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5-6 Year Old Children Visual Efficiency Development in the Period of School Loading Adaptation by Means of Visual Exercises

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5-6 Year Old Children Visual Efficiency Development in the Period of School Loading Adaptation by Means of Visual Exercises

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Visual load, refractive genesis, visual adaptation, visual training

**Abbreviation:**
PP1 near point (punctum proximum), PP2 – near point of clear vision, VEM - Visual efficiency marker, VPI - Visual performance index

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**Abstract**
Modern school load burdened by a primary school child have a disastrous influence both on vision current state and visual analyzer development implicitly. The 5-6 year old children visual load specificity is connected with the school work peculiarities determined by near visual zone burden. Reading, writing, calculation training are the activities performed in this zone. 5-6 year old schoolchildren age peculiarities aggravate a myopia problem expansion. Visual load high level together with natural refractive genesis encourages children nearsightedness. School work intensification as a result of modern society computerization leads to the wholesale nearsightedness that is viewed as a vision forced adaptation to the school load. Age visual peculiarities of 6-year-old alumni aggravate the myopia problem among pupils. Visual load increases and becomes more specific. Natural refractive genesis is being layered on the mentioned factors encouraging children nearsightedness. The educational load sanitation can be achieved by visual training course at the initial stage of school education.

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1. Introduction

1.1 Visual load dynamics
School education initial stage is characterized by the visual load increasing up to 5-6 hours per day. Educational visual load is characterized not only by volume increasing (two- or three-fold in comparison with preschool period) but also by its intensity (eye accommodative apparatus tension). Reading, writing and arithmetic schooling that are concentrated in the near visual zone seem to be main factors for the mentioned problems.

1.2 Visual load peculiarities
The visual work at reading schooling analysis evidences that visual system requires 2-9 main vertical and horizontal hairlines and some voids per each letter (Kiyuka, 1987). Visual analyzer oculomotor muscles work irregularly and discontinuously. The text is understood mainly at a pause – reading recording. The pauses quantity and thus visual load – depends primarily on the reading skills level. Visual load is being increased due to multiple reverse eyes motion to unidentifiable letter, obscure word, missed line (Glushkova, 1987).

TV viewing on a day-to day basis together with computer games makes negative impact on children visual analyzer that is still being formed (Akhmadeev et al., 2001). The above mentioned factors are characterized by a recurrent screen illumination in a wide diapason, flicker frequency impose a visual load in addition to an educational one.
So the elementary schooling problem seems to be as follows: the visual load volume and specificity distort significantly visual analyzer refractive genesis of the 6-year-old pupils.

2. Literature Review

2.1 Children vision age peculiarities

It is known that preschool-elementary school age (3-10 years old) is a period of hyperopia decline and emmetropia and myopia increase (Avetisov et al., 1986). Refraction variants quantity is inconsistent, yet, as E.S. Avetisov says, age-related refractive genesis regularity seems to be generally agreed (Avetisov, 1999).

It signifies that the child visual analyzer functional age-related changes are determined by the necessity to form a vague hypermotropic and emmetropic refraction (Mamatkhuzhaeva, 2002).

Besides preschool-elementary school age is characterized by eye refringence lability. Visual analyzer muscular apparatus is bent on spastic state and inadequate reaction to visual load. Dynamic refraction vision zone is instable and is easily shifted to myopia (Borodina et al., 2012). Older preschool age evidences almost completely developed chromatopsia, but the complete development is registered at the age of 8-9 years old.

Binocular vision is based on monocular visual structures dismaturity (Arciniegas et al., 1986).

Visibility pick-up range borders are narrower as compared with that of older pupils (Onufriychuk et al., 2007).

The object shape perception and vision acuteness is fully developed in schooling period. The engagement tempo of the shape vision may vary since it is determined by 6-year-old children biological maturation specificity (Dolzhich et al., 2008).

Thus the distinctive feature of elementary school pupils’ refractive genesis is a continuous and gaterochronous vision transition into emmetropic sphere due to immature visual functions used for increased visual educational load. This period is often thought of as a critical period that determines the vision level in the future life. Since visual analyzer is an optic system that facilitates visual orientation, its development should be analyzed together with an organism vital activity (initial elementary schooling visual load specificities predominant for a 6-year-old child) (Tarutta, 2006).

2.2 Children refractive genesis regularities under school load

A factor that is determinant to visual mechanisms adaptation to visual work specificity is a correlation between age determined unstable anatomic eye static refraction and an optic component which is almost constant after 5 years old. The correlation is as follows: more powerful refractivity goes with a shorter anterior-posterior axis; weaker refractivity goes with a longer anterior-posterior axis. It proves that anatomic component is fundamental for static refraction harmonizing (Sato, 1986).

Dynamic refraction is a functional system aiming at eye adjustment to a finite distance. Its functioning is determined by three components correlation: visual axis length (anatomic component), refractivity within debilitated accommodation (optic component) and accommodative capability (Rozenblum et al., 2007).

E.S. Avetisov, the three-factor myopia theory underlines the near distance vision prevailing role in schooling. It can be presumed that the mentioned factors development and correlation are aimed to maintain the near distance activity (Avetisov, 1999).

2.3 School load adaptation types

Educational visual work maintenance which actually signifies eye adaptation to new vital activity is explained by William Horatio Bates theory. The theory states that refraction deviations are connected with oculomotor muscles inefficiency and consequently – perispheric eye shape changes. To reduce tension resulted from continuous near vision load visual analyzer modifies the optical system to ease the near distance visual work. It is achieved by the refraction anatomic component modification. Thus if the optical axis is lengthened within 1 mm it release the tension but leads to myopia refraction (Bates, 1987).

By this means myopia may be interpreted as child vision adaptation to schooling visual load. It is proved by school age adjusted myopia incidence rate.
3. Objective of Research

The aim of the research is to justify the therapeutic and developing training possibility and necessity at the period of children adaptation to the near zone visual work. The annual pedagogical experiment involving visual games complexes (after Avetisov, Bates) systematic applying gave definite results. Ergographic visual indexes (after Avetisov classification) increased according to the statistics as well as the visual efficiency markers. It helped to reduce the accommodative (school) myopia risk. The search results offer the challenge for primary education health saving technologies. It conforms to the modern schooling valeological paradigm: “Teach without health ruining”.

4. Materials and Methods

The following methods were applied to study 6-year-old primary school pupils’ visual analyzer functions. The near distance eye functioning was tested.

Oculomotor muscles ergography that shows time-series identification of the nearest point (PP1) and near point of clear vision (PP2).

Ergogram has been taken unioocularly with the help of a proximotor with a kymograph for 3 minutes. The test object (amid steady illumination) was an adjustable ground glass screen with an optotype – Landolt ring relevant to vision sharp 0.7 for the distance of 33 centimeters.

The ergogram data was analyzed according to Avetisov classification (Avetisov et al., 1987).

58 ergograms of 6-year-old children had been obtained and analyzed.

General visual test was based on correction task methodology. 6-year-old children vision study was accomplished with the help of correction task table fragment (Tagayeva, 1976).

Character structure, size and spacing served as a model of a visual work at literacy schooling. Visual efficiency (testees’ performance ability) evaluation was done according to Weston H. methodology.

The tables were completed before, during and after measured schooling load. The load contemplated visual analyzer substantive tension while working within the nearest zone (reading, writing schooling). Correction task table work was carried out at pupils working places at a permanent illumination. 56 6-year-old pupils were tested. 174 answers were received and analyzed.

All the testees on thorough medical evidence demonstrated vague hypermotropic and emmetropic refraction and a vision sharp of 0,9 which corresponds to the visual analyzer normal state at this period.

An experimentative factor was as follows. During the academic year (September-May) the everyday visual exercises (special games and tasks) were suggested to exercise the eye muscular system. They aimed at eye adaptation to vision load at near distance (myopia type of refraction). The visual analyzer exercises complexes aimed at visual analyzer straining and laxity were suggested. They are based on Avetisov, Bates methodology adapted for 6-year-old children.

5. Justification of Research

Every year millions of pupils start learning. Millions of people graduate from the schools and colleges with accommodative (school) myopia resulting from school load. Due to the visual load increase the myopia problem will only be escalating. The above mentioned stands for the necessity to new visual methodology implementation aimed at visual analyzer sanitation. In reliance on visual age peculiarities, refraction genesis development, visual load influence, proper theoretical studies and experimental results the author suggests ways for primary school children visual efficiency developing and control.

6. Results

Ergometry-based visual efficiency study was based on one-year experiment of the everyday supportive-evolutive visual exercise in experimental group and traditional recreational physical exercises in a control group. The exercises volume and duration were equal. The study proved the following.
### Table 1: 6-year-old Pupils Eyes Classification by Ergographic Efficiency (Experimental Case)

<table>
<thead>
<tr>
<th>Experiment stages</th>
<th>Groups</th>
<th>Researched eyes quantity</th>
<th>Visual efficiency types</th>
<th>White’s T-criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td>IIA</td>
</tr>
<tr>
<td>Academic year start (September)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental (n=12)</td>
<td></td>
<td>24</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>Control (n=12)</td>
<td></td>
<td>24</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>Academic year midpoint (December)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental (n=12)</td>
<td></td>
<td>24</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Control (n=12)</td>
<td></td>
<td>24</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

To characterize sufficiently the visual analyzer (complex functional system) adaptation to schooling load, the visual efficiency was studied by a general correction task test, processed by Weston H.

### Table 2: 6-year-old Pupils Visual Efficiency at the Experiment Initial Stage (September)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Statistical Measures</th>
<th>Accuracy Measures</th>
<th>Velocity Measures</th>
<th>Visual Efficiency Integral Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>0.91</td>
<td>0.122</td>
<td>0.111</td>
</tr>
<tr>
<td>(n=38)</td>
<td>m</td>
<td>0.026</td>
<td>0.0054</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Control</td>
<td>x</td>
<td>0.90</td>
<td>0.119</td>
<td>0.107</td>
</tr>
<tr>
<td>(n=24)</td>
<td>m</td>
<td>0.024</td>
<td>0.0064</td>
<td>0.0073</td>
</tr>
</tbody>
</table>

### Table 3: 6-year-old Pupils Visual Efficiency at the Experiment Final Stage (May)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Statistical Measures</th>
<th>Before Educational Visual Load</th>
<th>At the Process of Educational Visual Load</th>
<th>After Educational Visual Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>0.193</td>
<td>0.199</td>
<td>0.149</td>
</tr>
<tr>
<td>(n=38)</td>
<td>m</td>
<td>0.013</td>
<td>0.008</td>
<td>0.0059</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>&lt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Control</td>
<td>x</td>
<td>0.155</td>
<td>0.191</td>
<td>0.148</td>
</tr>
<tr>
<td>(n=24)</td>
<td>m</td>
<td>0.009</td>
<td>0.009</td>
<td>0.12</td>
</tr>
</tbody>
</table>
7. Discussion

Visual schooling load adaptation difficulties of 6 year old pupils at the initial level are reflected at Table 1. Eye muscular apparatus is not able to provide a stable response reaction within three-minute standard visual load in the nearest (PP1) and the near (PP2) clear vision points.

As a result none of the normal age-determined visual function ergograms can be classified as the I etalon type. At the same time the ergograms of the IIa type (Avetisov methodology) demonstrate certain characteristics with a tendency to be developed up to the I type. Reasonably sinuous amplitude characterizes the experiment final stage as well as relative regularity of PP1 and PP2 at ergograms extended fragments. Both groups amplitude value resembled accommodation reflex. The data received stands for the homogeneous visual efficiency within both groups.

Intermediate test conducted after 3.5 months visual training program showed competed results in the groups tested (Table 1). Experimental group is illustrated mainly by IIa type ergograms which is a result of IIb i IIla types deviations. The middle phase of the experiment demonstrates the III type ergograms absence and I type ergograms instance (2 cases). It results in visual efficiency increase which comes out of the schooling load visual component excessive exposure. The experimental group data is concentrated mostly within IIa type ergograms. It proves the intense schooling saturation importance while adapting to school education.

As a result none of the normal age-determined visual function ergograms can be classified as the I etalon type. At the same time the ergograms of the IIa type (Avetisov methodology) demonstrate certain characteristics with a tendency to be developed up to the I type.

The control group data is indicative of visual efficiency decrease: most ergograms belong to IIb type and witness accommodative function weakness. The III type ergograms emerge (5 cases) which is a result of visual efficiency feebleness. The changes came together with asthenopia symptoms (smarting eyes and caligation) that prevented from experiment continuation under predetermine condition.

III type ergograms analyses shows specific arcs as PP1 and PP2 points’ eye withdraw. The amplitude changes are not significant still distinctly graded. The PP1 and PP2 distance module at the ergogram final fraction equals to 30 %.

Visual efficiency correction task investigation (Table 2) testifies both groups statistical homogeneity at the beginning of the academic year. The test accuracy measured 1.1 % (p > 0.05) difference between two groups, velocity – 2.5 % (p > 0.05). Visual efficiency integral data spread measured to 3-4 % (p > 0.05).

The final three-stage VEM test showed the marker changes and VEM dynamics specificity under the conditions of visual tense schooling load (reading, writing, mathematics, foreign languages classes). To avoid the “training effect” the optotype suggested for the search in the correction task test varied.

VEM increase was recorded in both groups. The experimental group gained 73.9 % (p < 0.001), the control one – 44.9 % (p < 0.001). The visual work intellectualization predetermined by intensity of elementary schooling requires visual system maturity sufficient for complex images recognition - letters and figures (Hubel, 1990; Dolezanova et al., 1995). Consequently the higher VEM level of the experimental group correlates more to the increased demand for 6-year-old pupils schooling visual component.

Experimental group VEM development disparity stood for its higher level at the final phase with the differential of 24.5 % (p < 0.05). The 6-year-old pupils increasing exhaustion by the end of the academic year should be considered. It is accumulated notwithstanding school organization and management regulatory compliance.

VEM dynamics differed within the experimental and the control group accomplishing the same schooling visual load. Experimental group VEM demonstrated higher initial level and its level maintenance under the schooling visual load. The studied factor slightly increased to 3.1 % (p > 0.05).

Control group VEM demonstrated lower initial level and its sharp rise under the schooling visual load up to 23.2 % (p < 0.05) in the middle phase yielding slightly to the
experimental group VEM load (differential of 4.2 % \( p > 0.05 \)). The schooling visual load ended in the VEM reduction to the previous period within the limits of 22.5 – 25.1 % (\( p < 0.01 \div 0.001 \)).

Thus the control group VEM dynamics is characterized by significant dormant and visual work period delta. It testifies that the load had been accomplished by functional system mobilization and correspondingly to visual analyzer overtension leading to myopia refraction. The experimental group VEM dynamics is characterized by the data stability before, during and after the schooling visual load that proves the load lower "price" for the whole functional system. VEM reduction after the schooling load is a fatigue result and is a natural process.

Research Highlights

1. The research deals with primary school visual load problems. It explains the near zone visual load harmful influence on the primary school children refraction genesis process.
2. The investigation is focused on an accommodative myopia pathogenic case manifested by the test group ergographic indexes reduction.
3. The study shows the visual efficiency markers complex. It reflexes the different level of near zone school load visual adaptation tested experimentally.
4. The study proves the necessity of applying eye muscular system visual training for 5-6 year old children to prevent from accommodative (school) myopia type.

Limitations

The experiment results were obtained at a period of 1-year study. The same methodology cannot be applied to the 2-nd year of study pupils as it may lack predictive validity. Another restriction deals with impossibility of visual regime monitoring in out-of-class activity (watching TV, surfing Internet) that may influence the experiment results.

Recommendations

Near zone visual load adaptation types of primary school children are analyzed in the research. The study results (in particular – visual exercises complexes) are expected to be implemented to the school organization and management (school lessons content). The aim is to reduce overload and to train eye muscular apparatus as prevention from accommodative form of myopia development. The visual efficiency level control is exercised by eye ergography markers with the following analysis of PP1 and PP2 position change.

Funding and Policy Aspects

The research results may influence Ministry of Education of Ukraine and other countries policy towards the primary schools programs health improving orientation. The recommendations implementation will minimize the school load negative influence. It can be done on the basis of new estimation criterion of primary school teacher efficiency. The health improving training innovative program for the first year of schooling developed by the author requires state financing.

Justification of Research

The research proved that primary school children visual analyzer age peculiarities collide with the near zone visual load adaptation necessity. It may lead to accommodative type of myopia. Thus the demand arises to develop a technique that could preserve the children vision under the conditions of intensive and longtime eye accommodative apparatus work while reading, writing, calculating and working at the computer. The demand for the health-saving methodology will increase with the academic visual load increment.

Conclusion

The schooling intensification require specific adaptation of 5-6 year old children to visual component of school load peculiarities. The visual efficiency reduction in eye ergogram of II-b type during the period of reading, writing and calculating acquirement makes the child sensitive to eye functional dysfunction or accommodative myopia at worse.

The research done gives a definite answer to the principal possibility of visual efficiency development during the first year of study. Visual efficiency increment up to II-a type in ergograms together with visual efficiency integral data according to correction task test influence positively (73.9 % (\( p < 0.001 \)) eye stability towards school load visual component.

Thus everyday sanitary-developing visual training exercises complex (after Bates, Avetisov) is essential to establish a base for
emmetropic eye formation under the conditions of intensive influence of 5-6 year old pupils schooling visual component.

The further research may be directed on 5-10 year old children refraction genesis resulting from sanitary-developing visual training under the conditions of long-term experiment in the primary school.

Visual training therapeutic potential may predict the school myopia problem substantial decrease.

**Author’s Contribution and Competing Interests**

The author resides in the idea of visual training appliance to 5-6 year old schoolchildren visual analyzer efficiency improvement. The idea was actualized and justified during the sanitary-developing visual training of 5-6 year old schoolchildren.

**Concluding Remarks**

The 6-year-old children visual analyzer is the least human organ among those qualified for schooling education. The 6-year-old pupils schooling intensification demands education load visual component specific adaptation that leads to the eye myopia refraction. The experiment definitely justifies appropriateness of the visual efficiency special exercises provided for the elementary schooling.

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**References**


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