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Research Article

Assessing the Impact of Stress on the Objectivity of Dental Diagnostic Indicators

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Abstract

Background: Information on objective data and reference indicators characterizing the condition and relationship of maxillofacial organs (MFO) with general adaptation syndrome and stress is poorly understood. The aim of this study is an experimental and clinical investigation of the objectivity of a method for digital, comprehensive, and express diagnostics of students' dental status under stressful conditions based on metabolic, morphometric, and functional indicators of maxillofacial tissues.

Material and Methods: The study involved 30 students aged 18 to 21 years (17 females and 13 males) before and after mentally challenging classes, after physical exercise, after the end of the first year of study, and at the beginning and middle of the first semester of the second year of study. Electroodontodiagnostics, pH-metry and fluorescence diagnostics of saliva, thermometry of periodontal tissues, Stange test, calculation of the Sheikh-Zade formula, and the Spielberger psychological test were carried out. Statistical analysis of the results was performed using standard statistical complexes in Microsoft Excel.

Results: EOD: after two classes with mental stress - an increase in the indicator by 46.5% ($p < 0.01$). After physical unloading - recovery by 23.2% ($p < 0.05$). pH-metry of saliva: at the end of the academic year - 6.41 ± 0.19, after two months of summer vacation - 6.87 ± 0.11, and in the middle of the first semester of the second year - 6.63 ± 0.11. A comparative analysis of periodontal tissue thermometry readings in students at the end of the academic year and after a two-month rest revealed an average increase in gum temperature of 0.62 °C ($p < 0.05$). Measuring the fluorescence intensity of saliva samples before and after academic stress compared to baseline revealed a significant increase in the 600-650 nm wavelength range and a 10-30-fold increase in integral intensity, while a 7-10-fold decrease was observed after a night's rest. Stange's test revealed a 31.5% decrease ($p < 0.001$) after two mentally challenging sessions and a 19.3% improvement ($p < 0.001$) after physical stress. Sheikh-Zadeh formula: after two sessions with mental stress - an increase of 57.2% ($p < 0.001$), after physical unloading - dynamics to decrease by 18.6% ($p < 0.05$). Spielberger psychological test after summer vacation: prevalence of the average level of personal anxiety and a high level of reactive anxiety.

Conclusion: the specified examination methods can reasonably be included in a comprehensive assessment of the dental status with the intensification of their correction for the stress factor. The presented indicators of the maxillofacial region objectively and multifactorially reflect the dental status of the maxillofacial region and can be used as reference in assessing stress loads in students at the stages of their training. Key words: stress; reference indicators of stress; maxillofacial region; saliva; fluorescence. For citation: Alexandrov M.T.

Keywords: Maxillofacial Organs (MFO); Metabolic; Saliva

Introduction

Traditional methods for diagnosing dental diseases, such as clinical examination, probing, and radiography, have a number of significant limitations, including subjective assessment, low sensitivity in the early stages, exposure to ionizing radiation, and the inability to objectively quantify tissue condition. Furthermore, existing approaches often consider dental status in isolation, failing to consider its close relationship with the patient's overall health [1-4,16].

Currently, digital personalized medicine is actively developing in dentistry (anecdotal reports). This approach is based on the use of objective quantitative diagnostic methods. For example, biophotometric medical technologies, such as a combination of optical and digital diagnostic methods using the "speed of light" with a multifactorial, on-site, express assessment of oral biotopes at the metabolic, morphometric, functional, and, ultimately, clinical levels [31-33]. This enables comprehensive, multifactorial diagnostics of dental status components in real time, integrating and interrelating all studied elements. However, to date, this objective medical technology has not yet found its proper application for assessing dental status. Our research aims to develop and verify an innovative biophotometric platform for assessing dental status and to investigate potential errors in its clinical implementation. The main idea (concept) of the scientific and clinical study is to evaluate the objectivity of a multifunctional biophotometric system using modern optical technologies for a detailed analysis of tissue condition based on innovative, objective, scientifically and pathogenetically substantiated digital technologies [5,10]. This will make it possible to evaluate not only the actual state of the patient's dental health (based on an objective assessment of their dental status: expressly, on-site, comprehensively: multifactorial and morphofunctional, personalized), but also to predict the dynamics of the disease, as well as the effectiveness of treatment. The presented paradigm differs significantly from existing technologies for assessing dental status: most studies are limited to a single method and a single nosology, do not take into account a comprehensive assessment of dental status and validation, as well as the influence of error additivity (in conditions of multifactorial assessment) and the stress factor (physician and patient). These problematic issues, in the absence of a fundamental basis, may lead to both false-positive and false-negative results. The influence of exogenous and endogenous factors, as well as stress, on dental diagnostic results is particularly significant. For example, stress associated with a patient's visit to the dentist leads to changes in microcirculation, salivation, and autonomic status, which significantly distorts the measured parameters (see the analytical literature review). Studying the influence of this factor is a crucial task in developing objective methods for diagnosing dental health in health and disease.

In summary, the development and validation of an innovative multimodal biophotometric system for digital, personalized assessment of dental health, taking into account and eliminating the influence of additivity error and stress factors, represents a pressing scientific and practical challenge and has significant scientific, medical, and social significance.

It is known that prolonged exposure to stress can cause severe emotional instability and increased anxiety [9,11]. The aforementioned psychosomatic destabilized status of future young specialists may subsequently affect the effectiveness of their professional activities and the level of socialization in society [13-15]. At the same time, it is known that modern advances in medical technology in dentistry allow for the relevant studies (electroodontodiagnostics, periodontal thermometry, pH-metry, and fluorescent diagnostics of saliva) to be conducted without the need for special conditions [5,6,16-23], which can apparently be used to assess the dental status of students under stress. In our opinion, the information obtained as a result of the aforementioned types of studies will allow the use of these data for objective substantiation, assessment, and correction of the dental status based on the identification of signs of impaired functioning of the tissues and organs of the maxillofacial region under stress. This methodological approach is practically not reflected in the literature and is of undoubted scientific and practical interest. Thus, in accordance with the presented concept, it seems relevant to develop an algorithm for comprehensive and express diagnostics of dental status under stressful conditions (the educational process) by studying the bioresponse of a number of objective factors: metabolic (fluorescence diagnostics and pH-metry of saliva), morphofunctional (Stange test, Sheikh-Zadeh formula), functional (EOD, periodontal thermometry), and psychological (Ch.D. Spielberger test) characteristics of maxillofacial tissues and organs.

The aim of the study is to experimentally and clinically substantiate the "objectivity" of the method for comprehensive express diagnostics of dental status under stress in students using metabolic, morphometric, and functional indicators of maxillofacial tissues.

Material and Methods

The study involved 30 first- and second-year students of the Faculty of Dentistry aged 18 to 21 years (17 females and 13 males) before and after classes with mental stress, after physical relaxation, as well as after the end of the first year of study, at the beginning and in the middle of the first semester of the second year of study. Statistical analysis of the results was performed using standard statistical packages in Microsoft Excel. To determine the degree of conductivity of the nerve receptors of the dental pulp, electroodontodiagnostics (EDD) was performed using the Pulp EST device by Geosoft (Russia) before, after classes with mental stress and after physical relaxation. In this study, the passive electrode was fixed on the lip of the subject. The working surface of the active electrode was placed in the middle of the cutting edge of the anterior teeth. The minimum current was applied and the study was stopped when the first sensations appeared. Diagnostics were performed three times for each subject and the lowest value was selected [5]. In studying the thermoefflux index and metabolism in the body at the end and beginning of the academic year, the periodontal tissue thermometry method was used using a TEMP-1 semiconductor thermometer (Russia), measuring the periodontal tissue temperature by placing the device's sensor in the area of the marginal gum of the anterior maxilla for 1-2 minutes [20]. To study the level of metabolism and acid-base balance of the body in students at the end of the academic year, after the summer vacation period and in the middle of the first semester of the following academic year, the pH of saliva was determined using indicator litmus paper with an indicator scale and a pH meter [20]. In order to determine the level of porphyrins in saliva samples (a metabolic indicator of the intensity of tissue respiration and metabolic rate), examined at the beginning of the school day, after classes with mental stress and after a night's rest, fluorescence spectra were measured (according to the method of Professor M.T. Alexandrov) using a portable Raman luminescence spectrometer from Spektr-M LLC with a built-in solid-state Nd: YAG laser (wavelength 532 nm) [17]. In order to comprehensively assess physical activity and the adequacy of the body's oxygen balance, the Stange test was performed. To carry out this test, before and after classes with mental stress, as well as after physical unloading, students were asked to take 2-3 deep breaths in and out, and then after a deep exhalation, hold their breath, recording the time with a stopwatch [21]. To be able to evaluate the characteristics of the morphofunctional state of the body as a result of exposure to stress factors before the start of the school day, after a period of mental stress and after physical relaxation, the Sheikh-Zade formula was calculated: $S = f \cdot PBP \cdot M⅓ \cdot K$, in which S (conventional units) is the stress level, f (min-1) is the heart rate, PBP (mmHg) - pulse arterial pressure, K - normalizing coefficient: $0.8244 \cdot 10^{-4}$ (for males) and $0.9357 \cdot 10^{-4}$ (for females), M (kg) - body weight [23]. When determining the emotional (psychological) state of students associated with the current situation at the end of the academic year, at the beginning of the current year of study and after classes with mental stress, personal and situational anxiety was identified using the method of C.D. Spielberger [24,25].

Research Results

According to the results of the analysis of electroodontodiagnostics obtained from students after the end of classes with mental stress, an increase in the conductivity index of the nerve receptors of the dental pulp was revealed by 46.5% ($p < 0.01$) compared with the data of a similar study conducted before the start of the educational process. At the same time, after a period of physical unloading (physical education classes, transfer to another university educational base), a tendency towards normalization of EOD values by 23.2% ($p < 0.05$) was recorded during EOD. The obtained results are indirectly consistent with the provisions of the neurotrophic theory of caries by Entin D.A. (1935) and the results of an experimental study on the effect of stress on metabolic processes in the dental pulp, conducted by Ostrovskaya I.G. [26,27]. It is known that prolonged exposure to stress leads not only to metabolic shifts, but also to structural changes in the dental pulp, occurring due to destabilization of the functional state of the central nervous system and disruption of corticodental connections with subsequent disruption of trophic processes in dental tissues. Consequently, the electroodontodiagnostics method allows us to establish initial symptoms and dynamically monitor the severity of the effect of stress on the body. It has been established that the temperature of the body surface and oral mucosa indicates not only the state of heat transfer activity, but also the level of blood flow and metabolism in the body of the subject [28]. A comparative

analysis of the dynamics of periodontal tissue thermometry values conducted in students at the end of the first and beginning of the second year revealed an increase in values by 0.62 ° C ($p < 0.001$). Thus, the possibility of correcting the consequences of the influence of a stressful situation on the body in the form of dynamics towards the normalization of heat transfer, and, indirectly, metabolism as a result of a rest period of 1.5-2 months has been established. It is known that a rational ratio of acid-base balance components contributes to the optimal functioning of metabolic processes and enhances the body's resistance to various pathological influences, including stress. At the same time, a negative effect of increased acidity on the state of the immune system and the functional properties of body systems has been determined. A study of saliva pH in students after the first year of study revealed values of 6.41 ± 0.19, while after a two-month summer break, a normalization of the acid-base balance to 6.87 ± 0.11 was observed. Consequently, the aforementioned rest period resulted in a restoration of normal pH balance. However, pH analysis of saliva samples obtained from the same cohort of subjects in the middle of the first semester of the new academic year revealed values corresponding to 6.63 ± 0.11. Thus, the absence of stress on the students' bodies for two months allows for the normalization of the acid-base balance, and after two months of exposure to stress, a destabilization of this state occurs. As a result of numerous studies, a number of authors have found that an increase in the amount of porphyrins in tissues and biological fluids occurs due to a disruption of oxidative processes in the body under conditions associated with hypoxia, in a state of decompensation of the cardiovascular system, nervous strain, i.e., with those phenomena that can manifest themselves as a result of prolonged exposure to stress [25,26,36]. One of the most promising types of research for these purposes is the method of non-invasive laser fluorescence diagnostics [16,29,30,34,35]. When measuring the fluorescence spectra of student saliva samples after attending classes and comparing them with the results of similar studies at the beginning of the school day, high-intensity fluorescence was recorded in the wavelength range of 600-650 nm with an increase in the integrated intensity by 10-30 times on an individual basis. This result indicates an increase in the content of porphyrin compounds in the studied saliva samples. It should be noted that fluorescence diagnostics of saliva samples from the same cohort of students after a night's rest the following day revealed a 7-10-fold decrease in luminescence intensity compared to the result obtained at the end of the previous school day. Thus, we observed a decrease in the severity of the impact of stress on the body after.

Thus, we observed a decrease in the severity of the impact of stress on the body after a daytime rest. At the same time, the possibility of express diagnostics of the presence of stress symptoms and the degree of their relief using fluorescence indicators was established. Dynamic observation confirmed the obtained results. In order to determine the level of oxygen supply to the body of students, the Stange test was administered, which resulted in a deterioration in test indicators by 31.5% ($p < 0.001$) after the end of two classes, followed by a recovery of values by 19.3% ($p < 0.001$) when examined after a period of physical decompression. When calculating the stress level of students using the Sheikh-Zadeh formula, an increase in the corresponding indicator was found by 57.2% ($p < 0.001$) after the educational process during two classes. Subjecting the same contingent of subjects to physical decompression conditions ensured dynamics towards normalization of this level by 18.6% ($p < 0.05$). When Spielberger's psychological test was administered two months after the summer vacation, students showed a predominance of moderate levels of personal anxiety, despite the preceding long vacation. Meanwhile, a similar study of the same cohort of students after mentally demanding activities revealed high levels of reactive anxiety in most cases. This suggests that, in practical terms, the urgent need for a method for psycho-emotional relaxation of students during the school year is relevant.

Conclusion

Thus, these assessment methods are objective and can be reasonably included in a comprehensive assessment of dental status and, apparently, require adjustment under stress based on objective data. Stress alters basic (reference) indicators of dental status, requiring psycho-emotional correction for objective assessment. Errors in digital indicators in clinically healthy patients depend on both the object of study and the sensitivity of the diagnostic method used and range from 23-45% to 1000% or more. The presented indicators of the maxillofacial region (metabolic, morphofunctional, functional, psychological) objectively and multifactorially reflect the dental status of the maxillofacial region and can be used as reference indicators for their assessment under stress and its correction.

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