

## ORIGINAL ARTICLE

# A pilot study evaluating the efficacy and tolerability of a comprehensive, hydrating topical antioxidant developed specifically for men

Brooke C. Sikora MD<sup>1</sup> | Mitchell Wortzman PhD<sup>2</sup> | Diane B. Nelson RN, MPH<sup>2</sup>  | Jeffrey S. Dover MD, FRCPC<sup>1</sup>

<sup>1</sup>SkinCare Physicians, Chestnut Hill, MA, USA

<sup>2</sup>skinbetter science, LLC, Phoenix, AZ, USA

## Correspondence

Diane Nelson, RN, MPH, Vice President, Medical, Clinical, and Scientific Affairs, skinbetter science, LLC, Phoenix, AZ, USA.  
Email: diane.nelson@dermaforce.com

## Funding information

skinbetter science, LLC

## Abstract

**Introduction:** There is growing interest in skincare products designed for men. This pilot study evaluated the efficacy and tolerability of a comprehensive antioxidant product in men.

**Methods:** This 12-week study evaluated improvements from baseline in erythema, lines/wrinkles, skin tone, texture, brightness, dryness/flaking and pores (6-point scale), global improvements (5-point scale), and sebum levels following daily application in males with mild to moderate photodamaged skin. Subject self-assessments and adverse events (AEs) were captured.

**Results:** Twenty-two subjects completed the study. Early mean percent improvements from baseline were demonstrated in all categories at week 4 with visible improvements in skin tone (29%;  $p = .0001$ ) and pores (28%;  $p < .0001$ ). Reductions in skin surface sebum levels (forehead region) from baseline were demonstrated at 8 ( $p < .0001$ ) and 12 ( $p < .0003$ ) weeks. Ninety-six percent of subjects reported overall visible improvement of their skin and that the study product calmed/soothed skin, reducing redness and irritation after shaving. One subject reported mild dryness.

**Conclusion:** Once daily application of a comprehensive topical antioxidant designed for men led to significant improvements in skin appearance, substantial reductions in skin surface sebum levels, and was well tolerated with a high level of subject satisfaction over 12 weeks.

## KEYWORDS

antioxidants, hydration, male skin, pores, sebum reduction, skincare

## 1 | INTRODUCTION

Research in photoaging and cosmetics has historically focused on female skincare needs. However, the number of men seeking skincare

products and minimally invasive cosmetic procedures to address their specific needs has grown substantially over the past decade. In 2019, men accounted for 1.1 million minimally invasive cosmetic or plastic surgery procedures.<sup>1</sup> Notably, almost 20% of microdermabrasion

[Corrections added on August 9, 2021 after first online publication: Layout of figure parts has been updated.]

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2021 Skinbetter science, LLC/ Derma Forece. *Journal of Cosmetic Dermatology* published by Wiley Periodicals LLC

procedures were performed on men, along with nearly 61,000 hyaluronic acid (HA) soft tissue filler procedures.<sup>1</sup> Despite growing utilization of surgical and minimally invasive procedures, the vast majority of men are increasingly interested in non-invasive means to look younger, healthier and to improve their appearance.<sup>2</sup> Men are becoming more aware of the role skincare plays in improving the quality and appearance of their skin, particularly in light of increased use of social media and growing reliance on video-conferencing. In addition, greater access to information and products via the internet allows male consumers to bypass in-person shopping. Men also perceive that their busy lifestyle necessitates a streamlined approach to skincare that can be easily integrated into their shaving routine to efficiently optimize the time they spend on grooming. Interestingly, a comparative study from 2010 that included 1000 men and 1000 women reported that men spend only 7 minutes less than women on their appearance and nearly 75% of men reported feeling pressured to spend more time attending to their appearance.<sup>3</sup> As a result, men are incorporating skincare products into their daily regimens to help improve the overall quality of their skin and enhance their appearance.<sup>2,4</sup> Consequently, men's personal care and skincare products are anticipated to grow substantially over the next five years.<sup>5,6</sup>

The basic structure and function of skin biology between the genders is similar with regard to biochemical and cellular processes as well as sensorial response. However, there are structural differences in skin thickness, the amount of collagen and rate of collagen loss, the amount of subcutaneous fat, and the rate in which facial aging occurs.<sup>7-10</sup> Gender differences in facial skin anatomy and physiology as well as distinct preferences necessitate targeted and customized products developed specifically to address the unique needs of men.<sup>2</sup>

## 1.1 | Hormonal Influences

Differences between male and female facial skin are predominantly influenced by circulating hormones. Female skin is affected by estrogen and male skin is primarily affected by androgens, including testosterone and 5 $\alpha$ -dihydrotestosterone (DHT).<sup>2</sup> Estrogen provides favorable, protective benefits to skin, contributing to collagen synthesis and the production of elastic fibers and hyaluronic acid.<sup>8,11,12</sup> Estrogen has been shown to increase the water-binding capacity of skin and modulate local inflammation, granulation, and re-epithelialization of skin,<sup>12</sup> resulting in improved skin barrier integrity and wound healing capacity.<sup>9,12</sup> Furthermore, premenopausal females have greater subcutaneous fat compared to similarly aged males, providing protection from a thinning dermis.

Testosterone thickens the tissue surrounding the dermal and epidermal skin layers, facilitating collagen production. While both men and women produce sebum, greater production owing to higher levels of testosterone in men causes their sebum production rates to remain relatively stable with age. This has both positive and negative effects on male skin. While increased sebum helps facilitate the absorption of oils to moisturize skin, it also contributes to acne and

makes skin feel more tacky or oily and pores appear larger and more pronounced.<sup>8,13-15</sup>

Testosterone also stimulates terminal hair growth on the face. Terminal facial hair is coarse, thick and more darkly pigmented, which affords protection against UV rays and prevents the development of wrinkles in areas covered by facial hair.<sup>8,13,16,17</sup> Shaving exposes otherwise protected skin to ultraviolet radiation, strips and traumatizes skin causing irritation, razor burn, and pseudofolliculitis barbae. These routine insults to the skin barrier are compounded by slower wound healing rates and re-epithelialization in comparison to women's skin, as wound healing is accelerated by estrogen and inhibited by 5 $\alpha$ -DHT.<sup>9,13,18</sup>

## 1.2 | Skin Hydration and pH

Inconsistent findings have been reported regarding potential gender differences in skin hydration parameters, particularly in stratum corneum hydration and rates of transepidermal water loss (TEWL), as well as in skin pH.<sup>10</sup> Generally, greater levels of hydration of the stratum corneum are present in men as compared to their female counterparts.<sup>10,16</sup> While a number of early studies found no differences in TEWL between men and women,<sup>19-22</sup> a more recent study published by Lueberding et al. found that although gender differences in TEWL diminish over time, males consistently present with lower overall rates of TEWL than females.<sup>16</sup> Some reports suggest that skin hydration begins to decrease in men around age 40 (earlier than women),<sup>8,10</sup> with the highest rate of TEWL between 50 and 59 years of age, likely owing to diminished testosterone levels.<sup>8,16</sup> Among studies that found gender differences in pH, male skin consistently had a lower pH than female skin, which affects lipid metabolism and barrier homeostasis.<sup>8,10,13</sup>

## 1.3 | Environmental Effects

Male skin is believed to be phenotypically more chronically inflamed and responds differently to environmental insults such as UV, heat, and stress in comparison to female skin.<sup>9</sup> Research has shown that male skin has a 16% lower minimal erythema dose (MED) threshold versus female skin – likely due to a lack of estrogen and its protective benefits.<sup>23</sup> Consequently, male skin is more vulnerable to environmental insults, and particularly to UV exposure, contributing to skin damage and accelerated skin aging.<sup>9,10,24</sup> Additionally, recent data from the cross-sectional National Health Interview Survey – Cancer Control Supplement (NHIS) involving more than 31,150 adults reported that only 22.1% of men regularly used sunscreen with SPF $\geq$ 15 compared with 40.2% of women.<sup>25</sup> Similarly, another study of nearly 2,450 adult outdoor runners found that only 17% of males versus 33% of females reported adequate sun-protective behaviors.<sup>26</sup> Greater susceptibility to the effects of UV-radiation coupled with inadequate sun-protective measures leads to a greater risk and incidence of

both nonmelanoma and melanoma skin cancers, as well as skin aging effects in men.<sup>9,27-32</sup>

Skincare for men is evolving based on our understanding of the specific properties and needs of male skin.<sup>9,13</sup> Engineered to address the unique characteristics of male skin, a new formulation (Solo Hydrating Defense™ Men [SHD-M]) utilizes a balanced ratio of 19 water-soluble, enzymatic, and lipid-soluble antioxidants (WEL antioxidant technology) coupled with ingredients purposefully selected to hydrate and support the skin barrier, soothe and calm skin, and help balance skin surface sebum levels (Table 1). Previous clinical studies performed on a formulation employing WEL antioxidant technology demonstrated its ability to inhibit UV-induced erythema and the expression of biomarkers related to skin damage (thymine dimers, MMP-9, p53, and sunburn cells) and reduce the suppression of CD1a Langerhans cells.<sup>33</sup> Recent studies have demonstrated WEL's ability to inhibit ozone-induced oxidative stress utilizing a human skin model and inhibit the generation of reactive oxygen species (ROS) induced by blue light and pollution in human skin.<sup>34,35</sup>

The formulation being investigated herein evaluated efficacy and tolerability in males with mild to moderate photodamaged skin following daily use over 12 weeks.

## 2 | MATERIALS AND METHODS

### 2.1 | Study Design

This single-center, open-label, clinical trial was performed by two board-certified dermatologists under Independent Review Board (IRB; Advarra IRB, Columbia, MD, USA) approval in conjunction with current Good Clinical Practices (cGCP) guidelines. The study was conducted over the course of 12 weeks to evaluate the efficacy and tolerability of daily application (AM) of SHD-M in male subjects, Fitzpatrick Skin Types I-V, aged 25–65 years with mild to moderate photodamaged skin who routinely shave 3–4 times per week. Subjects were ineligible for enrollment if they had unshaven facial hair, had dermatologic conditions (such as severe acne vulgaris and/or cystic acne, acne conglobata, acne fulminans, severe rosacea, facial seborrheic dermatitis, or autoimmune diseases [e.g., systemic lupus erythematosus]), or had demonstrated previous hypersensitivity to any ingredients in the product. Subjects were ineligible if they had, in the prior 2 weeks, used any cosmetic product containing AHAs/BHA (e.g., glycolic acid, lactic acid, or salicylic acid), peptides, growth factors, antioxidants, or non-prescription retinoids/retinol or like ingredients, unless they agreed to a 2-week washout period during which they refrained from using the disqualifying product. Similarly, subjects who were currently or had used, in the prior 4 weeks, any oral or topical prescription or over-the-counter acne treatment products, or any prescription retinoid/retinol or like product, were eligible only if they agreed to a 4-week washout period during which they refrained from using the product.

Digital images were obtained at baseline, 4-, 8-, and 12-week visits. Investigators evaluated changes from baseline in the appearance

of erythema, lines/wrinkles, skin tone, skin texture, skin brightness, dryness/flaking, and pore size using a 6-point grading scale (0=None, 1=Minimal, 2=Mild, 3=Moderate, 4=Moderately Severe, 5=Severe). Photographic images were captured utilizing Canfield VISIA®-CR digital imaging system (Canfield Scientific, Parsippany, NJ). Global improvement was assessed by the investigators at the 4-week, 8-week, and 12-week visits using a 5-point grading scale (0=None, 1=Minimal Improvement, 2=Mild Improvement, 3=Moderate Improvement, 4=Marked Improvement). Photographs were taken 15–30 minutes after subjects had cleansed their face.

Skin surface sebum levels were obtained using non-invasive, bioinstrumentation (Sebumeter SM 815; Courage +Khazaka electronic GmbH, Köln, Germany) from the forehead, cheek, and chin regions at baseline, 4-, 8-, and 12-week visits. Measurements occurred at least 20 minutes after each subject had cleansed his face in the clinic to ensure skin had acclimated to the conditions in the clinic. Additionally, subjects were instructed not to apply study product the morning of their study visits so as not to interfere with measurements.

At 4-week, 8-week, and 12-week visits subjects completed a questionnaire to assess each subject's perception of their skin's appearance and their overall satisfaction with the study product. Evaluation and collection of adverse events (AEs) occurred throughout the study period.

### 2.2 | Statistical Analysis

Investigator evaluations and skin surface sebum measurements were analyzed as least squared (LS) mean improvement and percent (LS) mean improvement from baseline to each time point up to week 12. Global improvement was analyzed based on the observed values, and subject self-assessment responses were tabulated and calculated as average percent analyzed.

## 3 | RESULTS

Twenty-two of the 25 enrolled men completed the study and 3 were lost to follow-up. On average, subjects were 40 years of age; 60% were FST II, 36% were FST III, and 4% were FST V. Severity of photodamaged skin was almost evenly split with 52% of subjects presenting with mild severity and 48% of subjects presenting with moderate severity upon enrollment.

Early mean percent improvements from baseline were demonstrated in all categories at 4 weeks, with significant improvements from baseline in the appearance of erythema, lines/wrinkles, skin tone, skin texture, skin brightness, pores, and dryness/flaking (Table 2). Greatest improvements from baseline demonstrated at 4 weeks were observed in skin tone (29%;  $p < .0001$ ), pores (28%;  $p < .0001$ ), and skin texture (20%;  $p < .0005$ ). There was a significant improvement at 8 weeks in skin brightness (31%;  $p < .01$ ). After 12 weeks of daily use, there were significant mean visible

TABLE 1 Key Ingredients.

SKIN BENEFIT	INGREDIENT	INGREDIENT PROPERTIES
Hydration and Barrier Support	<b>Isosorbide Dicaprylate</b>	Supports skin hydration and the skin barrier.
	<b>Opuntia Ficus-Indica Stem Extract</b>	Skin soothing and water-binding properties.
	<b>Hydrolyzed Sodium Hyaluronate</b>	Moisture retention and antioxidant activity.
	<b>Sodium PCA</b>	Natural humectant derived from L-Glutamic acid that helps hydrate skin.
	<b>Ceramide Blend</b>	A skin-identical lipid designed to moisturize skin and enhance the skin barrier.
	<b>Carnosine</b>	A potent antioxidant and peptide that defends skin against UV and IR-induced oxidative stress.
Soothing and Calming	<b>Linoleic Acid and Linolenic Acid</b>	An essential fatty acid (Vitamin F) complex that supports the skin barrier.
	<b>Salicylic Acid</b>	Anti-inflammatory properties; reduces the appearance of redness, exfoliates and dissolves debris from pores.
	<b>Bisabolol and Zingiber Officinale (Ginger) Root Extract</b>	Ingredients work synergistically to help reduce redness and soothe the skin.
Oil Control	<b>Sea Whip Extract</b>	Possesses anti-inflammatory properties, soothes skin, and reduces the appearance of redness.
	<b>Nymphaea Caerulea Flower Extract (and) Nelumbo Nucifera Flower Extract</b>	Lotus flower blend that helps reduce excess skin surface sebum and has anti-inflammatory properties.
WEL Antioxidant Technology	<b>Cassia Alata Leaf Extract</b>	Plant extract that defends against UV-induced oxidative stress.
	<b>Proprietary Antioxidant Blend</b>	Provides synergistic antioxidant defense.
	<b>Vitamin C</b>	Provides antioxidant and collagen support.
	<b>Vitamin E</b>	Skin conditioning and antioxidant protection.
	<b>CoEnzyme Q10</b>	Potent antioxidant that enhances the skin's endogenous defense system.
	<b>Ergothioneine</b>	Potent antioxidant that defends against environmentally-induced oxidative stress.
	<b>Mediterranean Olive Extract</b>	Potent antioxidant rich in polyphenols that has anti-inflammatory properties, helps reduce TEWL and soothes skin.
	<b>Buddleja Officinalis Flower Extract</b>	Free radical scavenger that defends against the harmful effects of UV, blue light, and IR wavelengths.
	<b>Coffea Arabica (Coffee) Leaf Cell Extract (and) Crocus Sativus Leaf Cell Culture Extract</b>	Provides antioxidant defense against oxidative stress.
	<b>Superoxide Dismutase</b>	Enzymatic antioxidant that neutralizes the superoxide free radical and protects against environmentally-induced oxidative stress.
Anti-Pollution	<b>Licorice Root Extract</b>	Brightens the appearance of skin.
	<b>Ectoin and Hydroxyectoin</b>	Defends against oxidative stress induced by exposure to environmental pollutants.

improvements in erythema (24%;  $p < .01$ ) and lines/wrinkles (22%;  $p < .0005$ ). Dryness/flaking significantly improved throughout the study period through week 12 (30%;  $p < .01$ ). Global improvement was significant at all time points through week 12 ( $p < .0001$ ) (Figures 1–4).

Skin surface sebum measurements were analyzed from baseline at the 8- and 12-week time points only due to substantial fluctuations in readings and the capture of multiple measurements per region at week 4. Consequently, the protocol was amended to reflect the capture of only one reading per region and time point. Significant

reductions were achieved from baseline measurements at 8 and 12 weeks in skin surface sebum levels obtained from the forehead region (48%,  $p < .0001$  and 41%,  $p < .0003$ , respectively) (Table 3). There was also a significant reduction in skin surface sebum levels of the left cheek at 8 weeks (43%;  $p < .0007$ ), and nonsignificant reductions in skin surface sebum levels in the chin region (21% at 8 weeks and 7% at 12 weeks).

Subject satisfaction with the study product remained high over 12 weeks with 96% of subjects reporting an overall improvement

**TABLE 2** Mean Percent Improvements in Appearance from Baseline Continued Through Week 12.

Mean Percent Improvements in Appearance from Baseline Continued Through Week 12			
	4 WEEKS	8 WEEKS	12 WEEKS
ERYTHEMA	14% ( $p = .01$ )	8% (NS)	24% ( $p = .01$ )
LINES/WRINKLES	16% ( $p = .002$ )	19% ( $p = .001$ )	22% ( $p < .0005$ )
SKIN TONE	29% ( $p < .0001$ )	23% ( $p < .0002$ )	34% ( $p < .0001$ )
SKIN TEXTURE	20% ( $p < .0005$ )	13% ( $p = .03$ )	18% ( $p < .01$ )
SKIN BRIGHTNESS	23% ( $p = .02$ )	31% ( $p = .01$ )	13% (NS)
PORES	28% ( $p < .0001$ )	22% ( $p < .0002$ )	21% ( $p < .0005$ )
DRYNESS / FLAKING	20% ( $p = .02$ )	24% ( $p = .02$ )	30% ( $p = .01$ )

Abbreviation: NS, Not Statistically Significant.

in the appearance of their skin at week 4. Importantly, subjects reported that the study product calmed and soothed their skin, reducing redness and irritation after shaving. Subjects (96%) also reported that their skin tone was more even-looking in appearance and felt smoother after 12 weeks of use. Additionally, 91% of subjects reported that their pores were less visible in appearance at 12 weeks. All subjects reported that the study product absorbed well, did not leave their skin feeling greasy and had a pleasant texture and feel. One subject reported mild skin dryness at week 12. No other AEs were reported during the study period and no subject discontinued the study owing to an AE.

## 4 | DISCUSSION

Growing interest in noninvasive treatments to improve their appearance has led men to seek efficacious skincare products designed to address their specific needs and can easily be integrated into their daily routines. Male skin is predominantly influenced by testosterone and characterized by greater sebum production and epidermal thickness.<sup>8,10</sup> While increased sebum production affords skin moisturization and lubrication, it is also associated with acne and larger, more pronounced pores.<sup>8,13-15</sup> Additionally, the presence of terminal facial hair and regular shaving irritate skin resulting in erythema, dryness and flaking, and pseudofolliculitis barbae. Male skin is more vulnerable to environmental insults, such as UV and infrared (IR) radiation, heat, and stress.<sup>9</sup> Consequently, products that contain antioxidants and afford protection against environmental insults are an essential component to the overall health of male skin. The product evaluated in this clinical trial was purposefully developed to address the unique



**FIGURE 1** (A). Baseline (B). Week 4

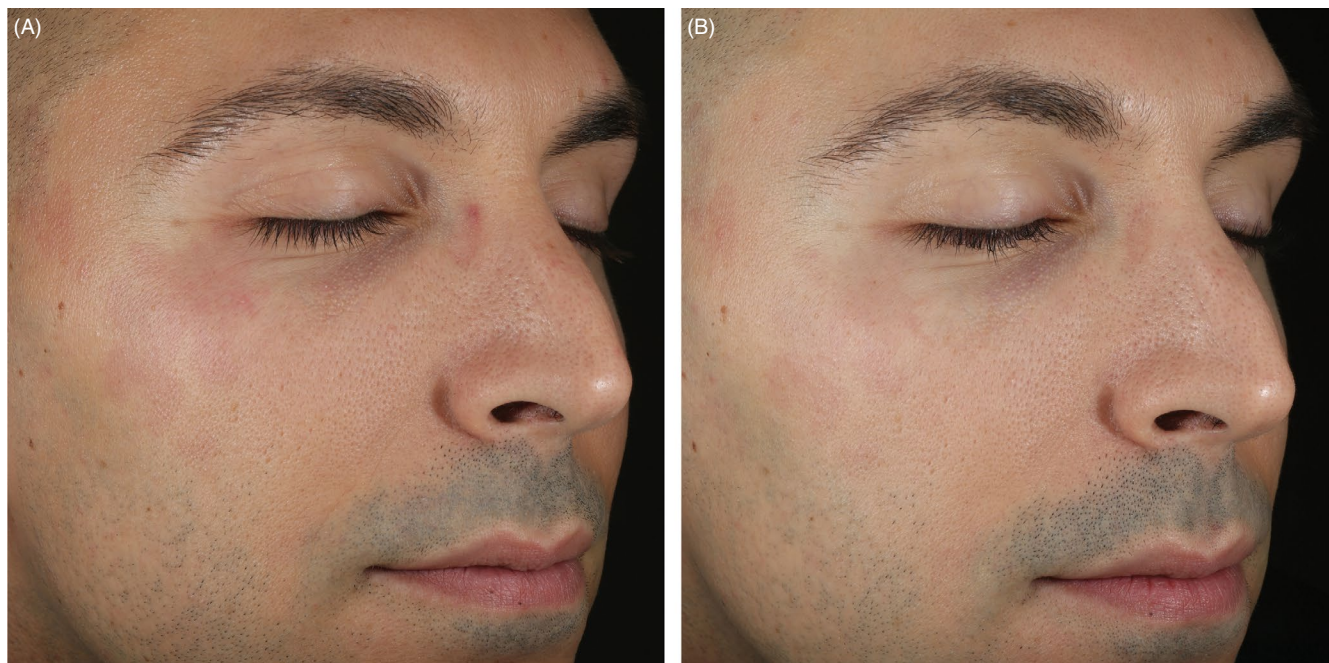


FIGURE 2 (A). Baseline (B). Week 8



FIGURE 3 (A). Baseline (B). Week 12

characteristics of male skin utilizing established antioxidant technology that combines 19 water-soluble, enzymatic, and lipid-soluble antioxidants (WEL), formulated with ingredients to hydrate, soothe and calm skin following shaving, and balance skin surface sebum levels.

Once-daily use of the study product resulted in early improvements demonstrated across all investigator-assessed categories at 4 weeks with subjects achieving significant mean percent improvements from

baseline in the appearance of erythema, lines/wrinkles, skin tone, skin texture, skin brightness, pores, and dryness/flaking. Improvements in the appearance of skin and dryness/flaking progressively improved throughout the study period demonstrating 34% and 30% significant improvements from baseline ( $p < .0001$  and  $p < .01$ , respectively) at week 12. Global improvement remained statistically significant from baseline at all time points throughout the study ( $p < .0001$ ).



FIGURE 4 (A). Baseline (B). Week 12

TABLE 3 Mean Percent Reductions in Skin Surface Sebum Levels from Baseline ( $\mu\text{g}/\text{cm}^2$ ).

Mean Percent Reductions in Skin Surface Sebum Levels from Baseline ( $\text{Mg}/\text{Cm}^2$ )			
	FOREHEAD	CHEEK	CHIN
Baseline	47	21	35
8 WEEKS	21 (48%) ( $p < .0001$ )	9 (43%) ( $p < .0007$ )	19 (21%) (NS)
12 WEEKS	26 (41%) ( $p < .0003$ )	13 (14%) (NS)	26 (7%) (NS)

Abbreviations: NS, Not Statistically Significant.

Objective biometric measurements of skin surface sebum levels were obtained at each study visit. Subjects were instructed not to apply study product or support products the morning of their scheduled visits so as not to influence readings. Greatest reductions from baseline in skin surface sebum levels were observed in the forehead region, with significant reductions at both 8 and 12 weeks (48% [ $p < .001$ ] and 41% [ $p < .0003$ ], respectively). As has been demonstrated previously, sebum production varies by location and is highest in the forehead region.<sup>8</sup>

Owing to challenges in recruiting for a 12-week all-male clinical trial, this pilot study was limited by a small number of subjects. A larger, controlled study would further validate our initial findings. Additionally, while the concurrent use of a light moisturizer may have contributed to reductions in skin dryness and flaking, the study occurred in the Northeast region of the United States from October through January and eliminating the use of a moisturizer may have negatively influenced the skin barrier,

particularly among those men accustomed to using a moisturizer. Nevertheless, high and early levels of subject satisfaction were reported including improvements in the overall appearance of skin, skin tone, and pores. Noteworthy, 96% of subjects reported that the use of the study product calmed and soothed their skin, reducing redness and irritation after shaving. Moreover, while 40% of subjects acknowledged they had never previously used a moisturizer, 91% of subjects reported they would continue to use the study product after the study concluded.

In conclusion, once-daily use of a comprehensive, hydrating topical antioxidant developed to address the specific needs of male skin demonstrated early, significant visible improvements in the appearance of skin and substantial reductions in skin surface sebum levels over 12 weeks. Subjects reported high levels of satisfaction in their appearance. The study product was well tolerated throughout the study period.

#### ETHICAL APPROVAL

This single-center, open-label, clinical trial was performed by two board-certified dermatologists under Independent Review Board (IRB; Advarra IRB, Columbia, MD, USA).

#### CONSENT FOR PUBLICATION

All subjects have provided consent for their photographs to appear in any publication stemming from the findings of the study.

#### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

## ORCID

Diane B. Nelson  <https://orcid.org/0000-0002-5584-1574>

## REFERENCES

- American Society of Plastic Surgeons (ASPS). Plastic Surgery Statistics Report for 2019. 2020. <https://www.plasticsurgery.org/documents/News/Statistics/2019/plastic-surgery-statistics-full-report-2019.pdf>
- de Lacerda D, Thioly-Bensoussan D, Burke K. Cosmeceuticals for men. *Cutis*. 2013;Suppl:6–12.
- Donahue K. Do you get flack for taking too long to get ready? *Allure*, 2010. <http://www.allure.com/beauty-trends/blogs/daily-beauty-reporter/2010/07/do-you-get-flack-for-getting-r.html> Accessed August 3, 2020.
- Makino ET, Jiang LI, Tan P, Cheng T, Mehta RC. Addressing male facial skin concerns: clinical efficacy of a topical skincare treatment product for men. *J Drugs Dermatol*. 2018;17(3):301-306.
- Businesswire. Global men's skincare products market 2020-2024; Growing popularity of antipollution skincare products to boost growth (Technavio). Available at: <https://www.Businesswire.com/news/home/20200615005302/en/Global-Mens-Skincare-Products-Market-2020-2024-Growing>
- CNBC. Men are a multibillion-dollar growth opportunity for the beauty industry. Published May 17 2019. <https://www.CNBC.com/2019/05/17/men-are-a-multibillion-dollar-growth-opportunity-for-the-beauty-industry.html>
- Draelos ZD. Cosmeceuticals for male skin. *Dermatol Clin*. 2018;36:17-20.
- Luebberding S, Krueger N, Kerscher M. Age-related changes in male skin: quantitative evaluation of one hundred and fifty male subjects. *Skin Pharmacol Physiol*. 2014;27:9-17.
- Oblong JE. Male skin care: shaving and moisturization needs. *Dermatol Ther*. 2012;25(3):238–243.
- Rahrovan S, Fanian F, Mehryan P, Humbert P, Firooz A. Male versus female skin: what dermatologists and cosmeticians should know. *Internat J Women's Dermatol*. 2018;4:122-130.
- Lephart ED. A review of the role of estrogen in dermal aging and facial attractiveness in women. *J Cosmet Dermatol*. 2018;17(3):282-288.
- Shu YY, Maibach HI. Estrogen and skin: therapeutic options. *Am J Clin Dermatol*. 2011;12(5):297-311.
- Draelos ZD. Male skin and ingredients relevant to male skin care. *Br J Dermatol*. 2012;166(Suppl 1):13-16.
- Lovási M, Szegedi A, Zouboulis CC, Töröcsik D. Sebaceous-immunobiology is orchestrated by sebum lipids. *Dermatoendocrinol*. 2017;9(1):e1375636.
- Mizukoshi K, Akamatsu H. The investigation of the skin characteristics of males focusing on gender differences, skin perception, and skin care habits. *Skin Res Technol*. 2013;19(2):91-99.
- Luebberding S, Krueger N, Kerscher M. Skin physiology in men and women: in vivo evaluation of 300 people including TEWL, SC hydration, sebum content and skin surface pH. *Int J Cosmet Sci*. 2013;35:477-483.
- Luebberding S, Krueger N, Kerscher M. Mechanical properties of human skin in vivo: A comparative evaluation in 300 men and women. *Skin Res Technol*. 2014;20:127-135.
- Gilliver SC, Ruckshanthi JP, Hardman MJ, et al. Sex dimorphism in wound healing: the roles of sex steroids and macrophage migration inhibitory factor. *Endocrinology*. 2008;149(11):5747-5757.
- Jacobi U, Gautier J, Sterry W, Lademann J. Gender-related differences in the physiology of the stratum corneum. *Dermatology*. 2005;211:312-317.
- Lammintausta K, Maibach HI, Wilson D. Irritant reactivity in males and females. *Contact Dermatitis*. 1987;17:276-280.
- Tupker RA, Coenraads PJ, Pinnagoda J, Nater JP. Baseline transepidermal water loss (TEWL) as a prediction of susceptibility to sodium lauryl sulphate. *Contact Dermatitis*. 1989;20(4):265-269.
- Wilhelm KP, Cua AB, Maibach HI. Skin Aging. Effect on transepidermal water loss, stratum corneum hydration, skin surface pH, and casual sebum content. *Arch Dermatol*. 1991;127:1806-1809.
- Broekmans WM, Vink AA, Boelsma E, et al. Determinants of skin sensitivity to solar irradiation. *Eur J Clin Nutr*. 2003;57:1222-1229.
- Xu H, Zheng Y-W, Liu Q, et al. Reactive oxygen species in skin repair, regeneration, aging, and inflammation. Chapter 5. <http://dx.doi.org/10.5772/intechopen.72747>
- Holman DM, Ding H, Guy GP Jr, et al. Prevalence of sun protection use and sunburn and association of demographic and behavioral characteristics with sunburn among US adults. *JAMA Dermatol*. 2018;154(5):561-568.
- Duarte AF, Nagore E, Silva JNM, et al. Sun protection behaviour and skin cancer literacy among outdoor runners. *Eur J Dermatol*. 2018;28(6):803-808.
- Akiba S, Shinkura R, Miyamoto K, et al. Influence of chronic UV exposure and lifestyle on facial skin photo-aging – results from a pilot study. *J Epidemiol*. 1999;9(Suppl. 6):S136-S142.
- Cormier JN, Xing Y, Ding M, et al. Ethnic differences among patients with cutaneous melanoma. *Arch Intern Med*. 2006;166:1907-1914.
- Madan V, Lear JT, Szeimies RM. Non-melanoma skin cancer. *Lancet*. 2010;375:673-685.
- Rigel DS. Epidemiology of melanoma. *Semin Cutan Med Surg*. 2010;29:204-209.
- Selgrade MK, Smith MV, Oberhelman-Bragg LJ, et al. Dose response for UV-induced immune suppression in people of color: differences based on erythral reactivity rather than skin pigmentation. *Photochem Photobiol*. 2001;74:88-95.
- Sortino-Rachou AM, Curado MP, Cancela MC. Cutaneous melanoma in Latin America: a population-based descriptive study. *Cad Saude Publica*. 2011;27:565-572.
- McDaniel DH, Waugh JM, Jiang LI, et al. Evaluation of the Antioxidant Capacity and Protective Effects of a Comprehensive Topical Antioxidant Containing Water-soluble, Enzymatic, and Lipid-soluble Antioxidants. *J Clin Aesthet Dermatol*. 2019;12(4):46-53.
- Pecorrelli A, McDaniel DH, Wortzman M, Nelson DB. Protective effects of a comprehensive topical antioxidant against ozone-induced damage in a reconstructed human skin model. *Arch Dermatol Res*. 2021;313(3):139-146.
- Wortzman M, Nelson DB. A Comprehensive Topical Antioxidant Inhibits Oxidative Stress Induced by Blue Light Exposure and Pollution in Human Skin Tissue. *J Cosmet Dermatol*. 2021;20(4):1160-1165. <https://doi.org/10.1111/jocd.13991>

**How to cite this article:** Sikora BC, Wortzman M, Nelson DB, Dover JS. A pilot study evaluating the efficacy and tolerability of a comprehensive, hydrating topical antioxidant developed specifically for men. *J Cosmet Dermatol*. 2021;20:2816–2823. <https://doi.org/10.1111/jocd.14314>