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The Effect of Lighting Variability on a Facial Skin Analysis Device

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Abstract: Facial artificial intelligence (AI) skincare applications offer patients simple and effective means of obtaining quantitative information regarding their skin characteristics. Advances in AI may facilitate dermatologic assessments by providing accurate and reliable scores for common skin concerns. The objective of our study was to assess the effect of different lighting on facial characteristic scores produced by an iPad-based AI skin analysis system. Participants were recruited from dermatology clinics. Images were captured using an AI skincare app in different lighting settings: below average lighting (L1), standard room lighting (L2), and enhanced studio lighting (L3). Raw scores produced for twenty facial characteristics were recorded. Higher raw scores indicated better skin health. Scores were compared between the three lighting conditions. Below average lighting had the highest mean raw scores for facial characteristics (79.67 ±10.56). Mean raw scores were lowest for enhanced studio lighting conditions (74.43 ±10.24). The difference in scores produced by the different lighting conditions was not statistically significant ($p=0.79$). Enhanced studio lighting did not appear necessary as scores were similar without the additional lighting. The application used in our study may serve as a cost-effective and convenient tool both within and outside clinical settings allowing enhanced quantitative analysis of facial characteristics.

Keywords: general dermatology; artificial intelligence; lighting; facial characteristics; assessment

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1. Body of Manuscript

Advances in artificial intelligence (AI) medical applications have surged within the field of dermatology. The integration of quantitative measures to assess and document skin conditions offers a standardized approach and allows for more objectivity in diagnosis and management of skin pathologies [1,6]. Facial analysis systems can provide an instantaneous numerical score for skin characteristics including facial redness, pigmentation, wrinkles, and sun damage [1–3,7]. Traditional AI devices available for dermatologic clinical practice have a bulky design [4,9]. Most devices currently in practice are not transportable as they require specialized equipment and are often expensive.

The transition to newer AI models may offer a convenient, portable, handheld approach that facilitates collection of data on facial characteristics, which aids providers in tracking patient progress and tailoring treatments [1,3,8,9]. The potential for more convenient, handheld solutions may also simplify facial skin data collection for patients. These emerging AI facial analysis devices can also provide more accessibility, particularly in remote or resource-limited settings [10]. Despite these advances, newer AI systems still face challenges, with factors such as distance, lighting, and color correction impacting the accuracy of facial assessments [8,11]. These limitations can lead to inconsistent and unreliable facial analysis results [12]. The objective of our study was to assess the effect of different lighting on facial characteristics' scores produced by an iPad-based AI skin analysis system.

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2. Materials and Methods

Upon institutional review board approval, 14 patients were recruited from Wake Forest Baptist Health's dermatology clinic during the month of May 2024. Signed informed consent was obtained from all participants. Inclusion criteria included patients age ≥11 years, a Fitzpatrick skin type (FST) I-VI and the ability to remove any facial makeup, covering or glasses. An equal distribution of patients was recruited to fit two categories: FST I-III and FST IV-VI. Exclusion criteria included facial tattoos, sunburns, and significant facial scarring. Facial images were captured using an iPad-based AI skincare app (Perfect Corporation Skincare Pro Corporation) (Figure 1). Lighting conditions were standardized using a digital illuminance meter; lux (LX) and foot-candle (FC) were recorded as units of light (Figure 2). Three different lighting settings were used: below average lighting (L1: mean 161.64 LX/14.06 FC), standard room lighting (L2: mean 519 LX/48.61 FC), and enhanced studio lighting (L3: mean 650.57LX/61.15 FC) (Figures 3–6). Raw scores for the following facial characteristics were recorded: spots, wrinkles, texture, dark circle, acne, redness, oiliness, moisture, eyebags, texture, eyes, forehead, lower, ex eyes, pores, radiance, firmness, upper lid, and lower lid. Higher raw scores indicated better skin health. Scores were compared between the three lighting conditions. Data collection and statistical analysis were performed using Excel and SPSS.

Figure 1. Photography setup for AI Skincare application assessments.

Figure 2. Digital illuminance device used to calculate lighting scores.

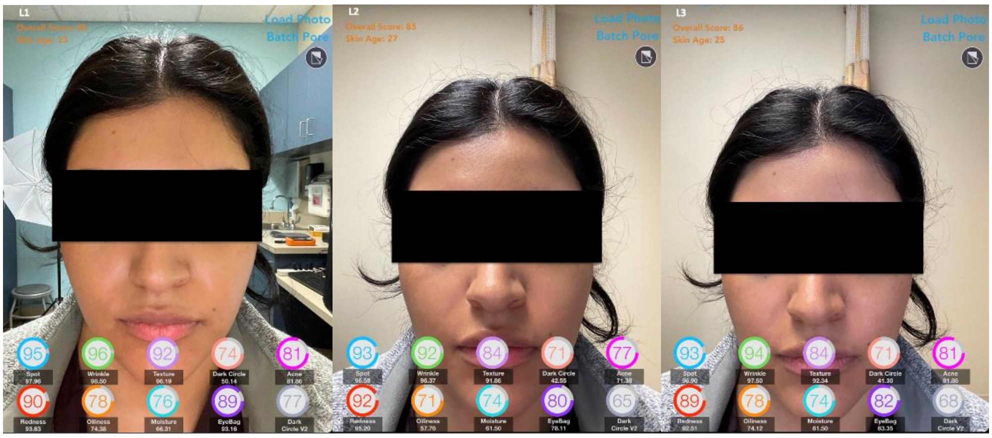

Figure 3. Facial analysis application interface for L1, L2, and L3 (from left to right) lighting conditions in an individual with Fitzpatrick Skin Type IV.

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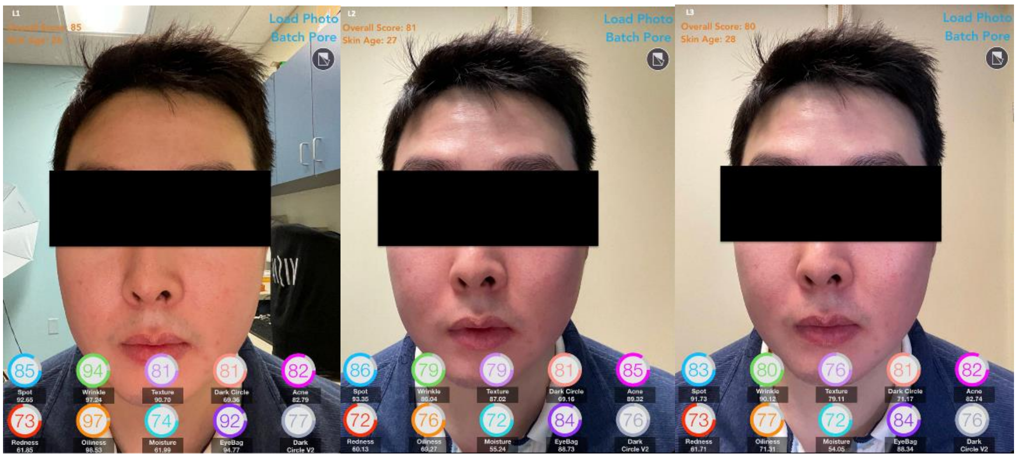

Figure 4. Facial analysis application interface for L1, L2, and L3 (from left to right) lighting conditions in an individual with Fitzpatrick Skin Type II.

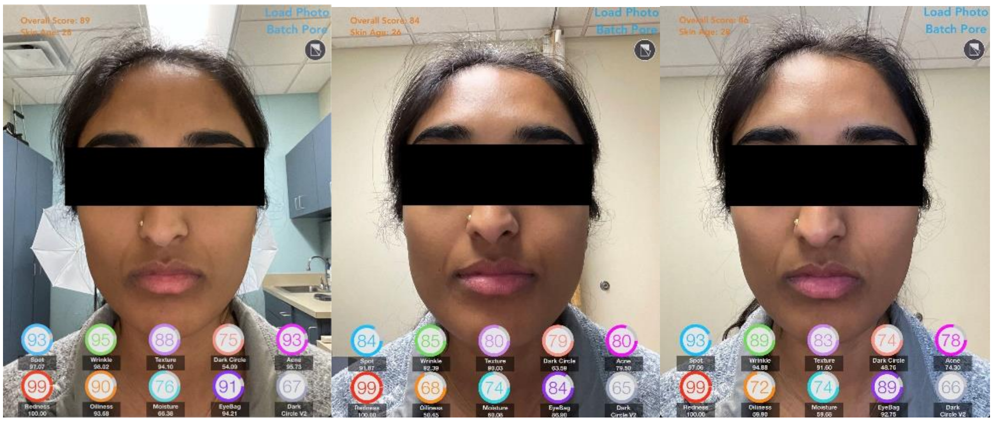

Figure 5. Facial analysis application interface for L1, L2, and L3 (from left to right) lighting conditions in an individual with Fitzpatrick Skin Type IV.

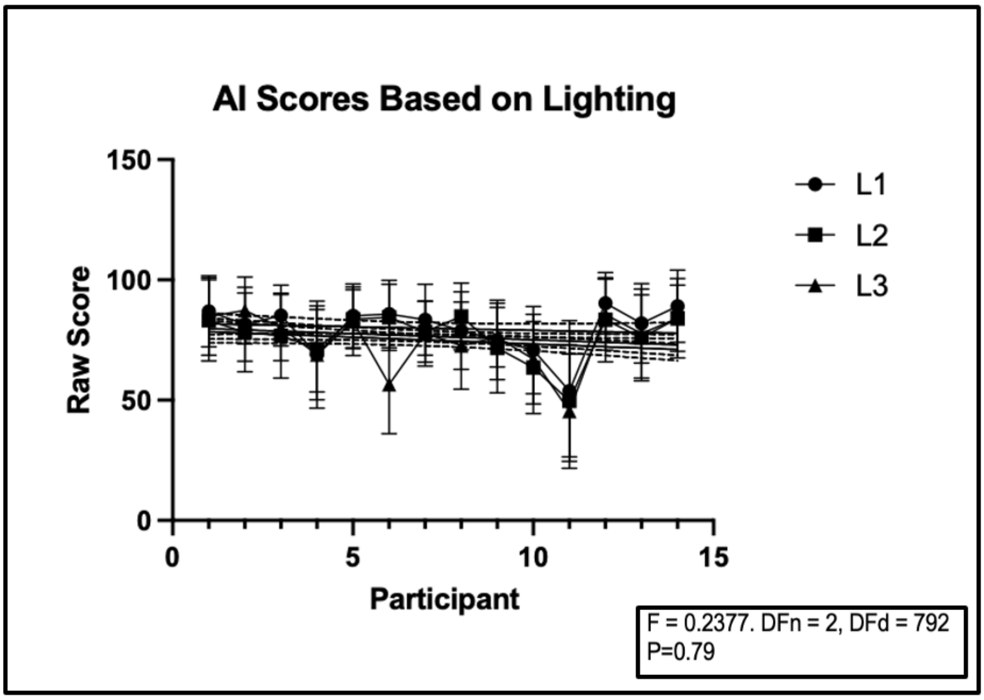

Figure 6. Changes in scores for facial characteristics based on lighting: below average lighting (L1), standard room lighting (L2), and enhanced studio lighting (L3).

3. Results

The demographics of the participants were primarily Black (57%) females (71%) with a mean age of 41 years (range: 19-74). Participants were evenly distributed among FST; seven participants (50%) comprised both FST I-III and FST III-VI groups. Below average lighting had the highest raw scores for facial characteristics (79.67 ± 10.56). Mean raw scores were lowest for enhanced studio lighting conditions (74.43 ± 10.24) (Figure 7). The difference in scores produced by the different lighting conditions was not statistically significant (p=0.79) (Figure 7). Scores for L1, L2, and L3 settings had an intraclass correlation coefficient (ICC) and Cronbach's alpha measure of 0.893, 0.904, and 0.928, respectively (CI 95% 0.88-0.93, p<0.001), indicating excellent reliability.

4. Discussion

Compared to lower lighting, enhanced studio lighting allowed the AI facial app to detect more facial details, which correlated with lower raw scores. While studio lighting improved the level of detail captured, it was not significant, as similar results were obtained without additional lighting. This suggests that the new AI system's ability to assess facial characteristics may remain consistent across different lighting conditions. The application used in our study may serve as a cost-effective and convenient tool both within and outside clinical settings allowing enhanced quantitative analysis of facial characteristics. Its portability and accessibility make it highly adaptable for a range of uses across different environmental settings without impacting the reliability of the results.

The future direction of AI-based analysis tools in dermatology holds potential for innovation and expanded applications [16,17]. The perception of skin color, texture, and fine details were not given as much emphasis prior to the emergence of AI technology [15,18–20]. Environmental lighting conditions are an important factor in aiding dermatologic diagnosis as the AI-based analysis tools initially had complications differentiating nevus to melanoma [12,13]. Newer AI-based analysis models are being developed to differentiate between various shades of erythema in inflammatory dermatoses and to capture the texture of wrinkles and subtle pigmentation differences, which are areas that current AI models in cosmetic dermatology have yet to fully address [14]. AI facial analysis systems must also ensure accuracy and reliability across various lighting conditions while considering the full spectrum of Fitzpatrick skin types, as differences in skin color tones can greatly influence the evaluation of pigmentation, erythema, and other key dermatologic characteristics.[9,18] AI-based analysis tools had lower performances in detecting dermatological manifestations of participants with darker Fitzpatrick skin types [15]. Ensuring that these AI-analysis tools are standardized for diverse factors such as lighting conditions and skin tones can optimize accurate dermatologic assessments and provide equitable, accessible care to diverse patient populations.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Conflicts of Interest: Steven Feldman has received research, speaking and/or consulting support from Eli Lilly and Company, GlaxoSmithKline/Stiefel, AbbVie, Janssen, Alovtech, vTv Therapeutics, Bristol-Myers Squibb, Samsung, Pfizer, Boehringer Ingelheim, Amgen, Dermavant, Arcutis, Novartis, Novan, UCB, Helsinn, Sun Pharma, Almirall, Galderma, Leo Pharma, Mylan, Celgene, Ortho Dermatology, Menlo, Merck & Co, Qurient, Forte, Arena, Biocon, Accordant, Argenx, Sanofi, Regeneron, the National Biological Corporation, Caremark, Teladoc, BMS, Ono, Micreos, Eurofins, Informa, UpToDate and the National Psoriasis Foundation. He is founder and part owner of Causa Research and holds stock in Sensal Health. The other authors have no conflicts to disclose.

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