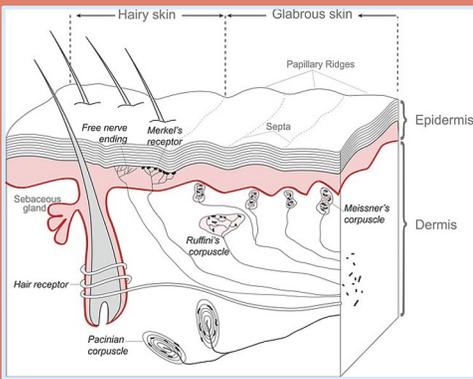


Effects of Academic and Social Stressors on Adolescent Skin Microbiome

Zenia Babool
Glenbrook South High School



Abstract & Safety Sheets

Purpose or Problem

The adolescent skin microbiome is an ecosystem of internal neuroendocrine pathways, yet the immediate impact of acute stressors remains under-researched. Previous studies have primarily addressed chronic allostatic load, with little research on the short-term academic and social stressors that affect adolescents' skin health in real time. This study addresses that gap.

Procedure

This study was conducted with a group of fourteen high schoolers across all grades over a two-week period, with data collected using an adapted version of the University of Pennsylvania's Perceived Stress Questionnaire, sebum collection via blotting paper transparency, and initial and final photographs to observe physical changes on each participant's face.

Conclusion

The analysis of participant data (n=14) revealed a mean initial stress score of 22.62 and a mean final stress score of 21.31. Despite these small differences, the average skin score remained stable, shifting slightly from 2.92 to 2.85. Significant overlap in stress ranges was observed across participants with varying skin qualities, indicating that the skin microbiome homeostasis cannot be disrupted over a short period. This research provides a framework for future research that captures the transition from short-term to long-term stress, beyond which adaptive defensive mechanisms fail.

Safety Hazards

Human participants were involved as test subjects

Safety Precautions

Participants were given two surveys documenting stress levels, skin health and history, and basic medical history. Photographs were taken of their face to assess skin condition. Participants used oil collection wipes on their facial skin and submitted photos of these used sheets

Some risk of privacy violations. Participants were assigned numbers to maintain anonymity. Eyes were covered with black boxes in intake photos to protect identities.

Purpose & Hypothesis

The purpose of this study is to analyze the relationship between adolescent stress and skin at the micro and macro levels by observing responses to potential experimental factors: stress questionnaires, changes in sebum collection, and time constraints. The observations from this study aim to provide a more concrete understanding of the relationship between stress and the skin. They will enable future research to identify other factors that contribute to changes in the adolescent skin biome. In my study, I hypothesized that stress and skin are positively correlated, even over a short study period, and that this relationship will be reflected in participant surveys and sebum samples. This hypothesis was supported by past studies examining the links between psychological, physical, and environmental stressors and skin, showing a pattern of correlation between elevated skin damage and elevated stress levels. However, in these studies, many external factors remained, and some data were not statistically significant, allowing for further exploration of the correlation between stress and skin.

Background Research

Three main articles were reviewed over the course of the study on homeostasis and the interconnected systems of the body, allostatic load, and a previous, similar, study. The skin biome's homeostasis is disrupted by exposure factors (non-genetic factors), such as environmental stressors (extreme weather, solar radiation, pollution) and internal stressors (unhealthy diet, hormonal variations, psychological stress) (T. Passeron et al., 2021). These exposure factors induce tissue-level stress and can lead to changes in skin function (including the skin barrier, hyperpigmentation, and immune defense) and alterations in skin structure (such as the extracellular matrix and neuroendocrine regulation) that work towards restoring homeostasis in the skin's microlocal environment (T. Passeron et al., 2021). On an internal level, systems such as the sympathetic nervous system, also known as the "fight or flight" response, reacts immediately to stress by releasing adrenaline, triggering the HPA axis (the Hypothalamic-Pituitary-Adrenal axis coordinates the whole body's stress response system), and leading to the release of cortisol and other glucocorticoids from the adrenal glands. This activation triggers both genomic (slow, involving changes in gene expression) and non-genomic (fast, direct signaling) mechanisms. In addition to activating the central HPA axis, the sympathetic nervous system also activates the peripheral HPA axis, a mechanism equally critical for skin health (Bin Saif et al., 2019). To control response to stress and adapt, the brain operates as an allostatic load (the stress burden that causes physiological dysregulation) carrier and reacts by activating an intertwined network of neuroendocrine, autonomic, immune, and metabolic systems connected to peripheral tissues, such as the skin (McEwen, 2012). The buildup of chronic stress can alter the brain's structure, potentially changing immune and inflammatory pathways, which could, in turn, impact the skin microbiome. Under chronic stress, the parasympathetic tone (anti-inflammatory) is suppressed, leading to a pro-inflammatory state throughout the body (McEwen, 2012). Our study used procedures similar to a previous study in Saudi Arabia about stress and academic performance in medical students, where researchers analyzed the data on stress effects on the skin by using a Predictive Analysis Software to group participants into percentiles; the 0-25th percentile, representing the least stressed population; the 75th-100th percentile, representing the most stressed; and the 25th-75th percentile, representing the group in between. In the SSQC, data revealed that acne (23.8%) and eczema (10.2%) were the most common previously diagnosed dermatological diseases. The highest stress was reported among 4th- and 5th-year medical students, suggesting that stress may accumulate and affect the skin over time. Medical stress is not uniform, as clinical rotations, residency applications, and board exams all contribute to the cycle of compounding acute stressors. In the study, compared with less stressed students, highly stressed students had the most skin complaints, with p-values <0.0001 for itchy/sweaty skin, dry/cracked rash, warts, pimples, itchy skin, hand rashes, and hair loss (Bin Saif et al., 2018).

Materials & Methods

Equipment

- Chronosbook
- Blotting Sheets
- iPhone Camera
- Google Sheets/Microsoft Excel
- Google Forms
- Google Drive

The Test

The testing for this research was conducted over two weeks, following a school schedule (Monday to Friday), from Wednesday, November 5th, 2025, to Monday, November 24th, 2025. This study involved fourteen participants, from ages 14-18, who all attend Glenbrook South High School. Before the start of the study, all participants were given an IRB consent form that was completed by November 4th, 2025. To determine the correlations between academic and social stress and skin, and to track other factors that influence skin health, participants completed a 30-question questionnaire, with the first 10 questions inspired by the Perceived Stress Questionnaire (PSQ) from the University of Pennsylvania. The questionnaire was administered both before and after the study. In this questionnaire, participants were asked to rate statements about academic and social stressors on a scale from 1 to 5, such as "I feel that I am under pressure from other people" and "I feel calm", allowing them to score up to 50 points. They were also asked questions about the effects of high stress levels, including extraneous factors that might account for discrepancies in skin health, such as menstrual cycles, sleep, and over-the-counter medicine.

Additionally, questions about skin concerns were asked, including "Do you have any over-the-counter skin conditions?" and "Which skin complaints have you experienced since the beginning of the school year?". Participants could report pre-existing concerns such as acne, dermatitis, redness, inflammation, etc., as well as hair loss. In the initial and final questionnaires, participants were also asked to assign a skin score to their skin condition, with 1 indicating poor and 5 indicating perfect. An initial photo and a final photo of each participant were taken throughout the two-week study period. These photos were taken in a controlled environment in front of the Glenbrook South Science Office, with adequate lighting, using an iPhone camera. Participants collected and tracked sebum samples throughout the study. Every 3 days at 7 pm throughout the study, participants swabbed their faces with blotting paper; more transparent blotting paper indicated higher sebum production. Photos of these samples were submitted via a Google form, along with a question asking for a transparency score of 1-5 (1 being the least transparent, 5 being the most transparent). An indicator of greater sebum production was the greater transparency in the blotting sheets. Oiliness was quantified through self-reported scores; in other words, participants rated the amount of oil on their sheets on a scale of 1-5.

Procedure of Study

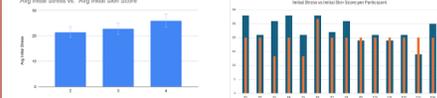
1. Participants were given an IRB consent form, which was completed and returned on November 4, 2025.
2. Participants' initial photos were taken in a controlled environment in their free time (during school hours) on Wednesday, November 5, 2025.
3. All participants were required to complete the initial survey by 11:59 p.m. on Wednesday, November 5, 2025.
4. Participants were instructed on how to use blotting paper and collected their first sebum sample at 7 p.m., November 5, 2025. Participants were asked to take a new sebum sample every three days at 7 p.m. (including weekends) until the end of the study.
5. Participants took their final sebum sample at 7 p.m. on Sunday, November 23, 2025.
6. Participants had their final photos taken in a controlled environment during school hours on Monday, November 24th, 2025.
7. All participants were required to take the final survey by 11:59 p.m. on Monday, November 24, 2025.

Procedure of Graphical Analysis

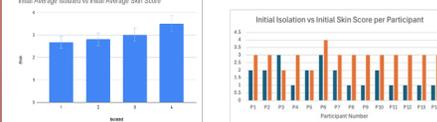
1. All responses to the initial and final surveys were transported to Google Sheets.
2. All responses of the sebum collection form, including information for a blotting paper and of individual response questions, were transported to Google Sheets and Google Drive.
3. Initial and Final photos of participants were transported to individual file folders of each participant in Google Drive.
4. Using data from the initial and final surveys, the responses to the first 10 PSQ-based questions for each participant were summed to create an individualized stress score.
5. Specific stress-based questions that emphasize both academic and social stress were compared against skin scores and were analyzed (both the initial and the final).
6. From these questions, the stress score and specific question scores were grouped into 1-5 values and averaged to create a generalized bar graph of participant responses.
7. In addition to the average graphs, individual response graphs were also charted to observe extraneous data that other factors could explain.

Results

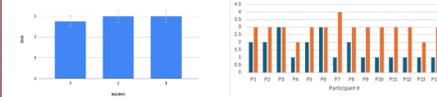
Overall Stress vs. Skin Score



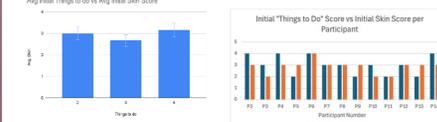
"I feel I have too many things to do" vs. Skin Score



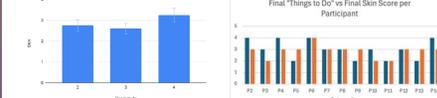
Final Avg Isolated vs Final Avg Skin Score



"I feel lonely or isolated" vs. Skin Score



Final Things to do vs Final Skin Score



Oil collection sheets



Figures 9a (left), 9b (middle), and 9c (right) are pictures of collected sebum samples through the blotting paper used in the study. Figure 9a represents a participant who scored their oiliness a 1, Figure 9b represents a participant who scored their oiliness a 3, and Figure 9c represents a participant who scored their oiliness a 5.

This study was conducted over two weeks with fourteen participants (n=14). The collected data include initial and final responses to the PSQ, 50 individualized sebum-collection self-reports, and photography. Upon analyzing the data, much of the distribution remained identified from the start to the conclusion of the study. On a more analytical level, by grouping participants by self-reported skin score, we were able to obtain a more accurate trend in the relationship between skin and stress across all participants. Participants were grouped as follows (according to their self-reports): excellent (score 4) at 7.1% (1/14 participants), good (score 3) at 7.1% (10/14 participants), and fair (score 2) at 21.4% (3/14 participants). These values did not change over the course of the study; only fluctuations in individual data occurred, with one participant going from good to fair and another from fair to good, resulting in a net-zero difference. The initial and final stress scores (fair, good, and excellent groups) from the PSQ (out of 50) ranged from 14-21 (initial) and 18-24 (final) for the fair group, 16-28 (initial) and 11-28 (final) for the good group, 27 (initial and final) for the excellent group. There is an overlap in all three groups, specifically, a student with a very low stress score (11) and a student with a very high stress score (28) both self-reported to have good skin, even though participants in the fair group had stress scores starting at 14 (4-11), proving stress not to be a dominant variable and most likely, one of many variables affecting skin in the course of this two-week study.

Conclusion

Given the results of this study, the trends in data, and the differences between stress and skin scores across participants, my original hypothesis remains inconclusive. Rather than seeing skin worsen alongside increased stress, the majority of participants exhibited stable or even better skin scores over the two-week study period; however, stress scores fluctuated modestly. This lack of substantial change in skin condition, coupled with minimal shifts in cumulative stress scores for most participants, suggests that the two-week study was insufficient in capturing the biological processes emphasized in prior studies, namely the effects of an accumulated allostatic load and chronic stress exposure on the skin.

Much of the literature reviewed for this study highlighted that skin dysfunction is rooted in a variety of factors across interconnected neuroendocrine, immune, and metabolic pathways. It was emphasized across studies that allostatic load develops when stress response systems, such as the HPA axis, the sympathetic nervous system, and inflammatory signaling networks, are repeatedly or chronically engaged. In contrast, the study I led, conducted with high school students in an academically and socially intense environment, indicated that the short two-week interval was insufficient to produce sufficient change in skin levels. In particular, 12 of 14 participants in this study reported no change in their skin scores between the initial and final surveys. These findings suggest that participants may have been operating within an adaptive rather than a pathological stress window, in which mechanisms maintained skin homeostasis despite perceived stress.

Additionally, given the mediation of stress by overlapping pathways mentioned above (See Background Research), some of these systems may not have been persistently activated in stress defense throughout the duration of this study. Prior research demonstrates that acute or moderate stress can transiently enhance immune surveillance and barrier repair. In contrast, chronic stress shifts immune balance, disrupts the skin barrier, and alters sebum production over time. The absence of meaningful deterioration in skin scores, therefore, supports the interpretation that the study period did not allow for cumulative pathway activation or for measurable downstream effects to manifest in skin outcomes.

Additionally, measuring sebum collection using blotting sheets may not have been the most accurate way to assess skin stress. Participant 6, for example, reported her skin's oiliness to be 2.5 on average across all trials over the course of the study, while her average stress score (both initial and final) was 27, which is quite high and not what previous studies and my hypothesis predicted.

It is possible that data discrepancies indicating an inconclusive trend in this study could be further analyzed to reveal additional factors influencing its success, such as menstrual cycles and sleep. These were both recorded over the course of this two-week study. Scientific research suggests that during the early follicular phase of the menstrual cycle, certain genetic pathways actually suppress T-cell activation and inhibit the signaling of inflammatory cytokines. This biological mechanism essentially creates a state of resilience in the skin-stress barrier, which explains why some participants could experience high levels of psychological pressure without a physical decline in skin quality (Adele et al., 2025).

Participants in the high-stress range who reported their skin score as fair were most commonly those who also reported their sleep as falling below 5.5 hours. This is a significant physiological deficit, considering that the average teenager should strive for 8 to 10 hours of sleep per night for healthy development and proper skin barrier recovery (Shao et al., 2022). One participant who averaged 8.5 hours of sleep per night reported a skin score of 3 (Good) and a stress score in the low range. This suggests that the physical toll of sleep deprivation may be a more aggressive driver of skin degradation than psychological stress alone, as sleep is the primary period during which the body undergoes nocturnal repair and reinforces the moisture barrier. Ultimately, these variables of sleep and hormonal timing likely acted as competing factors, masking the direct correlation between stress and skin health in this fourteen-day study.

The findings of this study do not invalidate the established relationship between stress and skin health described in previous research; instead, they reinforce the importance of measuring the duration and understanding long-term effects when studying stress and skin concerns. The neutral/inconclusive correlation observed in this study likely reflects a system of temporary equilibrium in adolescent skin biome, in which adaptive responses preserved skin condition despite prevailing academic and social stressors.

Recommendations for Future Work

To better track the correlation between skin and stress and yield more conclusive results, future studies should prioritize ensuring a large enough sample size and recruiting adolescents from multiple schools, thereby improving statistical power and external validity. Another adjustment that would significantly enhance this study's results would be to extend it over several months or an academic semester. This would better shape chronic stress patterns and the accumulation of allostatic load, enabling researchers to see the trends observed in earlier studies. Additionally, we found that sebum does not accurately reflect each participant's skin biome or the actual effect of stress on the skin. Future research could address this by tracking a different biomarker, such as salivary cortisol, which could provide more accurate results. Future studies should also focus on improving human response by developing participant training models and simplifying data collection protocols to increase compliance and ensure more timely, accurate data.

Acknowledgements

I would like to thank Ms. Reiser for her mentorship and critical role in its development. Throughout the research process, Ms. Reiser guided me in selecting appropriate methodological tools, taught me to navigate data production and analysis, and helped me approach each step of this study thoughtfully and deliberately. I would also like to thank Mr. Rylander for his continued support throughout this program. From our first meetings to the final revisions of this paper, Mr. Rylander provided guidance and encouragement that helped me navigate the challenges of long-term research and refine my work with clarity and purpose. Finally, I would like to acknowledge the University of Pennsylvania for the use of their Perceived Stress Questionnaire, which was adapted and used in this study.