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Assessment of Functional Disorders in Students Under Academic Internet Load Conditions Associated with Cervical Osteochondrosis

Linchenko S.N.[1], Kostylev A.N.[1], Kiyok O.V.[1], Makukhin V.V.[1,2], Kostyleva S.A[2], Onbysh T.E.[1], Fomina Ya.V.[1]

[1]Kuban State Medical University, Krasnodar, Russia
[2]Regional Clinical Hospital No. 2, Krasnodar, Russia

ABSTRACT:

Aim. To assess the adaptive responses of central hemodynamics in medical university students with cervical osteochondrosis under conditions of intensive academic internet load.

Methods. In a screening survey of 315 students aged 17–23 years, clinical symptoms associated with cervical osteochondrosis were identified in 43.5% (n=137), of whom radiographically confirmed changes in the cervical spine (on referral by a neurologist) were detected in 74.5% (n=102) of cases. Based on the dynamics of subjective complaints, two groups were formed: with episodic (Group II, n=68) and persistent (Group III, n=34) clinical symptoms of cervical osteochondrosis. The reference group (Group I, n=40) comprised individuals without the above disorders. Central hemodynamic parameters were assessed at three time points: at rest, immediately after a physical test (20 squats), and after a 10-minute recovery period.

Results. In Groups II and III, the predominant radiographic markers were reduced intervertebral disc height and narrowing of intervertebral spaces (54.9% and 18.3%, respectively), pathological mobility of the vertebral motion segment (VMS) (21.7% and 78.1%), its displacement (30.9% and 52.3%), and Kovac subluxation (6.1% and 34.0%). Students in Groups II and III showed considerable variability in stroke index (SI) and total peripheral vascular resistance (TPVR), particularly at the load stage, against a background of a significant increase in cardiac output (CO), with a clear predominance of the hyperkinetic type of blood circulation. This type of hemodynamic response retained its leading position during the recovery phase in Group III subjects as well, which was interpreted as evidence of narrowing adaptive reserves of the cardiovascular system (CVS). Most Group II subjects with mild transient clinical symptoms showed the eukinetic type, whereas the hypokinetic variant predominated in the control group, reflecting a higher adaptive potential.

Conclusions. Radiographically verified findings (instability and lateral displacement of the VMS in the cervical spine, Kovac subluxation) correlate with the regular occurrence of clinical manifestations of functional disorders in students, including those of the cardiovascular system, against the background of academic load at university involving the use of internet resources.

INTRODUCTION

According to a nationwide sociological survey conducted in 2025 among students at several leading Russian universities (RSSU, HSE University, Lomonosov Moscow State University, RSUH, Plekhanov Russian University of Economics, and their branches), daily time spent online exceeds 4 hours in 48.5% of respondents, is 3–4 hours in 42.4%, and is less than 3 hours in only 9.1% of respondents. At the same time, 36.4% of respondents do not perceive such time expenditure as excessive.

The level of well-being among young people in higher education is largely determined by the success of psychosocial adaptation to the educational process. Under current conditions, personal characteristics may act as predictors of psychological patterns involving elements of behavioral maladaptation under increased intellectual and static loads, particularly in the early years of study, compounded by the presence of cervical osteochondrosis [1, 2, 3, 4, 5]. A previous survey of students at Voronezh State Medical University showed that 61.15% were aware of the nosological entity "osteochondrosis," while 31.65% lacked sufficient knowledge of the specific clinical manifestations of its cervical localization, which complicates its differentiation from other somatic conditions [6].

In the current scientific literature, osteochondrosis is regarded as a "disease of civilization," since its prevalence is closely linked to the nature of everyday activity, including prolonged static posture in front of a computer screen, physical inactivity, and dietary imbalance [7, 8, 9]. These factors provoke a deterioration in the trophism of the musculoligamentous apparatus and disc structures, creating the preconditions for degenerative-dystrophic changes [10, 11, 12]. An additional significant etiopathogenetic factor is psychoemotional strain, inherent to the fast pace of modern life [5, 13]. The intensity of the educational process at a medical university involves pronounced neuropsychic tension, resulting from the need for prolonged concentration in mastering a large volume of information (including practical sessions in anatomy halls) and from developing professional communication skills in clinical settings [14].

Recently, growing interest has been observed in juvenile osteochondrosis (manifesting as back pain syndrome and increased fatigability), which is associated with an increasing incidence of degenerative lesions of the intervertebral discs with secondary involvement of the bodies of adjacent vertebrae and subsequent mechanical effects on radicular structures, the spinal cord, and vascular formations [15, 16]. In the pathogenesis of osteochondrosis, disturbances in the statodynamic organization of the spinal column resulting from insufficient motor activity acquire substantial significance. Under such conditions, degenerative transformations in the ligamentous-muscular apparatus develop relatively slowly, and a fully developed clinical picture does not form, which objectively complicates the early diagnosis of cervical spine pathology in young individuals [16, 17, 18].

Cervical osteochondrosis frequently remains outside the focus of clinicians' attention [19, 20]. The vertebrogenic effect on the vertebral arteries (VA) in the cervical spine is due to their topographic-anatomical location within the transverse foramina, which creates the preconditions for impaired blood flow in the vertebrobasilar system (VBS). This is one of the key factors in the development of cerebrovascular disorders and the manifestation of neurological symptoms against the background of vertebrobasilar insufficiency (VBI) [17, 21].

Vertebral artery syndrome (VAS) is recognized as a clinically and socially significant medical and social problem. The specific features of regional cerebral hemodynamic disturbances include a reflex angiospastic component that arises upon compression of the neurovascular bundle at the level of the cervical vertebrae, which reduces the resistance of the brainstem structures responsible for the central regulation of the cardiovascular system (CVS). In this context, particular relevance is acquired by the study of the relationship between subjective sensations and objective radiographic findings in cervical osteochondrosis among young people, for the purpose of accurate differential diagnosis of functional abnormalities affecting the CVS [22].

Despite the availability of highly informative imaging methods (CT, MRI), verification of VAS in cervical osteochondrosis is often difficult due to the absence of strict clinical and diagnostic criteria, which in a number of cases requires dynamic follow-up and a personalized approach to examination. Cervical osteochondrosis, therefore, represents a collective concept encompassing a complex of cerebral, vascular, and autonomic manifestations of VAS, determined by the anatomical specificity of the neurovascular structures of the cervical spine. The prevalence of VAS in degenerative-dystrophic manifestations of cervical spine pathology ranges from 30.0% to 42.5% [22, 23, 24, 25, 26].

The proportion of cervical osteochondrosis among vertebrogenic pathologies reaches 60%, with circulatory disturbances in the VBS predominantly (in 80% of cases) associated with extracranial lesions [17, 27]. A promising direction is the study of cause-and-effect relationships from the standpoint of the restructuring of the body's functional systems in cervical osteochondrosis,

which is important for differentiating it from general somatic and psychosomatic disorders affecting the overall adaptation and quality of life of students [18, 28].

The present work is not aimed at the nosological verification of a neurological or cardiological diagnosis, but at identifying transient functional disorders caused by prolonged psychoemotional and static load under conditions of educational digitalization: daily testing, laboratory work, preparation of reports and publications, work with electronic library systems, creation of multimedia presentations, and participation in scientific events.

Aim of the study. To assess the adaptive responses of central hemodynamics in medical university students with cervical osteochondrosis under conditions of intensive academic internet load.

METHODS AND STUDY DESIGN

Given the polymorphism and multifactorial nature of clinical manifestations in cervical osteochondrosis [1, 16, 23, 26, 29], at the initial stage of the study two categories were distinguished: with intermittent (short-term, spontaneously resolving) symptoms of mild to moderate intensity, and with persistent (regularly occurring, prolonged, occasionally requiring pharmacological correction) manifestations of moderate to severe intensity.

The study included 315 undergraduate students in their early years of study (mean age 20±3 years). According to the survey results, complaints of varying severity characteristic of cervical osteochondrosis were identified in 43.5% (n=137), with the following gender distribution: 60 female (43.8%) and 77 male (56.2%) students. Of these, 74.5% (n=102) had radiographic findings (predominantly on referral by a neurologist), including 48 female (47.1%) and 54 male (52.9%) students. Based on the severity of symptoms, this sample was used to form Group II (n=68, 66.7%) — with episodic manifestations — and Group III (n=34, 33.3%) — with persistent symptoms. The control group (Group I, n=40) consisted of individuals without the above complaints and without radiographic examination of the cervical spine.

Hemodynamic parameters were recorded at three stages: at baseline, immediately after a functional test (20 squats in 30 seconds), and after 10 minutes of rest, at the University Health Center. Heart rate (HR) and mean arterial pressure (MAP), calculated using the Hickam formula, were assessed, along with the following derived parameters: stroke index (SI), cardiac output (CO), and total peripheral vascular resistance (TPVR), used to classify the type of hemodynamics (hyper-, eu-, or hypokinetic). Anthropometric measurements were performed using standard methods. The statistical significance of differences within and between groups was assessed using Student's two-tailed t-test; differences were considered statistically significant at $p < 0.05$. Data processing was performed using Statistica 6.1 software.

Inclusion criteria: full-time students aged 17–23 years, presence of the functional stage of clinical variants of VAS, radiographs of the cervical spine with an official report. **Exclusion criteria:** age under 17 or over 23 years, absence of radiographic documentation, presence of type 2 diabetes mellitus, arterial hypertension, coronary artery disease (CAD), spinal or brain trauma, chronic somatic diseases under dispensary follow-up, and the organic stage of VAS (persistent cerebral circulatory disturbances, systemic vertigo, ataxia, dysarthria, nausea, and vomiting).

The study was conducted with the informed consent of the students, using non-invasive methods, in accordance with the Declaration of Helsinki of the World Medical Association, "Ethical Principles for Medical Research Involving Human Subjects," as amended in 2013.

DISCUSSION OF RESULTS

The functional stage of VAS is characterized by a triad of symptom groups: cephalgic syndrome with autonomic manifestations, cochleovestibular disorders, and visual disturbances. The headache is paroxysmal in nature, intensifying with movement or prolonged forced head position. Vestibular disturbances manifest as non-systemic dizziness (a sensation of unsteadiness, instability) or systemic vertigo during physical activity, sometimes combined with mild hearing loss. Ophthalmological phenomena are limited to photopsia, a sensation of sand in the eyes, or darkening of vision. In addition, VAS may be accompanied by cognitive dysfunction: memory impairment, difficulty concentrating, and difficulty assimilating new material and processing large volumes of information [3, 4, 5, 7, 17, 22, 26].

The clinical presentation of VAS is primarily determined by the nature of the compressive effect on the VA and the surrounding nerve plexus. According to ICD-10, the leading etiopathogenetic factors are: subluxation of the articular processes, pathological

mobility (instability, hypermobility) of the vertebral motion segment (VMS), osteophytic compression, reflex vasospasm due to irritation of the periarterial plexus, Kovac subluxation, uncovertebral arthrosis, muscle-tonic syndromes, and others [30].

In Group II, the initial complaints were of mild to moderate intensity and episodic in nature: general weakness (38.6%), sleep disturbances, decreased attention concentration, rapid fatigability, periodic cephalgia, and tachycardia. Discomfort in the cervical-collar zone was noted in 23.8% of cases, and a sensation of "stiffness" requiring head rotation until a click occurred in 14.4%. Decreased visual acuity while writing was accompanied by cephalgia of varying intensity in 16.7% of students.

In Group III, clinical signs of the functional stage of VAS predominated: occipital discomfort and unsteadiness on standing up (23.8%), tinnitus and ringing in the ears against a background of psychoemotional tension (27.4%), photopsia during prolonged writing tasks with a slowing of writing pace (19.1%), and protracted, moderate-intensity cephalgia relieved by analgesics (53.3%).

No statistically significant gender differences in the spectrum of symptoms were established. In Group II, static disturbances predominated radiographically: flattening or accentuation of the physiological lordosis (57.9% with mild and 24.5% with moderate clinical symptoms) (Table 1).

Table 1. Correlation between clinical manifestations and radiographic findings in students with cervical osteochondrosis, (%)

Radiographic signs of cervical osteochondrosis	Groups			
	II (n=68) Intermittent clinical symptoms		III (n=34) Persistent clinical symptoms	
	Mild intensity (n=19)	Moderate intensity (n=49)	Moderate intensity (n=22)	Severe intensity (n=12)
Straightening of physiological lordosis, accentuation of lordosis	57,9	24,5	_____	_____
Reduced disc height, narrowing of intervertebral space	26,3	28,6	18,3	_____
Displacement of vertebral motion segment (VMS)	10,5	20,4	27,3	25,0
VMS instability (detected on functional tests)	5,3	16,4	36,4	41,7
Kovac subluxation (articular process of the lower vertebra displaced anteriorly)	_____	6,1	9,0	25,0

The most significant associations were found between clinical presentation and radiographic findings: reduced disc height and narrowing of the intervertebral space were more common in Group II (54.9% versus 18.3% in Group III). Symptoms comparable in intensity but differing in duration between Groups II and III were associated with more pronounced structural changes: VMS displacement (20.4% and 27.3%, respectively) and VMS instability (16.4% and 36.4%), which accounted for the regularity of exacerbations during academic internet load in Group III; in cases of severe symptomatology, the latter indicator reached 41.7%.

Two or more radiographic signs were frequently combined (for example, straightening of the physiological lordosis with narrowing of the intervertebral space, or Kovac subluxation with VMS instability). In the present study, students were assigned to the group corresponding to the most significant radiographic pattern.

The development of VBI is associated with dysfunction of the VA, vein, and sympathetic nerve within the bony canal, mediated through compression-irritative and reflex-angiospastic mechanisms, owing to the shared innervation of the VA, discs, and joints. The VA is most frequently affected by VMS displacement; however, VMS instability (mobility), detected on functional tests, is of greater significance. Kovac subluxation, identified not only in Group III (34.0%) but also in Group II (6.1%), requires long-term therapy. Degenerative-dystrophic processes generate a flow of pathological afferentation to the sympathetic plexus of the VA, inducing vasospasm and neurological symptoms.

The radiograph presented shows instability of the cervical vertebrae on functional testing (head flexion-extension) (Fig. 1).

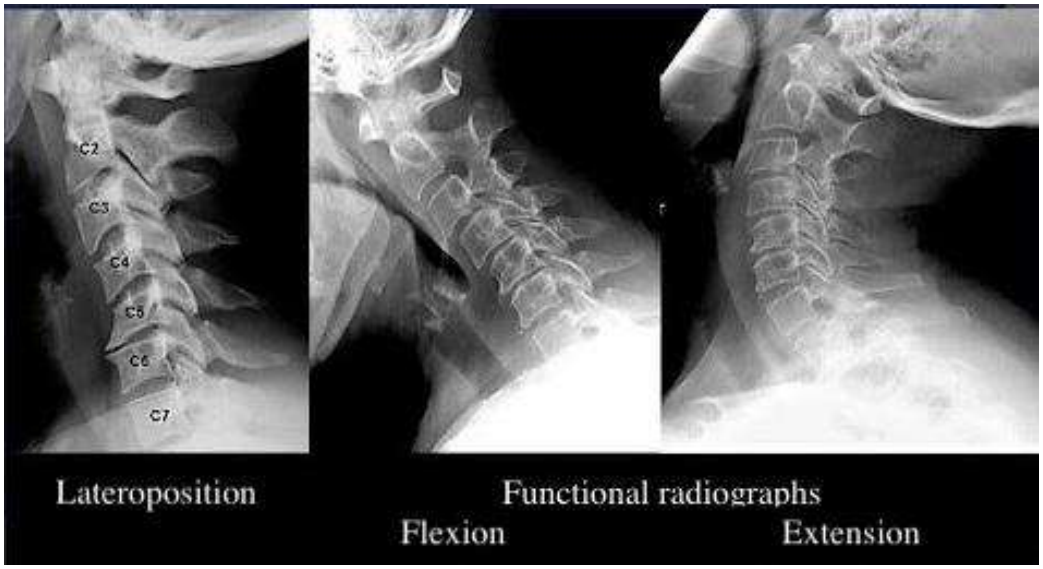

Figure 1. Radiograph of the cervical spine in functional positions (head flexion–extension).

Psychological and static tension associated with internet load acts as a trigger for the manifestation of clinical symptoms. The duration of exacerbations in Groups II and III depended on the time spent in a forced posture and on the condition of the muscular corset (limited mobility and hypertonicity in 15.3% and 44.4%, respectively). It was established that subjective disturbances more often correlate with 2–3 radiographic signs when daily internet activity exceeds 3–4 hours. Among such manifestations, Groups II and III showed: occipital discomfort/pain (11.9% and 28.7%, respectively), dizziness on standing up (15.3% and 29.1%, respectively), tinnitus (8.8% and 17.4%, respectively), moderate-intensity cephalgia requiring analgesics (9.8% and 22.2%, respectively), and tachycardia with delayed recovery (16.3% and 24.8%, respectively). In Group III, memory impairment (15.4%) and transient weakness/heaviness in the arms (12.7%) were also recorded.

Particular attention should be paid to the interpretation of hemodynamic parameters at the load and recovery stages. No significant gender differences in baseline parameters were found. At the first stage, no differences in HR or MAP were found between groups. In Group III students, CO was significantly ($p < 0.05$) elevated at the second and third stages compared with Group I, indicating persistent tachycardia and reduced efficiency of cardiac function. In Groups II and III, SI and TPVR values varied over a wide range during the load, with a predominance of the hyperkinetic type, which persisted into the recovery period in Group III — this was interpreted as a limitation of the adaptive reserve of the CVS. The hemodynamic response in Groups II and III differed significantly ($p < 0.05$) from that of the control group, in which the hypokinetic type with high adaptive potential predominated. The eukinetic type was recorded mainly in Group II students with minimal symptomatology.

These findings are consistent with the results reported in [31], which showed delayed recovery of HR, SI, and CO in non-athletic female subjects following a bicycle ergometry test, indicating reduced adaptive mechanisms. They also confirm the data of Belyaeva V.A. [14] on tension of CVS adaptation in 35.3% of medical students during the pre-examination period.

Novelty. Functional disorders in students are examined in the context of vertebrobasilar insufficiency associated with cervical osteochondrosis. Given the anatomical and topographic features of the neurovascular bundle in the cervical vertebrae, prolonged forced posture combined with academic internet load provokes local hemocirculatory and neuroconductive disturbances, resulting in both exacerbations of neurological symptoms and CVS dysfunction, the innervation of which is closely linked to the cervical segments of the cervical vertebrae. With prolonged psychoemotional overstrain, generalization of the disorders to other systems is possible (autonomic, cognitive, ophthalmological, gastrointestinal, endocrine — for example, according to routine medical check-up data, female students show menstrual cycle disturbances and mammary gland fibromyomas), which warrants further investigation.

Scientific and practical significance. Under conditions of educational digitalization, greater attention needs to be paid to the quality of life and psychosocial adaptation of students. It has been shown that anatomical features of the cervical spine are among the causes of transient functional abnormalities. Timely diagnosis of VBI in cervical osteochondrosis (with radiographic monitoring) will allow accurate differentiation of functional disorders from somatic pathology, including cardiovascular disease. Further research using modern technologies is needed to develop comprehensive medical and preventive programs [24, 32, 33, 34, 35].

CONCLUSION

In our opinion, the present study directs the attention of clinicians to the need for differential diagnosis of general somatic functional disorders occurring under psychophysical academic load from the symptomatology of cervical osteochondrosis. Underestimation of hemodynamic disturbances against the background of VBI leads to the formation of psychosomatic and cardiovascular disorders. In clinical practice, insufficient attention is paid to the vertebral syndrome of the cervical spine owing to the mild severity and polymorphism of its symptoms. The vulnerability of the VBS vessels, determined by the topography of the VA within the bony canal of the cervical vertebrae, is realized as VBI in osteochondrosis. The key link in the pathogenesis is the reflex-angiospastic syndrome arising from compression of the neurovascular bundle, which reduces the resistance of the brainstem structures regulating the CVS. Additional clinical and neurological examination, guided by targeted clinical reasoning, would allow early verification of VBI even in cases of vertebral pathology with minimal symptoms. Careful palpation and examination of the cervical-collar zone in young individuals justify referral for radiography and preventive therapy, including osteopathic correction, strengthening of the muscular corset, physiotherapy, psychological support, and social adaptation.

Diagnostic error and, as a consequence, incorrect therapy and prevention reduce the body's adaptive reserves. The quality of life of young people deteriorates with the manifestation of general somatic symptoms such as vegetative-vascular dystonia, psychasthenic syndrome, neurasthenia, depressive states, recurrent abdominal pain, and functional cardiorespiratory syndrome. Prevention at the university level should be aimed at the active identification of students with this pathology, their allocation to health groups with differentiated physical load, dispensary follow-up, and, where necessary, consultation with a cardiologist, neurologist, vertebroneurologist, and psychologist.

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