5 and 2.5 mm, respectively. On the basis of a previous study that reported a mean skin thickness ranging from 2.15 mm in the abdomen to 2.41 mm in the buttocks,[24] we chose a measurement depth of 1.5 mm to avoid measuring the subcutaneous fat layer. Transepidermal water loss (TEWL) and skin pH were measured to determine whether the barrier functions of the skin were intact or broken down. TEWL is defined as the amount of water per skin surface area and per time unit that passes from inside the body through the epidermis to the surrounding atmosphere via diffusion and subsequent evaporation; this was measured using a device based on a closed, unventilated chamber (VapoMeter SWL-4001TJ; Delfin Technologies).[25,26] Skin pH is usually slightly acidic, and this was determined using the glass electrode method (Skin-pH-meter PH905®; Courage Khazaka Electronic, GmbH).[27] All physiometric measurements were performed at least three times on the abdomen and buttock of interest. Average values were used for data analysis.

The intra-assay coefficients of variance of the Corneometer CM-825, MoistureMeter D and Skin-pH-meter PH905 used in this study were 6.0%, 7.1% and 1.0%, respectively, indicating sufficient reliability of all three devices. Although the intra-assay coefficient of variance of the VapoMeter SWL-4001TJ was 15.4%–19.8%, we determined that the values were valid because the intra-assay coefficient of variance of TEWL in this study was equivalent to that documented in previous studies.[28,29]

Appearance of macerated skin

The surface of the skin is not smooth, but is laced with multiple networks of fine grooves called sulci cutis. The thickness and interval of the sulcus cutis (skin morphology parameters) were evaluated to confirm the shape change of the skin surface using digital image analysis according to the method described by Tanaka and colleagues (Fig 2).[30] Briefly, a digital image of the skin surface was obtained using a microscope with a ×15 lens (i-scope USB version 2.0; Moritex, Tokyo, Japan). Subsequently, the images were processed using an image analysis software (Kobalab). High values indicated a thick, broad-interval sulcus cutis.

We used the erythema index (EI) for quantitation of the degree of skin redness and the white index (WI) for quantitation of the degree of skin brightness when evaluating the skin colour from the photograph. All regions were photographed using a digital point-and-shoot camera (IXY; Canon, Tokyo, Japan) to evaluate skin colour. A commercially available reference colour chart with nine calibrated colours (Casmatch; Bear Medic, Ibaraki, Japan) was placed at the measurement site, and acquired pictures were subjected to image processing, including colour calibration.[31] Colour calibrations were per-

formed according to the manual for the colour chart using level adjustments in an image editing software (Photoshop CS5; Adobe Systems, Tokyo, Japan). Image calculations using EI and WI were performed using ImageJ (National Institutes of Health, Bethesda, USA). High values indicated strong red and white light, respectively. The gold standard of colour research is the CIE L*a*b* colour system.[32] Therefore, we assessed the validity of EI and WI by comparing them with the a* and L* parameters of the L*a*b* colour system (NF-333; Nippon Denshoku Industries, Tokyo, Japan). The results indicated that EI was significantly correlated with a* (Spearman's rank correlation coefficient=0.788, p<0.01) and WI was significantly correlated with L* (Spearman's coefficient=0.896, p<0.01). Consequently, we used EI and WI as colour parameters.

Procedure

At the time of changing, the absorbent pads were worn for four hours (between 9 a.m. and 1 p.m.) by the patients. The same researcher evaluated the skin properties and took pictures to ensure the reliability of data. Pictures were taken after patients were turned onto their side for 10 mins to eliminate the influence of any temporary skin redness. Physiological and imaging data were obtained from a buttock that had been exposed to urine and/or faeces. The buttock was chosen as the measurement site because we could not anatomically measure the perineal or perianal region. Moreover, in Japan, most institutionalised older individuals have an extremely bony prominence. Therefore, the development of pressure ulcers in the buttocks is rare, and the most common site of pressure ulcer development is in the sacral region.[33] To limit the influence of pressure and shear forces as much as possible, the buttock was chosen as the measurement site. The buttock without pigmentation or scars (or, if present, these being of lesser intensity than those on the other buttock) was chosen for measurements. The subumbilical region was chosen as the non-exposed (non-maceration) site (Fig 3). The mean room temperature was 22.7 °C [standard deviation (SD), 2.2 °C], and the mean relative humidity was 49.8% (SD, 10.2%). Measurement of skin condition parameters took approximately 10 mins per patient.

Data analysis

All data were statistically analysed using SPSS Version 20.0 for Windows (IBM, Chicago, USA). Differences between categorical variables were determined using a x^2 test. Categorical variables were expressed as the number and percentage of patients. Differences in interval variables were assessed using the Mann–Whitney U-test. Numerical values were expressed as the median and interquartile range (IQR). To assess skin morphology and colour, differences in thickness (Δthickness), sulcus cutis interval (Δinterval), EI (ΔEI) and WI (ΔWI) between the buttocks region and the subumbilical region were used because there was a greater variation in skin morphology and colour among individuals. We evaluated the discriminatory performance of the skin appearance variables in identifying skin maceration using receiver operating characteristics (ROC) curve analysis: the greater the area under the curve (AUC), the better the predictive capability. To determine the optimal cut-off values for skin maceration, we computed and searched for the shortest distance between any point on the curve and the top left corner on the y-axis. p<0.05 was considered statistically significant.

Table 3. Relationship between skin maceration and skin physiology

	No maceration (n = 25)	Maceration (n = 44)	P-value
Subumbilical region*			
• Stratum corneum hydration	22.5 (16.3–31.7)	23.1 (19.1–30.1)	0.847
• Dermis hydration	36.8 (34.4–45.3)	36.9 (32.7–44.9)	0.901
• TEWL (g/m²h)	7.1 (5.6–10.0)	8.0 (6.3–15.7)	0.233
• Skin pH	5.9 (5.5–6.1)	5.8 (5.5–6.0)	0.365
Buttocks region*			
• Stratum corneum hydration	32.5 (22.5–37.3)	50.7 (39.3–70.3)	<0.001
• Dermis hydration	44.4 (36.1–49.6)	52.1 (45.2–58.4)	0.002
• TEWL (g/m²h)	11.5 (7.6–25.9)	30.2 (21.6–48.4)	<0.001
• Skin pH	6.1 (5.7–6.7)	6.9 (6.6–7.2)	0.001

*Mann–Whitney U test
Median (Inter quartile range)

Results

A total of 103 patients were available for this observational study, and 69 were included on the basis of the inclusion/exclusion criteria. Skin maceration on the buttock was found in 44 (63.8%) patients. The characteristics of the patients are shown in Table 1. Their median age was 90 years. In total, 53 patients (76.8%) suffered from cerebrovascular disease and 52 (75.4%) were physically immobile. No significant differences in patient characteristics were found between the maceration and non-maceration groups.

The number of patients with dual incontinence, frequency of changed absorbent pads and those with buttocks exposed to urine was significantly higher in the maceration group than in the non-maceration group (p<0.001, p<0.001 and p<0.001, respectively; Table 2). The extent of exposure to faeces was not significantly different between the maceration and non-maceration groups.

The physiological variables of the skin in the subumbilical region were not significantly different between the non-maceration and maceration groups (Table 3). In contrast, all physiological variables for the skin on the buttocks were significantly

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Table 4. Differences in sulcus cutis interval and thickness between the buttocks region and the subumbilical region in the two groups

	No maceration (n = 25)	Maceration (n = 44)	P-value
ΔThickness (pixel)*†	0.76 (−0.76–1.20)	0.72 (−0.01–1.29)	0.481
ΔInterval (pixel)*‡	-0.76 (−1.81–0.47)	0.64 (−0.76–1.48)	0.009

*Mann–Whitney U test
† Δ Thickness = Median thickness in buttocks region − Median thickness in subumbilical region
‡ Δ Interval = Median interval in buttocks region − Median interval in subumbilical region

Table 5. Differences in skin colour between the buttocks region and the subumbilical region in the two groups

	No maceration (n = 25)	Maceration (n = 44)	P-value
ΔEI*†	9.4 (5.75–17.2)	19.1 (25.4–31.4)	<0.001
ΔWI*‡	-38.5 (−29.3–−16.6)	−44.3 (−69.0–−23.5)	0.019

*Mann-Whitney U test
† ΔEI = Median EI in buttocks region − Median EI in subumbilical region
‡ ΔWI = Median WI in buttocks region − Median WI in subumbilical region

higher in the maceration group than in the non-maceration group.

The relationship between skin maceration and its appearance characteristics is shown in Tables 4 and 5. Differences in sulcus cutis interval between the buttocks region and the subumbilical region (Δinterval) were significantly greater in the maceration group than in the non-maceration group (Table 4). Differences in skin colour were shown by ΔEI, which was significantly higher in the maceration group than in the non-maceration group. In contrast, ΔWI was significantly lower in the maceration group than in the non-maceration group (Table 5).

We performed ROC analysis to estimate the predictive performance of each physiological and appearance variable in identifying skin maceration (Table 6), and this revealed that the greatest point estimate of the AUC was for EI [0.870; 95% confidence interval (CI), 0.792–0.954] compared with the other variables. The best EI cut-off value for identifying skin maceration was 43.0, with 84% sensitivity and 76% specificity.

Discussion

To the best of our knowledge, this is the first study to investigate skin maceration caused by urine and/or faeces in elderly patients with urinary and/or faecal incontinence. We showed that not only dermal hydration but also epidermal hydration is increased in macerated skin resulting from exposure to urine or faeces in patients with incontinence. This is an interesting finding because structural changes in macerated skin have mostly been associated with the epidermal layer in previous studies.[13-16] In addition, we showed that the barrier functions of macerated skin were broken down and that the colour and morphology of such skin differed from those of normal skin. These findings indicate that skin maceration caused by urine and/or faeces is a severe condition. Notably, our data indicated that the original (pre-exposed) skin condition in the maceration group was equivalent to that in the non-maceration group because the physiological variables of the skin in the subumbilical region (control site) were not significantly different between groups. Therefore, the significant differences between the groups in the physiological variables of the skin in the buttocks region can be considered as changes caused by incontinence. Furthermore, among the physiological and appearance characteristics analysed, EI was found to be the best index for identifying skin maceration caused by incontinence.

We consider inflamed oedema to be responsible for the high level of dermis hydration observed in macerated skin. A previous study that determined dermal hydration using the same instrument used in the present study showed that compared with baseline dermal hydration, there was a 45%

Table 6. Physiological and appearance characteristics for identifying skin maceration

	Area under ROC* curve (95% CI)	Cut-off point	Sensitivity (%)	Specificity (%)
Physiology				
• Stratum corneum hydration	0.800 (0.691–0.910)	37.3	79	76
• Dermis hydration	0.720 (0.590–0.850)	48.5	67	72
• TEWL	0.820 (0.704–0.935)	18.6	86	72
• Skin pH	0.734 (0.607–0.861)	6.5	74	72
Appearance				
• Interval of sulcus cutis	0.620 (0.478–0.761)	-	-	-
• EI	0.870 (0.792–0.954)	43.0	84	76
• WI	0.330 (0.204–0.457)	-	-	-

* ROC: Receiver operating characteristic
TEWL: transepidermal water loss
EI: erythema index
WI: white index

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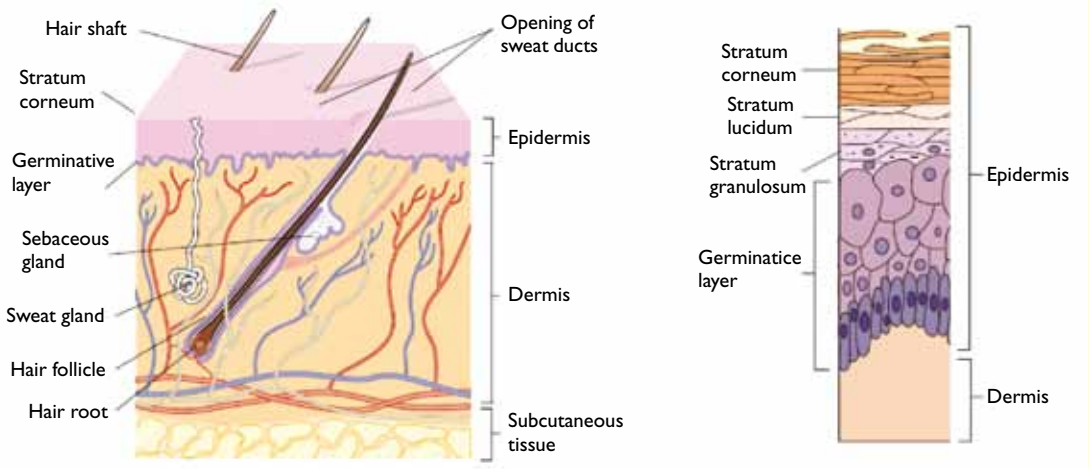

Fig 1. The structure of the skin.[44]

increase in dermal hydration in the presence of inflamed oedema related to sodium lauryl sulfate-induced irritant contact dermatitis.[34] Similar reactions caused by irritating chemicals in urine and faeces are likely to be responsible for the increased dermal hydration observed in this study. Minematsu et al. reported expansion of the interstices of the stratum corneum, spinosum and basale of the epidermis in macerated skin.[18] They observed penetration of small and large fluorescent molecules in the dermis of macerated skin using a transdermal penetration test in older rats. Because of the expansion of the interstices in the epidermal layer, irritating chemicals in urine and/or faeces can easily penetrate the dermis layer and cause inflammation. In fact, our finding of significantly higher ΔEI values in the maceration group compared with those in the non-maceration group confirms this. EI is typically used to quantify inflammation.[35,36] Ohshima et al. quantitatively evaluated the degree of erythema caused by patch tests using image analysis (EI) and visual grades.[36] They calculated ΔEI between a patch test site and normal skin. The ΔEI values in their study indicated that there was slightly perceptible erythema at the patch test site, similar to our finding (ΔEI = 19.1). As seen from the above, we consider that these findings indicate that inflammation may occur in macerated skin resulting from incontinence.

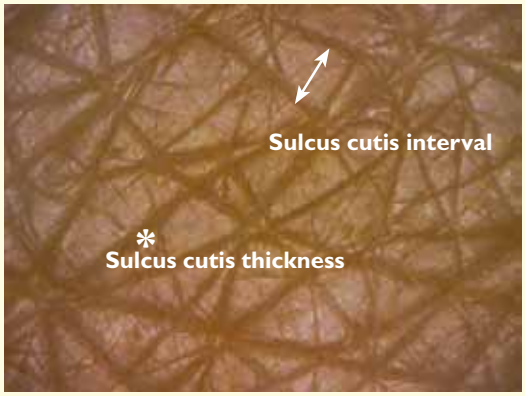

Fig 2. A digital image of the skin surface obtained using a microscope with a ×15 lens

TEWL and skin pH were also greater in the maceration group than in the non-maceration group. We found that TEWL [median: 30.2 (g/m²h)] in the macerated area was greater than that in healthy adult skin [median: 5.1–16.9 (g/m²h)].[37,38] The median pH of the macerated areas was 6.9, which is more alkaline than the pH of normal skin (pH=5.4–5.9).[39] Andersen et al.[40] reported that digestive enzymes in faeces induced significantly higher TEWL and skin pH compared with a buffer solution; therefore, we determined that these results were appropriate because many subjects with skin maceration were exposed to faeces in the buttocks region in this study. These changes indicate that the barrier functions of the skin were poor at the site of maceration. This study also revealed that differences in sulcus cutis interval between the buttocks region and the subumbilical region (Δinterval) were significantly greater in the maceration group than in the non-maceration group. A broader sulcus cutis interval may be indicative of dry skin because a previous study reported that skin hydration decreased with a decrease in the density of the sulcus cutis.[41]

ROC analysis for identifying skin maceration showed that the greatest point estimate of the AUC was for EI (0.870; 95% CI, 0.792–0.954) compared with the other variables. This study revealed new colour characteristics of skin maceration caused by incontinence, thus demonstrating that EI was the best index for identifying skin maceration. In clinical practice, it is often difficult for medical staff to

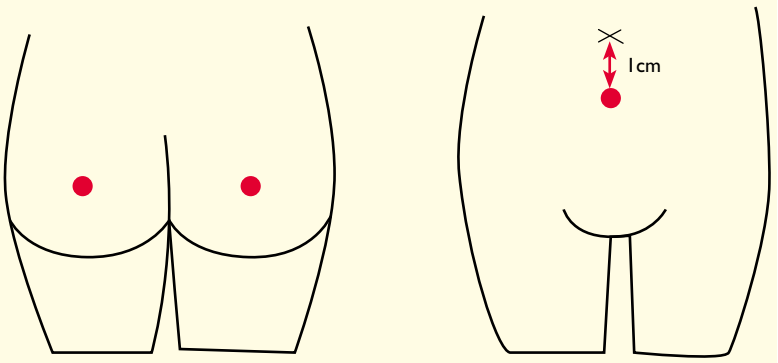

Fig 3. The measurement sites
The site exposed to urine/faeces was the highest part of either buttock. Areas 1cm below the subumbilical region were not exposed.

identify macerated skin with the naked eye. This is because the skin of elderly individuals, particularly the perineal skin, is highly individualised in appearance and can be pigmented and loose.[42,43]

Clinical implications

If inflamed oedema observed in macerated skin is caused by contact with urine and/or faeces, then skin maceration is more likely to be a risk indicator for IAD and necessitates prevention. Although skin maceration is considered a normal condition, it has the potential to develop into a more severe problem and should be recognised as a condition requiring attention. The EI can be used for easy and accurate identification of skin maceration. Although identification of skin maceration has been influenced by the observer's experience and knowledge till date, identification using the EI may contribute to early prevention of IAD. Further research is required to assess the presence and extent of inflammation in macerated skin. Moreover, whether or not EI is an appropriate risk indicator for IAD needs to be confirmed in further studies.

Limitations

Several limitations of this study need to be addressed. First, there were no significant differences between the two groups with regard to faecal exposure. In contrast, our previous study revealed that the presence of diarrhoea was significantly associated with IAD.[5] Our findings may not have supported this initial prediction because of the measurement site analysed. Most IAD regions in our previous study were found in the perianal region and gluteal cleft, whereas in this study, measurements involved the buttocks region only. A second limitation is that the degree of whiteness of macerated skin could not be satisfactorily assessed using the WI, probably because most of the study participants had pigmentation on their buttocks. Finally, extrapolation of our results from elderly women to elderly men may be possible because the structure of their skin does not differ. However, further examination of skin maceration in younger individuals is required.

Conclusion

This is the first report, as per our knowledge, of hydration of not only the epidermal but also the dermal layers of macerated skin in incontinent elderly individuals, and it shows that skin maceration caused by incontinence is a severe condition. It is also the first to note that EI values are higher in individuals with maceration than in those without. Of the physiological and appearance characteristics analysed, EI was found to be the best index for identifying skin maceration caused by incontinence, suggesting that EI can be used for precise and easy diagnosis of this severe condition in clinical practice, contributing to the early prevention of IAD. ■

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