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Multi-Wavelength LED Photobiomodulation Improves Photoaged Skin of the Face, Neck, and Décolleté

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Abstract

Photoageing of the face, neck, and décolleté is driven predominantly by chronic ultraviolet exposure and can cause substantial aesthetic and psychosocial burden. Although red and near-infrared photobiomodulation (PBM) may improve wrinkles and skin quality, the effects of simultaneous 633, 830, 1072 nm light delivered by at-home light-emitting diode (LED) devices across these regions have not been evaluated in women. This study assessed biophysical, clinical and participant-reported effects of multi-wavelength PBM. Thirty-three women aged 41–55 years with dry, photoaged skin were enrolled. Thirty-one completed 56 days of treatment. Participants used face, neck and décolleté masks containing Veritace®-tested LEDs for 10 min per session, five times weekly. Endpoints included skin texture, elasticity, firmness, hydration, barrier function, colour, and erythema. A dermatologist graded fine lines and wrinkles at baseline and day 56, and participants completed satisfaction questionnaires. By day 56, significant improvements were observed in skin texture, elasticity, hydration, barrier function, erythema, and colourimetric indices. Dermatologist-assessed fine lines and wrinkles decreased significantly across all sites. Participants reported improved hydration, smoothness, radiance, firmness, and overall appearance. At-home mask use was associated with improvements in multiple measures of photoaged skin, but the study is limited by absence of a control group.

Keywords: low-level light therapy; LED; photobiomodulation; photoageing; skin texture; wrinkle reduction; red light therapy; led light therapy; skin rejuvenation; near infrared light therapy

1. Introduction

Ultraviolet (UV) radiation exposure can lead to premature skin ageing, also known as photoageing. Photoageing predominantly affects areas of repeated sun exposure, including the face, neck, and décolleté. Clinical features of photoageing include wrinkling, changes in skin texture and uneven pigmentation [1]. Telangiectasia and reduced skin laxity may also be observed [2]. Chronic UV exposure is associated with actinic keratoses and keratinocyte cancers, including cutaneous squamous cell carcinoma and basal cell carcinoma [3]. Increased reactive oxygen species (ROS) promote the up-regulation of matrix metalloproteinases (MMPs) and impair transforming growth factor β signalling, contributing to extracellular matrix degradation and reduced collagen synthesis in the skin [4]. Photoageing is also characterised by collagen fragmentation and loss, abnormal accumulation of elastin, and alterations in glycosaminoglycans and proteoglycans, collectively reducing the mechanical strength and elasticity of the skin.

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Although photoageing is neither a disease nor a life-threatening condition, visible changes associated with skin ageing may affect self-perception and confidence, which can be accompanied by feelings of self-consciousness or anxiety [5].

Low-level light therapy (LLLT), now more commonly termed photobiomodulation (PBM), uses red light (620–700 nm) and near-infrared light (700–1440 nm) to treat a range of dermatological concerns, including acne, hair loss, and skin rejuvenation, wound healing, and scarring [6,7]. An important light-absorbing target is cytochrome c oxidase (complex IV of the mitochondrial respiratory chain), which may absorb red and near-infrared photons, altering electron flow, mitochondrial membrane potential, adenosine triphosphate (ATP) production, and cellular redox balance [8]. PBM may also increase nitric oxide (NO) bioavailability through cytochrome c oxidase-dependent and other intracellular pathways, potentially influencing local blood flow and signalling pathways involved in collagen synthesis, antioxidant defense, and anti-inflammatory responses [9].

Clinical studies support the use of 633 nm (red) and 830 nm (near-infrared) light-emitting diode (LED)-based PBM for improving photoaged facial skin and supporting wound healing. In a prospective trial, Goldberg et al. treated 36 subjects with combined 633 nm and 830 nm LEDs over nine sessions across five weeks, reporting statistically significant wrinkle reduction, improved patient-reported skin quality, and electron microscopy evidence of thicker collagen fibres in photodamaged skin [10]. Similarly, home-use face masks emitting 630–635 nm red light have demonstrated good tolerability and significant improvements in wrinkles, texture, radiance, pore visibility, and overall photoageing scores following two to three months of twice-weekly use, alongside high patient-reported satisfaction [11]. Studies using comparable wavelengths have also reported improvements in skin elasticity, wrinkle severity, and dyspigmentation, further supporting investigation of low-level light therapy for skin rejuvenation [12–15].

Emerging data also support the rejuvenation potential of longer-wavelength 1072 nm near-infrared PBM. In a self-reported, double-blind, randomised controlled trial, regular non-thermal periorbital irradiation with 1072 nm light produced significant reductions in wrinkle scores compared with placebo [16]. In another six-week study, a home-use mask delivering simultaneous 633, 830, and 1072 nm LED wavelengths to seven male participants resulted in favourable changes on digital photographic analysis, including improvements in wrinkles, UV spots, brown spots, pores, and porphyrins, alongside high subjective satisfaction and perceived improvements in fine lines, texture, and youthful appearance [17]. Collectively, these findings support the potential utility of multi-wavelength 633/830/1072 nm PBM for facial rejuvenation.

Although previous studies have explored simultaneous 633/830/1072 nm LED PBM for facial rejuvenation, these investigations have been limited to small cohorts and have not evaluated concomitant treatment of the face, neck, and décolleté using comprehensive biophysical, clinical, and patient-reported outcome measures. In addition, despite women representing the predominant users of at-home aesthetic technologies and experiencing distinct structural and hormonal skin-ageing changes compared with men, there remains a lack of studies specifically evaluating this tri-wavelength approach in a female population. Furthermore, although LED devices are commonly described according to nominal wavelength outputs, device-level verification of wavelength and irradiance characteristics is not routinely reported in dermatological studies. In the present study, manufacturer-performed Veritace® quality-assurance testing was used to assess wavelength and output characteristics of the LEDs and completed masks.

In the current study, we evaluated devices incorporating Veritace®-tested LEDs delivering simultaneous 633, 830, and 1072 nm wavelengths. Veritace® testing is designed to verify wavelength accuracy and output consistency, helping ensure that the wavelengths

delivered correspond to those reported. Using masks providing full-face, neck, and décolleté coverage together with a defined irradiance-time profile, we investigated the effects of 56 days of at-home treatment with simultaneous 633/830/1072 nm LED PBM on mechanical and biophysical measures of skin quality, alongside clinical and participant-reported outcomes, in women with photoaged skin of the face, neck, and décolleté.

2. Materials and Methods

2.1. Tested Devices

The tested devices were the CurrentBody Series 2 Red Light Face Mask (The Beauty Tech Group, Macclesfield, UK) and Neck & Décolletage Mask (The Beauty Tech Group, Macclesfield, UK). Both fixed-output masks were specified to emit simultaneous red, near-infrared, and deep near-infrared light at nominal peak wavelengths of 633, 830, and 1072 nm, respectively. The face mask contained 110 633-nm LEDs, 110 830-nm LEDs, and 16 1072-nm LEDs; the neck and décolletage mask contained 110, 110, and 9 LEDs at the respective nominal wavelengths.

The irradiance of 30 mW/cm^2 represents the combined irradiance from all three wavelength channels, rather than the irradiance of each channel individually. With the fixed 10-min treatment cycle, this equates to a calculated total radiant exposure of 18 J/cm^2 per session (0.030 W/cm^2 $\times$ 600 s). Wavelength-specific irradiance and radiant-exposure values were not reported.

Device verification was conducted under the manufacturer's proprietary Veritace® quality-assurance programme. According to manufacturer documentation, individual LEDs and completed devices undergo verification of wavelength and output characteristics. Peak wavelength was measured using a spectrometer at the LED source. The manufacturer-specified wavelength acceptance criteria were 633 $\pm$ 2 nm and 830 $\pm$ 2 nm for the red and near-infrared channels, respectively, and 1072 $\pm$ 8 nm for the deep near-infrared channel. Device power output, battery capacity, temperature, LED placement and electrical safety were also checked; electrical-safety testing was performed by a third-party laboratory. Veritace® measurements were conducted by the manufacturer with CurrentBody team review and were not independently performed.

The reported combined irradiance reflects the device specification and was not independently mapped across the treatment area or measured at the skin interface in this study. All participants used the same fixed-output mask models for the prescribed 10-min sessions (Figure 1).

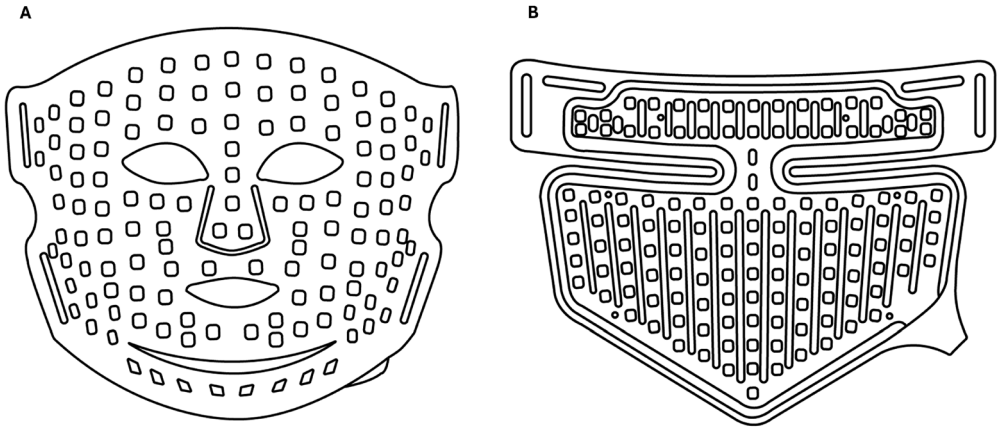


Figure 1. Veritace®-tested light-emitting diode (LED) placement for the CurrentBody Series 2 Face Mask (**A**) and Neck & Décolletage Mask (**B**).

2.2. Subjects

This study initially recruited 33 women aged between 41 and 55. Two participants withdrew due to personal reasons not related to the study. Therefore, 31 participants completed the study. All participants satisfied the inclusion criteria of dry dehydrated skin, fine lines and wrinkles, inelastic skin, and skin redness on the face, neck, and décolleté. Participants were not eligible for this study if they were in an exclusion period for another study; were deprived of liberty by an administrative or legal decision, under guardianship, or otherwise legally protected; could not be contacted in an emergency; planned hospitalisation during the study; or were staff members of the investigating centre. Pregnancy, breastfeeding, planned pregnancy, a history of adverse reactions to similar products, vaccination within the preceding two weeks or planned vaccination during the study, photosensitivity, and excessive natural or artificial UV exposure in the preceding month or planned UV exposure during the study were also grounds for non-inclusion. Washout periods were six months for systemic retinoids or desensitisation treatment; three months for other systemic anti-acne medication or starting or changing hormonal contraception or treatment; two months for topical retinoids or invasive aesthetic procedures on the face, neck, or décolleté; one month for other topical anti-acne medication or non-invasive aesthetic procedures on those areas; two weeks for anti-acne cosmetics, topical or systemic anti-inflammatory or antihistamine medication, or antibiotics; and five years for medication used to treat cancer. Participants were also ineligible if they anticipated starting an interfering treatment, changing hormonal treatment, or undergoing the specified aesthetic procedures during the study.

All data presented in this manuscript were collected and statistically analysed as part of Eurofins study 2025-753-4136, which was commissioned and funded by The Beauty Tech Group [18]. This study was coordinated by the Eurofins Cosmetics & Personal Care (Vimodrone, Italy) business line and conducted at Eurofins Cosmetics & Personal Care Italy Srl (Vimodrone, Italy). The lab is certified ISO 9001:2015 [19] and ISO 22716:2007 [20] and equipped with material and technical means suitable for non-invasive clinical efficacy research compatible with Good Clinical Practice (GCP) scopes and values, and the safety requirements for human subjects as recommended in the Helsinki Declaration.

Eurofins C&PC was responsible for the execution of the specific clinical and instrumental assessments described in this publication, in accordance with the approved study protocol.

All study procedures were conducted under applicable ethical and regulatory requirements, selected subjects voluntarily participated in the study, and minimum reimbursement was guaranteed in line with GCP and Helsinki declaration recommendations.

All participants provided written informed consent, including specific consent for the capture and publication of clinical images.

The study was designed, commissioned and conducted as an exploratory cosmetic efficacy/human-use study in healthy volunteers, rather than as a clinical trial investigating a therapeutic or health-related intervention. The LED mask evaluated is a commercially available consumer cosmetic device and was used by healthy participants under its normal intended conditions of use. It was not being investigated for the diagnosis, prevention or treatment of a disease or medical condition, and no therapeutic or medical claims were being evaluated. The study was conducted by Eurofins as a cosmetic efficacy study, with assessments designed to investigate changes in skin appearance and biophysical properties associated with normal product use. Accordingly, it was not prospectively registered as a clinical trial.

2.3. Endpoints

No single primary endpoint was prospectively designated. The study was designed to assess multiple aspects of skin quality across the face, neck and décolleté. All instrumental and clinical outcomes were evaluated without a primary-secondary hierarchy. Participant-reported perceptions and treatment tolerability were also assessed.

Skin texture—Antera 3D Pro (Miravex, Dublin, Ireland): Skin texture was quantified using Antera 3D Pro, which reconstructs a 3D height map from multi-directional illumination and computes texture (roughness) over a standardised region of interest (ROI).

Skin elasticity and firmness—Cutometer (Courage + Khazaka, Cologne, Germany): Skin mechanical properties were assessed using a Cutometer with a 2 mm probe, primarily sampling the epidermis. Deformation curves were recorded over 10 cycles in mode 1, with a three-second suction phase followed by a three-second relaxation phase at a negative pressure of 450 mbar. These were used to compute R2 (gross elasticity), R5 (net elasticity), R7 (biological elasticity), and F4 (passive resistance of the skin to force). Increases in R2, R5, and R7 from baseline were interpreted as improved skin elasticity. Decreases in F4 were interpreted as improved firmness.

Skin hydration—Corneometer (Courage + Khazaka): Skin surface hydration was measured using a Corneometer CM825, which quantifies changes in skin capacitance as relating to water content in the upper 10–20 μm of the epidermis. Higher Corneometer values (>45) reflect sufficiently moisturised skin; an increase from baseline was interpreted as an improvement in skin hydration.

Barrier protection (trans-epidermal water loss, TEWL)—Tewameter (Courage + Khazaka): TEWL was assessed using the Tewameter® TM Hex, which determines the water vapour density gradient directly above the skin surface, computing TEWL in $g/h/m^2$. Higher TEWL values indicate greater passive water loss and reduced barrier function. Lower TEWL values reflect improved barrier integrity.

Colorimetry—Colorimeter (Courage + Khazaka): Skin colour was assessed with a Skin-Colorimeter Flex CL 440, which provides CIE Lαb* index values; L* was used as a measure of skin luminance (lightness). Individual Typology Angle (ITA°) was computed as $ITA^\circ = \arctan[(L^* - 50)/b^*] \times 180/\pi$, allowing classification of skin colour from very light ($ITA^\circ > 55^\circ$) to dark ($ITA^\circ < -30^\circ$). Higher ITA° values indicate lighter skin.

Erythema index—Mexameter (Courage + Khazaka): Erythema was quantified using a Mexameter MX 18, which determines an erythema index (0–999 arbitrary units) from the absorption/reflection of green and red light by cutaneous haemoglobin. Higher Mexameter erythema index values reflect increased cutaneous redness; therefore, a decrease in erythema index from baseline was interpreted as a reduction in erythema.

Clinical grading of wrinkles and fine lines: A dermatologist used a 10-point scale to evaluate the presence of wrinkles and fine lines on the face, neck, and décolleté. 0 = No wrinkles/fine lines; 9 = Presence of severe wrinkles/fine lines.

Before and after images: Images of the face were taken using a VISIA 7 skin analysis system (Canfield Scientific, Inc., Parsippany, NJ, USA). Images of the neck and décolleté were taken with a digital camera (Nikon Corporation, Tokyo, Japan) and compared to determine clinical effect.

Participant perception of the treatment: At Day 56, participants completed study-specific questionnaires concerning perceived changes in skin appearance and quality and the usability of each mask. Items used either yes/no responses or a four point Likert scale (0 = disagree; 1 = slightly disagree; 2 = slightly agree; 3 = agree). Positive response rates were assessed against a neutral reference value of 50% using a sample-size-dependent, two-sided 95% criterion. A conservative threshold of 69.6%, for a 26–30 subject group was applied to this study.

2.4. Protocol

This was a monocentric, single-arm study. Baseline assessments, including efficacy measurements and clinical photography, were performed at Day 0 at the testing centre, during which participants also received their Veritace®-tested LED masks. Participants were instructed to use the devices for 10 min per session, five days per week, over 56 consecutive days. They were instructed to wash and dry the treatment areas and ensure that no skincare products were present before each session. They could apply their usual skincare products after the session ended. Efficacy assessments, clinical photography, and participant-reported outcome questionnaires were repeated at Day 56 following completion of the treatment period.

2.5. Statistics

Analyses compared baseline (Day 0) and Day 56 measurements in the 31 participants who completed the study. For each continuous outcome and anatomical site, the distribution of within-participant differences was assessed using the Shapiro–Wilk test. A paired Student's *t*-test was used when the differences met the normality criterion; otherwise, a Wilcoxon signed-rank test was used. The test applied to each outcome is identified in the study report. Statistical significance was defined as $p < 0.05$. All 31 participants who completed the study were included in the reported paired analyses, with baseline and Day 56 data available for each reported endpoint. No adjustment was made for multiple comparisons. Positive response rates were assessed against a neutral reference value of 50% using a sample-size-dependent, two-sided 95% confidence-interval-based criterion. A conservative threshold of 69.6% was applied to this study. An approximate two-sided 95% criterion was used, with the upper confidence-interval-based criterion calculated as $50 + 100/\sqrt{n}(\%)$. Using the smallest sample size in the 26–30 subject group ($n = 26$) gives 69.6% after rounding. This conservative threshold was applied to the 31-subject sample.

3. Results

Consistent use of the Veritace® LED masks for 56 days was associated with improvements in multiple parameters of skin quality and photoageing, including skin texture, elasticity, firmness, hydration, wrinkle severity, erythema, and pigmentation. Participants reported no adverse events or treatment-related discomfort and the dermatologist observed no issues.

3.1. Clinical Photography and Visible Skin Changes

Representative clinical photographs demonstrated visible improvements in the appearance of the face (Figure 2A), neck, and décolleté (Figure 2B) following 56 days of treatment, including reductions in erythema and an overall brightening effect.

3.2. Improvements in Skin Texture, Elasticity, Firmness, and Wrinkles

Significant improvements in skin texture were observed across the face, neck, and décolleté following treatment (Figure 3, Table A1). Skin texture scores significantly decreased in the face (5.53%, $p = 0.003$), neck (4.94%, $p = 0.041$), and décolleté (5.41%, $p = 0.007$), with lower scores indicating an improvement in skin texture.

Measures of elasticity and firmness also improved significantly across all anatomical sites. (Figure 4, Table A2). In the face, gross elasticity increased by 15.44% ($p = 0.002$), net elasticity increased by 15.32% ($p = 0.016$), and biological elasticity increased by 10.41% ($p = 0.027$) whilst F4 values decreased by 16.97% ($p = 0.016$), indicative of increased skin firmness. Similar improvements were observed in the neck, where gross elasticity increased by 12.82% ($p = 0.016$), net elasticity increased by 12.11% ($p = 0.008$), and biological elasticity

increased by 7.76% (p = 0.048) alongside a 12.13% reduction in F4 (p = 0.001). On the décolleté, gross elasticity increased by 13.09% (p = 0.0005), net elasticity increased by 12.47% (p = 0.005), and biological elasticity increased by 9.85% (p = 0.028) with a corresponding 12.55% reduction in F4 (p = 0.0001). Overall, the greatest biomechanical improvements were observed in the face.



Figure 2. (**A**) VISIA image of the left side of a participant's face at (**left**) day 0 and (**right**) day 56. (**B**) Nikon digital camera images of the neck and décolleté at (**left**) day 0 and (**right**) day 56.

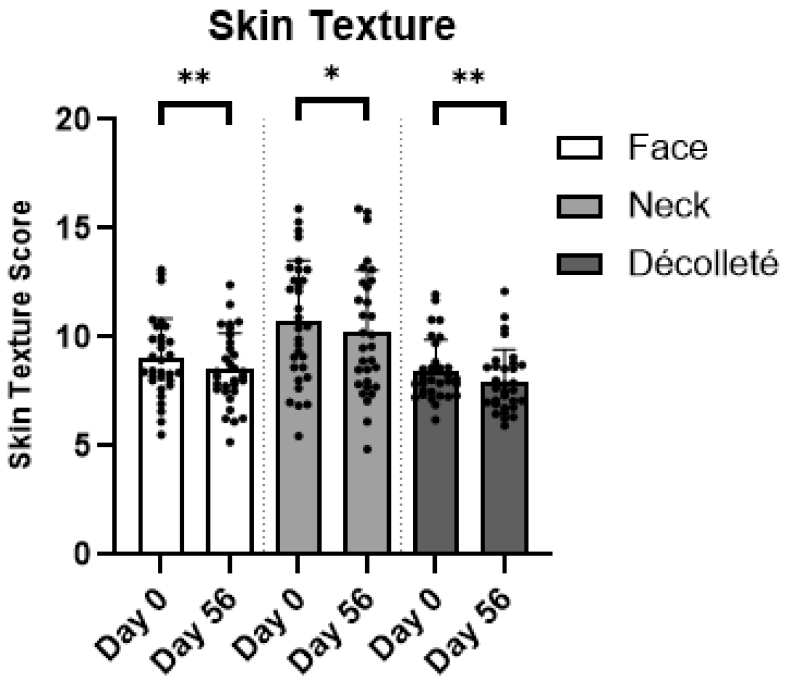


Figure 3. Effect of Veritace® light-emitting diodes (LEDs) on mean skin texture scores at Day 0 and Day 56. Error bars = standard deviation. Dots = individual data points. * = $p < 0.05$; ** = $p < 0.01$.

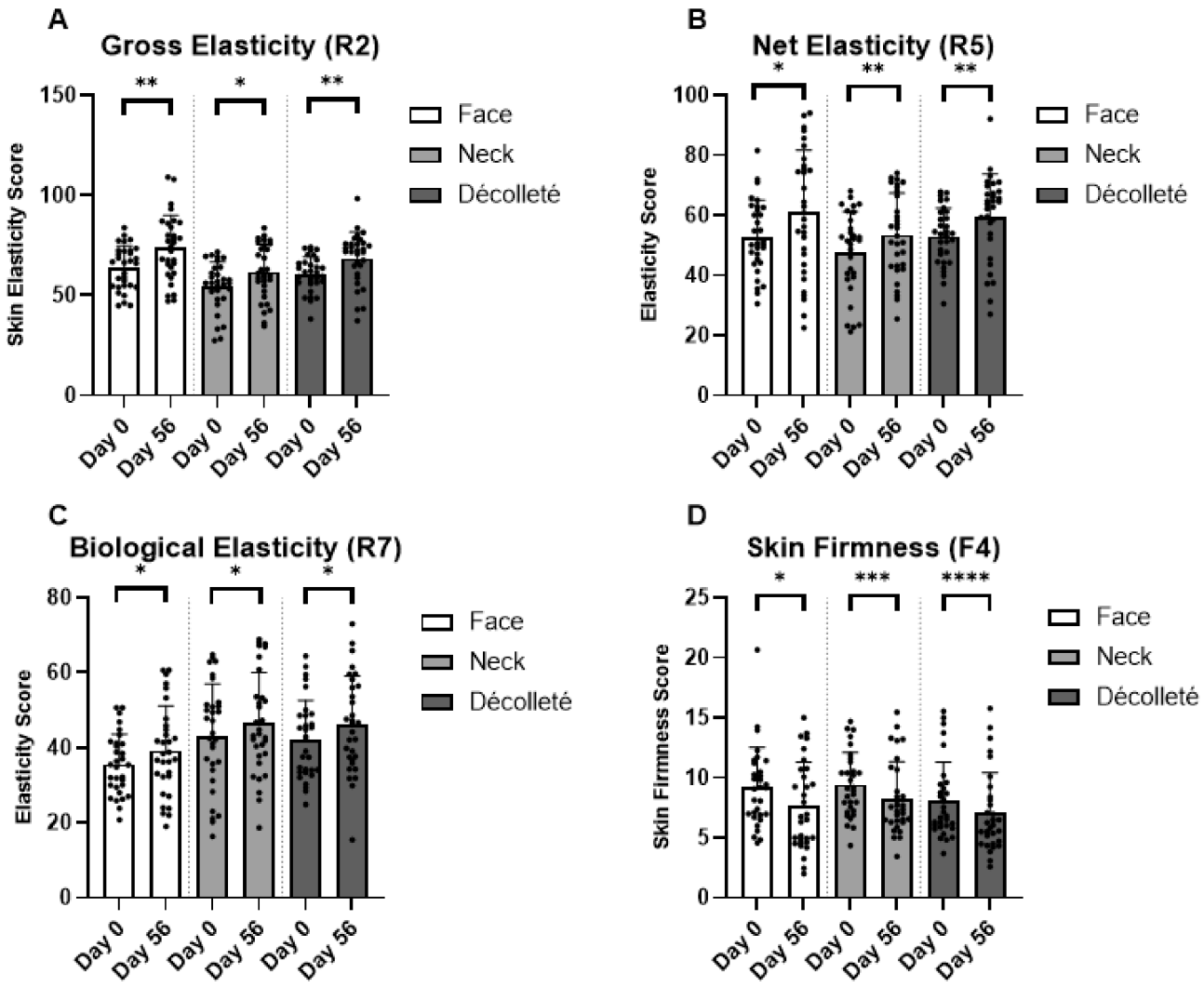


Figure 4. Effect of Veritace® light-emitting diodes (LEDs) on mean (**A**) Gross elasticity (R2), (**B**) Net elasticity (R5), (**C**) Biological elasticity (R7), and (**D**) Skin firmness (F4) at Day 0 and Day 56. Error bars = standard deviation. Dots = individual data points. * = $p < 0.05$; ** = $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

Wrinkle-associated parameters also significantly improved following treatment (Figure 5, Table A3). In the face, wrinkle depth decreased by 9.48% ($p = 0.001$), wrinkle length decreased by 8.13% ($p < 0.0001$), and wrinkle width decreased by 6.96% ($p = 0.001$). Comparable reductions were observed in the neck, including decreases in wrinkle depth (9.03%, $p = 0.001$), wrinkle length (7.99%, $p = 0.004$), and wrinkle width (6.88%, $p = 0.001$).

Dermatologist assessment further supported these findings, demonstrating significant reductions in fine line and wrinkle severity across all treatment areas (Table A4). Fine line and wrinkle scores decreased by 6.36% in the face, 6.70% in the neck, and 7.11% in the décolleté (all $p < 0.0001$).

3.3. Improvements in Skin Hydration and Barrier Function

Significant improvements in skin hydration and barrier integrity were observed following treatment (Figure 6, Table A5). Skin hydration significantly increased across all anatomical sites by Day 56, with the largest improvement observed in the face (35.33%, $p < 0.0001$). Correspondingly, TEWL significantly decreased across all sites, with the greatest improvement observed on the face (19.98%, $p < 0.0001$), indicative of enhanced skin barrier function.

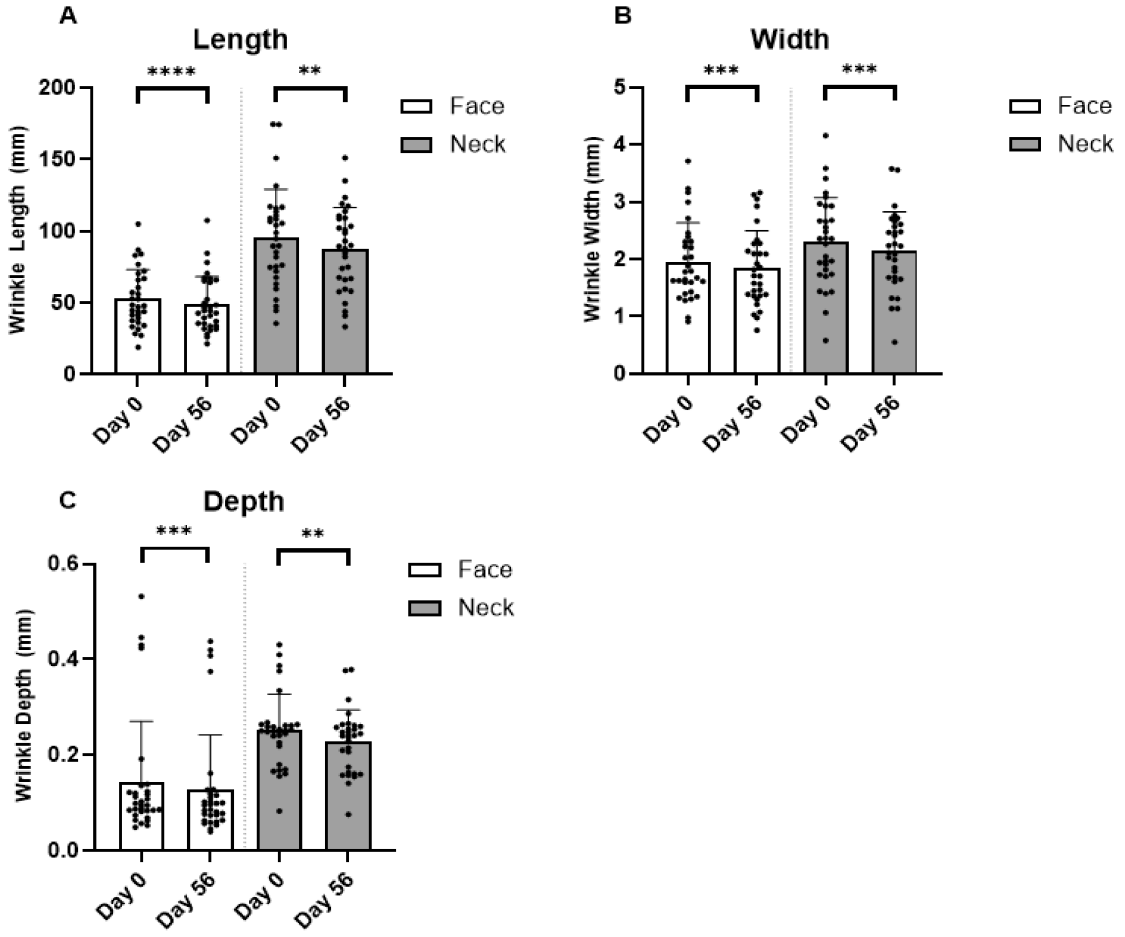


Figure 5. Effect of Veritace® light-emitting diodes (LEDs) on mean (**A**) Wrinkle length, (**B**) Wrinkle width, and (**C**) Wrinkle depth (mm) at Day 0 and Day 56. Error bars = standard deviation. Dots = individual data points. ** = $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

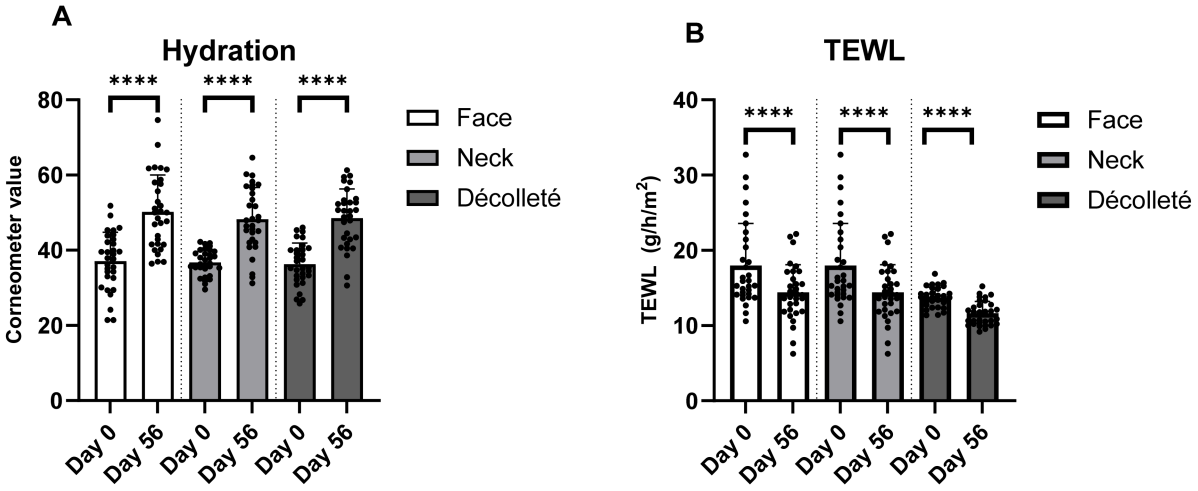


Figure 6. Effect of Veritace® light-emitting diodes (LEDs) on mean (**A**) Skin hydration and (**B**) Transepidermal water loss (TEWL) at Day 0 and Day 56. Error bars = standard deviation. Dots = individual data points. **** $p < 0.0001$.

3.4. Improvements in Erythema and Skin Tone

Significant changes in erythema and skin tone measurements were also observed following treatment (Figure 7, Table A6). Colorimetric analysis demonstrated a significant increase in skin luminance within the décolleté area (1.41% increase, $p = 0.008$). Individ-

ual Typology Angle (ITA) measurements also increased significantly in the neck (3.30%, $p = 0.019$) and décolleté (7.91%, $p = 0.0001$), indicating a skin brightening effect. Erythema index scores decreased significantly in the face (5.63%, $p = 0.012$), neck (4.93%, $p = 0.023$), and décolleté (5.51%, $p = 0.005$).

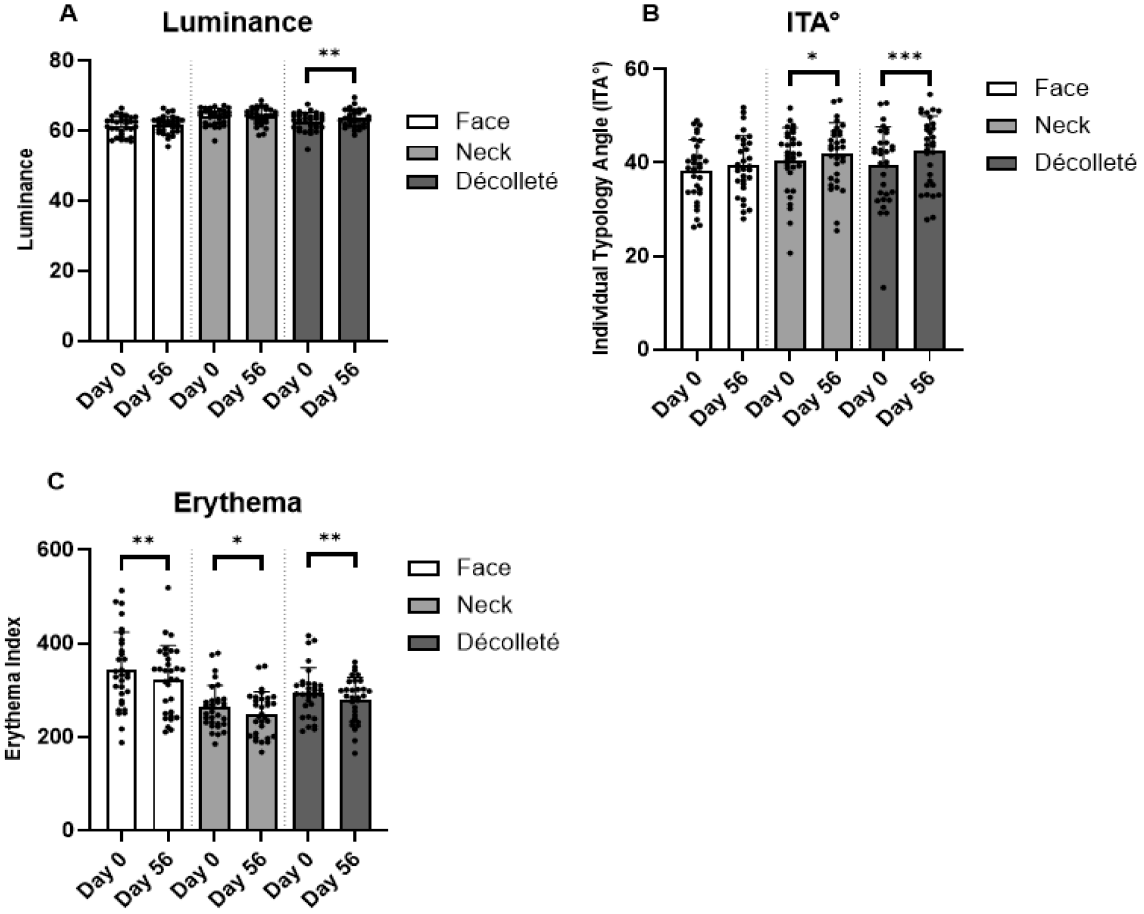


Figure 7. Effect of Veritace® light-emitting diodes (LEDs) on mean (**A**) Skin Luminance, (**B**) Individual Typology Angle (ITA), and (**C**) Erythema Index at Day 0 and Day 56. Error bars = standard deviation. Dots = individual data points. * = $p < 0.05$; ** = $p < 0.01$; *** $p < 0.001$.

3.5. Participant-Reported Outcomes

Participants reported high satisfaction with both the cosmetic properties and perceived efficacy of the devices (Tables A7–A9). These subjective outcomes were broadly consistent with the objective biophysical and clinical findings observed throughout the study. After 56 days, 87–100% of participants reported improvements in overall skin appearance, hydration, smoothness, and radiance across the face, neck, and décolleté. 87–97% reported visible improvements in fine lines and wrinkles, firmness, and skin rejuvenation across treated areas. Participants exhibited high satisfaction (94–97%) and felt that the device was comfortable and easy to integrate into existing skincare routines. While these findings were positive, it should be noted that due to the lack of blinding and control groups, responses may have been influenced by participants' expectations of the product.

4. Discussion

In this open-label, single-arm study, 56 days of at-home use of masks delivering simultaneous 633, 830, and 1072 nm wavelengths were well tolerated and associated with statistically significant improvements from baseline in multiple parameters of photoaged skin of the face, neck, and décolleté.

The present findings are consistent with the growing body of literature supporting the use of red and near-infrared PBM for skin rejuvenation. Previous studies using 633 nm and 830 nm LEDs have reported improvements in wrinkles, skin texture, elasticity, and overall skin appearance, alongside evidence of increased collagen fibre thickness and dermal remodelling [10]. More recently, simultaneous multi-wavelength 633/830/1072 nm PBM was shown to improve facial skin quality parameters in a small cohort of male participants following six weeks of home use [17]. Our findings add prospective data from a female cohort and include assessment of the neck and décolleté, two chronically photo exposed yet comparatively understudied anatomical regions.

The inclusion of women exclusively in the present study provides a clinically relevant focus, given sex-related differences in some facial skin characteristics and the age-related changes in skin parameters observed in women [21]. Despite this, relatively few PBM studies have specifically focused on female cohorts or incorporated treatment of the neck and décolleté alongside the face. The current findings, therefore, provide clinically relevant data within a population likely to represent the primary end users of at-home PBM technologies.

An additional consideration in PBM research is the accurate characterisation and reporting of light delivery. Although LED devices are commonly described by their nominal wavelengths, independent validation of delivered dose is not consistently reported in dermatological studies [22]. This is relevant because differences in wavelength, irradiance, fluence, and other treatment parameters can complicate the interpretation and comparison of PBM findings. In the present study, the masks emit a combined irradiance of 30 mW/cm^2 across the nominal 633-, 830-, and 1072-nm channels, corresponding to a calculated total radiant exposure of 18 J/cm^2 during the fixed 10-min cycle. Veritace® testing provided unit-level verification of selected wavelength and output characteristics; however, wavelength-specific irradiances, independent verification, and irradiance mapping across the treatment area were not available. These details should be reported in future studies to facilitate dose–response interpretation and cross-study comparison.

An important strength of the present study was the inclusion of multiple objective biophysical measurements alongside dermatologist grading and patient-reported outcomes, allowing simultaneous assessment of multiple clinically relevant aspects of skin ageing. Improvements in elasticity, firmness, and wrinkle-associated parameters may reflect previously proposed PBM-mediated effects on extracellular matrix (ECM) remodelling [8]. Red and near-infrared wavelengths have been shown to influence mitochondrial activity, cellular redox balance, nitric oxide signalling, and downstream pathways involved in collagen synthesis, tissue repair, and matrix metalloproteinase regulation [6,7,23]. Although mechanistic and definitive efficacy conclusions cannot be drawn directly from the current study, the observed improvements in skin biomechanics are consistent with the hypothesis that multi-wavelength PBM may support dermal remodelling and restoration of structural skin integrity.

In addition to biomechanical improvements, treatment was associated with significant increases in skin hydration and concomitant reductions in TEWL, suggesting improvements in epidermal barrier integrity and overall skin homeostasis. Enhanced barrier function may also indirectly contribute to the perceived improvements in skin smoothness, softness, radiance, and overall appearance reported by participants. Furthermore, significant reductions in erythema and improvements in colorimetric measurements were observed across treated sites, indicating that PBM may also influence visible skin tone and redness associated with photoaged skin. Collectively, the observed baseline-to-Day-56 changes are consistent with the hypothesis that simultaneous 633/830/1072 nm PBM may influence multiple aspects of skin quality beyond wrinkle-related measures.

Several limitations should be considered when interpreting these findings. The study used a single-arm, open-label design without a placebo or sham-treated control group, increasing the risk of expectation bias and limiting causal inference regarding the specific contribution of PBM relative to placebo effects or other confounding variables. Participants were permitted to continue their usual skincare routines to reflect real-world use of the at-home devices. However, a contribution from concomitant skincare to the observed changes cannot be excluded. In addition, although statistically significant improvements were observed across multiple endpoints, the absence of histological or molecular analyses limits mechanistic insight into the biological pathways underlying these changes. No direct assessment of collagen organisation, elastic fibre architecture, extracellular matrix remodelling, or inflammatory mediators was performed.

Randomised controlled studies incorporating histological and molecular analyses of skin biopsies obtained following the same treatment regimen will be important to further define the mechanisms underpinning the observed clinical and biophysical improvements.

5. Conclusions

In this 56-day at-home study, use of LED masks simultaneously delivering 633, 830, and 1072 nm wavelengths to the face, neck, and décolleté was associated with improvements from baseline in elasticity, wrinkle-associated parameters, hydration, texture, barrier function, and erythema, with changes in colourimetric measures at some anatomical sites. These findings were accompanied by high participant-reported satisfaction and no reported treatment-related adverse events, supporting the tolerability and potential efficacy of the at-home regimen. This study is limited by its open-label design, use of normal skincare routines and lack of molecular analyses. Therefore, randomized, sham-controlled studies would help establish the extent to which the observed improvements are attributable to LED treatment, while histological and molecular analyses could clarify the underlying biological mechanisms.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Internal Revision Committee of Eurofins Cosmetics Personal Care Italy S.r.l. (study reference STUN725AA0022-1; protocol version 2; approval date 13 February 2025).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: The original data presented in this study are openly available on the webpage 'CurrentBody Veritace®-tested LED clinical studies' at https://www.currentbody.com/pages/currentbody-skin-user-and-clinical-trials. The specific report can be accessed directly at https://cdn.shopify.com/s/files/1/3097/7858/files/Eurofins_Series2_LED_Report.pdf?v=1771586303. The complete underlying statistical output is not publicly available but can be made available upon reasonable request to the authors.

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Abbreviations

The following abbreviations are used in this manuscript:

ATP	Adenosine triphosphate
C&PC	Cosmetics & Personal Care
CIE	Commission Internationale de l'Éclairage
ECM	Extracellular matrix
GCP	Good Clinical Practice
ITA	Individual Typology Angle
LED	Light-emitting diode
LLLT	Low-level light therapy
MMPs	Matrix metalloproteinases
mbar	Millibar
mm	Millimetre
nm	Nanometre
NO	Nitric oxide
PBM	Photobiomodulation
ROI	Region of interest
ROS	Reactive oxygen species
SD	Standard deviation
TEWL	Transepidermal water loss
UV	Ultraviolet

Appendix A

Table A1. Skin Texture Scores for the Face, Neck, and Décolleté. (n = 31).

Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
D0	31	9.02 ± 1.83	10.74 ± 2.78	8.45 ± 1.42
D56		8.52 ± 1.67; −5.53%	10.21 ± 2.86; −4.94%	8.00 ± 1.46; −5.41%

Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A2. Elasticity and Firmness Measurements for the Face, Neck, and Décolleté. (n = 31).

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
R2	D0	31	63.86 ± 10.99	54.66 ± 12.03	60.66 ± 8.69
	D56		73.72 ± 16.29; 15.44%	61.66 ± 13.75; 12.82%	68.60 ± 13.08; 13.09%
R5	D0	31	52.91 ± 12.19	47.78 ± 13.54	52.93 ± 9.53
	D56		61.01 ± 20.73; 15.32%	53.57 ± 13.89; 12.11%	59.53 ± 14.29; 12.47%
R7	D0	31	35.55 ± 8.09	43.13 ± 13.92	42.10 ± 10.52
	D56		39.25 ± 11.91; 10.41%	46.48 ± 13.55; 7.76%	46.25 ± 12.90; 9.85%

Table A2. *Cont.*

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
F4	D0	31	9.21 ± 3.33	9.43 ± 2.65	8.09 ± 3.20
	D56		7.64 ± 3.63; −16.97%	8.29 ± 3.03; −12.13%	7.08 ± 3.35; −12.55%

R2 = Gross elasticity, R5 = Net elasticity, R7 = Biological elasticity, F4 = Passive resistance of the skin to force (firmness). Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A3. Wrinkle Depth, Width, and Length Measurements for the Face and Neck. (*n* = 31).

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)
Wrinkle Depth	D0	31	0.143 ± 0.138	0.251 ± 0.076
	D56		0.129 ± 0.114; −9.48%	0.229 ± 0.0065; −9.03%
Wrinkle Length	D0	31	52.96 ± 20.25	95.26 ± 34.15
	D56		49.05 ± 19.43; −8.13%	87.65 ± 28.92; −7.99%
Wrinkle Width	D0	31	1.96 ± 0.68	2.30 ± 0.78
	D56		1.84 ± 0.65; −6.96%	2.15 ± 0.68; −6.88%

Measurements in millimeters (mm). Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A4. Dermatologist Wrinkle Grading for the Face, Neck, and Décolleté. (*n* = 31).

Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
D0	31	7.61 ± 0.76	7.23 ± 0.84	6.35 ± 0.88
D56		7.13 ± 0.85; −6.36%	6.74 ± 0.89; −6.70%	5.90 ± 1.04; −7.11%

Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A5. Skin Hydration and Transepidermal Water Loss Scores for the Face, Neck, and Décolleté. (*n* = 31).

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
Skin Hydration	D0	31	37.12 ± 7.64	36.78 ± 3.43	36.33 ± 5.58
	D56		50.24 ± 9.82; 35.33%	48.20 ± 8.51; 31.06%	48.57 ± 7.74; 33.68%
Barrier (TEWL)	D0	31	18.00 ± 5.60	12.03 ± 2.76	13.76 ± 1.34
	D56		14.40 ± 3.69; −19.98%	10.34 ± 2.7; −14.04%	11.63 ± 1.60; −15.46%

TEWL = Transepidermal Water Loss. Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A6. Erythema and Skin Tone Scores for the Face, Neck, and Décolleté. (*n* = 31).

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
Luminance	D0	31	61.50 ± 2.67	64.08 ± 2.32	62.67 ± 2.57
	D56		61.73 ± 2.44; 0.37%	64.18 ± 2.37; 0.15%	63.55 ± 2.47; 1.41%
ITA°	D0	31	38.41 ± 6.51	40.56 ± 6.97	39.43 ± 8.31
	D56		39.47 ± 6.31; 2.76%	41.90 ± 6.69; 3.30%	42.54 ± 7.47; 7.91%

Table A6. *Cont.*

	Time	*n*	Face (Mean ± SD; % vs. D0)	Neck (Mean ± SD; % vs. D0)	Décolleté (Mean ± SD; % vs. D0)
Erythema	D0	31	342.19 ± 81.61	262.75 ± 47.37	295.93 ± 52.22
	D56		322.94 ± 72.48; −5.63%	249.80 ± 46.48; −4.93%	279.61 ± 47.48; −5.51%

ITA° = Individual Typology Angle. Mean scores at D0 and Day 56 ± SD. (% = Mean change from D0).

Table A7. Participant Satisfaction with the CurrentBody Series 2 LED Face Mask for Face Skin Quality Parameters. (*n* = 31).

Face		
Items		**Percentage of Satisfied Participants (*n* = 31)**
1	I have noticed an improvement in the overall appearance of my skin on my face after using the LED Face Mask.	100%
2	My skin on my face feels significantly more hydrated after regular use of the LED Face Mask.	97%
3	My skin on my face looks noticeably more radiant and glowing.	87%
4	The texture of my skin on my face feels smoother and more refined to the touch.	94%
5	I have observed a visible reduction in the appearance of fine lines and wrinkles on my face.	94%
6	My skin on my face feels firmer and shows increased elasticity.	90%
7	The LED Face Mask effectively reduced redness in my skin on my face.	90%
8	My skin tone on my face appears more even and consistent after using the LED Face Mask.	84%
9	The LED Face Mask noticeably improved the overall appearance of my face.	100%
10	My face appears more rejuvenated and youthful after using the LED Face Mask.	90%
11	The LED Face Mask is comfortable and pleasant to use during treatment sessions.	87%
12	The treatment with the LED Face Mask integrates easily into my daily skincare routine.	87%
13	I noticed a significant improvement in my skin's hydration levels on my face after using the LED Face Mask.	97%
14	My skin on my face feels softer and less rough following use of the LED Face Mask.	94%
15	The LED Face Mask enhanced the overall quality and health of my complexion on my face.	90%

Table A7. *Cont.*

Face		
Items		**Percentage of Satisfied Participants (*n* = 31)**
16	I feel more confident about the appearance of my skin on my face after using the LED Face Mask.	94%
17	I noticed a reduction in skin dryness on my face after using the LED Face Mask.	90%
18	I am highly satisfied with the results achieved from the treatment with the LED Face Mask.	97%
19	I would recommend the LED Face Mask to others.	97%
20	The LED Face Mask was user-friendly and easy to operate.	94%

Table A8. Participant Satisfaction with the CurrentBody Series 2 LED Neck & Décolletage Mask for Neck Skin Quality Parameters. (*n* = 31).

Neck		
Items		**Percentage of Satisfied Participants (*n* = 31)**
1	I have noticed an improvement in the overall appearance of my skin on my neck after using the LED Neck & Décolletage Mask.	97%
2	My skin on my neck feels significantly more hydrated after regular use of the LED Neck & Décolletage Mask.	90%
3	My skin on my neck looks noticeably more radiant and glowing.	90%
4	The texture of my skin on my neck feels smoother and more refined to the touch.	90%
5	I have observed a visible reduction in the appearance of fine lines and wrinkles on my neck.	90%
6	My skin on my neck feels firmer and shows increased elasticity.	87%
7	The LED Neck & Décolletage Mask effectively reduced redness in my skin on my neck.	81%
8	My skin tone on my neck appears more even and consistent after using the LED Neck & Décolletage Mask.	81%
9	The LED Neck & Décolletage Mask noticeably improved the overall appearance of my neck.	97%
10	My neck appears more rejuvenated and youthful after using the LED Neck & Décolletage Mask.	94%
11	The LED Neck & Décolletage Mask is comfortable and pleasant to use during treatment sessions.	84%
12	The treatment with the LED Neck & Décolletage Mask integrates easily into my daily skincare routine.	87%
13	I noticed a significant improvement in my skin's hydration levels on my neck after using the LED Neck & Décolletage Mask.	90%

Table A8. *Cont.*

Neck		
Items		**Percentage of Satisfied Participants (*n* = 31)**
14	My skin on my neck feels softer and less rough following use of the LED Neck & Décolletage Mask.	90%
15	The LED Neck & Décolletage Mask enhanced the overall quality and health of my complexion on my neck.	87%
16	I feel more confident about the appearance of my skin on my neck after using the LED Neck & Décolletage Mask.	90%
17	I noticed a reduction in skin dryness on my neck after using the LED Neck & Décolletage Mask.	90%
18	I am highly satisfied with the results achieved from the treatment with the LED Neck & Décolletage Mask.	94%
19	I would recommend the LED Neck & Décolletage Mask to others.	94%
20	The LED Neck & Décolletage Mask was user-friendly and easy to operate.	94%

Table A9. Participant Satisfaction with the CurrentBody Series 2 LED Neck & Décolletage Mask for Décolleté Skin Quality Parameters. (*n* = 31).

Décolleté		
Items		**Percentage of Satisfied Participants (*n* = 31)**
1	I have noticed an improvement in the overall appearance of my skin on my décolleté after using the LED Neck & Décolletage Mask.	97%
2	My skin on my décolleté feels significantly more hydrated after regular use of the LED Neck & Décolletage Mask.	94%
3	My skin on my décolleté looks noticeably more radiant and glowing.	94%
4	The texture of my skin on my décolleté feels smoother and more refined to the touch.	90%
5	I have observed a visible reduction in the appearance of fine lines and wrinkles on my décolleté.	90%
6	My skin on my décolleté feels firmer and shows increased elasticity.	90%
7	The LED Neck & Décolletage Mask effectively reduced redness in my skin on my décolleté.	87%
8	My skin tone on my décolleté appears more even and consistent after using the LED Neck & Décolletage Mask.	90%
9	The LED Neck & Décolletage Mask noticeably improved the overall appearance of my décolleté.	97%
10	My décolleté appears more rejuvenated and youthful after using the LED Neck & Décolletage Mask.	97%
11	The LED Neck & Décolletage Mask is comfortable and pleasant to use during treatment sessions.	87%

Table A9. *Cont.*

Décolleté		
Items		**Percentage of Satisfied Participants (*n* = 31)**
12	The treatment with the LED Neck & Décolletage Mask integrates easily into my daily skincare routine.	87%
13	I noticed a significant improvement in my skin's hydration levels on my décolleté after using the LED Neck & Décolletage Mask.	94%
14	My skin on my décolleté feels softer and less rough following use of the LED Neck & Décolletage Mask.	90%
15	The LED Neck & Décolletage Mask enhanced the overall quality and health of my complexion on my décolleté.	90%
16	I feel more confident about the appearance of my skin on my décolleté after using the LED Neck & Décolletage Mask.	94%
17	I noticed a reduction in skin dryness on my décolleté after using the LED Neck & Décolletage Mask.	94%
18	I am highly satisfied with the results achieved from the treatment with the LED Neck & Décolletage Mask.	97%

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