PECULIARITIES IN VISUAL FUNCTIONS AND THEIR RESTORATION IN TEENAGERS WITH EMMETROPIC REFRACTION AFTER WORK ON COMPUTERS AND THE METHOD OF ITS REDUCTION

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Abstract

Introduction. Modern IT penetration leads to the usage of information devices, especially PCs, in the teaching and learning process. Nowadays, according to expert research in the Ukraine, more than 9.5 million people are PC users (in fact, one in five people), but half of them are children and teenagers. As a result, the changes in functional activity of different organs and systems are produced, however, work with video-display terminals exerts the most influence on the visual analyser.

Aim. To study the visual acuity and contrast sensitivity in senior pupils while working in front of a computer monitor. and to recommend the effective way of its correction, if any parameters’ disorders are determined.

Material and methods. Sixty, healthy 14-16-year-old senior pupils (120 eyes) with emmetropic reaction were examined. These schoolchildren did not present any ophthalmic, somatic or mental disorders. Visual acuity, its threshold limit values and contrast sensation were studied using special techniques. The investigation consisted of three stages. At the first stage, the effect of one-hour, uninterrupted computer work on visual functions was studied. Their state after 15-minute passive rest was determined at the second stage. The author’s programme “Eyesight Preservation and Restoration”, including special exercises for the eyes, upper limb girdle and neck, with the elements of breath-holding, followed by the determination of the parameters in question, was used at the third stage [1].
Results. A decrease in visual acuity by 7.4% after one-hour constant visual strain on the computer monitor was found. The fact performing restoration exercises for fifteen minutes after one-hour visual strain increased visual acuity by 7.2% is quite conspicuous. It is worth pointing out that contrast sensitivity increases to 36.1 ± 1.42% and 36.08 ± 1.65%, respectively, in the right eye and the left eye after a one-hour visual workload. This indicates a contrast sensitivity decrease in the eyes and the reduction of successful implementation of visual work under changes in brightness.

Conclusions. Indices of visual functions, such as visual acuity and contrast sensitivity change under the impact of working on the PC, however, the 15-minute set of restoration exercises brings them closer to baseline levels.

Introduction

Nowadays, computers are widely used all over the world and have significant popularity. Right before, those devices could only be found at research institutions, universities and at the workplace, but now, many of them are at homes and the number of modern technology owners is growing. Work using a computer display is characterized by heavy visual strain on the visual analyzer, and for this very reason, such professional activity is considered to be visually strenuous. Visual strain and visual working capacity are closely connected with the state of the accommodative convergent system [2]. The intensive computerization process creates many medical and social problems. Up to 40-60% of people suffer from computer eye syndrome [3-5].

The problems regard especially young people with refractive disorders due to using video-display terminals (VDT). The number of individuals is increasing every year, while we may also note the emergence of late acquired myopia in computer users [5-7].

Attention was drawn to the investigation of computer impact on eyesight in recent years in the Ukraine [2,8], but the impact of the computer monitor on visual functions in senior pupils has not been yet determined. Some studies have suggested the necessity of the ergonomic workplace organization for a computer user that would provide visual comfort [4]. But meeting these requirements would not improve much due to the fact that the changes in the functional state of the visual analyzer under the impact of operating a PC would still remain [9]. Modern programmes and finding new drug-free physiological recommendations for a set of restoration exercises require further improvement. The implementation of such exercises will reduce the negative affect of the computer technology and protect eyesight. (тут їхні зміни відповадають твоєму українському тексту)

The aim of our work is to study visual acuity and contrast sensitivity in senior pupils while working in front of a computer monitor, and when disorders are determined, to offer a method for their effective correction.

Method of the study

60 healthy 14-16 year-old senior pupils (120 eyes) with emmetropic refraction but without ophthalmic, physical or mental deviations were examined. The study group consisted of 20 males and 40 females. Significant differences between visual functional indexes in the males and females were not found. These indexes belong to the same population. This conclusion was very important. Otherwise, it would be necessary to carry out data analysis for the males and females separately.

The conditions of the study met hygiene requirements [9] and counted changes of higher nervous activity by academic school day. All schoolchildren had worked on 17-inch LCD screens (screen resolution 1280x1024). The examined pupil was offered to sit down face-to-PC screen so that the eyes were at the middle level of the test field. The test was carried out under standard lighting conditions. Uninterrupted computer work took one hour. A screen picture differs from a natural one: a screen image is a blink, light-absorbing and more contrastless [5].

So, visual strain in this study met to the following requirements:
- subject’s load did not include significant mental activity; (їх корекція – ок)
- programme authoring did not require any special training in computer technique.

After the given requirements, of the participant was asked to read a scientific text (14 pt. font size, “Word” text editor – as visual strain [10,11].

The visual acuity, its threshold limit values and contrast sensitivity were determined by special computer techniques [12,13].

The visual acuity and contrast sensitivity were determined monocularly, starting with the right eye. The head was in a straight position. The second eye was closed with an opaque shield. Visual acuity was determined by means of Landolt’s rings, the dimensions of which were determined with regard to the proportion of symbols from Sivtseva-Golovin’s table. The contrast of symbols with the background screen constituted 100%. The black
symbols were shown against the white background. The
examination was conducted from a distance of 4 m. The
presence or absence of the complaints in the examined
pupils served as the criterion for selecting the initial
number of optotypes for the study.
Thus, when there were no complaints of decreased
visual acuity, the table with Landolt’s rings was shown
on the monitor screen, the dimensions of which fitted
the visual acuity of 1.0. The table with Landolt’s rings,
the dimensions of which corresponded to the data of
subjective vizometry under contrast at 100%, was dis-
played. The contrast of the symbols and the background
were reduced each time by 10.0%. and along with this,
the orientation of Landolt’s rings was changed on the
screen due to the law of software random distribution
that eliminated undesired formation of a consistent
image of maximum contrast optotypes.
The data were clarified by the increase in contrast to
0.2–0.8 % with each step. The range of possible contrast
measurement was 100-0.8%. The examination was con-
ducted at three stages. During the first stage, the impact
of one-hour computer operation on the visual functions
was studied. The visual acuity and contrast sensitivity
after one-hour of computer work and a 15-minute break
(closing eyes or shifting eyes away from the monitor)
were determined at the second stage.
The third stage included the study of the investi-
gational visual functions after work on the computer
and a set of restoration exercises with the elements of
breathing exercises.

The results were processed on the PC with the aid
of the Statistica 6.0 (Statsoft. USA) application pack-
age. The digital data were processed concerning sta-
tistical analysis according to the Ukrainian State DSTU
3008-95 standard. After implementing the requirements,
the results were given as average number (M). standard
error of the mean (m), relative error and checking the
null hypothesis and The Student’s $t$-test for independent
variables [14]. Analysis of the given data was provided
in normal distribution of results within groups or sub-
groups. If data distribution deviated from the norm (ac-

### Results of the study

It can be stated that the visual acuity of the pupils
with emmetropic retraction decreased by 7.4% from
baseline after their visual workload and constituted 1.20
± 0.07 and 119 ± 0.07 in the right and left eye, respec-
tively. It was found out that the 15-minute restitution did
not significantly effect that index (Table 1).

It is worth mentioning that the performance of res-

toration exercises for fifteen minutes after the one-hour
visual strain increased visual acuity by 7.2%, which
reached values closer to baseline and was: right eye –
1.29 ± 0.09, left eye – 1.28 ± 0.08.
The contrast sensitivity at baseline (Table 2) was
28.30 ± 1.31% in the right eye and 28.34 ± 1.28% in
the left one.

### Table 1. Visual acuity before and one-hour after visual computer workload, after 15-minutes of rest and following the set of restoration exercises (c.u.).

<table>
<thead>
<tr>
<th>Indices of visual acuity</th>
<th>OD (right eye)</th>
<th>OS (left eye)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before visual strain</td>
<td>1.30±0.03 a</td>
<td>1.29±0.06 a</td>
</tr>
<tr>
<td>After visual strain</td>
<td>1.29±0.07 b</td>
<td>1.19±0.07 b</td>
</tr>
<tr>
<td>After 15-minutes of rest</td>
<td>1.23±0.08</td>
<td>1.22±0.06</td>
</tr>
<tr>
<td>After the set of restoration exercises</td>
<td>1.29±0.09</td>
<td>1.28±0.08</td>
</tr>
</tbody>
</table>

Note: a – the probability of data before the visual strain ($P<0.05$), b – the probability of data after the visual strain ($P<0.05$).

### Table 2. Contrast sensitivity before and after one-hour of computer visual strain, after 15-minutes of rest and following the set of the restoration exercises (%).

<table>
<thead>
<tr>
<th>Indices of contrast sensitivity</th>
<th>OD (right eye)</th>
<th>OS (left eye)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before visual strain</td>
<td>28.30±1.31</td>
<td>28.34±1.28</td>
</tr>
<tr>
<td>After visual strain</td>
<td>36.10±1.42 a</td>
<td>36.08±1.65 a</td>
</tr>
<tr>
<td>After 15-minutes of rest</td>
<td>35.10±1.52 a</td>
<td>35.20±1.64 a</td>
</tr>
<tr>
<td>After the set of restoration exercises</td>
<td>31.50±1.42 a</td>
<td>31.70±1.42 a</td>
</tr>
</tbody>
</table>

Note: a – the probability of data before the visual strain ($P < 0.05$), a – the probability of data after the visual strain ($P<0.05$)
The increase in the contrast index to 36.1 ± 1.42 % and 36.08 ± 1.65 %, respectively, in the right and left eye after one-hour of visual strain should be noted. This proves the decrease in contrast sensitivity of the eyes and the reduction of successful implementation of visual work under the changes in brightness. This is in agreement with the scientists’ findings that prolonged and repeated contact with displays impact the ability of the visual system to contrasting eyesight [15,16].

The unreliable results were achieved after the 15-minute rest. Thus, the contrast sensitivity was 35.1 ± 1.52% in the right eye and 35.2 ± 1.64% in the left one, which was close to the data obtained after 1-hour of visual strain. The determined indices show significant improvement of the contrast sensitivity after the set of restoration exercises, the duration of which was 15 minutes. This proves their effectiveness and expediency for reducing sensory fatigue as the index of contrast sensitivity decreased and amounted to 31.5 ± 1.42% in the right eye and 31.7 ± 1.42% in the left one.

Conclusions and discussion

Our results coincide with the findings of some scholars, who outline the positive correlation between the duration of work on a personal computer and the decrease in visual acuity [15-17].

Normal visual perception of the world requires not only high acuity but full spatial-frequency channels of contrast sensitivity. These channels provide high frequency filtering which inform us about the details of an object: low ones, without which the perception of a complete image is impossible even when distinguishing small and medium details, and medium ones which set the preconditions for high-quality analysis of object contours. Thus, the study of visual contrast sensitivity at all frequencies gives full and good knowledge about the possibilities of the perception of visual information. The determination of contrast sensitivity can be used for initial diagnosis of visual system diseases in all cases, and for establishing pathophysiological approaches to improve visual functions. Contrast sensitivity is physiologically a more delicate function and does not always correlate with visual acuity [18-21]. It is believed that the changes in contrast sensitivity are early manifested, which provides better information about the functional state of the visual analyzer compared to visual acuity.

Our study points out that the exercises, which are followed by a set of breathing exercises, are the most effective rehabilitation means for improving visual acuity and contrast sensitivity. So, possible increase in the supply of the brain with blood and oxygen results in the functional restoration of neurons in the visual centres and with them, in the indices of acuity and contrast sensitivity [22].

Thus, 1-hour computer visual workload caused a decrease in visual acuity by 7% in the teenagers. The index of contrast sensitivity increased: 36.1 ± 1.42% and (36.08 ± 1.65%, in the right and left eye, respectively, under the impact of 1-hour computer work. This indicates a disorder in visual function. The 15-minute passive rest did not significantly change the index. The performance of the restoration exercises brought the visual functions closer to baseline.

The study provides deep insight into the current understanding of visual analyzer functioning in senior pupils with emmetropic refraction, who experience strains working on a computer. The obtained findings demonstrate the positive dynamics in functional indices of the “Eyesight Preservation and Restoration” programme developed by the author. Thus, the programme can be recommended both for autonomous work on a computer and for educational institutions in the restoration of visual functions and the prevention of visual disorders.

References

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