**The Impact of psychological stress levels on the biophysical properties of the skin among university students**

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**Abstract**

Psychological stress can play a crucial role in detrimental physiological and functional consequences on the skin. Psychological stress cannot be monitored directly, hence in this study, we tried to monitor stress via recording some biophysical parameters of the skin (skin moisture, skin sebum (oil), and skin temperature) and compared to stress levels assessed based on Perceived Stress Scale. Skin biophysical parameters were recorded from 20 subjects, which experienced three different psychological stress levels. The answers to the Perceived Stress Scale questionnaire were used to assess the subject's stress levels. Skin moisture, sebum, and temperature were reduced as a function of psychological stress levels. However, statistically, no significant differences were observed among the three levels of stress. This study illustrated that different psychological stress levels led to a reduction in biophysical parameters of the skin. These findings suggest that the skin parameters might be used as a method for monitoring psychological stress.

**Keywords:** Biophysical properties, perceived Stress Scale, psychological stress, skin, skin hydration, skin temperature

**Introduction**

Stress is defined as any internal or external state which challenges the homeostasis of an individual (1). In addition, it can be studied as a set of events that occur due to a stimulus that precipitates a reaction in the brain and subsequently activates physiological systems in the body (2, 3). Moreover, stress produces a set of neuroendocrine responses that can influence various aspects of skin physiology (2). Stress varies in duration and intensity and can be acute which lasts for hours and chronic which lasts up to months (4).

The responses to stress are different, but mainly the release of stress hormones is included, which leads to an increase in heart rate, respiratory rate, blood flow, skin temperature, and cognitive activity (5). The stress response is quantitively assessed by using stress-specific hormonal responses and some other biomarkers (5). Stress can be assessed either subjectively via structured questionnaires, or objectively by measuring different body responses to stress (6).

The skin is the largest organ of the body. It contains efferent and afferent neural networks, blood vessels, glands, muscle elements, connective tissues, and immune cells. Functions of the skin are regulated by the neuroendocrine and immune systems. Under the stress conditions, the skin reacts and the hypothalamic-pituitary-adrenocortical axis is activated. In addition, catecholamines are released by the sympathetic-adrenal-medullary axes. Epinephrine (adrenaline) and norepinephrine (noradrenaline) are also released via the adrenal medulla (7). Furthermore, cutaneous peripheral nerve terminals release various neuropeptides that act as local stress mediators which play an important role in skin health (8).

Clinically, stress is commonly assessed based on self-reported questionnaires, however, researchers in diverse studies have assessed stress via recording physiological signals of the body responding to stress (9). Skin bioelectrical parameters such as skin conductance also change in responses to the release of sweat during stress (10). Human stress can also be detected by a single physiological sensor such as a galvanic skin response (5). Kim et al. (11) monitored driver stress by recording galvanic skin response. Bitkina et al. (12) employed electrodermal activity signals for detecting driving stress versus road type and traffic conditions. Li et al. (13), detected daily life stress by measuring ECG and analysis of heart rate variability.

The current study aimed to examine the correlation between psychological stress and the biophysical (skin moisture and skin temperature) properties of skin via using a portable skin hydration monitor and an infrared thermometer. We hypothesized that an increase in stress levels may alter some of the skin's biophysical parameters (skin moisture, skin lipids (sebum), and skin temperature) and that these parameters increase directly with increased stress levels.

**Participants and Procedure**

**Study protocol and participants**

Experiments were carried out on 20 healthy subjects (6 male and14 female) ranging in age from 19 to 21 years (mean 20 years). All participants were recruited from the University of Duhok, College of Engineering, and all of them gave written informed consent before taking part in the project. They were seated in a comfortable chair throughout the experiments in a silent laboratory. The laboratory temperature was 22-23 °C.

For monitoring the stress levels of the subjects, the perceived stress level has been used which was contain questions (14). The questions were asked the subject about his feelings and thoughts over THE PAST MONTH. In each question, he was been asked HOW OFTEN he felt or thought a certain way. The subject was asked also to answer fairly quickly and do not try to count up the exact number of times he felt a particular way but to choose the answer that in general seems the best. Each item was rated on a 5-point scale ranging from never (0) to almost always (4). Positively worded items were reverse-scored, and the ratings were summed, with higher scores indicating more perceived stress. Perceived Stress Scale-10 scores were obtained by reversing the scores on the four positive items: For example, 0=4, 1=3, 2=2, etc., and then summing across all items. Items 4, 5, 7, and 8 were positively stated items. Scores around 13 were considered average or low. While high stress groups had a stress score of around 20 points. A score of more than 20 was considered very high stress.

**Research tools**

Skin moisture, oil (sebum), and temperature were recorded by using two different portable instruments. SK-IV digital moisture monitor (Riuty- China) was employed to measure skin moisture and oil. It was dependent on the bioelectric impedance analysis technology and could measure the skin moisture within the range of 0-99.9%. The skin temperature was monitored by utilizing an infrared thermometer device (EFT-162-China).

**Statistical analysis**

In order to quantify the difference between the skin biophysical parameters and the stress levels one-way repeated analysis of variation (ANOVA) was conducted followed by a post hoc multiple pairwise comparison using IBM SPSS Statistics 22.

**Results**

**Skin moisture**

Skin moisture as a function of psychological stress for all test subjects is shown in Figure 1. Inspections of the figure reveal that as the stress levels are raised skin moisture is lowered. However, this reduction trend was statistically insignificant (*p*>0.05).

**Fig. 1.** Box-plot with medians, quartiles, and the min and max as whiskers, showing the skin moisture for all test subjects (n=20) with respect to the stress level.

**Skin sebum**

The skin sebum content as a function of stress levels is shown in Figure 2. It can be seen that the skin sebum is also decreased following exposure the participants to the high stress level. However, ANOVA analysis showed that these findings were statistically insignificant (p>0.05).

**Fig. 2.** Box-plot with medians, quartiles, and the min and max as whiskers, showing the skin sebum content for all test subjects (n=20) with respect to the stress level.

**Skin temperature**

The skin temperature as the third biophysical parameter of the skin was also changed as a function of the stress level. Figure 3 shows that the median value of skin temperature decreased due to higher stress levels, but insignificantly (*p*>0.05).

**Fig. 3.** Box-plot with medians, quartiles, and the min and max as whiskers, showing the skin temperature for all test subjects (n=20) with respect to the stress level.

**Discussion**

The aim of this was to investigate the relationship between the skin biophysical parameters and stress levels. The data presented in this study illustrate that the biophysical parameters of the skin are associated with the psychological stress level, but statistically insignificantly.

Skin moisture was influenced by the stress as reflected by the lowered skin moisture in all test subjects (Figure 1). According to Chen et al. (15) review study, the stress can impair the physiological and barrier function of the skin, which lowers the skin water retention. In addition, the underlying mechanism is still unclear; however, reduction in ceramide and pyrrolidone carboxylic acid was associated with stress in mice (16, 17).

Similarly, in this study stress caused a reduction in the skin sebum content. The finding that skin sebum content decreased in response to stress is surprising, as skin sebum content generally increases in response to stress. According to [Yosipovitch](https://pubmed.ncbi.nlm.nih.gov/?term=Yosipovitch+G&cauthor_id=17340019) et al. (18), increased sebum production is associated with stress. Sun and Rieder (19), also pointed to increases in skin sebum secretion following stress. The fact that we monitored skin sebum from the forearm with little hair may at least partially explain this discrepancy.

Effects of stress levels on the skin temperature were also observed. In addition, skin temperature was decreased following an increased level. Herborn et al. (20), reported that high stress level triggers peripheral vasoconstriction leading to a fast temporary drop in skin temperature. [Vinkers](https://scholar.google.com/citations?user=YOUuvFsAAAAJ&hl=en&oi=sra) et al. (21), showed that stress causes changes in skin temperatures. Moreover, they found that stress causes a reduction in facial skin temperature. In two different preclinical studies using rats and rabbits Blessing (22), and Busnardo et al. (23), noted that the hypothalamus is involved in the reduction of skin temperature after exposure to stress.

It is obvious that our hypotheses were not fully supported by these results and were controversial in comparison with other studies in many aspects. This is also still in line with the hypothesis that the evidence that variables increase with increasing stress levels is inconclusive (24). Some early studies reported occasionally observing suppression of sweat under high stress conditions (25, 26).

***Study limitations:***

The main limitation of this study is the small number of recruited participants, particularly females. Also, in this study, we focused only on questionnaires related to some aspects of stress other than to life-related events.

**Conclusions**

In this study, we found that skin moisture, sebum content, and skin temperature decreased following psychological stress. However, changes in these biophysical parameters of the skin were insignificant. It might be suggested that these skin parameters could be employed as a method for monitoring psychological stress.

**Ethical approval**

The protocol has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration.

**Conflict of interest**

Author states no conflict of interest.

**References**

1. Kagias K, Nehammer C, Pocock R. Neuronal responses to physiological stress*.* Front Genet 2012; 3: 222.

2. Altemus M, Rao B, Dhabhar FS, et al. Stress-induced changes in skin barrier function in healthy women*.* J Invest Dermatol 2001; 117(2): 309-17.

3. Drabhar F, McEwen B. Acute stress enhances while chronic stress suppresses immune function “in vivo”: a potential role for leukocyte trafficking*.* Brain Behav Immun 1997; 11(4): 286-306.

4. Dhabhar FS. Psychological stress and immunoprotection versus immunopathology in the skin*.* Clin Dermatol 2013; 31(1): 18-30.

5. Iqbal T, Elahi A, Redon P, et al. A review of biophysiological and biochemical indicators of stress for connected and preventive healthcare*.* Diagnostics 2021; 11(3): 556.

6. Goyal A, Singh S, Vir D, Pershad D. Automation of stress recognition using subjective or objective measures. Psychol Stud, 2016; 61(4): 348-64.

7. Alexopoulos A, Chrousos GP. Stress-related skin disorders*.* Rev Endocr Metab Disord 2016; 17(3): 295-304.

8. Botchkarev VA, Yaar M, Peters EM, et al. Neurotrophins in skin biology and pathology. J Invest Dermatol 2006; 126(8): 1719-27.

9. Alberdi A, Aztiria A, Basarab A. Towards an automatic early stress recognition system for office environments based on multimodal measurements: A review. J Biomed Inform 2016; 59: 49-75.

10. Gjoreski M, Luštrek M, Gams M, et al. Monitoring stress with a wrist device using context. J Biomed Inform 2017; 73:159-70.

11. Kim J, Park J, Park J. Development of a statistical model to classify driving stress levels using galvanic skin responses*.* Hum Factors Ergon Manuf 2020; 30(5): 321-28.

12. Bitkina OV, Kim J, Park J, et al. Identifying traffic context using driving stress: A longitudinal preliminary case study. Sensors 2019; 19(9): 2152.

13. Li T, Chen Y, Chen W. Daily stress monitoring using heart rate variability of bathtub ecg signals. In: 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) 2018: 2699-2702.

14. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983; 24(4):385-96.

15. Chen Y, Lyga J. Brain-skin connection: stress, inflammation and skin aging*.* Inflamm Allergy Drug Targets 2014;13(3):177-90.

16. Denda M, Tsuchiya T, Hosoi J, et al. Immobilization-induced and crowded environment-induced stress delay barrier recovery in murine skin*.* Br J Dermatol 1998; 138(5): 780-85.

17. Aioi A, Okuda M, Matsui M, et al. Effect of high population density environment on skin barrier function in mice. J Dermatol Sci 2001; 25(3): 189-97.

18. Yosipovitch G, Tang M, Dawn AG, et al. Study of psychological stress, sebum production and acne vulgaris in adolescents*.* Acta Derm Venereol 2007; 87(2): 135-39.

19. Sun MD, Rieder EA. Stress, Skin, and Beauty: The Basic Science Base. In Rieder E, Fried R (Eds.). Essential Psychiatry for the Aesthetic Practitioner. Hoboken: Wiley Balckwell; 2021 :1-21.

20. Herborn KA, Graves JL, Jerem P, et al. Skin temperature reveals the intensity of acute stress*.* Physiol Behav 2015; 152: 225-30.

21. Vinkers CH, Penning R, Hellhammer J, et al. The effect of stress on core and peripheral body temperature in humans*.* Stress, 2013; 16(5): 520-30.

22. Blessing WW. Lower brainstem pathways regulating sympathetically mediated changes in cutaneous blood flow. Cell Mol Neurobiol 2003; 23(4): 527-38.

23. Busnardo C, Tavares RF, Resstel LB, et al. Paraventricular nucleus modulates autonomic and neuroendocrine responses to acute restraint stress in rats*.* Auton Neurosci 2010; 158(1-2): 51-7.

24. Harker M. Psychological sweating: a systematic review focused on aetiology and cutaneous response*.* Skin Pharmacol Physiol 2013; 26(2): 92-100.

25. Darrow CW. Neural mechanisms controlling the palmar galvanic skin reflex and palmar sweating: a consideration of available literature*.* Arch Neurol Psychiatry 1937; 37(3): 641-63.

26. Harrison J, MacKinnon P. Physiological role of the adrenal medulla in the palmar anhidrotic response to stress*.* J Appl Physiol 1966; 21(1): 88-92.