STUDY PROTOCOL

Skin Hydration and Facial Aging: A Correlational Observational Study Using Bioimpedance Analysis in Women Aged 30–60 Years

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Abstract

Background: How skin ages is shaped by many factors, but hydration stands out as one that is both biologically well-established and underrepresented in applied esthetic research. Adequate skin moisture is not merely a cosmetic concern — it reflects the structural health of the epidermis and dermis. Despite this, few studies in cosmetology have directly linked objective hydration measurements to standardized visual aging scores.

Objective: This study examines whether skin hydration levels, measured with the BT-Analyze bioimpedance device at seven facial zones, correlate with visual signs of aging rated by a blinded expert cosmetologist using a modified Glogau scoring system, in women aged 30 to 60 years.

Methods: A cross-sectional observational study will enroll 30 women divided into three age groups of 10 each (30–40, 40–50, and 50–60 years). Skin hydration will be measured at seven standardized facial zones; each zone will be tested three times and the mean recorded. An expert cosmetologist will rate aging from standardized photographs without knowing the participants' ages or hydration data. Spearman rank correlation will be the primary statistical test. A questionnaire will capture water intake, menopausal status, Fitzpatrick skin type, smoking history, and skincare habits.

Expected Outcomes: We expect that lower BT-Analyze scores will correspond to higher Glogau aging scores, supporting a negative correlation between skin hydration and visual aging. If confirmed, these findings will provide practical, measurement-based support for hydration-focused skincare protocols in U.S. cosmetology practice.

Keywords: *skin hydration; facial aging; bioimpedance; BT-Analyze; Glogau scale; cosmetology; transepidermal water loss; observational study; anti-aging; skin moisture*

1. Background and Rationale

Skin aging is driven by both internal and external forces — genetics, sun exposure, hormonal shifts, and daily lifestyle all leave their mark over time. Among the many factors involved, skin hydration is one that practitioners observe closely but rarely measure objectively. This is a gap worth addressing, because the biology connecting dehydration to structural skin aging is well established.

The skin holds water through three systems: the natural moisturizing factor (NMF) inside skin cells, hyaluronic acid (HA) in the dermal matrix, and the lipid barrier of the outermost layer. HA is particularly important here — it can hold up to 1,000 times its own weight in water, helping the skin stay plump and firm [1]. As we age, the body produces less HA and breaks it down faster, leaving the dermis progressively drier. This weakens the scaffolding that keeps collagen organized and intact [2,3].

When the skin barrier is compromised, water escapes through a process known as transepidermal water loss (TEWL). Elevated TEWL triggers enzymes called matrix metalloproteinases (MMPs) — particularly MMP-1, MMP-3, and MMP-9 — that break down collagen and elastin [4]. The result is a self-reinforcing cycle: dehydration weakens the skin structure, which leads to more water loss, which leads to more structural damage. Over time, this cycle shows up as fine lines, sagging, uneven tone, and rough texture.

Despite this well-understood biology, there is a shortage of studies in applied cosmetology that actually pair objective hydration measurements with standardized visual aging scores, especially for women in the 30–60 age range. This study aims to fill that gap.

The BT-Analyze device (Bio-Therapeutic, Seattle, WA) uses bioimpedance technology with a patented membrane sensor to quantify skin moisture on a scale of 0 to 65 units (manufacturer reference ranges: ≤25 dry; 35–45 optimal; ≥55 high hydration). It maps seven facial zones in a single session, is non-invasive, and has shown good reproducibility in cosmetological settings [5]. For visual aging, this study uses a modified version of the Glogau scale that scores six specific features on a 0–3 scale each, yielding a total of 0–18 points. This approach converts a traditionally categorical classification into a continuous variable, making it suitable for correlation analysis [6].

Study Rationale

Studying women aged 30 to 60 captures a range where both hydration levels and visible aging features vary meaningfully. Dividing participants into three decade-based groups allows us to describe age-related trends as well as individual variation — which is where the correlation analysis becomes most informative.

2. Objectives

2.1 Primary Objective

To calculate the Spearman rank correlation coefficient between mean BT-Analyze skin hydration scores (across seven facial zones) and total modified Glogau visual aging scores in 30 women aged 30 to 60 years.

2.2 Secondary Objectives

- To compare mean BT-Analyze hydration scores across three age groups (30–40, 40–50, 50–60 years) using the Kruskal-Wallis test.
- To identify which of the seven facial zones shows the strongest correlation between hydration and visual aging.
- To test whether the hydration-aging correlation holds after accounting for confounders: menopausal status, daily water intake, Fitzpatrick skin type, smoking history, and skincare habits.

- To describe the distribution of modified Glogau grades (I–IV) across the three age groups.

2.3 Hypotheses

Primary hypothesis (H_1): Women with lower average BT-Analyze scores will show significantly higher modified Glogau scores — that is, a statistically significant negative correlation ($r_s < 0$, $p < .05$) will be found between skin hydration and visual aging.

Null hypothesis (H_0): No significant correlation between skin hydration and visual aging scores will be detected in this sample.

3. Methods

3.1 Study Design

This is a single-visit, cross-sectional observational study. Each participant attends once; all data — hydration measurements, photographs, and questionnaire — are collected during that visit. No treatment or intervention is administered. The study follows STROBE reporting guidelines for observational research.

The protocol is registered at ClinicalTrials.gov (Registration No. NCT07564869; Protocol ID: IAS-SKIN-2025-001; Acronym: SHFA-30-60).

3.2 Setting

All data will be collected at IAS Skin Care, a licensed esthetic practice in Florida, United States. A single dedicated room will be used throughout the study, maintained at 20–22°C with 40–60% relative humidity.

3.3 Participants

Eligibility Criteria

Inclusion criteria:

- Female, aged 30 to 60 years
- Willing to attend one visit without makeup
- No cosmetics applied for at least 4 hours before the visit
- Able to sit in the study room for 20 minutes before measurements
- Signed written informed consent

Exclusion criteria:

- Active skin conditions such as eczema, psoriasis, or rosacea in flare
- Injectable treatments (botulinum toxin or fillers) in the past 6 months
- Systemic medications that affect skin: oral retinoids or corticosteroids
- Pregnancy or breastfeeding
- Uncontrolled systemic disease known to significantly affect skin integrity (e.g., uncontrolled diabetes mellitus)

Sample Size and Recruitment

A sample of 30 is appropriate for this pilot correlational study. Using G*Power 3.1 with a target correlation of r_s=0.50, alpha=.05, and power=0.80, the minimum required sample is 26; enrolling 30 provides a 15% buffer for incomplete data.

Participants will be recruited through announcements at the esthetic practice. They will be assigned to one of three age groups — Group 1 (30–40 years), Group 2 (40–50 years), Group 3 (50–60 years) — with 10 participants per group.

3.4 Primary Outcome: Skin Hydration (BT-Analyze)

Skin moisture will be measured using the BT-Analyze bioimpedance device. The procedure:

- All measurements are taken after 20 minutes of room acclimation
- Seven facial zones are assessed: forehead center, nose, chin, right cheek, left cheek, right periorbital area, and left periorbital area
- Each zone is measured three times; the zone score is the average of the three readings
- The primary variable, BT-mean, is the average of all seven zone scores (range 0–65)
- The sensor is wiped with a dry cloth between zones and disinfected with an alcohol wipe between participants
- All measurements take place between 10:00 AM and 2:00 PM to limit time-of-day variation

3.5 Secondary Outcome: Visual Aging (Modified Glogau Scale)

An expert cosmetologist with at least 5 years of clinical practice will rate each participant's skin aging from standardized frontal photographs. The assessor will not know the participant's age, group, or BT-Analyze data at the time of scoring (single-blind design). The scoring instrument:

Criterion	0 — Absent	1 — Mild	2 — Moderate	3 — Severe
Forehead rhytids	None	Dynamic only	Static, shallow	Static, deep
Periorbital rhytids	None	On smiling	Visible at rest	Deep, multiple
Nasolabial folds	Absent	Barely visible	Distinct fold	Deep, overhanging
Skin turgor / laxity	Preserved	Mild reduction	Visible ptosis	Marked ptosis
Dyspigmentation	Even tone	Minor unevenness	Visible spots	Marked pigmentation
Skin texture	Smooth	Slight roughness	Visible dryness	Coarse, keratotic

Table 1. Modified Glogau scoring instrument. Total score = sum of six criteria (0–18 points). Interpretive grades: 0–4 = Grade I (minimal aging); 5–8 = Grade II (early aging); 9–13 = Grade III (moderate aging); 14–18 = Grade IV (advanced aging).

3.6 Photography Protocol

Photographs will be taken under standardized conditions for every participant:

- Camera-to-face distance: 50 cm, marked with tape on the floor
- Camera height: eye level of the participant
- Background: neutral gray or white
- Lighting: ring light at 5500K, positioned frontally at eye level
- Camera in manual mode with settings locked throughout the study

- Three views per participant: frontal, right profile, left profile
- Neutral expression, lips closed, hair secured with a headband
- No post-processing or color correction applied
- Files saved as: P[XX]_front.jpg, P[XX]_right.jpg, P[XX]_left.jpg

The assessor receives all frontal photographs in randomized order, labeled only with participant codes (P01–P30). No identifying information is shared until after all photographs have been scored.

3.7 Covariate Questionnaire

Each participant will complete a short questionnaire covering: exact age; Fitzpatrick skin type (I–VI); daily water intake in liters; smoking status (yes/no; pack-years if applicable); menopausal status (premenopausal, perimenopausal, or postmenopausal); regular use of moisturizing products (yes/no); and general sun exposure history (low, moderate, or high).

3.8 Visit Procedure

Each visit takes approximately 45 to 50 minutes and follows this sequence:

1. Informed consent and questionnaire completion (10 minutes)
2. 20-minute acclimation in the study room
3. BT-Analyze measurements at 7 zones, 3 readings each (10 minutes)
4. Standardized photography: three angles (5 minutes)
5. File organization by participant code

4. Statistical Analysis

4.1 Primary Analysis

Spearman rank correlation (r_s) will be calculated between BT-mean score and total modified Glogau score for all 30 participants. Significance threshold: $p < .05$, two-tailed. Effect size interpretation: r_s up to 0.3 weak; 0.3–0.5 moderate; above 0.5 strong.

4.2 Secondary Analyses

- Kruskal-Wallis test to compare BT-mean scores across the three age groups; Mann-Whitney U pairwise comparisons with Bonferroni correction if the overall test is significant
- Zone-specific Spearman correlations for each of the seven facial zones against total Glogau score, to identify the most informative zone
- Multiple linear regression with BT-mean as the predictor of Glogau score, adjusting for age, Fitzpatrick type, water intake, menopausal status, and skincare habits

4.3 Descriptive Statistics

Mean ± SD, median, and range will be reported for BT-mean and Glogau scores in each age group and overall. Glogau grade distribution will be presented as counts and percentages.

4.4 Software

All analyses will be run in IBM SPSS Statistics (v27+) or R (v4.3+). All tests are two-tailed. Missing data will be handled using complete-case analysis, given the single-visit design and expected low rate of missing values.

5. Results

This is a protocol paper; data collection has not yet begun. Results will be reported in a separate manuscript once the study is complete.

6. Discussion

6.1 Principal Considerations

One of the challenges in everyday esthetic practice is that skin aging is assessed visually, without knowing the patient's actual hydration status. This study is designed to bridge that gap by pairing instrument-based hydration data with blinded visual aging scores from the same participants.

The three-group age design is particularly useful here. Including women from 30 to 60 years creates a meaningful spread in both hydration levels and visible aging, making it more likely to detect a real correlation if one exists. It also allows us to describe how hydration typically changes across the decades — information that practitioners can use directly.

6.2 Anticipated Limitations

- Cross-sectional design: association can be established, but not causality
- Sample of n=30: results should be treated as preliminary and confirmed in a larger study
- The BT-Analyze measures stratum corneum hydration only; deeper dermal hydration requires other tools such as high-frequency ultrasound
- A single expert assessor was used; inter-rater reliability could not be assessed
- Convenience sampling limits how broadly the findings can be generalized
- Seasonal variation and ambient humidity at the time of measurement may affect readings

6.3 Conclusion

This protocol describes a clear, reproducible approach to studying the relationship between skin hydration and visible aging. Publishing it before data collection ensures that the methods are transparent and that the eventual results can be properly evaluated. If the findings support the hypothesis, they will add objective, measurement-based evidence to what many practitioners already observe in clinical practice: that keeping skin well-hydrated appears to slow certain visible signs of aging.

7. Ethical Considerations

This study involves only non-invasive measurements and poses minimal risk to participants. The following safeguards will be in place:

- Written informed consent will be obtained from all participants before any study procedures begin
- Participants may withdraw at any time without consequence
- All data will be stored under anonymous participant codes (P01–P30); the code-to-name key is held only by the principal investigator
- Photographs will be used solely for blinded expert assessment and will not be published without separate written consent from the participant
- Data will be stored securely for a minimum of five years after study completion

The study was designed in accordance with the principles of the Declaration of Helsinki. As a non-interventional observational study conducted in a licensed esthetic practice, formal IRB review is not required; however, the investigator will seek guidance from an appropriate ethics oversight body before recruitment begins.

8. Dissemination Plan

Results will be submitted for publication to a peer-reviewed journal in dermatology or cosmetic science, including:

- JMIR Research Protocols
- Skin Research & Technology (Wiley)
- Journal of Cosmetic Dermatology (Wiley)
- International Journal of Cosmetic Science

Findings will also be presented at regional esthetic conferences in Florida and, where appropriate, at national meetings. Results will be shared with participants upon request.

9. Projected Timeline

Phase	Activity	Timeframe
Preparation	Protocol finalization, IRB consultation, expert calibration	Month 1
Recruitment	Participant screening and enrollment	Months 1–2
Data collection	Study visits (n=30)	Months 2–3
Expert assessment	Blinded photograph evaluation	Month 3
Analysis	Statistical analysis and interpretation	Month 4
Manuscript preparation	Writing and review	Months 4–5
Submission	Journal submission	Month 6

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