

## ORIGINAL ARTICLE

# Apple cider vinegar soaks [0.5%] as a treatment for atopic dermatitis do not improve skin barrier integrity

Lydia A. Luu BS<sup>1</sup>  | Richard H. Flowers MD<sup>1</sup> | Ann L. Kellams MD<sup>2</sup> |  
Steven Zeichner MD, PhD<sup>3</sup> | DeVon C. Preston MD<sup>4</sup> | Barrett J. Zlotoff MD<sup>1</sup> |  
Julia A. Wisniewski MD<sup>4</sup>

<sup>1</sup>Department of Dermatology, University of Virginia, Charlottesville, Virginia

<sup>2</sup>Division of General Pediatrics, Department of Pediatrics, University of Virginia, Charlottesville, Virginia

<sup>3</sup>Division of Pediatric Infectious Diseases, Department of Pediatrics, University of Virginia, Charlottesville, Virginia

<sup>4</sup>Division of Allergy and Immunology, Department of Pediatrics and Internal Medicine, University of Virginia, Charlottesville, Virginia

## Correspondence

Lydia A. Luu, BS, Department of Dermatology, University of Virginia, P.O. Box 800718, Charlottesville, VA 22908  
Email: lal2ta@virginia.edu

## Funding information

This study was funded by the University of Virginia, UVA Child Health Research Center, and the Department of Dermatology.

## Abstract

**Background/Objectives:** Atopic dermatitis (AD) is a common chronic inflammatory skin condition associated with high transepidermal water loss, high skin pH, and *Staphylococcus aureus* skin colonization. The treatment of AD with bath additives remains highly debated. Recent evidence suggests that dilute apple cider vinegar (ACV) may improve skin barrier integrity in AD, but its safety and efficacy are not well studied. This pilot split-arm study analyzed the effect of dilute apple cider vinegar soaks on skin barrier integrity in patients with atopic dermatitis as measured by skin transepidermal water loss and skin pH.

**Methods:** A total of 22 subjects (11 AD and 11 healthy controls) were enrolled. Subjects soaked both of their forearms for 14 days, with one arm in dilute ACV (0.5% acetic acid) and the other in water 10 minutes daily. Transepidermal water loss and pH were measured pre- and post-treatment.

**Results:** In both groups, transepidermal water loss increased and pH decreased at 0 minutes post-ACV treatment, but these effects were not sustained at 60 minutes. In total, 72.7% (16/22) of subjects reported mild side effects from ACV with improvement after discontinuing the soaks.

**Conclusions:** Dilute ACV soaks have no significant effect on skin barrier integrity but caused skin irritation in a majority of subjects. Study limitations include analysis of a single brand, dilution, and application of ACV. Future studies are needed to explore whether lower concentrations of ACV soaks or other applications such as a leave-on acidic ointment could improve skin barrier integrity in a safe, nonirritating way.

## KEYWORDS

apple cider vinegar, atopic dermatitis, eczema, epidermal acidification, skin barrier integrity, skin pH, transepidermal water loss

## 1 | INTRODUCTION

Atopic dermatitis (AD) is the most common allergic skin disease, with prevalence estimates of 20% in children and 6% in adults.<sup>1</sup> AD is characterized by impaired barrier function and epidermal acidification, along with increased bacterial infections.<sup>2</sup> The pathogenesis of AD is closely linked to elevated skin pH caused by many factors, including reduced levels of filaggrin.<sup>3</sup> Filaggrin is an epidermal differentiation complex protein that plays a key role in epidermal acidification by forming pyrrolidone carboxylic acid and transurocanic acid (t-UCA).<sup>3</sup> Reduced levels of filaggrin in AD skin lead to reduced levels of t-UCA and other natural acidifiers.<sup>3</sup> AD skin has therefore been shown to be more alkaline than normal skin, which promotes the activation of proteases that enhance skin transepidermal water loss (TEWL) and disrupt the normal skin flora.<sup>3,4</sup> Epidermal alkalization has been shown to contribute to inflammation in AD, and

so researchers are now exploring epidermal acidification as an approach to treating AD.<sup>5,6</sup>

Commonly prescribed treatments for AD include topical corticosteroids, emollients, antibiotics, biologic immune modulators, and bleach baths.<sup>7,8</sup> Acetic acid, particularly apple cider vinegar (ACV), is prominent among emerging natural remedies used by patients who seek therapies perceived as “safer” and “more natural” than prescriptions such as topical steroids.<sup>9</sup> Patients currently use ACV for skin infections and other maladies ranging from common warts to AD.<sup>8,10</sup> Even some dermatologists have recently started recommending ACV baths for AD.<sup>9</sup> ACV soaks are theoretically appealing given their antimicrobial activity and potential to acidify the skin.<sup>11,12</sup> However, little is known about the efficacy or safety of ACV on skin in AD, and reports of positive effects are often anecdotal.<sup>11</sup> The primary objective of this split-arm pilot study was to examine the effects of dilute ACV application to AD and healthy skin on TEWL

**TABLE 1** Characteristics of study participants at enrollment

|                                              |                                     | Atopic dermatitis<br>N = 11 | Control subjects<br>N = 11 | P-value |
|----------------------------------------------|-------------------------------------|-----------------------------|----------------------------|---------|
| Age (y) <sup>a</sup>                         |                                     | 20.6 [16.2-26.2]            | 28.8 [22.6-36.8]           | 0.15    |
| Gender <sup>b</sup>                          | Male                                | 36.4% (4/11)                | 45.5% (5/11)               | 1.00    |
|                                              | Female                              | 63.6% (7/11)                | 54.5% (6/11)               |         |
| Ethnicity <sup>b</sup>                       | Caucasian                           | 45.5% (5/11)                | 36.4% (4/11)               | 1.00    |
|                                              | African American                    | 18.2% (2/11)                | 0% (0/11)                  |         |
|                                              | Asian                               | 36.4% (4/11)                | 45.5% (5/11)               |         |
|                                              | Other                               | 0% (0/11)                   | 18.2% (2/11)               |         |
| Birth history <sup>b</sup>                   | Vaginal delivery                    | 72.7% (8/11)                | 90.9% (10/11)              | 0.59    |
|                                              | Caesarian delivery                  | 27.3% (3/11)                | 0.09% (1/11)               |         |
| Medical history <sup>b</sup>                 | Allergies <sup>c</sup>              | 100% (11/11)                | 36.4% (4/11)               | 0.0039  |
| Family history <sup>b</sup>                  | Allergies <sup>c</sup>              | 100% (11/11)                | 63.6% (7/11)               | 0.09    |
| SCORAD <sup>a</sup>                          |                                     | 32.9 [23.8-45.4]            | 0 [0-0]                    | N/A     |
| Atopic dermatitis (AD) severity <sup>d</sup> | Mild                                | 36.4% (4/11)                | N/A                        | <0.01   |
|                                              | Moderate                            | 45.5% (5/11)                |                            |         |
|                                              | Severe                              | 18.2% (2/11)                |                            |         |
| AD medications <sup>b</sup>                  | Emollients                          | 100% (11/11)                | 0% (0/11)                  | <0.01   |
|                                              | Topical steroids                    | 90.9% (10/11)               | 0% (0/11)                  |         |
|                                              | Systemics                           | 18.2% (2/11)                | 0% (0/11)                  |         |
| Skin barrier <sup>a</sup>                    | Transepidermal water loss           | 11.1 [8.6-14.3]             | 7.1 [6.0-8.4]              | 0.0064  |
|                                              | pH                                  | 4.88 [4.67-5.1]             | 4.86 [4.6-5.13]            | 1.00    |
| Presence of dermatitis <sup>b</sup>          | Apple cider vinegar-treated forearm | 72.7% (8/11)                | 0% (0/11)                  | <0.01   |
|                                              | Water-treated forearm               | 72.7% (8/11)                | 0% (0/11)                  |         |

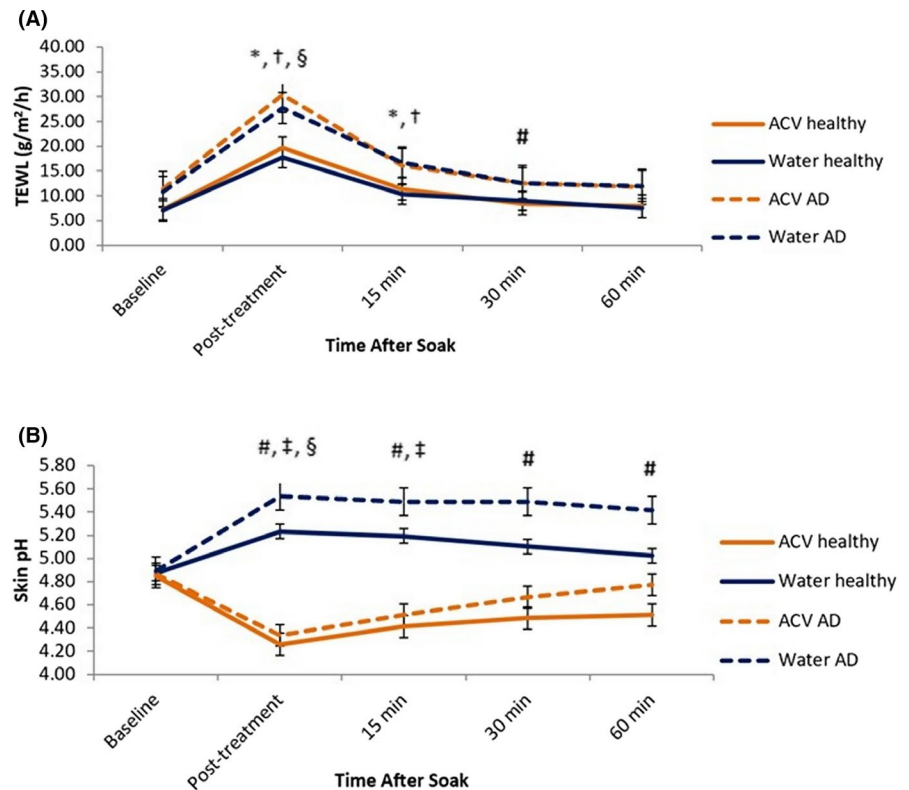
<sup>a</sup>Geometric mean [95% confidence interval].

<sup>b</sup>Percentage of subjects (prevalence).

<sup>c</sup>Positive history of allergies included asthma, food, or environmental allergies.

<sup>d</sup>AD severity was mild (if SCORAD < 25), moderate (if SCORAD 25-50), or severe (if SCORAD > 50).

**FIGURE 1** Immediate effects of dilute apple cider vinegar (ACV) on skin barrier integrity. Repeated measurements of skin transepidermal water loss (A) and skin pH (B) were recorded on the volar forearm of atopic dermatitis (AD) and control subjects at baseline and following 10-min forearm soaks in dilute ACV or water. § denotes  $P < 0.01$  for water-treated arms of AD subjects compared to control subjects. Compared to baseline within groups: \* denotes  $P < 0.01$  for ACV-treated arms in controls; † denotes  $P < 0.01$  for ACV-treated arms of AD subjects; # denotes  $P < 0.05$  for ACV-treated arms of controls; ‡ denotes  $P < 0.05$  for ACV-treated arms of AD subjects



and pH, surrogate markers for skin barrier integrity. The secondary objective was to determine the safety of ACV soaks.

## 2 | MATERIALS AND METHODS

Subjects with AD and healthy controls, age  $\geq 12$  years, were recruited at the University of Virginia and enrolled in the study between June 2017 and October 2017. Subjects who used topical or systemic antimicrobials in the previous month were excluded. All other treatments being used by subjects at enrollment, including topical steroids and other immune modulators, were recorded and continued throughout the study. Informed consent was obtained. The University of Virginia Institutional Review Board approved this study.

Atopic dermatitis and control subjects were randomly assigned to soak one forearm in dilute ACV (0.5% concentration acetic acid: apple cider vinegar; White House©) and the other forearm in tap water for 10 minutes daily for 14 days. A concentration of 0.5% acetic acid was selected based on previous data regarding safety, tolerability, and antimicrobial qualities.<sup>13</sup> TEWL and pH were recorded from volar forearms at study visit 1 before the first soak; at 0, 15, 30, and 60 minutes after the first soak; and 24 hours after completing 14 days of daily 10-minute soaks (study visit 2). TEWL and pH were measured using Tewameter TM 300 (Courage+Khazaka Electronic) and Skin pH Meter PH 905 (Courage+Khazaka Electronic) according to the manufacturer's instructions.<sup>14,15</sup> Subjects reported and graded skin discomfort they experienced during the 14-day study on a subjective scale from 0 to 3 (0 = none, 1 = mild, 2 = moderate, and 3 = severe).

The Mann-Whitney  $U$  test and Wilcoxon matched-pairs signed rank test were used to compare measurements between and within groups of subjects, respectively. Intention-to-treat analysis was performed.

## 3 | RESULTS

Eleven subjects with atopic dermatitis (AD) (geometric mean [GM] age 20.6 years; GM SCORAD 32.9 [23.8-45.4]) and 11 healthy controls (GM age 28.8) were enrolled in the study. Baseline characteristics of AD and healthy subjects are summarized in Table 1. All study subjects returned for follow-up on day 14 of the study except one AD subject. One of 11 control subjects and two of 11 AD subjects were noncompliant with the daily treatments, with noncompliance defined as missing three or more days of treatment.

Transepidermal water loss was significantly elevated in AD subjects at baseline (TEWL 11.1 [8.6-14.3] g/m<sup>2</sup>/h) compared to healthy controls (TEWL 7.1 [6.0-8.4] g/m<sup>2</sup>/h) (Figure 1A). Transepidermal water loss in AD and healthy subjects was significantly increased at 0 and 15 minutes post-ACV treatment, compared to baseline ( $P \leq 0.01$ ). Transepidermal water loss returned to baseline 30 minutes after each soak in AD subjects and 60 minutes after in controls and was unchanged from baseline 24 hours following the day 14 soak ( $P = 0.30$ ) (Figure 2A). No significant differences in TEWL between the ACV or water arms for AD vs controls were found.

Skin pH in AD (pH 4.88 [4.67-5.10]) and healthy subjects (pH 4.86 [4.60-5.13]) was comparable at baseline (Figure 1B). Atopic

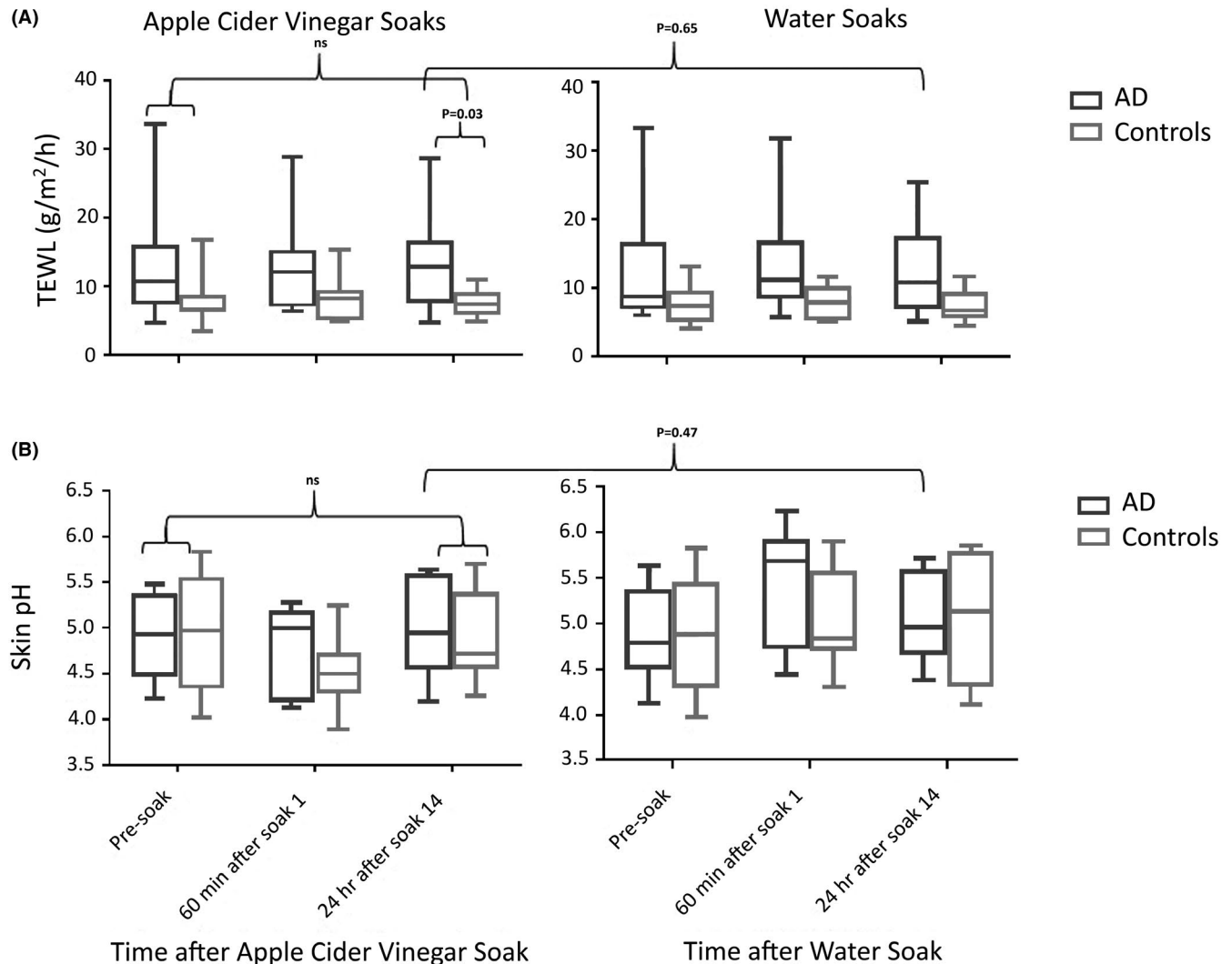


**FIGURE 2** Skin barrier integrity after 14 daily 10-min apple cider vinegar (ACV) soaks. Skin transepidermal water loss (A) and skin pH (B) were recorded on the volar forearm of atopic dermatitis and control subjects 24 h following their day 14 soak in dilute ACV (column 1) or water (column 2)

dermatitis skin had a significantly higher shift toward alkaline pH immediately following water soak (pH 5.54 [5.16-5.94]) compared to healthy subjects (pH 5.23 [4.91-5.59]) ( $P \leq 0.01$ ). In contrast, adding ACV to the tap water resulted in skin pH levels comparable to healthy subjects for AD subjects immediately postsoak (pH 4.34 [4.14-4.55] in AD vs 4.26 [4.03-4.50] in controls) ( $P = 0.08$ ). Skin pH remained decreased 15 minutes following ACV soaks in AD subjects (pH 4.52 [4.29-4.75] vs 4.87 [4.57-5.18] at baseline) and 60 minutes in controls (pH 4.51 [4.26-4.78] at 60 minutes vs 4.85 [4.45-5.27] at baseline) ( $P < 0.05$ ). pH was unchanged compared with baseline at day 14 ( $P = 0.49$ ) (Figure 2B).

Seventy-three percent (16/22) of subjects reported forearm skin discomfort, mostly rated as mild and confined to the ACV-treated arm. Skin irritation was rated severe in one AD subject with severe pruritus, moderate burning, and erosion on the ACV-treated forearm. This reaction resolved within 2 days of discontinuing ACV soaks; the

subject did not resume the study. One subject in the control group experienced a nonpruritic papular rash. All skin discomfort, including the rash, resolved without treatment.

## 4 | DISCUSSION

Due to skin barrier dysfunction, patients with AD often have increased skin TEWL and alkaline skin pH.<sup>6,16</sup> TEWL is known to increase after bathing due to a temporary increase in skin hydration followed by evaporation and water loss.<sup>17</sup> This study showed transient decrease in skin pH in AD subjects for 15 minutes and healthy subjects for 60 minutes ( $P < 0.05$ ) after soaking in dilute ACV, which suggests temporary acidification of the skin that has theoretical benefit of correcting disrupted skin pH in AD. Skin exposed to water did not receive the same acidification benefit, as skin pH increased

after soaking in water to a level significantly different from that of soaking in ACV ( $P < 0.05$ ) (Figure 1B). However, our study found no long-term effects of soaking AD skin in dilute ACV on skin TEWL or pH. Among AD subjects, the effect of 14 days of ACV soaks on skin TEWL and pH was comparable with soaking in water alone ( $P = 0.65$  and  $P = 0.47$ , respectively, among all AD subjects;  $P = 0.94$  and  $P = 0.81$ , respectively, excluding noncompliant AD subjects). This suggests that ACV soaks do not improve skin barrier integrity in AD in a significant manner.

The concentration we chose of 0.5% acetic acid is comparable to the minimum inhibitory concentration of 0.312% acetic acid against methicillin-sensitive *S. aureus* and 0.625% acetic acid against methicillin-resistant *S. aureus*,<sup>12</sup> two organisms that frequently colonize skin in AD. The concentration is notably nearly 10-fold above the 1:80 (0.06% acetic acid) ACV bath preparations recently recommended by Lee and Jacobs.<sup>9</sup> Other literature reports that concentrations of 2.5% acetic acid have been used successfully to prevent *Pseudomonas aeruginosa* wound infections in burn centers, while concentrations above 3% acetic acid are associated with severe pain and itching.<sup>13</sup> Although our concentration of 0.5% acetic acid was far below this threshold, a large proportion of AD subjects in our study experienced skin discomfort (burning, itching), which was unexpected and limits the ability to test acetic acid concentrations higher than 0.5% in future studies.

This study has several limitations. First, this was a small study with a fairly homogenous group of patients. The average ages of healthy and AD subjects were 28.8 and 20.6 years, respectively. This may make the study less applicable to young children, as adult patients may have more recalcitrant disease. Further studies in a more diverse population will be necessary to fully characterize the risk/benefit profile of topical dilute ACV treatments. Of note, although our study population was small, subjects were representative of patients with moderate-to-severe AD with elevated skin TEWL [11.1 (8.6–14.3) g/m<sup>2</sup>/h]. Second, this study only tested ACV on volar forearms. Other body sites may respond differently, especially in patients with sensitive skin. Third, due to the intrinsic appearance and smell of dilute ACV compared to water, it was impossible to blind study subjects and researchers in this split-arm study, which may cause potential bias in the data. Lastly, our study was an analysis of a single brand and dilution of ACV. Future studies are needed to test skin barrier effects of different concentrations of acetic acid from different sources.

In conclusion, acetic acid, particularly apple cider vinegar, is prominent among emerging natural remedies used in AD.<sup>9</sup> Therefore, determining the safety of this commonly used product is crucial. This study used skin TEWL and pH in addition to reports of skin discomfort to evaluate the safety and efficacy of ACV for treating AD. Results showed that soaking in dilute acetic acid yielded no benefit as measured by changes in skin TEWL and pH, yet caused substantial adverse effects. Therefore, although epidermal acidification would theoretically be beneficial in treating AD, our study shows that acidification by way of topical bathing

in a 0.5% ACV solution as performed in this study is not useful in AD treatment. Future studies are needed to explore whether lower concentrations of acetic acid soaks or other applications such as a leave-on acidic ointment would be more effective in acidifying the skin and improving skin barrier integrity in a safe, nonirritating way.

## ORCID

Lydia A. Luu  <https://orcid.org/0000-0001-6512-4686>

## REFERENCES

1. Dizon MP, Yu AM, Singh RK, et al. Systematic review of atopic dermatitis disease definition in studies using routinely collected health data. *Br J Dermatol*. 2018;178(6):1280–1287.
2. Ong PY, Leung DYM. Bacterial and viral Infections in atopic dermatitis: a comprehensive review. *Clin Rev Allergy Immunol*. 2016;51(3):329–337.
3. Rippke F, Schreiner V, Doering T, Maibach HI. Stratum corneum pH in atopic dermatitis: impact on skin barrier function and colonization with *Staphylococcus Aureus*. *Am J Clin Dermatol*. 2004;5(4):217–223.
4. Hachem J-P, Crumrine D, Fluhr J, Brown BE, Feingold KR, Elias PM. pH directly regulates epidermal permeability barrier homeostasis, and stratum corneum integrity/cohesion. *J Invest Dermatol*. 2003;121(2):345–353.
5. David Boothe W, Tarbox JA, Tarbox MB. Atopic dermatitis: pathophysiology. *Adv Exp Med Biol*. 2017;1027:21–37.
6. Panther DJ, Jacob SE. The importance of acidification in atopic eczema: an underexplored avenue for treatment. *J Clin Med*. 2015; 4(5): 970–978.
7. Eichenfield LF, Tom WL, Berger TG, et al. Guidelines of care for the management of atopic dermatitis: section 2. Management and treatment of atopic dermatitis with topical therapies. *J Am Acad Dermatol*. 2014;71(1):116–132.
8. Pham Q, Eberting CL. Epidermal acidification and skin barrier optimization in the management of atopic dermatitis: a series of three cases successfully managed by a novel approach. *J Dermatol Nurses Assoc*. 2016;8(5):329–333.
9. Lee KW, Jacob SE. Apple cider vinegar baths. *J Dermatol Nurses Assoc*. 2018;10(1):59.
10. Kuwabara AM, Rainer BM, Basdag H, Cohen BA. Children with warts: a retrospective study in an outpatient setting. *Pediatr Dermatol*. 2015;32(5):679–683.
11. Angelova-Fischer I, Fischer TW, Abels C, Zillikens D. Accelerated barrier recovery and enhancement of the barrier integrity and properties by topical application of a pH 4 vs. a pH 5–8 water-in-oil emulsion in aged skin. *Br J Dermatol*. 2018;179(2):471–477.
12. Fraise AP, Wilkinson MA, Bradley CR, Oppenheim B, Moiemien N. The antibacterial activity and stability of acetic acid. *J Hosp Infect*. 2013;84(4):329–331.
13. Halstead FD, Rauf M, Moiemien NS, et al. The antibacterial activity of acetic acid against biofilm-producing pathogens of relevance to burns patients. *PLoS One*. 2015;10(9):e0136190.
14. Eberlein-König B, Schäfer T, Huss-Marp J, et al. Skin surface pH, stratum corneum hydration, trans-epidermal water loss and skin roughness related to atopic eczema and skin dryness in a population of primary school children. *Acta Derm Venereol*. 2000;80(3):188–191.
15. Kelleher M, Dunn-Galvin A, Hourihane JO, et al. Skin barrier dysfunction measured by transepidermal water loss at 2 days and

2 months predates and predicts atopic dermatitis at 1 year. *J Allergy Clin Immunol*. 2015;135(4):930-935.e1.

16. Shi VY, Foolad N, Ornelas JN, et al. Comparing the effect of bleach and water baths on skin barrier function in atopic dermatitis: a split-body randomized controlled trial. *Br J Dermatol* 2016;175(1):212-214.
17. Lee NR, Lee H-J, Yoon NY, Kim D, Jung M, Choi EH. Application of topical acids improves atopic dermatitis in murine model by enhancement of skin barrier functions regardless of the origin of acids. *Ann Dermatol*. 2016;28(6):690-696.

**How to cite this article:** Luu LA, Flowers RH, Kellams AL, et al. Apple cider vinegar soaks [0.5%] as a treatment for atopic dermatitis do not improve skin barrier integrity. *Pediatr Dermatol*. 2019;00:1-6. <https://doi.org/10.1111/pde.13888>