

Hygienic Aspects of Students' Health at Secondary Polytechnic Schools in the Context of Education Informatization in Tyumen

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Abstract— Aside from general subjects, students of primary and secondary vocational schools also study subjects pertaining to school's particular profile under advanced programs using active teaching methods and computerization. At the same time, they are exposed to multiple adverse factors such as a forced unhealthy body position, unfavorable microclimatic conditions, poor lighting, and electromagnetic radiation. When studying their health status, it has been revealed that 4.2% of students have functional disorders of the circulatory system, 3.8% had neuro-psychic problems, 3.7% had problems with digestion; chronic pathology has been found in 18.1% for the visual analyzer, in 12.8% for digestive organs, in 8.2% for the musculoskeletal and nervous systems, and in 3.1% for psyche. This necessitates further studies into the learning process and how it could be optimized.

Keywords— vocational education, health, adverse conditions, informatization of education, computerization

1. INTRODUCTION

Over the last decade, negative trends in the population-wide health in Russia have emerged on top of deteriorating quality of life and worsened demographics; this especially applies to children and adolescents. [1, 2] This is of tremendous medical, social, and economic importance, as young people will shape the country's reproductive, economic, and cultural potential for the decades to come. Comprehensive dynamic analysis of students' health status at primary and secondary vocational schools produces the most objective data on this topical issue. [3, 4, 5]

I. RELEVANCE

It is now known that students of primary and secondary vocational schools have apparent vegetative-vascular disorders, a weakened immunobiological resistance, unbalanced physical development, locomotor disorders, respiratory and digestion-related diseases, gynecological pathologies, and sundry pathologies. [6, 7, 8] This is especially relevant in the light of modernization and computerization in education, which raises the bar of requirements to young people's health. [9-12] As of today, the

learning environment is not in line with the optimized recommendations in most aspects. [13, 14, 15]

One of the main adverse factors of human-computer exposure is the effects of display-generated low-frequency electromagnetic fields as well as the effects of computer circuit boards, where unshielded cables (extenders) of computer power supplies might generate industrial-frequency electromagnetic fields.

Systematic exposure to electromagnetic fields (EMF) has adverse health effects manifesting as trophic disorders: brittle nails, dry skin, hair loss; functional disorders in the cardiovascular system, the endocrine system, and the nervous system entailing a lability of systolic and diastolic pressure, an altered conductivity of the heart muscle, a slower heartbeat, and headaches, apart from rapid emergence of fatigue or even neuro-psychiatric disorders. There are apparent changes in the receptor excitability of the vestibular, visual, and olfactory analyzers. It has been found out that at an industrial frequency of 50 to 60 Hz, the EMF might cause cellular change in the body, with some sources indicating changes as grave as breach in the synthesis of genetic material. A lower intensity of such radiation sometimes increases rather than decreases the risk, as some fields affect body cells at certain frequencies are at low intensity. Some data indicate such fields are capable of causing cataracts (eye-lens clouding). [16]

Display front surface accumulates electrostatic charge, which causes the air around the user to de-ionize, which in its turn depresses the central and the peripheral nervous system, causing eyestrain, headache, depression, and stress.

A large concentration of positively charged ions in the air is negative for the human psyche. Some skin diseases of exposed body parts and face are also associated with electrostatic fields. An electrified display is capable of attracting airborne dust particles, which deteriorates the air quality nearby, forcing the user to work and breathe in a dusty environment. Some data suggest that electrostatic fields are capable of altering or interrupting the cellular development, which is also unsafe for health. [17]

II. THEORETICAL SIGNIFICANCE

Comprehensive study of the sanitation and hygiene of students making use of advanced computer technologies will further the theory on creating a healthy learning environment at polytechnic schools. [18, 19, 20]

III. PRACTICAL SIGNIFICANCE

This research will produce guidelines on optimizing the learning environment for students of primary and secondary vocational schools.

IV. RESEARCH SUBJECTS AND METHODS

Students of innovative vocational colleges in Tyumen were the subjects of this study. We carried out comprehensive research into the students' health and their learning environment. We studied the microclimatic conditions, the lighting, the air ionization, the electromagnetic fields in classrooms, and sundry parameters. For instrumental control of these parameters, we used instruments listed in the State Registry of Instruments certified to have passed State Certifications (with such certificates being valid to date) and having an acceptable relative error of measurement.

In the Russian Federation, the health of personal computer users in terms of electromagnetic field exposure is the subject-matter of the norms approved by the Order of the Chief Medical Officer of Russia dd. June 3, 2003 No. 118 (rev. September 3, 2010) On the Entry Into Force of the Sanitary-Epidemiological Rules and Regulations SanPiN 2.2.2/2.4.1340-03 (together with SanPiN 2.2.2.4.1340-03. 2.2.2 Occupational Health, Processes, Raw Materials, Equipment, and Tools. 2.4. Hygiene of Children and Adolescents. Hygienic requirements to personal computers and using them. Sanitary-Epidemiological Rules and Regulations, as approved by the Chief Medical Officer of the Russian Federation on May 30, 2003 (registered by the Ministry of Justice of the Russian Federation on June 10, 2003 under No. 4673). SanPiN 2.2.4.1294 – 03 Hygienic Requirements to the Aeroionic Composition of Air in Industrial and Public Space sets forth the requirements to indoor air in terms of its aeroionic composition. [21, 22]

The parameters of the learning environment were compared against the regulatory criteria, while the health status was assessed based on the total sample and expressed in percent.

V. RESULTS AND DISCUSSION

Innovative educational institutions are distinguished by a rigorous and intense learning process. Aside from general subjects, students of primary and secondary vocational schools also study subjects pertaining to the school's particular profile under advanced programs using active teaching methods and computerization; such subjects also contain some advanced assignments of higher difficulty. Learning and productive efforts expected from students are sometimes stipulated without taking into account the physiological status of the systems that help a person adapt to such loads. [23, 24, 25]

We found out that students were exposed to multiple adverse factors such as a forced unhealthy body position, unfavorable microclimatic conditions, and non-ionizing electromagnetic radiation.

Each classroom contained 4 to 18 computers. 45% of classrooms used PCs with LCD screens while 55% used CRT (cathode ray tube) screens. Most students (65%) would work at computers for 3 to 4 hours, 25% worked for 2 to 3 hours, and 10% worked for 1 to 2 hours.

The hygienic analysis of computer classrooms identified a number of key deficiencies characteristic of all such rooms.

1. Verification of the presence of auxiliary and hygienic equipment revealed absence of auxiliary rooms, fire extinguishers, and first-aid kits.

2. Total space per workstation, total air volume per workstation, and the mean inter-monitor distance was below recommended values in 91% of such rooms. Each workstation equipped with a screen must have at least 6.0 m² of space. The minimum air consumption (by carbonic acid) per person was assumed to be within 36 to 40 m³; 35% of classrooms had this 36 to 40 m³, while 30% had only 30 to 35 m³, and 15% of rooms had less than 30 m³.

The effective guidelines actually regulate the placement of PC workstations. The distance between desks with displays (from the display of one monitor to the back panel of another one) must exceed 2.0 meters, while the distance between displays side-to-side must exceed 1.2 meters. 55% of all classrooms did not comply with this requirement.

3. The recommended daylight factor (DF) must be at least 1.5% for the bulk of the Russian territory, and at least 1.2% for areas with a long-lasting snow cover. Window apertures must mostly face north or northeast, while also being sufficiently large. The window-to-floor area ratio must be within the range of 1/4 to 1/6.

24% of the classrooms studied either had no daylight or had insufficient daylight (with both of the above indicators being substandard). When analyzing the artificial lighting, we found out that the number of lamps had to be increased by 15% to 20%; besides, internet centers had to use lamps of the same type within the same room (either only incandescent lamps, or only fluorescent lamps).

4. The indoor temperature was mostly in excess of norms by 4-6°C. However, most classrooms did meet the requirements to maximum temperature fluctuations (2-3°C within 24 hours, 2°C within one horizontal meter and 1°C within one vertical meter). Humidity exceeded the optimal values by 20% to 25% and the maximum permissible values by 10% to 15%. The ventilation rate was insufficient in 84% of classrooms.

5. There are recommendations on the type of desks and chairs that must be suitable for the user's height as well as the type and duration of workstation use. None of the classrooms met the ergonomic requirements in this respect. Chairs and desks were not marked, were all of the same type, and did not match the users' height.

6. Note that the spectrum of display-generated frequencies contains frequencies (from below 10 Hz to several dozens Hz)

that are way below the vertical scan frequency, approaching the human biorhythm frequencies. Human body organs and systems vulnerable to electromagnetic fields are the nervous system, the hematopoietic system, the cardiovascular system, the neuroendocrine system, the immunity, the eyes, and the gonads.

Alternating electric and magnetic fields are generated by computer components having high AC voltage or large currents. In terms of the frequency spectrum, electromagnetic fields fall into two groups: fields generated by the display power supply and by the vertical scan unit; and fields generated by the horizontal scan unit and the PC power supply. In terms of the energy spectrum, these field groups fall into two frequency bands: 5 Hz to 2 kHz, and 2 kHz to 400 kHz. We noted violations of requirements to the parameters of non-ionizing electromagnetic radiation of some displays with respect to (i) the electric component in both of the above frequency bands; (ii) the magnetic flux density in the 5 Hz – 2 kHz band; and (iii) the electrostatic field strength.

Instrumental studies of the aeroionic air composition, electrostatic and electromagnetic display fields of working computers revealed that most of the displays in use did not meet the requirements to the electrostatic and electromagnetic field parameters. 85% of displays exceeded the tentative permissible electrostatic field tension values by 10% to 20%. We noted that 75% of displays exceeded the tentative maximum permissible levels of electric field strength by 50% to 100%, and the rest by up to 50%. 60% of displays had more than double the tentative MPL of magnetic flux density in the 5 to 2,000 Hz band. In the 2 to 400 kHz band, 30% of displays exceeded the tentative MPL of magnetic flux density by 50% to 100%, while 30% exceeded it by more than 100%. It should be noted that the same display might have deviations across the electromagnetic field spectrum and in different bands.

With the existing PC use schedule, classrooms often do not comply with the recommended ventilation schedules. Analysis of the aeroionic air composition revealed unfavorable ionic composition of the air both before, during, and after PC use.

Negatively and positively charged ions were absent in the air before PC start, i.e., the air was virtually deionized. Some increase in the number of ions (mostly positively charged) was noted during PC use. By the end of PC work, positive ion numbers reached the peak. Negative ion content was 6 to 10 times less than recommended.

We noted unfavorable indoor ionization levels in 76% of classrooms (the air was deionized or insufficiently ionized). At the same time, after work and carrying out the necessary ventilations, negative ionization would approach the recommended values.

Analysis of the visual ergonomics revealed that 18% of classrooms did not meet the requirements to display brightness and illumination, while 5% had insufficient workplace illumination.

Thus, in all computer classrooms, only 6.55% of workstations met the requirements to alternating electric fields, 40.2% workstations met the alternating magnetic field

requirements, and only 15% of workstations met the electrostatic potential requirements.

At the same time, 100% students used PCs at home. The home computer is used for a variety of purposes other than studying and learning from the Internet, e.g. chatting, watching movies, listening to music, gaming, etc.

PC use is associated with subjective fatigue in 20%, permanent fatigue in 50%, no fatigue in 30%.

Up to 80% adolescents take breaks, do some exercises to relieve muscle and eye strain, while 20% do not do it.

In this regard, we decided to study the non-ionizing radiation of home computers, which revealed excess of the maximum permissible electromagnetic field level in terms of the electric component in 93.45% of home PCs, while 76.6% of terminals exceeded the maximum permissible level in LF bands. In terms of the magnetic component, 19% home workstations exceeded the maximum permissible levels in the HF band, and 28% exceeded it in the LF band. Excess of the maximum permissible electrostatic-field strength levels amounted to 22%. These values indicated an exacerbation of the adverse effects of magnetic fields that adolescents were exposed to.

These factors in combination have a negative impact on thermoregulation (as such environments cause disruptions in all heat exchange processes), adaptation, and other physiological functions and systems. The most frequent symptoms are alterations in the cortical processes, i.e., the weakened excitation process and differentiation; neurological disorders manifesting as vegetative dysfunction, astheno-vegetative syndrome, altered functional status of the cardiovascular system with a tendency to hypertension, disruptions in cardiac rhythms and myocardium metabolism. One might also observe disorders of the gastrointestinal tract and endocrine system (increased activity of the thyroid, lower functional activity of the adrenals and sex glands). The developmental dynamics of the growing body is compromised. All the reactions of the cardiovascular system, respiration, and nervous system are more pronounced and less adequate in adolescents than in adults, while their recovery takes longer. It takes an adolescent 1 to 2 or more years to adapt to such conditions, while some adolescents (especially girls) do not adapt at all.

In-depth health checkups of vocational school students have identified that only 8.0% of boys and 5.2% of girls checked-up over the last 2 years could be deemed healthy, while 64.5%/72.7% have chronic diseases, with the rest having functional disorders. Total pathological susceptibility exceeds 3,500%.

Advanced health studies have revealed the following top-ranking functional disorders: circulatory disorders (4.2%), neuro-psychic disorders (3.8%), and digestion disorders (3.7%).

The top-ranking chronic pathologies are visual analyzer diseases (18.1%), diseases of digestive organs (12.8%), musculoskeletal and nervous diseases (8.2%), psychic pathologies (3.1%) and urogenital pathologies (1.6%).

Most adolescents have two or more chronic diseases and two or three functional disorders. Chronic pathologies, persistent and severe functional disorders limit the range of occupations available to 80% of professional school graduates and applicants.

The morbidity structure of students of some vocational schools shows clear signs of exposure to adverse occupational factors beside chronic diseases and functional disorders typical of adolescence. Some of the first-encountered diseases and functional disorders as well as some exacerbations of the pre-existing conditions could be deemed a result of the specific and non-specific effects of the industrial factors that vocational school students are exposed to during studies and internships. At the same time, boys and girls are exposed to adverse factors while growing and developing intensively, which is why their bodies are especially sensitive to such factors. Future workers of such industries have a very high chance to develop occupational diseases.

VI. CONCLUSION

It is therefore apparent that elimination of adverse factors requires maintenance of recommended hygiene as well as an optimized learning process necessary to create a favorable learning environment to prevent pathologies from emerging in young people, as their bodies develop and most systems and organs are being shaped; this becomes especially true in the context of informatization of the learning environment.

VII. PRACTICAL RECOMMENDATIONS

1. Reduce the number of workstations to bring it in line with the classroom size; increase the inter-display distance pursuant to the norms and guidelines. This requires drafting guidelines on workstation placement optimization, which must be reflected in the classroom-specific data sheets. This improves such sanitation and hygiene parameters as temperature, humidity, and ventilation rate by carbon dioxide.

2. Further microclimatic improvements necessitate higher ventilation rates, cooler and less humid air. To that end, classrooms must use dry air conditioning or have air humidity controlled by opening the doors before and after classes as proposed in classroom-specific data sheets.

3. Displays must be adjusted to conform to the hygienic requirements in terms of brightness, illumination, electromagnetic and ionization parameters.

4. Computer classrooms must be equipped with a fire extinguisher, a first-aid kit, and an auxiliary room.

References

- [1] E. Zhiljakov "Health of the population as an integral indicator of the quality of the environment" *J. Taxes, investments, capital*, vol. 1, 2004, pp. 211-214.
- [2] E. Zhiljakov, N. Bajrakov «Ecological and hygienic analysis of life safety factors in the Tyumen region and their danger for the health of people» //International scientific-practical conference "Modern problems of life safety: experience, problems, solutions" /Kazan: Gov. Resp. Tatarstan, febr., 2010 pp. 844-847
- [3] T.V. Yakovleva, V.Yu. Albitskiy, A.A. Ivanova, M.V. Sukhinin "Main directions of the organization of preventive care for adolescents in primary and secondary vocational schools" *J. of Rus. Pediatr.* vol. 17, 2014, pp. 33-36.
- [4] V.K. Chulanov, N.E. Sedova, N.N. Ul'yanova, E.F. Gurdina, T.V. Karpova and E.V. Sevba "Colleges in small town as a new format of institutions of secondary vocational education". *J. Srednee professional'noe obrazovanie.* 2012; vol. 1: pp. 5–10 (in Russian).
- [5] D.V. Livanov, O.N. Smolin and V.M. Demin "A new vocational education for the new economy". *J. Secondary vocational education.* -2013. Vol. 8. pp. 3-5.
- [6] A.A. Baranov, V.Yu. Al'bitskiy, T.V. Yakovleva, A.A. Modestov, S.A. Kosova and R.N. Terletskaia "Groundbreaking technologies in activity of children health centers". *J. Sotsial'nye aspekty zdorov'ya naseleniya.* 2013; vol. 34 (6): p. 10 (in Russian).
- [7] V.R. Kuchma, E.I. Shubochkina, E.M. Ibragimova, V.V. Moldovanov and, V.Yu. Ivanov "Conditions of health formation in work potential: problems and solutions" *J. Occup. Med. and industrial ecology.* 2017, vol. 8, p. 50-54
- [8] S.V. Lazareva "Health and way of life of students of primary and secondary professional educational institutions" *Public health and health care.* 2010. vol 4. pp. 6-16.
- [9] L.S. Namazova-Baranova, V.R. Kuchma, A.G. Ilyin, LM Sukharev, I.K. Rapoport "Morbidity of children aged 5 to 15 years in the Russian Federation ". *J. Medical advice.* -2014. vol. 1. pp. 6-10.
- [10] Z.N. Monakhova, E.V. Zhiljakov "The concept of environmental and hygienic monitoring of vocational education" *Problems of engineering and socio-economic education in a technical university in the conditions of modernization of higher professional education // Regional Scientific and Methodical Conference.* Tyumen - 2013. - pp.132-134.
- [11] E.V. Zhiljakov, S.E. Zhiljakova "Hygienic assessment of the influence of the computer on the health of students." In the collection: *Actual problems of architecture, construction, energy efficiency and ecology – 2016/ Col. of mat. of the int. scientific and practical conf. TIU.* 2016. pp. 49-53.
- [12] G.N. Danylenko, I.V. Mezhybetska, L.I. Ponomareva, I.A. Klygina "Medico-social problems of health maintenance of the students in the system of vocational education" *J. Health and the environment.* Scientific Practical Center of Hygiene, Minsk, 2012. vol.. 20. pp. 177-183
- [13] A.M. Davydok, A.A. Malahova "Optimization of sanitary and epidemiologic requirements for establishments of professional and secondary education to preserve pupils' health" *J. Health and the environment.* Scientific Practical Center of Hygiene, Minsk, 2013. vol.. 23. pp. 122-125
- [14] A.M. Davydok, A.A. Malahova "Education environment of the institution of vocational training as condition for formation of health and healthy lifestyle of teenagers" *J. Health and the environment.* Scientific Practical Center of Hygiene, Minsk, 2014. vol.. 2. №. 24. pp. 81-84
- [15] E.I. Shubochkina, E.M. Ibragimova, V.V. Moldovanov, V.Yu. Ivanov "Sanitary and epidemiological welfare of adolescents and health risks in the learning process in primary and secondary education" *J. Questions of school and university medicine and health.* 2015. Vol. 2. pp. 18-22
- [16] N. B. Suvorov "Medico-biological aspects of electromagnetic ecology" *Medical academic journal,* 2010, Vol. 4, pp. 191-200.
- [17] A. S. Guskov "hygienic evaluation of ionization of the air environment of the closed premises" *Avtoref. ... cand. of med. Sci., Moscow,* 2005, 125p.
- [18] S.A. Magomedova "To the question about the impact of healthy lifestyle on formation of health of children and adolescents in the Republic of Dagestan"// *International scientific-practical conference: East-Siberian State University of Technology and Management/ Ulan-Ude,* 2016, pp. 187-188
- [19] I.V. Mezhibetskaja "Health of adolescents receiving education in vocational education institutions" *Materials of the 3rd All-Russia. Congress. with intern. participation in school and university medicine, M.: Nauch. Center for Children's Health, RAMS,* 2012. - pp. 246-248.
- [20] M.I. Stepanova, Z.I. Sazanyuk, M.A. Polenova, A.S. Sedova, I.E. Aleksandrova, I.P. Lashneva, T.V. Shumkova and S.A. Ulanova

- “Prevention of health impairments in schoolchildren during learning” J. of Rus. Pediatr. vol. 3, 2011, pp. 46-49.
- [21] SanRandN 2.2.2/2.4.1340-03 “Hygienic requirements to personal electronic computers and work organization. Sanitary-epidemiological rules and standards”
- [22] SanRandN 2.2.4.1294-03 “Hygienic requirements for aeroion composition of air in industrial and public premises”
- [23] I.K. Rapopor, Ye. G. Byrjukova “Morbidity among schoolchildren and vocational college students upon completion of education” J. Hygiene and sanitation. -2007. – vol. 1.- pp. 67-70.
- [24] E.S. Bogomolova, M.V. Shaposhnikova, N.V. Kotova, E.A. Olushina, M.V. Ashina, T.V. Badeeva, S.N. Koval’chuk, N.V. Korolenko “Sanitary and hygienic well-being and health of schoolchildren in schools with different intensity of the education process” J. Health of the population and habitat. 2014. vol. 11 (260). pp. 20-23.
- [25] A.N. Sokorev, S.G. Nemilostivaya, V.V. Momot “Teaching load and adolescents health” CITISE, 2015. Vol. 4, p. 24