Defence Life Science Journal, Vol. 9, No. 3, July 2024, pp. 242-249, DOI : 10.14429/dlsj.9.19267


# Human Saliva Quality and Holistic Practices: A Review on the Effects of Meditation, Dance, and Exercise

Manisha Yadav and Arup Giri*
*Department of Zoology, Baba Mastnath University, Rohtak, Haryana - 124 021, India*
**E-mail: arupsatadal@gmail.com*

**ABSTRACT**

This review article provides an overview of the effects of meditation, dance, and exercise on human saliva quality. Physical and mental fitness is essential for overall well-being, and engaging in these activities has been shown to promote physical and mental health. However, with the decline in physical activity due to technological advancements, stress has become a prevalent issue in modern society. Meditation, dance, and exercise have emerged as effective strategies for stress management. Stress levels can be measured through biomarkers, including those found in blood and saliva. Saliva may serve as a potential indicator of stress levels. Saliva contains various components that can serve as biomarkers for detecting systemic diseases and assessing overall health. Exploring the changes in saliva composition and understanding the physiological significance in response to meditation, dance, and exercise can provide valuable insights into the mechanisms underlying their positive effects on health. Saliva biomarkers have been associated with stress, inflammation, immune function, and even neurodegenerative disorders. Therefore, investigating the impact of these practices on saliva quality can uncover novel connections between mind-body interventions and overall well-being. This review highlights the importance of considering saliva as a valuable biofluid and encourages further research on salivary biomarkers in the context of meditation, dance, and exercise to expand our understanding of their therapeutic potential and optimise health outcomes.

**Keywords:** Biomarker; Bioindicator; Biofluid; Saliva; Stress

## 1. INTRODUCTION

In recent years, there has been a growing interest in exploring the intricate connections between mind, body, and overall well-being. As individuals seek ways to enhance their physical and mental health, various practices, such as meditation, dance, and exercise, have gained considerable attention. These activities have been found to contribute significantly to improving human health, with emerging evidence suggesting their impact on multiple physiological systems[1–3].

It is well known that maintaining physical and mental fitness is essential for individuals. Engaging in various physical activities promotes a healthy state within our bodies. However, recent technological advancements have led to a decline in human physical activity over the past few generations, resulting in physical inactivity and increased stress in daily life[4]. To address this stress, practices such as meditation, dance, and exercise have proven beneficial[5]. Measuring stress levels requires assessing biomarkers, which can be found in both blood and saliva[6]. Saliva quality has emerged as an intriguing area of research. Saliva, often regarded as a simple bodily fluid, is far more complex than initially perceived. It contains a rich array of biomarkers, including hormones, enzymes, antibodies, and other compounds[7], that reflect the state of an individual's health. Consequently, the analysis of saliva has become an invaluable tool in assessing the physiological and psychological well-being of individuals across different populations.

While extensive research has been conducted on blood biomarkers[8], salivary biomarkers have received less attention. Nonetheless, considering the historical significance of saliva, it has been discovered that saliva plays a vital role in reflecting an individual's health condition, acting as a mirror. Saliva contains various components that can help detect systemic diseases and serve as effective biomarkers for assessing health and disease[9].

In this review, we have critically examined the literature on the effects of meditation, dance, and exercise on saliva quality. Exploring how these practices influence saliva quality can provide valuable insights into the underlying mechanisms behind their positive effects on health. Saliva biomarkers have been associated with stress[6], inflammation[10], immune function[11], and even neurodegenerative disorders[12]. Therefore, investigating changes in saliva composition and understanding its physiological significance in response to meditation, dance, and exercise may reveal novel connections

Received : 28 June 2023, Revised : 17 December 2023
Accepted : 19 December 2023, Online published : 21 August 2024

between mind-body practices and overall well-being. Several methodologies have been explored in this review to identify key biomarkers affected by these practices, and discuss the potential mechanisms underlying their impact. Furthermore, we have highlighted gaps in the current understanding and propose directions for future research in this fascinating area.

By synthesising and analysing the available evidence, this review seeks to deepen our understanding of the complex relationship between mind-body practices and human saliva quality. Ultimately, such knowledge may inform the development of innovative therapeutic interventions, and personalised wellness strategies for the overall enhancement of human health and well-being.

## 2. HUMAN SALIVA AND ITS CHEMICAL COMPOSITION

Saliva, a vital biofluid produced by salivary glands, serves as a protective and lubricating agent within the oral cavity. Composed predominantly of water (approximately 99 %), saliva exhibits a clear and watery consistency[13]. However, this seemingly simple fluid contains a myriad of minor components that contribute to its diverse functionalities. Immunoglobulins, bacterial cells, cytokines, mucus, growth factors, digestive enzymes, antibacterial peptides, low molecular weight metabolites, and salts are among the various constituents present in saliva[14,15].

Saliva production primarily originates from the major salivary glands, with the submandibular gland accounting for approximately 70-75 % of the total output, followed by the parotid gland at 20-25 %, and the remaining 5 % generated by minor salivary glands. On average, an individual produces approximately 0.75 to 1.5 litres of saliva per day[16]. Notably, human saliva is a rich source of metabolites, as evidenced by a study conducted by Dame[13], *et al*. They identified 853 metabolites corresponding to 1237 chemical species, with approximately 300 metabolites being measured.

The production of saliva can be influenced quantitatively by various pathological and physiological factors. Hormonal changes, hereditary traits, taste and smell stimulation, psychological state, age, oral hygiene[17], medication use, and physical exercise[18] are known to impact saliva composition[19–21]. Alterations in these factors can result in observable changes in the composition of saliva, emphasizing the dynamic nature of this biofluid.

## 3. STRESS-RELATED DISEASE AND SALIVA QUALITY

In today's world of demanding occupations and increased stress levels, it is crucial to prioritize our health and monitor our body fluids effectively and affordably. Among these fluids, saliva plays a significant role in providing valuable insights into our well-being. Saliva has a long-standing history of being a physiologically important fluid, acting as a reflective mirror of an individual's health status. It contains numerous components that can aid in the detection of various systemic diseases, making it a promising biomarker for assessing health and disease conditions[6].

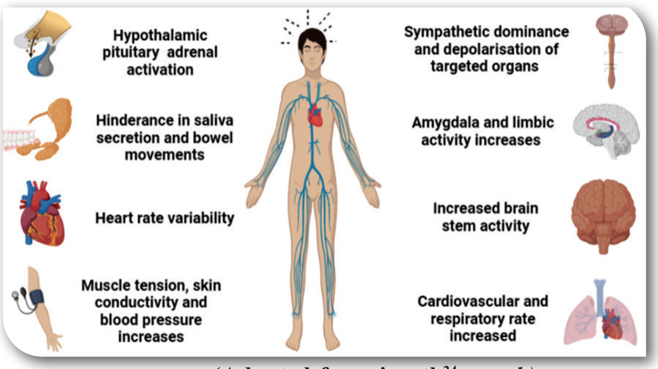
The association between hyposalivation and glandular inflammation suggests an intriguing connection. Stimulants such as radiation, Lipopolysaccharide (LPS), and Reactive Oxygen Species (ROS) can induce diseases such as xerostomia and rapid glandular inflammation. The down regulation of aquaporin 5 (AQP5) expressions and the development of Sjogren's syndrome (SS)-like complications can be attributed to LPS-induced proinflammatory cytokines, mediated by nuclear factor kappa-B (NF-Kβ) signalling and alterations in tight junctions. Similarly, oxidative stress caused by ROS can lead to hyposecretion, subsequently progressing to glandular inflammation. The induction of proinflammatory cytokines and interferons by Inducible Nitric Oxide Synthase (iNOS) can trigger epithelial apoptosis. Additionally, radiation-induced Inducible Nitric Oxide Synthase (iNOS) can reduce salivary secretion by altering the functions of nucleic acids, lipids, and proteins through the production of peroxynitrite ($ONOO^-$)[22].

Understanding the intricate relationship between saliva and these pathological mechanisms can provide valuable insights into the patho physiology of various diseases and their impact on salivary function. By exploring the multifaceted nature of saliva and its role in health maintenance, we can gain a deeper understanding of the complex interplay between systemic conditions and saliva composition. Such knowledge paves the way for the development of innovative diagnostic and therapeutic strategies that utilise saliva as a non invasive and informative tool for assessing and monitoring health conditions.

## 4. EFFECT OF MEDITATION ON SALIVARY STRESS-RELATED PARAMETERS

Mindfulness-Based Interventions (MBI) have been widely acknowledged in the literature for their effectiveness in reducing stress levels. However, there is still a scarcity of research conducted on psychobiological stress biomarkers using a momentary ecological approach in routine settings. Aguilar-Raab[23], *et al.* conducted a study to shed light on the effects of MBI on perceived stress, state mindfulness, and markers of sympathetic-nervous-system activation (sAA) and hypothalamic-pituitary-adrenal axis activation (saliva cortisol, sCort) during daily routines. The study involved 28 participants who underwent a three-month MBI program, compared to a control group consisting of 48 individuals. Ecological Momentary Assessment (EMA) was employed to evaluate stress parameters, and multilevel modelling was used to analyze the data on a moment-to-moment basis. The findings indicated that MBI led to decreased levels of sAA from pre- to post intervention, whereas the control group showed the opposite pattern. A brief analysis revealed that reduced stress and sAA levels were associated with mindfulness, but no significant changes were observed in saliva cortisol, sCort. These results suggest that MBI can reduce hypothalamic-pituitary-adrenal activation and sympathetic activation in daily routines, thereby reducing stress levels when incorporated into regular practices[23] (Table 1).

During times of stress, the body often exhibits sympathetic dominance, resulting in the depolarization of target organs. Increased amygdala and limbic activity, as well as decreased alpha waves and connectivity, are commonly observed. Brain stem activity rises, leading to increased cardiovascular and respiratory rates. Heart rate variability measurements are dominated by low-frequency components. Muscle tension, blood pressure, and skin conductivity also increase, while saliva secretion and bowel mobility may be hindered. Additionally, stressed individuals often display unpleasant facial expressions. The sympathetic branch of the autonomic nervous system surpasses the parasympathetic branch in the absence of meditation, whereas the opposite occurs with meditation[24] (Fig. 1).




**(Adapted from jerath[24], *et al.)***

**Figure 1. Body under stress without meditation.**

## 5. EFFECT OF DANCE ON SALIVARY STRESS-RELATED PARAMETERS

Dance stands out among various physical activities not only as a means to improve health but also as an entertaining, enjoyable, and engaging form of exercise. Its unique qualities make it an effective alternative for mitigating the detrimental effects of diseases and promoting overall well-being. A study revealed that dance can lead to increased levels of serotonin, nitric oxide, High-Density Lipoprotein (HDL) cholesterol, Low-Density Lipoprotein (LDL) cholesterol, and estrogen hormones, while reducing serum glucose, LDL cholesterol, serum triglycerides, and dopamine levels. Furthermore, cortisol levels in saliva can either increase or decrease depending on the type of dance performed[25].

A study conducted by klement[26], *et al.* explored the psychological and physiological effects of dance. The findings demonstrated that participants experienced increased physiological stress, as indicated by higher levels of the hormone cortisol, before and during the dance. However, contrasting results were observed in terms of psychological stress, which decreased before and during the dance (Table 1)[26]. Similarly, in a study focusing on Dance Movement Training (DMT), it was discovered that this program effectively improved cortisol regulation in adults. These findings suggest that DMT holds promise as a beneficial intervention for older adults as well[27] (Table 1).

**Table 1. Change in salivary biomarkers concerning different activities**

| S. No. | Biomarker | Activity | Outcome | Reference |
|---|---|---|---|---|
| 1. | Lactoferrin | Elite weightlifters and basketball players, rowing endurance exercise | Decreased during training and competition, increased postexercise and rowing | 31 |
| 2. | Lysozyme | Rowing exercise | Increased postexercise | 32 |
| 3. | Salivary alpha-amylase (sAA) | Meditation | Decreased from pre- to post-meditation | 23 |
| | | Cycling | Increased postexercise | 33 |
| 4. | Cortisol | Dance and exercise | Increased post dance | 26, 27 |
| 5. | Antioxidants | Exercise | Increase postexercise | 29, 30 |
| 6. | Uric acid | Resistance exercise | Increased postacute training | 34 |
| 7. | Testosterone | Resistance training and rugby league | Increased after exercise | 35, 36 |
| 8. | Salivary immuno globulin (IgA) and antimicrobial proteins | Acute exercise | Increased postexercise | 37 |
| | | Overtraining | Decreased postover training | |
| 9. | Monocyte chemotactic protein -1 (MCP-1), Interleukin (IL-8) and Interleukin (IL)-1β | Yoga | Decreased post yoga | 38 |
| 10. | Melatonin | Exercise | Increased postmorning exercise than afternoon exercise | 39 |
| 11. | Cystatins | Aerobic and anaerobic exercise | S- type cystatins secretion is increased, and cystatin C increased after anaerobic and aerobic exercise | 40 |
| 12. | Lactate | Running | Increased post running | 41 |

## 6. EFFECT OF EXERCISE ON SALIVARY STRESS-RELATED PARAMETERS

Over the past 350 generations, human physical activity levels have declined significantly due to advancements in technology brought about by agricultural, digital, and industrial revolutions. Consequently, physical inactivity has emerged as the fourth leading cause of death in today's society. The escalating risk of cardio metabolic disorders and suboptimal cardiovascular health is closely linked to the growing trend of physical inactivity, which often begins during adolescence (13-15 years)[4]. While exercise serves as a proxy for physical activity, it is important to note that exercise, with its more intense stimuli, is believed to induce more profound biological adaptations compared to general physical activity. Therefore, successful and efficient exercise training can play a crucial role in improving cardiovascular health[28].

In terms of saliva, significant metabolic changes occur in the body during activities such as exercise. It has been observed that antioxidant parameters and scavenging activities in saliva increase to a certain extent following exercise[29] (Table 1). A review encompassing 14 studies reported that in 8 of them, antioxidant parameters were found to increase after exercise, while lipid peroxidation increased in some cases. Additionally, two research studies observed elevated nitrite levels postexercise. However, it is important to note that the quality of evidence, as assessed through the Grading of Recommendations, Assessment, Development, and Evaluation analysis, was generally low due to factors such as indirectness, inconsistency, and high heterogeneity among the studies[30] (Table 1).

## 7. SALIVA AS A BIOMARKER

Saliva serves as a valuable source for quantifying and identifying various oxidative stress biomarkers. These biomarkers include oxidized proteins, lipids, and DNA, which undergo in vivo modification in the presence of ROS. The total antioxidant capacity of these biomarkers is indicative of the extent of oxidative stress. One measurable index used to assess the degree of DNA oxidation is 8-oxodG[42]. Salivary biomarkers such as cortisol are utilized for diagnosing conditions such as Cushing syndrome or stress disorders[41,43].

In the context of cardiovascular disease, biomarkers such as creatine kinase isoform MB, C-reactive protein (CRP), and myoglobin are employed[44]. Glycosylated haemoglobin and α-2-macroglobulin serve as biomarkers for diabetes[45], while InterLeukin (IL) biomarkers are associated with gut diseases, cancers, and muscle or joint disorders[46]. Salivary analysis of these biomarkers provides valuable insights into the patho physiology and diagnosis of various diseases.

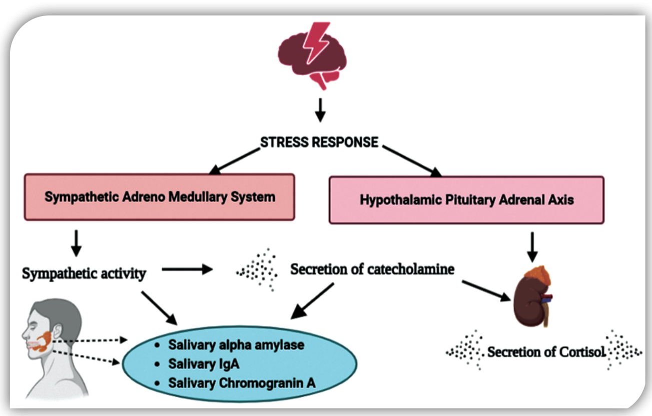
### 7.1 Saliva as Potential Stress Biomarker

The presence of a stressful stimulus leads to the activation of specific areas within the peripheral and central nervous systems. Salivary alpha-amylase, lysozyme, cortisol, and chromogranin A are potential biomarkers that indicate the presence of stress (Fig. 2). This response to stress involves stimulation of the brainstem and hypothalamus, activation of the Autonomic Nervous System (ANS) and Hypothalamic-Pituitary-Adrenal (HPA) axis, and involvement of the Sympathetic-Adrenal-Medullary (SAM) system (Fig. 2). These interconnected systems play a significant role in the pathogenesis of stress-related diseases and interact closely with the immune system[47]. Consequently, certain chemical changes occur in both blood and saliva as a result of these physiological responses. CgA, sAA, lysozyme, and cortisol are among the observed potential stress biomarkers found in saliva[6] (Fig. 2). Furthermore, studies have shown that levels of salivary immune globulins increase in response to heightened stress[48,49].

In our review, we identified cortisol as a physiological and psychological stress indicator, antioxidant molecules as biomarkers of oxidative stress, and salivary alpha-amylase and immune globulins as biomarkers of psychological stress.

Undergraduate courses often incorporate physiology, biopsychology, and neuroscience, where responses to sympathetic nervous system stimulation are assessed through measures such as galvanic skin response, blood pressure, or heart rate. In a laboratory study, undergraduate students measured sAA using a colorimetric enzyme assay and found that sAA could serve as a novel bio indicator of sympathetic nervous system activity. Specifically, increased sAA levels were observed in students experiencing stress during class presentations[50].

In the event of a nuclear incident in a densely populated area, there would be a sudden need for rapid medical assessment. This could overwhelm our disaster care system and raise concerns about our ability to effectively evaluate victims with life-threatening exposures or injuries. Therefore, there is a need for a deployable biological assay for radiation exposure that can be performed by individuals without medical training. Saliva is well-suited for this purpose due to its easy collection method and the presence of a wide range of biomolecules. In a study investigating the human salivary proteome's response to ionizing radiation exposure, researchers categorized various




**(Adapted from obayashi[49])**

**Figure 2. Mental stress proteins and mental stress response.**

saliva proteins and identified three proteins (intercellular adhesion molecule 1, monocyte chemoattractant protein 1, and interleukin 8) that significantly responded to radiation. This suggests that saliva has the potential to serve as an indicator of radiation exposure[51].

Saliva is also a convenient, non invasive biofluid that plays an important role in the diagnostic and biochemical assessment of both adults and children. Patients with blood clotting disorders can use saliva as an alternative to blood, as it does not coagulate. Saliva remains stable for diagnosis for up to 24 hours at room

temperature and one week at 4ºC. Therefore, it represents a viable option for scientific investigations[19,52].

## 8. SIGNIFICANCE AND FUTURE ASPECTS OF THIS REVIEW

This review aims to draw attention to the prevalent issue of stress and its significant impact on both physical and psychological well-being. Despite being overlooked, stress can have serious consequences if left unaddressed and allowed to become chronic. Early measurement and diagnosis of stress are crucial in preventing long-term harm. Our study highlights saliva as the only biofluid that offers ease of collection and non invasiveness for stress assessment (Fig. 3). Additionally, we discuss the therapeutic benefits of meditation, dance, and exercise in stress reduction. The review also sheds light on saliva's potential as a biomarker for stress. However, further research is needed to explore changes in saliva composition in response to internal and external environmental factors. Currently, there is a lack of studies examining psychobiological stress biomarkers through a momentary ecological approach in routine settings. Moreover, investigating saliva's diagnostic capabilities, such as specificity and sensitivity, and establishing correlations between saliva and blood biomarkers warrant further investigation. Future research should involve larger populations to enhance our understanding of saliva's role in stress assessment[53].

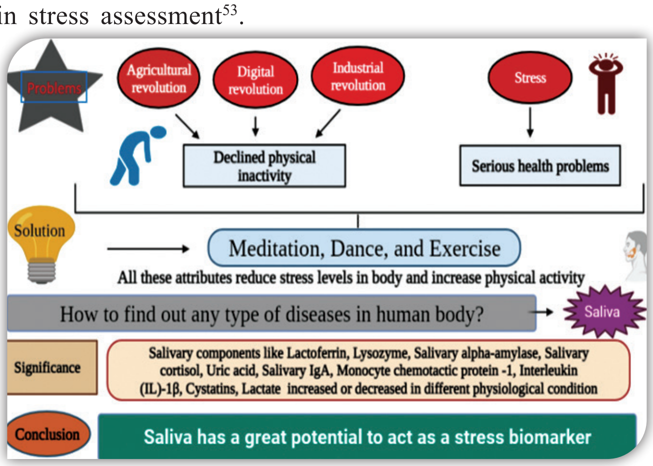



**Figure 3. Overall view of human saliva as a stress biomarker.**

## 9. CONCLUSIONS

Based on our review, it is evident that regular engagement in physical activities such as meditation, dance, and exercise is crucial for achieving mental and physical well-being. These activities serve as effective stress management interventions. Notably, the quality of saliva undergoes changes in response to physiological and psychological shifts within the body, with stress causing disruptions in saliva composition. Cortisol, sAA, lysozyme, cortisol, CgA, and immune globulins have been identified as potential biomarkers of stress. Saliva also holds promise as a bio indicator for stress and environmental exposures, including radiation. This review emphasizes the significance of incorporating physical activities into daily life, be it through meditation, dance, or exercise. Additionally, it highlights the importance of saliva as a stress biomarker, which may contribute to future research endeavours. Meanwhile, the sustainability of health and well-being practices relies on their positive impact on human health and well-being. Meditation, dance, and exercise have the potential to improve overall physical and mental health, which can indirectly affect saliva quality. Sustained engagement in these practices can contribute to long-term well-being and promote a healthier lifestyle. By considering human sustainability aspects, individuals can optimize their engagement with meditation, dance, and exercise to sustain the positive effects on saliva quality and achieve long-term benefits for their health and well-being.

## REFERENCES

1 Demmin, D.L.; Silverstein, S.M. & Shors, T.J. Mental and physical training with meditation and aerobic exercise improved mental health and well-being in teachers during the COVID-19 pandemic. *Front. Hum. Neurosci.,* 2022, **16**, 847301. doi: 10.3389/fnhum.2022.847301

2. Barranco-Ruiz, Y.; Paz-Viteri, S. & Villa-González, E. Dance fitness classes improve the health-related quality of life in sedentary women. *Int. J. Environ. Res. Public Health,* 2020, **17**. doi: 10.3390/ijerph17113771

3. Edwards, M.K. & Loprinzi, P.D. Comparative effects of meditation and exercise on physical and psychosocial health outcomes: A review of randomized controlled trials. *Postgrad. Med.,* 2018, **130**, 222–228. doi: 10.1080/00325481.2018.1409049

4. Hallal, P.C.; Andersen, L.B.; Bull, F.C.; Guthold, R.; Haskell, W. & Ekelund, U. Global physical activity levels: Surveillance progress, pitfalls, and prospects. *Lancet,* 2012, **380**, 247–257. doi: 10.1016/s0140-6736(12)60646-1

5. Koch, S.C.; Riege, R.F.F.; Tisborn, K.; Biondo, J.; Martin, L. & Beelmann, A. Effects of dance movement therapy and dance on health-related psychological outcomes. A meta-analysis update. *Front. Psychol.,* 2019, **10**, 1806. doi: 10.3389/fpsyg.2019.01806

6. Chojnowska, S.; Ptaszyńska-Sarosiek, I.; Kępka, A.; Knaś, M. & Waszkiewicz, N. Salivary biomarkers of stress, anxiety and depression. *J. Clin. Med.,* 2021, **10**, 1–11. doi: 10.3390/jcm10030517

7. Yoshizawa, J.M.; Schafer, C.A.; Schafer, J.J.; Farrell, J.J.; Paster, B.J. & Wong, D.T. Salivary biomarkers: Toward future clinical and diagnostic utilities. *Clin. Microbiol. Rev.,* 2013, **26**, 781–791. doi: 10.1128/cmr.00021-13
8. Angioni, D.; Delrieu, J.; Hansson, O.; Fillit, H.; Aisen, P. & Cummings, J. blood biomarkers from research use to clinical practice: What must be done? A report from the EU/US CTAD task force. *J. Prev. Alzheimer's Dis.,* 2022, **9**, 569–579. doi: 10.14283/jpad.2022.85
9. Motamayel, F.A.; Davoodi, P.; Dalband, M. & Hendi, S.S. Saliva as a mirror of the body health. *Avicenna J. Dent. Res.,* 2018, **1**, 41–55. doi: https://ajdr.umsha.ac.ir/Article/ajdr-13 [Accessed on 16.04.2023]
10. Desai, G.S. Saliva as a non-invasive diagnostic tool for inflammation and insulin-resistance. *World J. Diabetes,* 2014, **5**, 730. doi: 10.4239/wjd.v5.i6.730
11. Engeland, C.G.; Bosch, J.A. & Rohleder, N. Salivary biomarkers in psychoneuroimmunology. *Curr. Opin. Behav. Sci.,* 2019, **28**, 58–65. doi: 10.1016/j.cobeha.2019.01.007
12. Farah, R.; Haraty, H.; Salame, Z.; Fares, Y.; Ojcius, D.M. & Sadier, N.S. Salivary biomarkers for the diagnosis and monitoring of neurological diseases. *Biomed. J.,* 2018, **41**, 63–87. doi: 10.1016/j.bj.2018.03.004
13. Dame, Z.T.; Aziat, F.; Mandal, R.; Krishnamurthy, R.; Bouatra, S.; Borzouie, S.; & Wishart, D.S. The human saliva metabolome. *Metabolomics,* 2015, **11**, 1864–1883. doi: 10.1007/s11306-015-0840-5
14. Soini, H.A.; Klouckova, I.; Wiesler, D.; Oberzaucher, E.; Grammer, K.; Dixon, S.J.; Xu, Y.; Brereton, R.G.; Penn, D.J. & Novotny, M.V. Analysis of volatile organic compounds in human saliva by a static sorptive extraction method and gas chromatography-mass spectrometry. *J. Chem. Ecol.,* 2010, **36**, 1035–1042. doi: 10.1007/s10886-010-9846-7
15. De Almeida, P.D.V.; Grégio, A.M.T.; Machado, M.Â.N.; De Lima, A.A.S. & Azevedo, L.R. Saliva composition and functions: A comprehensive review. *J. Contemp. Dent. Pract.,* 2008, **9**, 072–080. doi: 10.5005/jcdp-9-3-72
16. Sánchez-Pablo, M.A.; González-García, V. & Del Castillo-Rueda, A. Study of total stimulated saliva flow and hyperpigmentation in the oral mucosa of patients diagnosed with hereditary hemochromatosis. Series of 25 cases. *Med. Oral Patol. Oral Cir. Bucal.,* 2012, **17**, e45. doi: 10.4317/medoral.17206
17. Lingström, P. & Moynihan, P. Nutrition, Saliva, and Oral Health. *Nutri.,* 1998, 17–27. doi: 10.1016/s0899-9007(03)00062-5
18. Chicharro, J.L.; Lucía, A.; Pérez, M.; Vaquero, A.F. & Ureña, R. Saliva composition and exercise. *Sport. Med.,* 1998, **26**, 17–27. doi: 10.2165/00007256-199826010-00002
19. Kaufman, E. & Lamster, I.B. The diagnostic applications of saliva - A review. *Crit. Rev. Oral Biol. Med.,* 2002, **13**, 197–112. doi: 10.1177/154411130201300209
20. Chiappin, S.; Antonelli, G.; Gatti, R. & De Palo, E.F. Saliva specimen: A new laboratory tool for diagnostic and basic investigation. *Clin. Chim. Acta,* 2007, **383**, 30–40. doi: 10.1016/j.cca.2007.04.011
21. Walsh, N.P.; Laing, S.J.; Oliver, S.J.; Montague, J.C.; Walters, R.O.B.E.R.T. & Bilzon, J.L. Saliva parameters as potential indices of hydration status during acute dehydration. *Med. Sci. Sports Exerc.,* 2004, **36**, 1535–1542. doi: 10.1249/01.mss.0000139797.26760.06
22. Bhattarai, K.R.; Junjappa, R.; Handigund, M.; Kim, H.R. & Chae, H.J. The imprint of salivary secretion in autoimmune disorders and related pathological conditions. *Autoimmun. Rev.,* 2018, **17**, 376–390. doi: 10.1016/j.autrev.2017.11.031
23. Aguilar-Raab, C.; Stoffel, M.; Hernández, C.; Rahn, S.; Moessner, M.; Steinhilber, B. & Ditzen, B. Effects of a mindfulness-based intervention on mindfulness, stress, salivary alpha-amylase and cortisol in everyday life. *Psychophysiol.,* 2021, **58**, e13937. doi: 10.1111/psyp.13937
24. Jerath, R.; Barnes, V.A. & Crawford, M.W. Mind-body response and neurophysiological changes during stress and meditation: Central role of homeostasis. *J. Biol. Regul. Homeost. Agents,* 2014, **28**, 545–554. doi: 10.2202/1553-3840.1299
25. Lopez-Nieves, I. & Jakobsche, C.E. Biomolecular effects of dance and dance/movement therapy: A review. *Am. J. Danc. Ther.,* 2022, **44**, 241–263. doi: 10.1007/s10465-022-09368-z
26. Klement, K.R.; Lee, E.M.; Ambler, J.K.; Hanson, S.A.; Comber, E.; Wietting, D. & Sagarin, B.J. Extreme rituals in a BDSM context: the physiological and psychological effects of the 'Dance of Souls'. *Cult. Heal. Sex.,* 2017, **19**, 453–469. doi: 10.1080/13691058.2016.1234648
27. Vrinceanu, T.; Esmail, A.; Berryman, N.; Predovan, D.; Vu, T.T.M.; Villalpando, J.M.; Pruessner, J.C. & Bherer, L. Dance your stress away: Comparing the effect of dance/movement training to aerobic exercise training on the cortisol awakening response in healthy older adults. *Stress,* 2019, **22**, 687–695. doi: 10.1080/10253890.2019.1617690
28. Karlsen, T.; Aamot, I.L.; Haykowsky, M. & Rognmo, Ø. High intensity interval training for maximizing health outcomes. *Prog. Cardiovasc. Dis.,* 2017, **60**, 67–77. doi: 10.1016/j.pcad.2017.03.006
29. Thakur, U.; Thakur, D.; Sharma, K.; Kumari, N. & Giri, A. Effects of exercise and game on boy's physiology and salivary antioxidant properties. *Eur.*

*J. Biomed. Pharm. Sci.,* 2020, **7**, 578–581. https://www.ejbps.com/ejbps/abstract_id/6818 [Accessed on 16.04.2023]

30. Alves, R.C.C.; Ferreira, R.O.; Frazão, D.R.; de Souza Né, Y.G.; Mendes, P.F.S.; Marañón-Vásquez, G.; Royes, L.F.F.; Fagundes, N.C.F.; Maia, L.C. & Lima, R.R. The relationship between exercise and salivary oxidative stress: A systematic review. *Antioxidants,* 2022, **11**, 1489. doi: 10.3390/antiox11081489
31. He, C.S.; Tsai, M.L.; Ko, M.H.; Chang, C.K. & Fang, S.H. Relationships among salivary immunoglobulin A, lactoferrin and cortisol in basketball players during a basketball season. *Eur. J. Appl. Physiol.,* 2010, **110**, 989–995. doi: 10.1007/s00421-010-1574-8
32. West, N.P.; Pyne, D.B.; Kyd, J.M.; Renshaw, G.M.; Fricker, P.A. & Cripps, A.W. The effect of exercise on innate mucosal immunity. *Br. J. Sports Med.,* 2010, **44**, 227–231. doi: 10.1136/bjsm.2008.046532
33. Kivlighan, K.T. & Granger, D.A. Salivary α-amylase response to competition: Relation to gender, previous experience, and attitudes. *Psychoneuroendocrinol.,* 2006, **31**, 703–714. doi: 10.1016/j.psyneuen.2006.01.007
34. Deminice, R.; Sicchieri, T.; Payão, P.O. & Jordão, A.A. Blood and salivary oxidative stress biomarkers following an acute session of resistance exercise in humans. *Int. J. Sports Med.,* 2010, **31**, 599–603. doi: 10.1055/s-0030-1255107
35. McLellan, C.P.; Lovell, D.I. & Gass, G.C. Creatine kinase and endocrine responses of elite players pre, during, and post rugby league match play. *J. Strength Cond. Res.,* 2010, **24**, 2908–2919. doi: 10.1519/jsc.0b013e3181c1fcb1
36. Hough, J.; Robertson, C. & Gleeson, M. Blunting of exercise-induced salivary testosterone in elite-level triathletes with a 10-day training camp. *Int. J. Sports Physiol. Perform.,* 2015, **10**, 935–938. doi: 10.1123/ijspp.2014-0360
37. Papacosta, E. & Nassis, G.P. Saliva as a tool for monitoring steroid, peptide and immune markers in sport and exercise science. *J. Sci. Med. Sport,* 2011, **14**, 424–434. doi: 10.1016/j.jsams.2011.03.004
38. Twal, W.O.; Wahlquist, A.E. & Balasubramanian, S. Yogic breathing when compared to attention control reduces the levels of pro-inflammatory biomarkers in saliva: A pilot randomized controlled trial. *BMC Complement. Altern. Med.,* 2016, **16**, 1–10. doi: 10.1186/s12906-016-1286-7
39. Carlson, L.A.; Pobocik, K.M.; Lawrence, M.A.; Brazeau, D.A. & Koch, A.J. Influence of exercise time of day on salivary melatonin responses. *Int. J. Sports Physiol. Perform.,* 2019, **14**, 351–353. doi: 10.1123/ijspp.2018-0073
40. Sant'Anna, M.D.L.; Oliveira, L.T.; Gomes, D.V.; Marques, S.T.F.; Provance Jr, D.W.; Sorenson, M.M. & Salerno, V.P. Physical exercise stimulates salivary secretion of cystatins. *PLoS One,* 2019, **14**, e0224147. doi: 10.1371/journal.pone.0224147
41. Santos, R.V.T.; Almeida, A.L.R.; Caperuto, E.C.; Martins, E. & Costa Rosa, L.F.B.P. Effects of a 30-km race upon salivary lactate correlation with blood lactate. *Comp. Biochem. Physiol. - B Biochem. Mol. Biol.,* 2006, **145**, 114–117. doi: 10.1016/j.cbpb.2006.07.001
42. Wu, L.L.; Chiou, C.C.; Chang, P.Y. & Wu, J.T. Urinary 8-OHdG: A marker of oxidative stress to DNA and a risk factor for cancer, atherosclerosis and diabetics. *Clin. Chim. Acta,* 2004, **339**, 1–9. doi: 10.1016/j.cccn.2003.09.010
43. Pan, X.; Wang, Z.; Wu, X.; Wen, S.W. & Liu, A. Salivary cortisol in post-traumatic stress disorder: A systematic review and meta-analysis. *BMC Psychiatry,* 2018, **18**, 1–10. doi: 10.1186/s12888-018-1910-9
44. Agha Hosseini, F.; Sadat Moosavi, M.; Sadat Sadrzadeh Afshar, M. & Sheykh Bahaei, N. Assessment of the relationship between stress and oral lichen planus: A review of literature. *J. Islam. Dent. Assoc. IRAN,* 2016, **28**, 78–85. doi: 10.30699/jidai.29.2.78
45. Aitken, R.J. & Baker, M.A. Oxidative stress, sperm survival and fertility control. *Mol. Cell. Endocrinol.,* 2006, **250**, 66–69. doi: 10.1016/j.mce.2005.12.026
46. Rathnayake, N.; Åkerman, S.; Klinge, B.; Lundegren, N.; Jansson, H.; Tryselius, Y.; Sorsa, T. & Gustafsson, A. salivary biomarkers for detection of systemic diseases. *PLoS One,* 2013, **8**, e61356. doi: 10.1371/journal.pone.0061356
47. Sternberg, E.M. Neural regulation of innate immunity: A coordinated nonspecific host response to pathogens. *Nat. Rev. Immunol.,* 2006, **6**, 318–328. doi: 10.1038/nri1810
48. Marrelli, M.; Gentile, S.; Palmieri, F.; Paduano, F. & Tatullo, M. Correlation between surgeon's experience, surgery complexity and the alteration of stress related physiological parameters. *PLoS One,* 2014, **9**, e112444. doi: 10.1371/journal.pone.0112444
49. Obayashi, K. Salivary mental stress proteins. *Clin. Chim. Acta,* 2013, **425**, 196–201. doi: 10.1016/j.cca.2013.07.028
50. Bañuelos, M.S.; Musleh, A. & Olson, L.E. measuring salivary alpha-amylase in the undergraduate neuroscience laboratory. *J. Undergrad. Neurosci. Educ.,* 2017, **16**, A23–A27. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5777833/ [Accessed on 16.04.2023]
51. Moore, H.D.; Ivey, R.G.; Voytovich, U.J.; Lin, C.; Stirewalt, D.L.; Pogosova-Agadjanyan, E.L. & Paulovich, A.G. The human salivary proteome

is radiation responsive. *Radiat. Res.,* 2014, **181**, 521–530.
doi: 10.1667/rr13586.1

52. Poloni, T.R.; Oliveira, A.S.; Alfonso, H.L.; Galvo, L.R.; Amarilla, A.A.; Poloni, D.F.; Figueiredo, L.T. & Aquino, V.H. detection of dengue virus in saliva and urine by real time RT-PCR. *Virol. J.,* 2010, **7**, 1–4.
doi: 10.1186/1743-422x-7-22
53. Lindsay, A. & Costello, J.T. realising the potential of urine and saliva as diagnostic tools in sport and exercise medicine. *Sport. Med.,* 2017, **47**, 11–31.
doi: 10.1007/s40279-016-0558-1

## CONTRIBUTORS

**Ms. Manisha Yadav** has completed her masters degree in Zoology from Maharshi Dayanand University, Rohtak. She is currently perusing her Ph.D. work in Baba Mastnath University, Rohtak, Haryana. Her research area is human salivary biomarkers and its correlation with human physiology. She has contributed in literature survey and primary draft preparation.

**Dr. Arup Giri** is currently working as Associate Professor in Department of Zoology, Baba Mastnath University, Rohtak, Haryana. Earlier, he completed his Ph.D. in Life Sciences from DRDO-Defence Institute of High Altitude Research (DIHAR), Ladakh, India. His area of research expertise is environmental toxicology and animal physiology.
He conceived, supervised, revised and edited the final manuscript.