FEATURE

Factors Influencing Intact Skin in Women with Incontinence Using Absorbent Products: Results of a Cross-sectional, Comparative Study

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Abstract

Incontinence-associated dermatitis (IAD) is a common problem in elderly incontinent people. A comparative cross-sectional study was conducted to examine and compare properties of intact skin on the buttocks and subumbilicus area in elderly people wearing absorbent products and to identify pad environment factors that affect skin properties. Study participants included 45 elderly (age range: 68 to 103 years) female residents of one nursing home who were incontinent of feces and urine (dual incontinence group — DIG, n = 35) or feces only (fecal incontinence group – FIG, n= 10). Skin pH and hydration were measured and factors believed to affect the perineal environment and contribute to the development of IAD were assessed. In both DIG and FIG, skin hydration levels and pH were higher in the coccygeal than in the subumbilical area. Skin hydration of the sacral region in the DIG was significantly higher than in the FIG ($P = 0.019$) and skin pH on the coccygeal region and sacral region in the DIG was significantly higher than in the FIG (coccygeal region, $P = 0.013$; sacral region, $P = 0.023$). Absorbent pad surface pH ($P < 0.01$) and excessive sweating ($P = 0.006$) were significantly related to skin pH. Results show that properties of perineal skin in elderly women with incontinence are affected by occlusion with pads, increasing the risk of IAD. Studies comparing the effect of various types of pads and pad-change frequencies on skin properties are needed.

Key Words: cross-sectional comparative study, women, incontinence, absorbent pads, skin irritation

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Potential Conflicts of Interest: none disclosed

The prevalence of urinary incontinence increases with age and is estimated to range from 46% to 72% among nursing home residents.[1] One cross-sectional study in Japan[2] and one retrospective cohort study[3] in the US have shown that using absorbent products such as pads and briefs is the most common urinary collection strategy in nursing homes and used by 56.1% to 67.6% of residents with urinary incontinence.

Skin damage such as dermatitis is a common complication of pad use,[4] with incontinence-associated dermatitis (IAD) and pressure ulcers located in the buttocks and coccygeal regions[5,6] occurring in 3.4% to 42.5% of elderly people in nursing homes or hospitals.[1,6–8] Analyzing assessment data from 59,558 records in the Minimum Data Set of a nursing home, the recorded prevalence of IAD in this population was found to be 7.5% (n = 3,405) and 73% of persons with IAD were incontinent.[1] Bliss et al[6] conducted a multisite open-label, quasi-experimental study in 16 randomly selected nursing homes to compare the efficacy of four different IAD prevention regimens used in nursing home residents. Of the 1,918 nursing home residents screened, 981 (51%) qualified for prospective surveillance for IAD. Of those, 33 (3.4%) developed IAD during the study. Junkin and Selekof[7] examined the prevalence of incontinence and skin injury (IAD) or skin ulceration in areas exposed to incontinence among patients in medical, surgical,

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Key Points

- Many studies have documented that urinary and/or fecal incontinence increases the risk of skin damage, including incontinence-associated dermatitis (IAD).
- The results of this study show that, in elderly women, exposure to urine in particular increases skin hydration and skin pH.
- Absorbent pad pH and rewet volume were correlated with skin condition but only pad pH was independently associated with an increase in skin pH.
- Studies comparing the effect of various pad types on skin health in older adults are needed to help reduce the incidence of IAD.

and intensive care units at two community hospitals. The overall incontinence prevalence was 120 out of 608 (19.7%); some type of skin injury was observed in 42.5% of these incontinent patients. Skin injuries were present most often in the buttocks (16.7%) and coccyx (7.5%) areas. In a skin care study by Bale et al,[8] baseline assessment showed that 25% of the mostly female incontinent nursing home residents (N = 79) had IAD.

Elderly people are also at higher risk for developing skin damage because cell replacement rates decrease with aging, leaving the skin thinner and more easily damaged.[9] Additionally, the use of absorbent products can cause excessive local wetness and elevate pH, increasing the risk of skin damage. Berg et al[10] conducted an observational cohort study to measure skin wetness using transepidermal water loss (TEWL) measurements and skin pH in infant diaper areas. Diapered skin wetness was significantly elevated compared with that of adjacent undiapered skin ($P < 0.05$) and the pH of diapered skin was significantly higher than that of undiapered skin ($P < 0.05$). The authors concluded that wearing diapers is associated with significant increases in skin wetness and pH. However, this study was mainly experimental and involved infants.

Although the use of absorbent pads foretells an increased risk of developing IAD in elderly people, the properties of skin exposed to urine in elderly people wearing a pad have not been investigated. Absorbent product technology has made notable advances during the last decade and the performance of these products in terms of absorbent capacity and rewetting (rewet) prevention has improved. As a result, it has been reported that the severity of skin lesions, such as IAD in children, is declining.[11] Results of a cross-sectional study[12] showed that infants in diapers containing absorbent gelling material had significantly less diaper dermatitis than those in conventional disposable diapers ($P = 0.014$). However, the effect of pad characteristics on the skin properties of elderly people is unknown.

The aim of this study was to examine and compare intact skin properties of the buttocks and subumbilicus area in elderly people wearing absorbent products and to identify pad environment factors, including the absence or presence of absorbed urine in pads, that affect skin properties.

Materials and Methods

Participants and setting. Residents of a long-term care, 500-bed medical facility in Ishikawa Prefecture, Japan participated in this cross-sectional study. Persons eligible for enrollment in the study were elderly female patients who agreed to participate and who had urinary and/or fecal incontinence, constantly wore absorbent products, and could not change their pads by themselves. Exclusion criteria included patients with a serious medical problem, persons acutely ill, and/or those with skin damage on their buttocks. The presence or absence of some skin damage on the buttocks was determined by visual inspection. Even though inclusion of patients with urinary incontinence only would have been preferred, sample size concerns prevailed and patients with fecal incontinence also were included.

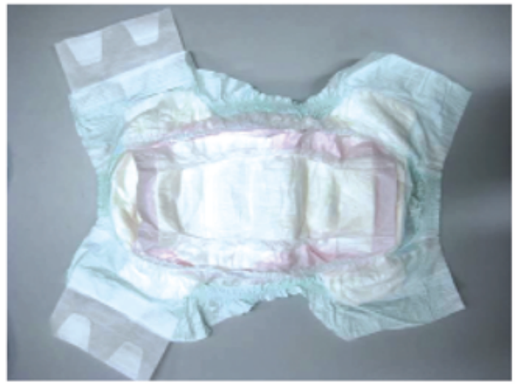

Figure 1. An adult diaper and a pad were consistently used together.

Participants were divided into two groups: those with both urine and fecal exposure from incontinence were included in the Dual Incontinent Group (DIG) and the Fecal Incontinent Group (FIG) consisted of participants with only fecal exposure, including those with indwelling urinary catheters. Participants were recruited from all 261 patients with dual incontinence and 96 patients with fecal incontinence in this hospital. The percentage of women in each group was 67%. Data were collected from March 5 to April 2, 2007.

All patients in Japan generally use an adult diaper (adult brief) in combination with a pad to prevent leakage of urine

(see Figure 1). An adult diaper encompasses the entire hip and perineum area and fastens with adhesive tape and a pad mainly absorbs urine and feces. The absorbent inner layer allows urine to spread throughout the entire pad, facilitating maximal absorption capacity while preventing leakage.[13] Common practice standards in Japan for pad changes and skin care procedures remained in effect during the study. Pads were changed three to five times a day for participants with dual incontinence and once a day in participants with fecal incontinence only.

At every pad change, the participant's buttocks and perineal area were wiped with a water-dampened cotton towel and the area enclosed by the absorbent products was washed with commercially available hand soap and water once a day. Patients were bathed twice a week.

Measurements. Pad environment variables were assessed in all participants and measurements were obtained one time (at the 9:00 a.m. pad change) before cleansing.

Skin properties. Skin hydration and pH were used as indicators for describing principle skin properties. Skin hydration was measured using a capacitive method (Corneometer CM-825®, Courage Khazaka GmbH, Koln, Germany)[14] and skin pH was determined using a glass electrode (Skin-pH-meter PH905®, Courage Khazaka GmbH, Koln, Germany).[15] The intra-assay coefficients of variance of the Corneometer CM-825® and Skin-pH-meter PH905® in this study were 6.3% and 2.3%, respectively, indicating sufficient reliability of the devices. At least three measurements were obtained on the same day for each participant from each of the following locations: subumbilical, coccygeal, and sacral regions. Averages calculated for each participant were used for data analysis.

Pad environment. To identify factors that influence skin properties, a conceptual model of perineal dermatitis was used.[16] Factors believed to affect the perineal environment and contribute to the development of IAD include character of incontinence (frequency and volume) and inducing agents (irritants). Therefore, the following variables were evaluated: fecal frequency, urine volume, rewet volume, pad pH, urease-producing bacteria, and diarrhea.

Information about fecal frequency and the presence of diarrhea over the previous 4 days was obtained from the medical record. Constipation is usually defined as two or fewer bowel movements within a week.[17] In this facility, laxatives are administered to inpatients who have not had a bowel movement for 3 days. For the purpose of this study, participants were classified as having constipation if they had one bowel movement every 4 days. Fecal exposure frequency was determined by reviewing bowel movements recorded in patient charts during the 4 days preceding the start of the study. Diarrhea was defined as type 6 (fluffy pieces with ragged edges or mushy) or 7 (watery or no solid pieces or entirely liquid) according to the Bristol stool form scale.[18] The locations where pad-absorbed urine had contacted skin were identified and the amount of urine measured from the used pad's weight. The amount of skin rewet (ie, the liquid forced back through the top sheet of a pad when a saturated pad is placed under load or pressure) was evaluated by the amount of urine absorbed by application of a paper filter to the used pad. Paper filters (100 mm x 100 mm) were placed on the top sheet of the pad where it had contacted the coccygeal region. A weight of 5.0 kg/(100 x 100 mm) was placed on the paper filter/pad combination for 10 seconds. The weight in grams of the urine absorbed by the paper filter was measured as rewet volume.

Surface pH of the same pad region, as used for rewet measurements, was measured in the same manner as skin pH. Elevated urine pH is caused by urease-producing bacteria, which also tend to yield alkaline urine.[19] To confirm the presence of urease-producing bacteria, a bacteria swab was taken from the same pad surface and the swab subsequently cultured at 35° C for 48 hours using CA and CPS agar. The presence of excessive sweating and vaginal fluor also was recorded.

Patient characteristics (eg, immobility, paralysis, contracture, excessive sweating, and presence of vaginal fluor) were obtained by direct observation or from patient medical records (eg, age, body mass index, nutrition route, underlying disease). Excessive sweating was defined as excessive and profuse perspiration.

Statistical analysis. To compare participants in the DIG and FIG, associations between categorical variables were determined using a chi-square test. Differences in interval variables were assessed using an independent *t*-test and Mann-Whitney U test. To evaluate pad environment factors that affected coccygeal area skin properties in the DIG, Spearman's rank-correlation coefficients were calculated among the independent variables. Variables potentially associated (significance $P < 0.20$) were entered as independent variables in a multiple linear regression model. Multiple linear regression analysis was conducted to determine patterns of relationship among the variables. To avoid multicollinearity, correlation coefficients between the independent variables were calculated and the $\rho > 0.15$ was considered as a potential risk of multicollinearity. In this study, $P < 0.05$ was considered statistically significant. The SPSS® software package version 14.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Ethical consideration. Participants or their families were informed of the procedure and written consents obtained. This study was approved by the Ethical Committee of the Graduate School of Medicine, The University of Tokyo, Japan.

Results

Demographics. A total of 45 women participated in the study, 35 in the DIG and 10 in the FIG. The average age for both groups was 86.5 ± 7.6 years. No significant differences between group demographic variables were observed (see Table 1).

Skin properties. Skin hydration and pH in the DIG were higher than in the FIG. Skin hydration on the sacral region (average 61.2) in the DIG was significantly higher than in the FIG (55.0 [range 17.0 to 120.0] versus 34.0 [range 15.8 to 116.3], $P = 0.019$) (see Table 2). Skin pH on the coccygeal region and sacral region in the DIG were significantly higher than in the FIG (coccygeal region; 6.8 ± 0.8 versus 6.0 ± 0.6, $P = 0.013$, sacral region; 6.7 ± 0.7 versus 6.1 ± 0.8, $P = 0.023$).

Pad environment. Pad environment results showed significant between-group differences in absorbent pad surface pH, amount of urine, and amount of rewet (see Table 3). Average pad surface pH in the DIG was significantly higher than in the FIG (8.1 [range 6.2 to 9.6] versus 6.4 [range 5.8 to 7.6], $P = 0.000$). The amounts of urine and rewet in the DIG were significantly higher than in the FIG (amount of urine: 405.0 [range 190.0 to 740.0] versus 0.0 g [range 0.0 to 50.0], $P = 0.000$; amount of rewet: 0.08 [range 0.00 to 5.30] versus 0.00 g [range 0.00 to 0.00], $P = 0.000$). All significant variables including pad pH, urine volume, and rewet volume were associated with contact with urine. In contrast, no significant difference was found between the two groups for the fecal contact variables.

Association between coccyx area skin properties and pad environment. In the DIG, the coccyx area of all participants (35 of 35) was exposed to urine and diffusion of urine to the sacral area was observed in 14 participants (40%). Bivariate analysis of the association between skin properties and pad environment in participants with urine exposure in the coccyx area showed that participant age, pad rewet volume, and the presence of urease-producing bacteria were associated with skin hydration and pad pH. Rewet volume, excessive sweating, and vaginal fluor were associated with skin pH (see Table 4).

In the multiple regression analysis, surface pH of the absorbent pad and excessive sweating were significantly related to skin pH (pad pH: $P < 0.001$, excessive sweating: $P = 0.006$) (see Table 5). Multiple regression analysis of potentially associated factors and skin hydration could not be conducted because age (amount of rewet: $\rho = 0.183$, urease-producing bacteria: $\rho = -0.191$), amount of rewet (urease-producing bacteria: $\rho = -0.214$), and urease-producing bacteria were correlated with each other.

Table 1. Participant demographic variables

	Dual incontinence group (n=35)	Fecal incontinence group (n=10)	*P*
Age (years; average, SD)	86.7 ± 7.8	85.7 ± 7.2	
Body mass index <18.5	22 (62.9%)	4 (40.0%)	0.642
Immobility	26 (74.3%)	6 (60.0%)	0.281
Paralysis	15 (42.9%)	7 (70.0%)	0.441
Contracture	20 (57.1%)	5 (50.0%)	0.165
Nutrition route			0.731
Oral nutrition	10 (28.6%)	4 (40.0%)	
Enteral nutrition	25 (71.4%)	5 (50.0%)	0.113
Intravenous nutrition	0 (0.0%)	1 (10.0%)	
Underlying disease			
Cerebrovascular disease	25 (71.4%)	7 (70.0%)	
Cardiac disease	5 (14.3%)	2 (20.0%)	0.873
Other disease	5 (14.3%)	1 (10.0%)	

Table 2. Skin hydration and pH

	Dual incontinence group (n=35)	Fecal incontinence group (n=10)	*P*
Skin hydration[a]			
Subumbilicus	27.0 (16.2 - 53.7)	24.7 (16.0 - 101.4)	0.396
Coccyx	75.0 (29.3 - 120.0)	51.8 (33.2 - 117.0)	0.099
Sacrum	55.0 (17.0 - 120.0)	34.0 (15.8 - 116.3)	0.019
Skin pH[b]			
Subumbilicus	5.4 ± 0.6	5.5 ± 0.8	0.670
Coccyx	6.8 ± 0.8	6.0 ± 0.6	0.013
Sacrum	6.7 ± 0.7	6.1 ± 0.8	0.023

a Median (range) reference level of skin hydration (test area is forearms): 45–50[36,37]
b Average + SD. Normal skin pH range: 5.4-5.9
Note: all three variables measured same day

Table 3. Pad environment difference between DIG and FIG

	Dual incontinence Group (n=35)	Fecal incontinence Group (n=10)	*P*
Fecal frequency (times/4 days)	3.0 (0 - 9)	2.5 (1 - 5)	0.657
Diarrhea (n, %)	1 (2.9%)	2 (20.0%)	0.119
Pad pH[a]	8.1 (6.2 - 9.6)	6.4 (5.8 - 7.6)	0.000
Urine volume (g)	405.0 (190.0 - 740.0)	0.0 (0.0 - 50.0)	0.000
Rewet volume (g)	0.08 (0.00 - 5.30)	0.00 (0.00 - 0.00)	0.000
Urease-producing bacteria (n,%)	8 (22.9%)	2 (20.0%)	1.000
Excessive sweating (n,%)	3 (8.6%)	1 (10.0%)	1.000
Vaginal fluor (n,%)	8 (22.9%)	1 (10.0%)	0.659

[a] Median (range) reference level of skin hydration (test area is forearms): 45–50[36,37]
[b] Average ± SD. Normal skin pH range: 5.4–5.9
Note: All variables average of 3 measurements collected on same day.

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Table 4. Bivariate analysis of association between skin properties and pad environment in the coccyx area (n=35)

	Skin hydration		Skin pH	
	ρ	P	ρ	P
Age	0.22	0.198	0.21	0.229
Fecal frequency (times/4 days)	-0.10	0.557	-0.11	0.517
Diarrhea (1 = yes)	-0.20	0.261	-0.03	0.846
Pad pH	-0.21	0.227	0.52	0.001
Urine volume	0.13	0.466	-0.01	0.967
Rewet volume	0.42	0.013	0.26	0.139
Urease-producing bacteria (1 = yes)	0.24	0.162	0.17	0.329
Excessive sweating (1 = yes)	0.19	0.269	-0.34	0.047
Vaginal fluor (1 = yes)	0.01	0.954	0.32	0.058

Spearman's rank correlation coefficient

Discussion

The results of this study show that measures of diaper or buttocks area skin hydration and pH in older adults whose skin is exposed to urine as well as feces are significantly higher than those with fecal contact only. Pad environment variables, including pH, also differed significantly between the two groups. Skin pH was also significantly associated with pad surface pH and excessive sweating in the DIG. This is the first report to describe the relationship between pad environment and intact skin in older adults and to document a high risk for IAD in persons with urinary incontinence and visually intact skin.

The demographic data of this study sample were similar to that of previous cohort and cross-sectional studies.[1,7] However, absorbent product usage differences in different countries must be considered when extrapolating and comparing study findings.

Skin properties. Past studies have suggested that wearing diapers is associated with significant increases in skin wetness and skin pH among infants.[10] In the current study, skin hydration and pH on the buttocks/sacrum were significantly higher in older adults with dual incontinence than older adults with fecal incontinence. Current understanding of IAD etiology suggests that skin hydration and pH are important factors for skin health in pad-covered regions[20] and both were observed in this study's DIG. Elevated skin hydration can compromise skin integrity by increasing its susceptibility to irritants and friction, as well as promote microbial growth. Laboratory studies have shown that an elevated pH increases the activity

Table 5. Multiple regression analysis of skin property in the coccyx area (n=35)

	Skin pH[a]			
	B	SE B	β	P
Pad pH	0.45	0.09	0.60	0.000
Rewet volume	0.06	0.11	0.06	0.602
Excessive sweating (1 = yes)	-0.98	0.34	-0.34	0.006
Vaginal fluor (1 = yes)	0.36	0.24	0.18	0.133
Fecal frequency	-0.02	0.05	-0.06	0.605

[a] F = 7.700; p=0.00; R^2 = 0.497; Adj. R^2 = 0.432. B = partial regression coefficient; SE = standard error

of fecal enzymes, which can further irritate the skin and increase its permeability.[16,21] Studies[22] have shown that the surface pH of human skin is 5.4 to 5.9 and relatively similar at different body sites except in the intertriginous areas. In the present study, skin pH in the subumbilical region not covered by the adult diaper and pad was within this range, confirming the validity of the study results. In this study, the average skin pH of the buttocks area was 6.7 to 6.8 in DIG and 6.0 to 6.1 in the FIG. Similarly, Nakagami et al[23] previously reported that perineal skin pH in continent elderly without diapers was 6.03. Thus, the results of this study confirm that exposure to urine increases skin pH in older adults.

Pad environment and skin pH. This study showed that pad surface pH and excessive sweating were significantly related to skin pH in DIG.

Depending on daily net acid excretion, normal urine pH can be 5.0.[24] In this study, average pad surface pH after urination was 8.1 (range: 6.2 to 9.6) and alkaline compared with normal urine pH. It has been reported that ammonia production from the action of fecal urease on urinary urea increases urine pH and results of clinical studies[25,26] have shown that pad top sheet pH after urination increased over time. In this study, the frequency of pad exchange (three to five times/day) increased the potential of an extended *in situ* period following urination, which in turn, may have increased pH. Pad ingredients and type also may affect pad environment and pH. Future studies should include the development of pH-balanced or antibacterial pads.

Preclinical research[27] suggests that digestive enzymes in feces contribute significantly to skin pH elevation. The authors of the current study reported previously that only diarrhea is a significant associated factor for IAD, but results of this study did not show a significant relationship between skin pH and variables regarding feces.[28] However, the number of participants with diarrhea in the DIG of this study was small (2.9%) and fecal frequency in the DIG was 3.0 times per 4 days. Thus, it could be concluded that the present results mainly apply to the relationship between skin pH and urinary incontinence.

In the DIG, skin pH also was found to be significantly associated with excessive sweating. A mixture of sweat and sebum may produce an acidic mantle or layer on the epidermis and force skin pH toward acidic conditions.[29] It is unknown if thermal sweat, sweat from covered body areas, and sweat from eccrine glands is more acidic than effort-induced sweat on air-exposed skin area and apocrine glands.[22] In this study, the correlation between excessive sweating and skin pH was negative; in patients with excessive sweating, skin pH of the coccygeal region decreased but many questions about the relationship between sweat and skin pH remain.

Pad environment and skin hydration. When the rewet amount is <0.5 g, the authors' laboratory data show that people do not feel discomfort and, as the average rewet observed in the current study was <0.5 g, the performance of these pads did not cause user discomfort. However, skin hydration in the DIG significantly correlated with rewet; skin hydration on the sacral region was significantly higher than in the FIG. A previous study[30] among older adults with moderate to heavy incontinence found no firm evidence of differences in skin health problems between different pad designs. Although pads create complete and prolonged occlusion of the skin and lead to higher humidity,[31] scant data exist in the literature regarding pad performance in clinical settings. Although some studies have been presented in which pad users tested types of pads and then completed a product performance questionnaire regarding subjective usability,[30,32,33] these studies were not able to explain the effects of the pads on skin. Other studies have weighed pads to measure rewet and absorbed amounts as pad performance parameters.[34,35] However, these studies did not assess the relationship between rewet amounts and skin properties of pad users.

Limitations and Implications for Future Study

This study is limited by several factors. First, all participants used pads made by a single manufacturer; therefore, the influence of pads from different manufacturers on skin properties was not addressed. Future research should evaluate various types of pads because pad function depends in part on the available brand and it is probable that differences in design and composition affect skin differently. Because pad change frequencies of all participants were about the same, the effect of differences, if any, in change frequencies could not be evaluated. The results of this study suggest that limited pad change frequency may have affected skin. Future studies are needed to confirm the need for regular pad changes and to evaluate optimal frequency. Moreover, a pad with rewet performance that is less than existing pads or that features greater topical absorption will eventually be required to more efficiently draw urine away from the skin. In the future, manufacturers may be required to modify and improve absorbent pads.

Conclusion

This study documents that skin properties of the buttocks among elderly women with incontinence are affected by occlusion with pads. Both skin hydration values and skin pH in the DIG were significantly higher than in the FIG. In addition, skin pH was significantly associated with pad surface pH and excessive sweating. These results suggest that pads could contribute to skin damage. Efforts to improve absorbent pad performance and/or develop pH-balanced or antibacterial pads, as well as studies to establish a prevention protocol for maintaining healthy skin in the pad-occluded areas, are needed.

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References

1. Bliss DZ, Savik K, Harms S, Fan Q, Wyman JF. Prevalence and correlates of perineal dermatitis in nursing home residents. *Nurs Res*. 2006;55(4):243–251.
2. Yoshida M, Wada Y, Takahashi W, Inadome A, Ueda S. Control of urination in elderly bedridden patients. *Nishinihon J Urol*. 1996;58(5):490–495. (In Japanese with English abstract).
3. Rogers MA, Mody L, Kaufman SR, Fries BE, McMahon LF Jr, Saint S. Use of urinary collection devices in skilled nursing facilities in five states. *J Am Geriatr Soc*. 2008;56(5):854–861.
4. Runeman B. Skin interaction with absorbent hygiene products. *Clin Dermatol*. 2008;26(1):45–51.
5. Bliss DZ, Zehrer C, Savik K, Thayer D, Smith G. Incontinence-associated skin damage in nursing home residents: a secondary analysis of a prospective, multicenter study. *Ostomy Wound Manage*. 2006;52(12):46–55.
6. Bliss DZ, Zehrer C, Savik K, Smith G, Hedblom E. An economic evaluation of four skin damage prevention regimens in nursing home residents with incontinence: economics of skin damage prevention. *J WOCN*. 2007;34(2):143–152.
7. Junkin J, Selekof JL. Prevalence of incontinence and associated skin injury in the acute care inpatient. *J WOCN*. 2007;34(3):260–269.
8. Bale S, Tebble N, Jones V, Price P. The benefits of implementing a new skin care protocol in nursing homes. *J Tissue Viabil*. 2004;14(2):44–50.
9. Nazarko L. Managing a common dermatological problem: incontinence dermatitis. *Br J Community Nurs*. 2007;12(8):358–363.
10. Berg RW, Milligan MC, Sarbaugh FC. Association of skin wetness and pH with diaper dermatitis. *Pediatr Dermatol*. 1994;11(1):18–20.
11. Odio M, Friedlander SF. Diaper dermatitis and advances in diaper technology. *Curr Opin Pediatr*. 2000;12(4):342–346.
12. Lane AT, Rehder PA, Helm K. Evaluations of diapers containing absorbent gelling material with conventional disposable diapers in newborn infants. *Am J Dis Child*. 1990;144(3):315–318.
13. Newman DK. Incontinence products and devices for the elderly. *Urol Nurs*. 2004;24(4):316–333.
14. Wendling PA, Dell'Acqua G. Skin biophysical properties of a population living in Valais, Switzerland. *Skin Res Technol*. 2003;9(4):331–338.
15. Ehlers C, Ivens UI, Møller ML, Senderovitz T, Serup J. Comparison of two pH meters used for skin surface pH measurement: the pH meter 'pH900' from Courage & Khazaka versus the pH meter '1140' from Mettler Toledo. *Skin Res Technol*. 2001;7(2):84–89.
16. Brown DS, Sears M. Perineal dermatitis: a conceptual framework. *Ostomy Wound Management*. 1993;39(7):20–25.
17. Castledine G, Grainger M, Wood N, Dilley C. Researching the management of constipation in long-term care: Part 1. *Br J Nurs*. 2007;16(18):1128–1131.
18. O'Donnell LJ, Virjee J, Heaton KW. Detection of pseudodiarrhoea by simple clinical assessment of intestinal transit rate. *BMJ*. 1990;300(6722):439–440.
19. Stickler DJ, Lear JC, Morris NS, et al. Observations on the adherence of Proteus mirabilis onto polymer surfaces. *J Appl Microbiol*. 2006;100(5):1028–33.
20. Gray M, Bliss DZ, Doughty DB, Ermer-Seltun J, Kennedy-Evans KL, Palmer MH. Incontinence-associated dermatitis: a consensus. *J WOCN*. 2007;34(1):45–54.
21. Berg RW, Buckingham KW, Stewart RL. Etiologic factors in diaper dermatitis: the role of urine. *Pediatr Dermatol*. 1986;3(2):102–106.
22. Schmid-Wendtner MH, Korting HC. The pH of the skin surface and its impact on the barrier function. *Skin Pharmacol Physiol*. 2006;19(6):296–302.
23. Nakagami G, Sanada H, Kitagawa A, et al. Incontinence induces stratum corneum vulnerability and impairs the skin barrier function in the perianal region. *Dermatology*. 2006;213(4):293–299.
24. Bazari H. Approach to the patient with renal disease. In: Arend WP, Griggs RC, Armitage JO, Larusso N, Clemmons DR, Drazen JM. *Cecil Medicine, 23rd edition*. Philadelphia, PA: Saunders Elsevier;2008:806.
25. Faria DT, Shwayder T, Krull EA. Perineal skin injury: extrinsic environmental risk factors. *Ostomy Wound Manage*. 1996;42(7):28–37.
26. Nakagami G, Sanada H, Shigeta Y, Konya C, Sugama J. Effect of bacteria in feces on pH of bladder control pad top sheet. *J Jap Soc Stoma Continence Rehabilit*. 2008;24(3):119–123. (In Japanese with English abstract).
27. Andersen PH, Bucher AP, Saeed I, Lee PC, Davis JA, Maibach HI. Faecal enzymes: *in vivo* human skin irritation. *Contact Dermatitis*. 1994;30(3):152–158.
28. Shigeta Y, Nakagami G, Sanada H, et al. Exploring the relationship between skin property and absorbent pad environment. *J Clin Nurs*. 2009;18(11):1607–1616.
29. Schmid MH, Korting HC. The concept of the acid mantle of the skin: its relevance for the choice of skin cleansers. *Dermatology*. 1995;191(4):276-280.
30. Fader M, Cottenden AM, Getliffe K. Absorbent products for moderate-heavy urinary and/or faecal incontinence in women and men. *Cochrane Database Syst Rev*. 2008;8(4):1–14.
31. Aly R, Shirley C, Cunico B, Maibach HI. Effect of prolonged occlusion on the microbial flora, pH, carbon dioxide and transepidermal water loss on human skin. *J Invest Dermatol*. 1978;71(6):378–381.
32. Baker J, Norton P. Evaluation of absorbent products for women with mild to moderate urinary incontinence. *Nurs Res*. 1996;9(1):29–33.
33. Fader M, Macaulay M, Pettersson L, Brooks R, Cottenden A. A multicentre evaluation of absorbent products for men with light urinary incontinence. *Neurourol Urodyn*. 2006;25(7):689–695.
34. Erekson EA, Meyer SA, Melick C, McLennan MT. Incontinence pads: recommending the best product-based wetback performance and price. *Int Urogynecol J Pelvic Floor Dysfunct*. 2008;19(10):1411–1414.
35. Edlich RF, Winters KL, Long WB III, Gubler KD. Scientific basis for the selection of absorbent underpads that remain securely attached to underlying bed or chair. *J Long-Term Effects Med Implants*. 2006;16(1):29–40.
36. Voegeli D. The effect of washing and drying practices on skin barrier function. *J WOCN*. 2008;35(1):84–90.
37. Bornkessel A, Flach M, Arens-Corell M, Elsner P, Fluhr JW. Functional assessment of a washing emulsion for sensitive skin: mild impairment of stratum corneum hydration, pH, barrier function, lipid content, integrity and cohesion in a controlled washing test. *Skin Res Technol*. 2005;11(1):53–60.