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Incontinence Briefs Containing Spiral-Shaped Fiber Acidify Skin pH of Older Nursing Home Residents at Risk for Incontinence-Associated Dermatitis

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ABSTRACT

PURPOSE: The study's purpose was to assess the pH of the skin of older (aged ≥75 years) incontinent nursing home residents after exposure to an incontinence brief containing spiral-shaped fiber wet with an alkaline solution mimicking urine or fecal pH and compared to skin pH after exposure to an industry standard brief wet with the same solution and various controls.

DESIGN: The design was experimental, as conditions were applied to skin and skin pH was measured in random order, and subjects served as their own controls.

SETTING AND SUBJECTS: The setting was a Midwestern nonprofit nursing home. The sample was 26 nursing home residents; their mean age was 87 years (SD = 6 years); 77% were female. Most (69%) had urinary incontinence alone, and 31% had dual urinary and fecal incontinence.

METHODS: Skin pH was measured in duplicate on 6 areas of the inner thighs and 6 areas of the volar surface of the forearms. Each area was exposed to 1 of 6 conditions applied in random order: an incontinence brief containing spiral-shaped fiber wet with an alkaline solution and one that was dry; a standard incontinence brief (without spiral-shaped fiber) wet with the same alkaline solution and one that was dry; the alkaline solution alone; and normal skin.

RESULTS: On both the thighs and the forearms, skin pH was significantly lower (more acidic) after exposure to the incontinence brief containing spiral-shaped fiber wet with an alkaline solution compared to the wet standard brief and all other control conditions ($P < .001$). On thighs, the mean skin pH was 5.7 (SD = 0.5) after exposure to the wet brief with spiral-shaped fiber versus 6.4 (SD = 0.5) after exposure to the wet standard brief. On forearms, the mean skin pH was 5.3 (SD = 0.4) after exposure to the wet brief with spiral-shaped fiber versus 6.0 (SD = 0.4) after exposure to the wet standard brief.

CONCLUSIONS: Incontinence briefs containing a spiral-shaped fiber significantly acidify the pH of the skin exposed to an alkaline solution, while industry standard briefs do not. Since alkaline skin pH is a risk factor for incontinence-associated dermatitis (IAD), results suggest that briefs with spiral-shaped fiber may help prevent IAD. Findings encourage further research.

KEY WORDS: Absorbent products, Incontinence-associated dermatitis, Nursing homes, Skin damage, Skin pH.

INTRODUCTION

The pH of the healthy skin is mildly acidic; its pH varies from 4 to 6, and it is an important component of epidermal barrier function and health.[1,2] Incontinence can cause damage to the epidermal barrier through an array of mechanisms.[3-7] Excessive moisture from urine or fecal materials,[4,8,9] local inflammation from contact with irritants in stool,[10,11] variations in the surface pH of the skin,[12,13] and colonization with potentially pathogenic microorganisms[14] have been proposed as major underlying causes of inflammatory skin damage associated with incontinence. Incontinence-associated dermatitis (IAD) causes discomfort and pain[15,16] and increases the risk of other morbidity such as pressure-related injury.[17]

Leaked urine or feces can expose the skin to an alkaline pH, which, in turn, raises the pH of exposed areas.[12,18] The pH of urine usually varies from 4.6 to 8.0,[19] whereas the pH of stool ranges from 5.8 to 7.9.[20,21] Various diseases, medications, and dietary factors may raise the pH of urine and feces. For example, a diet higher in fruits and vegetables and lower in meat has been shown to produce more alkaline urine.[22] A fiber-free tube-feeding formula results in more alkaline feces,[23] whereas different types of dietary fiber can raise or lower the pH of feces.[24]

Among older adults, the pH of the skin surface shows age-dependent signs of alkalinization.[25] In addition, mechanisms for repairing the epidermal barrier are less effective in older

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persons.[26] Maintaining skin pH at a more acidic pH might prevent IAD and promote its healing, especially among older adults. Recent advances in the development of absorbent briefs and pads to contain a spiral-shaped fiber enable these products to buffer the pH of alkaline fluid such as urine and maintain a more acidic environment near the skin.[27] The spiral-shaped fiber is a plant-based cellulose fiber (Curly fiber; Hartmann, Rock Hill, South Carolina) in the upper layer of the absorbent core of an incontinence brief or pad that lies near the skin. However, it is unknown whether incontinence briefs with the spiral-shaped fiber can lower the skin pH of older adults. The purpose of this study was to assess skin pH after exposure to an incontinence brief with and without spiral-shaped fiber wet with an alkaline solution and appropriate control conditions.

METHODS

Residents of a Midwestern nursing home and their families were informed about the study by the nursing home staff who were part of the study team. Subjects or their legal representatives provided informed consent. Recruitment methods included in-person contact, telephone call, or mailed letter with a return postcard and follow-up call as needed. Initial inclusion criteria were age 75 years or more and having urinary and/or fecal incontinence. Individuals were excluded if they had a known intolerance or allergy to study products, skin damage or disease at the body areas to be tested, active autoimmune disease or cancer, receiving topical steroid medication at the test sites, undergoing systemic corticosteroid treatment, receiving immunosuppressants, or receiving anticancer agents.

Eligibility for the study was assessed a second time immediately before measuring skin pH. Subjects were excluded if there was skin damage involving the cutaneous areas to be tested, if lotions or other skin care products other than the approved cleanser applied had been applied to body areas to be tested within 72 hours prior to testing, or if they indicated any reservations about study participation. Skin pH measurements occurred over 3 days, and a schedule for bathing subjects was planned around this schedule. Study procedures were reviewed and approved by the University of Minnesota institutional review board (IRB). As the nursing home did not have an IRB, it accepted the review of the IRB at the University of Minnesota.

Study Procedures

Data were collected about subjects' demographic, functional, and cognitive characteristics and continence status using data on the Minimum Data Set (MDS) v. 3.0,[28] resident's health record, and inspection of the skin. The MDS contains comprehensive assessment data of demographic and health characteristics of nursing home residents and its completion is required by Medicare- and Medicaid-certified nursing homes in the United States.

The study had an experimental design; conditions were applied to skin, and skin pH was measured in a randomly assigned order. Subjects served as their own controls. Skin pH was measured on 6 areas of the volar surface of the right and left forearms and 6 areas of the right and left inner thighs for a total of 12 areas (Figure 1). Each area was exposed to 1 of 6 conditions, randomly ordered. The test condition was an incontinence brief containing spiral-shaped fiber wet with an alkaline solution mimicking the alkaline pH of urine or feces. The test condition was compared to an industry standard incontinence brief (without spiral-shaped fiber) that was similarly wet with the alkaline solution. The wet brief with spiral-shaped fiber was also compared to the following control conditions: normal skin wet with distilled water; a dry brief containing spiral-shaped fiber; a dry standard brief; and the alkaline solution alone. The pH of these areas was tested because the volar surface of the forearm is a common area tested in studies of skin reactions, and the inner thigh is an area that may be exposed to incontinence while still allowing the subject's modesty to be maintained.

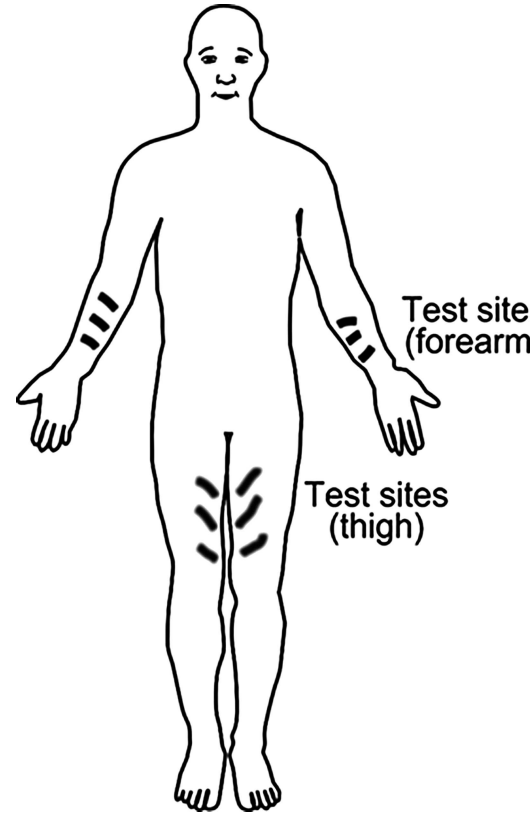

Figure 1. Body locations where pH was measured.

Skin pH was measured on each area in duplicate using a FiveGo pH meter (Mettler Toledo, Schwerzenbach, Switzerland). The instrument was calibrated daily before use. A surface flat-bed pH electrode (InLab pH electrode; Mettler Toledo), which was disinfected between subjects with 70% ethanol, was used.

The alkaline solution was prepared by adding 30 g of table salt to 1 gallon of distilled water and then adding 25% ammonia and/or distilled white vinegar until the pH was between 7.0 and 7.5 as measured by the pH meter. New solutions were prepared at the start of each day of data collection. At the end of each day of data collection, all solutions and open liquid sources remaining were discarded. Briefs were prepared each day of data collection by cutting two 20-cm long sections of each type (with spiral-shaped fiber and without spiral-shaped fiber) for each subject. One piece of each brief type was kept dry, while the other was moistened with 275 mL of the alkaline solution. The moistened or dry brief was slowly rubbed in a circular motion on the skin site 12 times before pH was measured. For those sites not exposed to the wet brief, it was necessary to apply a drop of distilled water to the skin prior to applying the pH meter probe. The same person applied each condition and the pH meter to the skin.

Skin condition was inspected by the study team at the nursing home site using the Incontinence-Associated Skin Damage and Severity (IASD.D.2) instrument, scores ranging from 0 (no damage) to 54 (most severe damage),[29] and a skin reaction scoring system developed for this study. The skin reaction scoring was 0 = normal skin, no evidence of irritation; 0.5 = equivocal (possible) reaction (minimal erythema [redness], barely perceptible); 1 = definite erythema; 2 = erythema, minimal edema (swelling), and/or minimal papules (small bump or pimple); 3 = erythema, induration (hardening of an area, a sign of edema) and papules; 4 = erythema, induration (edema) and vesicles (blister-like elevation of skin, with or without fluid); and 5 = strong reaction, clearly spreading beyond test site.

Data Analysis

Characteristics of the study sample were summarized using descriptive statistics. The mean of the 2 duplicate pH measurements was used in analyses. Differences in skin pH measurements were tested using analysis of variance. Post hoc multiple comparisons were made using Tukey's test. An α-level $P < .05$ was considered statistically significant.

Statistical testing used SAS version 9.4 (Statistical Analysis Software, Cary, NC). Measurements of pH on the inner thighs and volar surface of forearms were analyzed separately.

RESULTS

Twenty-six nursing home residents participated in the study (Table). The majority were female (n = 20; 77%); their mean age was 87 years (SD = 6 years); all were white, not Hispanic. Nearly half of the subjects (n = 12; 46%) had a high school diploma. All were incontinent of urine, and about one-third of subjects (31%) were incontinent of urine and feces. The short- and long-term memories of most of the subjects were "ok" as described on the MDS,[28] and most were classified as overweight based on body mass index. Their functional status showed moderate deficits in activities of daily living.[30,31]

TABLE.
Characteristics of Nursing Home Residents

	N = 26, n (%)
Female gender	20 (77)
Racial or ethnic background	
White, non-Hispanic	26 (100)
Education, highest level	
Less than high school	10 (39)
High school diploma	12 (46)
College degree (2-4 y)	4 (15)
Marital status	
Married	9 (35)
Divorced or separated	2 (8)
Widowed	15 (57)
Incontinence type	
Only urinary incontinence	18 (69)
Only fecal incontinence	0 (0)
Both urinary and fecal incontinence	8 (31)
Memory[a]	
Short-term memory	
Ok	20 (77)
Memory problem	5 (19)
Don't know	1 (4)
Long-term memory	
Ok	19 (73)
Memory problem	6 (23)
Don't know	1 (4)
	Mean (SD)
Age, y	86.5 (5.9)
Body mass index, kg/m²	28.2 (5.7)
Activities of daily living score[30]	15.5 (6.9)

[a]Categories according to Minimum Data Set v. 3.0.

Skin pH Measures

The pH of the skin of the inner thighs exposed to an incontinence brief containing spiral-shaped fiber and wet with an alkaline solution was the most acidic compared to all other conditions ($P < .001$) (Figure 2). The pH of the skin exposed to a wet incontinence brief containing spiral-shaped fiber was significantly more acidic (lower) (mean = 5.7, SD = 0.5), than the pH of skin exposed to the industry standard brief without spiral-shaped fiber wet with the same alkaline solution (mean = 6.4, SD = 0.5). Skin pH of the inner thighs after exposure to a wet incontinence brief containing spiral-shaped fiber was also significantly lower than after exposure to each control condition, mean (SD): pH of the normal skin = 6.6 (0.4); pH of the skin after exposure to a dry brief containing spiral-shaped fiber = 6.5 (0.4); after exposure to a dry standard brief = 6.6 (0.5); and after exposure to the alkaline solution alone = 6.4 (0.4).

The pH of the skin on the volar surface of the forearms exposed to an incontinence brief with spiral-shaped fiber wet with an alkaline solution was the most acidic compared to all other conditions ($P < .001$; Figure 2). Skin pH on the forearms after exposure to a wet incontinence brief containing spiral-shaped fiber was significantly more acidic (lower) (mean = 5.3 (SD = 0.4), than after exposure to an industry standard brief without spiral-shaped fiber wet with the same solution (mean = 6.0, SD = 0.4). Skin pH on the forearms after exposure to an incontinence brief containing spiral-shaped fiber was also significantly lower than after each control condition mean (SD): pH of the normal skin = 6.0 (0.5), pH of the skin after exposure to a dry brief containing spiral-shaped fiber = 6.1 (0.6), after exposure to a dry standard brief = 6.0 (0.4), and after exposure to the alkaline solution alone = 5.9 (0.4). There were no significant differences among other pH measures. The pH measures of the skin on the inner thighs, potentially exposed to incontinent urine or feces, tended to be higher than those of the volar surface of the forearms.

Adverse Events

There was no skin damage resulting from study procedures. Specifically, all scores of skin condition on the test areas of the inner forearms and inner thighs using the IASD.D.2

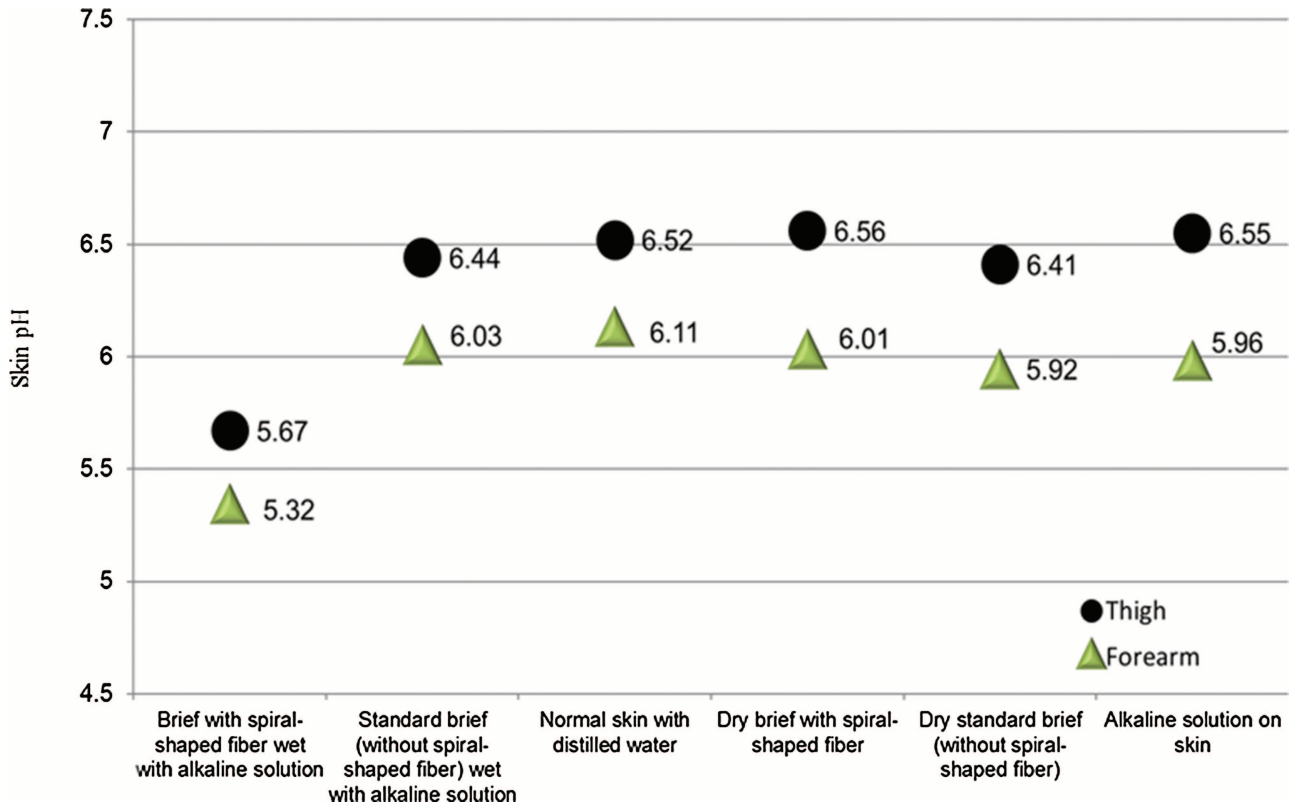

Figure 2. The pH measures, mean (SD) on the inner thighs and inner forearms of nursing home residents (n = 26). The pH values of skin after exposure to the brief with spiral-shaped fiber wet with an alkaline solution are significantly lower than all other conditions on both the thighs and in post hoc comparisons, $P = .001$ for both sets of comparisons. For comparisons of thigh pH, analysis of variance, $F(df) = 8.83$ (30, 125), and for comparisons of forearm pH, $F(df) = 10.12$ (30, 125), $P < .001$ for both.

instrument and the skin reaction scale were 0, showing nondamaged skin before and after skin pH measurements.

DISCUSSION

Study results show that incontinence briefs containing spiral-shaped fiber can lower (acidify) the pH of skin exposed to an alkaline solution with pH mimicking incontinent urine or feces. Results of this study extend the findings of Beguin and colleagues,[27] who showed that incontinence briefs containing the same spiral-shaped fiber buffered the pH of the incontinent briefs when wet with an alkaline solution. Alkaline skin pH has been identified as a risk factor for IAD.[11,12,15] An acidic pH provides an optimal environment for skin cells to establish and maintain the structure and cohesion of the lipid-protein epithelial barrier and also has antimicrobial effects.[1,13,32] An intact epithelial barrier contributes to normal skin functions such as maintaining fluid and electrolyte balance by preventing the loss of water and proteins, regulating body temperature, and protecting against allergens and microbial infection.[1,2,32] Blaak and associates[13] showed that acidifying the skin of elderly subjects increased skin's resistance to damage from experimental stripping and increased its hydration. An alkaline pH and inflammation from IAD, on the other hand, disrupt the integrity and protection of the epithelial barrier.

Incontinence is associated with an increased risk of IAD in nursing home residents[6] and of pressure-related injury in the perineal area in hospitalized patients.[33] The alkaline pH of urine and feces[19-21] contributes to skin damage from incontinence.[1,2,12] Furthermore, the presence of one type of skin damage appears to increase the likelihood of additional damage. For example, Demarre and colleagues[17] showed that having IAD was associated with a higher risk of pressure injury in the sacral area, while Bliss and associates[34] showed that the presence of pressure injury in the perineal area was associated with a higher likelihood of having IAD. By acidifying the pH of skin, incontinence briefs containing the spiral-shaped fiber promote the body's natural defense mechanisms to prevent IAD. Because of their ability to maintain a lower pH near the skin over time,[27] these briefs also have potential to reduce the severity of IAD and promote its healing. Results of this study encourage additional clinical studies to assess these effects.

The findings of this study support the practice of WOC nurses, many of whom provide educational and consultation services to nursing homes. Managing incontinence and preventing IAD are part of the expertise of the WOC nurse who is often a resource regarding new developments in incontinence and skin care and integrating them into plans of care. The older population in the United States is projected to be 82.3 million by 2040, more than double the number in 2000.[35] The lifetime probability of a 50-year-old person in the United States entering a nursing home is 50% to 59%.[36] Considering that as many as half of nursing home residents are incontinent,[37,38] the potential impact of IAD prevention on healthcare costs and resident well-being is great; hence, services of the WOC nurse in achieving these outcomes are of high value. Incontinent briefs have been used primarily for containing leaked urine and feces and are a useful adjuvant to interventions aimed to promote continence of nursing home residents. Use of briefs with spiral-shaped fiber has the potential to prevent IAD, and results of this study encourage

further clinical investigations. If effective, the lowering of skin pH would offer a new approach for preventing IAD.

STRENGTHS AND LIMITATIONS

Strengths of this study include its experimental design and inclusion of appropriate control conditions. Having subjects serve as their own controls decreased potential variability. The outcome of skin pH was measured using a pH meter providing a standard, precise, objective measurement. The IASD.D.2 instrument used is a valid and reliable tool for assessing IAD severity.[29] Obtaining pH measurements of the inner thighs of older nursing home residents with incontinence as well as the volar surface of forearms is the other strength that increases the clinical relevance and ability to compare results with other studies, respectively. The generalizability of findings is limited by the sample size and collection of data in a single nursing home. Another limitation is that the score for skin irritation developed for this study did not have prior testing. The focus of this study was on the effect of incontinent briefs with and without spiral-shaped fiber on skin pH. Further clinical studies are needed to assess if briefs with spiral-shaped fiber reduce the incidence of IAD.

CONCLUSIONS

Older nursing home residents who are incontinent are at high risk for incontinence-associated skin damage of the epithelial barrier. Acidic skin pH has an important role in keeping the skin barrier healthy and in preventing IAD. Incontinent briefs containing spiral-shaped fiber wet with a solution that had an alkaline pH similar to leaked urine and feces lowered (acidified) the skin pH of older incontinent nursing residents. In comparison, skin pH after exposure to an industry standard brief without spiral-shaped fiber wet with the same solution was significantly higher. Because of their acidification of skin pH, briefs containing spiral-shaped fiber may have potential to prevent IAD.

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