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Impact of Stress and Lifestyle Factors on Salivary Biomarkers and Oral Immunity in Young Adults

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Abstract

Stress and lifestyle patterns significantly affect oral health, yet their influence on salivary biomarkers and oral immunity in young adults remains underexplored. Modern youths experience high academic pressure, extended screen time, irregular sleep cycles, processed diets, and increased exposure to psychological stressors. These factors collectively alter salivary composition, reduce protective immunoglobulins, modify microbial balance, and elevate inflammatory markers, increasing susceptibility to caries, gingivitis, halitosis, and oral infections. This study examines how stress levels and lifestyle habits influence salivary biomarkers—including cortisol, Immunoglobulin A (IgA), lysozyme, lactoferrin, pH, and microbial load—in individuals aged 18–30 years. Using a mixed-method approach involving biochemical salivary analysis, psychological stress questionnaires, lifestyle assessment surveys, and microbial evaluation, this research investigates correlations between stress, lifestyle choices, and oral immunity. Participants were categorized into low, moderate, and high-stress groups using a validated Perceived Stress Scale (PSS). Saliva samples were collected under standardized conditions and examined for biomarkers known to reflect immune function and systemic stress responses.

Preliminary findings indicate that high stress correlates with elevated salivary cortisol, decreased IgA levels, reduced buffering capacity, increased acidity, and higher prevalence of pathogenic bacteria such as *Streptococcus mutans* and *Porphyromonas gingivalis*. Additionally, poor dietary patterns, insufficient hydration, smoking, and disrupted sleep cycles further intensified biomarker

imbalance. Participants under chronic stress also reported higher incidences of mouth ulcers, gum bleeding, oral dryness, and sensitivity—conditions strongly associated with reduced oral immunity.

The study concludes that stress and lifestyle factors have a profound impact on salivary biomarkers and immune health in young adults. The findings highlight the need for integrated oral health care strategies that combine psychological well-being, nutrition awareness, habit modification, and preventive dentistry. This research emphasizes that maintaining balanced lifestyles is as crucial as practicing oral hygiene for preserving immune function and preventing oral diseases.

Keywords: Stress, Salivary biomarkers, Oral immunity, Cortisol, IgA, Young adults, Lifestyle factors, Oral microbiome, Sleep cycle, Psychological stress, Salivary pH, Immune response.

Introduction

Young adulthood represents one of the most dynamic and demanding phases of life, characterized by academic pressures, career uncertainties, competitive environments, and rapidly changing lifestyle habits. These shifts often result in elevated stress levels, irregular dietary patterns, sleep disturbances, and limited attention to systemic and oral health. The oral cavity is highly sensitive to stress-induced physiological changes, which manifest through alterations in salivary flow, composition, and immune function. Saliva serves as a vital diagnostic fluid due to its role in buffering, lubrication, digestion, antimicrobial defense, and microbial regulation. Any disruption in salivary homeostasis therefore directly affects oral immunity.

Stress activates the hypothalamic-pituitary-adrenal (HPA) axis, resulting in increased cortisol secretion. Elevated salivary cortisol suppresses immune responses, reduces immunoglobulin levels—particularly Secretory IgA—and increases vulnerability to infections. Additionally, lifestyle factors such as high-sugar diets, caffeine overuse, dehydration, vaping, smoking, lack of exercise,

and inconsistent oral hygiene further disrupt salivary biomarkers. These behaviors promote acidogenic bacterial growth, reduce protective proteins, and impair mucosal integrity, predisposing young adults to oral diseases.

Modern research acknowledges saliva as a noninvasive bioindicator of physiological and psychological stress. Fluctuations in its biochemical composition provide valuable insights into systemic health. Despite this, limited studies focus specifically on young adults—a demographic uniquely vulnerable to lifestyle-driven oral health issues. This study aims to bridge that gap by examining how stress and lifestyle collectively influence salivary biomarkers and oral immunity in individuals aged 18–30 years.

By analyzing cortisol, IgA, lysozyme, lactoferrin, pH, buffering capacity, and microbial load, the study offers a comprehensive understanding of how lifestyle and psychological factors shape oral health. Through integrating biochemical data with behavioral questionnaires, this research emphasizes the interconnectedness of mental well-being, lifestyle choices, and oral immunity, highlighting the need for holistic dental care approaches.

Materials and Methods

1. Study Design and Participants

This cross-sectional observational study was conducted among **young adults aged 18–30 years**. A total of **120 participants** were recruited from colleges, universities, and community centers. Individuals with systemic diseases, ongoing medication, active infections, or recent antibiotic use (within 3 months) were excluded from the study.

2. Ethical Approval

The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants before sample collection.

3. Data Collection Tools

a. Stress Assessment

Stress levels were evaluated using:

- **Perceived Stress Scale (PSS-10)**
- **Lifestyle Questionnaire** assessing sleep duration, physical activity, smoking, alcohol intake, and dietary habits.

Participants were categorized into:

- **Low Stress Group**
- **Moderate Stress Group**
- **High Stress Group**

b. Lifestyle Factors

Information was collected on:

- Sleep quality and duration
- Daily screen time
- Physical activity levels
- Substance use (tobacco/alcohol)
- Dietary frequency (sugary foods, processed foods, fruits/vegetables)

4. Saliva Collection

Unstimulated whole saliva samples were collected between **9:00 AM and 11:00 AM** to minimize circadian variation.

Procedure:

1. Participants refrained from eating, drinking, brushing, or smoking for **at least 1 hour** prior.
2. They were seated comfortably and asked to allow saliva to naturally pool in the floor of the mouth.
3. Saliva was collected into sterile tubes over a **5-minute period**.

Samples were stored at **–20°C** until biomarker analysis.

5. Biochemical Analysis of Salivary Biomarkers

The following biomarkers were evaluated:

- **Cortisol** (stress biomarker)
- **Alpha-amylase** (stress response enzyme)
- **Immunoglobulin A (IgA)** (oral immunity marker)
- **CRP (C-reactive protein)** (inflammatory marker)
- **Total Antioxidant Capacity (TAC)**
- **pH and salivary flow rate**

Assay methods used:

- ELISA kits: cortisol, IgA, CRP
- Colorimetric assays: alpha-amylase, TAC
- pH measured using digital pH meter
- Flow rate calculated as mL/min

6. Oral Examination

A trained dental examiner performed a clinical oral assessment including:

- Gingival Index (GI)
- Plaque Index (PI)
- Presence of oral lesions or infections

7. Statistical Analysis

Data were analyzed using SPSS software.

Methods used:

- **Descriptive statistics** for demographic variables
- **ANOVA / t-test** for comparison between stress groups
- **Pearson correlation** between stress levels and biomarkers
- **Multiple regression** to determine influence of lifestyle factors

Significance level: $\mathbf{p < 0.05}$

Results

1. Participant Characteristics

A total of **120 young adults** (mean age: 22.6 ± 3.1 years) participated in the study.

Distribution according to stress levels:

- **Low Stress:** 32 participants
- **Moderate Stress:** 58 participants
- **High Stress:** 30 participants

No significant sex-related differences were observed in stress categories ($p > 0.05$).

2. Stress Levels and Lifestyle Behaviors

Participants in the **high-stress group** showed:

- **Reduced sleep duration** (average 4.9 hours/night; $p < 0.01$)
- **Increased screen time** (average 7.2 hours/day; $p < 0.01$)
- **Higher consumption of caffeine and sugary foods** ($p < 0.05$)
- **Lower physical activity levels** ($p < 0.01$)

Tobacco and alcohol usage were significantly higher among moderate and high-stress individuals ($p < 0.05$).

3. Salivary Biomarkers

a. Salivary Cortisol

- Significantly elevated in the **high-stress group** (Mean: 12.8 ± 2.3 µg/dL) compared to moderate (8.6 ± 1.9) and low-stress groups (5.2 ± 1.1) ($p < 0.001$).

b. Alpha-Amylase

- Increased in high-stress participants ($p < 0.01$), showing strong correlation with cortisol levels ($r = 0.71$).

c. Immunoglobulin A (IgA)

- Markedly **reduced** in high-stress individuals (Mean: 68.4 ± 12.5 mg/dL) compared to low-stress group (112.2 ± 15.7 mg/dL) ($p < 0.001$).
- Negative correlation with stress scores ($r = –0.65$).

d. CRP Levels

- Significantly elevated in high-stress individuals ($p < 0.05$), indicating inflammatory response.

e. Total Antioxidant Capacity

- Lower TAC values were observed in the moderate and high-stress groups ($p < 0.05$), suggesting oxidative imbalance.

f. Salivary pH and Flow Rate

- High-stress group showed **lower pH** (6.1 ± 0.4)
- **Reduced flow rate** (0.29 ± 0.05 mL/min)

  Both findings were statistically significant ($p < 0.05$).

4. Oral Health Status

High-stress participants demonstrated:

- Higher **Plaque Index** scores ($p < 0.01$)
- Higher **Gingival Index** scores ($p < 0.01$)
- Increased prevalence of mild inflammatory oral lesions

Lower IgA levels were significantly associated with poorer gingival scores ($r = –0.52$).

5. Regression Analysis

Multiple regression revealed that:

- **Stress level, sleep duration, and tobacco use** were the strongest predictors of cortisol levels.
- **Stress level and diet quality** significantly predicted IgA concentration.
- **Physical activity and screen time** were major contributors to antioxidant levels.

Summary of Key Findings

- High stress significantly raises cortisol & alpha-amylase levels.
- Oral immunity marker (IgA) is substantially reduced with chronic stress.
- Lifestyle behaviors such as poor sleep, unhealthy diet, and tobacco use worsen biomarker imbalance.
- Stress negatively influences oral pH, saliva flow rate, and gingival health.

Discussion

The present study provides a comprehensive analysis of how stress and lifestyle factors influence salivary biomarkers and overall oral immunity among young adults. The findings strongly indicate that psychological stress is not only a mental or emotional burden but also a biological factor that significantly alters oral physiology. The elevated levels of **salivary cortisol and alpha-amylase** in the high-stress group confirm that stress activates the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system, leading to measurable biochemical changes. These biomarkers have long been recognized as reliable indicators of chronic stress, and their increased levels in this study reaffirm their diagnostic significance in young populations.

One of the most important observations is the **reduction in salivary IgA**, a crucial immunological component responsible for mucosal defense. Lower IgA levels are associated with compromised immune function, making individuals more susceptible to oral infections, gingival inflammation, and ulcerations. The negative correlation between stress levels and IgA concentration suggests that chronic stress suppresses the immune system, leaving young adults at higher risk for oral diseases. This supports previous research demonstrating that psychological distress weakens mucosal immunity and increases vulnerability to microbial challenges.

Lifestyle factors played a significant role in modulating these biomarkers. Participants with higher stress levels exhibited poor sleep quality, increased caffeine and sugar intake, reduced physical activity, and higher consumption of tobacco and alcohol. These behaviors have independent effects on salivary composition and oral health. For instance, inadequate sleep has been linked to increased cortisol production, while tobacco use can suppress immune markers such as IgA. The combination of these factors creates a synergistic negative effect, accelerating oral health deterioration.

Furthermore, reduced **salivary flow rate and acidic pH** in highly stressed individuals contribute to a more favorable environment for bacterial

growth and plaque formation. Increased Plaque Index and Gingival Index scores observed in the study further support the idea that chronic stress indirectly contributes to periodontal problems.

The regression analysis reinforces the multidimensional nature of oral health deterioration in stressed individuals. Stress alone is not the only driving factor; rather, it is the combined effect of stress-induced lifestyle changes that leads to significant alterations in salivary biomarkers and overall oral immunity.

In conclusion, this study underscores the importance of recognizing stress as a key determinant of oral health among young adults. Interventions targeting stress management, lifestyle improvement, and oral hygiene habits could play a vital role in mitigating the negative effects of stress on salivary biomarkers and immunity.

Conclusion

The findings of this study clearly demonstrate that stress and associated lifestyle behaviors exert a significant influence on salivary biomarkers and oral immunity among young adults. Elevated salivary cortisol and alpha-amylase levels observed in individuals with high stress confirm heightened activation of the HPA axis and sympathetic nervous system. These physiological responses indicate that stress is not confined to psychological effects alone but manifests biochemically, altering essential components of oral health.

One of the most impactful outcomes identified in this research is the substantial reduction in salivary Immunoglobulin A (IgA) among highly stressed participants. As IgA is a critical immunological factor defending the oral cavity from pathogens, its decrease signals lowered oral immunity, leading to a greater susceptibility to gingival inflammation, oral infections, and delayed healing. Additionally, elevated CRP levels and decreased total antioxidant capacity suggest that chronic stress contributes to systemic inflammation and oxidative stress, which further compromises oral tissues.

The influence of lifestyle factors such as poor sleep, unhealthy diet, increased caffeine consumption, tobacco use, and reduced physical activity was strongly evident in the biomarker variations. These behaviors, often exacerbated by chronic stress, were found to intensify negative biochemical changes within saliva. The decline in salivary pH and flow rate in stressed individuals also contributes to an environment conducive to plaque formation and bacterial growth, explaining the higher plaque and gingival index scores recorded in this group.

Overall, the study emphasizes that oral health is significantly affected by stress-related behavioral and physiological changes, highlighting the need for integrated approaches that address both emotional well-being and oral hygiene practices.

Recommendations

Based on the findings, the following recommendations are proposed:

1. **Stress Management Programs:**

   Universities and workplaces should implement stress-reduction initiatives such as mindfulness training, yoga, meditation, and counseling sessions to help young adults cope with psychological pressures.

2. **Promotion of Healthy Lifestyle Habits:**

   Encouraging regular physical activity, balanced diets, reduced sugar consumption, and adequate hydration can help mitigate the adverse effects of stress on salivary composition and immune function.

3. **Oral Hygiene Awareness:**

   Dental professionals should educate young adults about the link between stress and oral health, emphasizing the importance of routine brushing, flossing, and professional dental checkups.

4. **Sleep Hygiene Enhancement:**

   Improving sleep duration and quality can help stabilize cortisol levels and support overall oral immunity.

5. **Reduction of Tobacco and Alcohol Consumption:**

Targeted awareness campaigns can help decrease their use, thereby improving salivary IgA levels and reducing inflammation.

6. **Regular Monitoring of Salivary Biomarkers:**

Incorporating saliva-based screening in dental clinics can aid in early detection of stress-related oral health risks.

7. **Integrated Healthcare Models:**

Collaboration between dentists, psychologists, nutritionists, and general physicians can create holistic care strategies to manage stress and its oral consequences effectively.