SLOBOZHANSKYI HERALD OF SCIENCE AND SPORT
Vollum 27 No. 1, 2023

The influence of loads of various magnitudes and directions on the visual acuity of high-qualified visually impaired sprinters

Leilia Adzhametova[1], Liudmyla Shesterova[2]

[1]*Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine*
[2]*Kharkiv humanitarian-pedagogical academy, Kharkiv, Ukraine*

Abstract

Purpose: determine the impact of loads of different magnitudes and directions on the visual acuity of a highly qualified female athlete with visual impairments, specializing in sprinting.

Material & methods. The study was conducted in the general preparatory period of the annual training cycle with the participation of the Honored Master of Sports of Ukraine in athletics among athletes with visual impairments. The following research methods were used: analysis of documentary materials (diaries and preparation plans of the studied athlete), pedagogical observation; Pedagogical experiment (author's experiment), visometry, methods of mathematical statistics.

Results. It has been established that an increase in the load has a negative effect on visual acuity. The results obtained in the course of the study indicate a general trend in the response of both eyes to a load of a different nature.

Conclusions. The use in the preparatory period of loads of a strength orientation, complex for endurance, coordination and flexibility, leads to an increase in visual acuity, which in turn has a positive effect on the functional state of the visual analyzer. Large loads aimed at speed endurance and having a speed-strength character lead to a decrease in visual acuity and, as a result, negatively affect the functional state of the visual analyzer.

Key words*:* visual acuity, visual impairment, visometry, preparatory period.

Анотація

Лейля Аджаметова, Людмила Шестерова. Вплив навантажень різної величини та спрямованості на гостроту зору висококваліфікованих спринтерів з порушенням зору. Мета: визначити вплив навантажень різної величини та спрямованості на гостроту зору висококваліфікованої легкоатлетки з порушеннями зору, яка спеціалізується у спринтерському бігу. **Матеріал і методи**. Дослідження проводилося у загально-підготовчому періоді річного циклу підготовки за участю Заслуженого майстра спорту України з легкої атлетики серед спортсменів з порушеннями зору. Були використані наступні методи дослідження: аналіз документальних матеріалів (щоденники та плани підготовки досліджуваної спортсменки), педагогічне спостереження; педагогічний експеримент (авто експеримент), візометрія, методи математичної статистики. **Результати**. Встановлено, що збільшення величини навантаження, негативно впливає на показники гостроти зору. Результати, отримані під час дослідження, свідчать про загальну тенденцію реагування обох очей на навантаження різного характеру**. Висновки.** Застосування у підготовчому періоді навантажень силової спрямованості, комплексної на витривалість, координацію та гнучкість призводять до підвищення показників гостроти зору, що в свою чергу позитивно впливає на функціональний стан зорового аналізатору. Навантаження великої величини, що спрямовані на швидкісну витривалість та носять швидкісно-силовий характер, призводять до зниження показників гостроти зору і, як наслідок, негативно впливає на функціональний стан зорового аналізатору.

Ключові слова: гострота зору, порушення зору, візометрія, підготовчий період.

Original Paper

DOI: 10.15391/snsv.2023-1.007

Received: 24.02.2023;
Accepted: 07.03.2023;
Published: 30.03.2023

Citation:
Adzhametova, L. & Shesterova, L. (2022). The influence of loads of various magnitudes and directions on the visual acuity of high-qualified visually impaired sprinters. *Slobozhanskyi Herald of Science and Sport*, 27(1), 48-53. https://doi.org/10.15391/snsv.2023-1.007

Corresponding author:
Leilia Adzhametova
Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine
orcid.org/0000-0001-6673-3686
e-mail: Leilia090394@gmail.com

Liudmyla Shesterova
orcid.org/0000-0001-8777-6386

Introduction

The study of the effect of physical activity on the functional state of the visual analyzer began in the late 1970s (Adzhametova & Shesterova, 2018, Barchenko & Bochkovskaya, 2018, Dill, 2005, Evseev et al., 2015, Sharon R. Ong et al., 2018, Ishiko S. et al., 2021). Sargent et al., (1981). found that moderate and intense aerobic exercise reduces intraocular pressure (IOP) in the short and long term (up to 6 months), the degree of reduction does not depend on the physical preparedness of athletes. However, a little later, Avunduk et al., (1999) found that isometric and isotonic exercises also lead to a decrease in IOP, while the magnitude of its decrease is higher with isotonic exercises. At the same time, Kiss et al., (2001), studying the characteristics of choroidal blood flow during isometric exercises, noted that such loads contribute to maintaining a constant blood flow in the choroid, despite changes in perfusion pressure. The author noted that this dependence persists with moderate changes in the level of carbon dioxide in the blood. It should be noted that the above results were obtained with the participation of athletes without violating the functions of the visual analyzer.

Alekseev et al., (2017), Suhr Thukjaer et al., (2017), Limwattanayingyong J. et al., (2022), Hansen M. H. et al., (2020) agree that small-scale physical activity improves the physiological parameters of the eye, increases the efficiency of the ciliary muscle and strengthens the sclera. Shmakov, (2014), Yang Y. et al., (2022) found that the use of adapted games and rhythmic gymnastics for children with visual impairments contributes to an increase in visual acuity and some weakening of eye refraction. But at the same time, according to Goldschmidt & Jacobsen, (2014), environmental factors, metabolism, physical activity and outdoor activity influence the fine correlation between the components of ocular refraction.

Arutyunova et al., (2006) showed that physical activity with an arterial pulse up to 175 beats/min. contribute to the improvement of blood supply to the anterior part of the eyeball, and the arterial pulse of more than 175 beats / min leads to a deficiency in the blood supply to the anterior and posterior parts of the eye. Scientists have shown that dynamic physical activity contributes to a decrease in IOP regardless of the degree of training and an increase in perfusion pressure of the eye, depending on the degree of training of the studied athletes. However, Read & Collins (2011), Lundberg K. et al., (2018) found that moderate-intensity dynamic exercise resulted in significant changes in ophthalmic functional parameters. Note that the author, unlike his predecessors, studied the performance of athletes both with visual impairments and with normal vision. Thus, he found that immediately after loading, there was a decrease in the axial length of the eye against the background of a decrease in IOP. At the same time, no significant differences were found in the magnitude of changes between athletes with and without visual impairments. Thus, the author notes that exercise has a short-term effect on the axial length of the eye and intraocular pressure.

Thus, the analysis of modern literature has shown that physical activity has a positive effect on the physiological parameters of the eye, helping to reduce intraocular pressure, improve blood supply to the posterior and anterior parts of the eye, as well as a short-term decrease in the axial length of the eye, which can help reduce the risk of developing and progressing (Cuellar-Partida et al., 2016, Dill, 2005, Shesterova, 2015, Wenbo et al., 2017, Wylęgała, 2016, Zhou et al., 2016, Frike TR et al, 2018, Burton MJ, et al, 2021). However, in the scientific and scientific-methodical literature, the effect of loads on the state of the visual analyzer in Paralympic athletes with visual impairments has not been practically studied. At the same time, the available data open the prospect for further research aimed at studying the effect of physical loads of various magnitudes and directions on the visual acuity of highly qualified sprinters with visual impairments.

Purpose of the study: to determine the effect of loads of different sizes and directions on the visual acuity of athletes with visual impairment, specializing in sprinting.

Material and Methods of the research

The study was conducted during the training camp of the national Paralympic athletics team of Ukraine in Antalya (Turkey). The Honored Master of Sports of Ukraine in athletics among athletes with visual impairments, Paralympic champion, world record holder took part in the study. According to the athlete's individual training plan, the training camp was held at the general preparatory stage of the preparatory period of the annual training cycle and lasted 3 weeks.

An female athlete at the age of 27 had a congenital damage to the visual apparatus: partial atrophy of the optic nerve in both eyes. The percentage of damage to the left eye is higher than the right. The athlete had a leading right eya. The visual acuity of the female athlete was determined by the doctor of the national Paralympic athletics team of Ukraine according to the Sivtsev table. Since the female athlete's vision did not allow seeing the symbols of the table from 5 m, Snellen's formula was used for accounting:

$$VISUS = d/D, \quad (1),$$

where V - visual,

d - distance from which the athlete saw the symbol of the table,

D - tabular value indicated on the left in the Sivtsev table.

Visometry was carried out three times after each training session, the athlete's rest between measurements lasted 10-12 minutes and took place in a sitting position with her eyes closed. According to the international classification, the visual acuity indicators of the athlete corresponded to the T13 class.

The following methods were used in the study: analysis of documentary materials (training diaries and training plans of the studied athlete), pedagogical observation, pedagogical experiment (author's experiment), visometry, methods of mathematical statistics.

Statistical analysis of the obtained data was carried out on a personal computer using Statgraphics Centurion 18 (version 18.1.11), using the quartel method, the Kruskal-Wallis test, the Gamma correlation coefficient and the Spearman coefficient.

Results of the research

The training camp (TC) of the female athlete was held at the general preparatory stage of the preparatory period of the annual training cycle and lasted 3 weeks. The female athlete trained 2 times a day. The female athlete's training week consisted of 4 workouts in the stadium, 3 workouts in the gym and 2 workouts on the sand. The duration of training sessions ranged from 1.5 to 2.5 hours. Rest between exercises ranged from 1 to 3-4 minutes, depending on the direction of the load. So, between exercises of a strength orientation, rest usually was 1-1,5 minutes, and between speed exercises - 3-4 minutes. During the entire training camp, visometry was performed after each training session. The variation in visual acuity indicators is shown in Figure 1 and Table 1.

Table 1. Indicators of visual acuity for the period of TC without taking into account the load

Visual acuity (n=60)	$\bar{X}$ (c. u.)	Me (c. u.)	Min (c. u.)	Max (c. u.)	Q1 (25%)	Q3 (75%)
Right eye	0,070	0,070	0,060	0,084	0,065	0,075
left eye	0,069	0,070	0,060	0,073	0,065	0,070

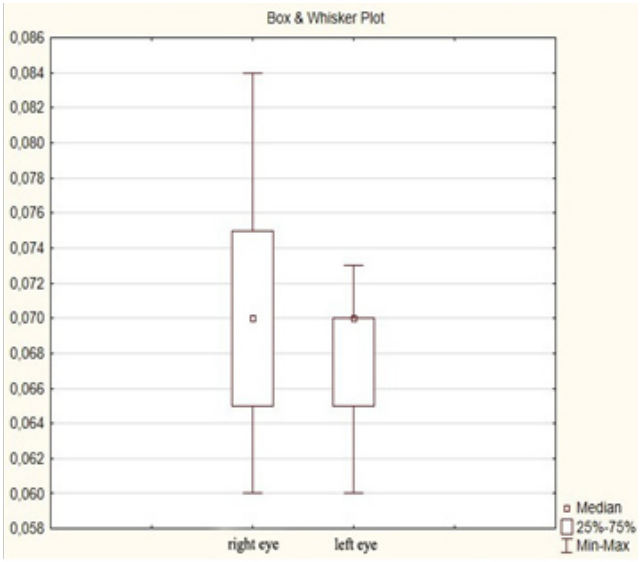


Fig.1. Indicators of visual acuity during TC in the general preparatory period

Figure 1 and Table 1 present a 5-digit summary of visual acuity indicators:

✓ the lower line corresponds to the minimum value of visual acuity in the data sample and is equal to 0.060 for both eyes;

✓ bottom of the box - 1st quartile, which is 0.065 for both eyes;

✓ point inside the box - medians corresponding to 0.070 for both eyes.

✓ the top of the box is the 3rd quartile, which is 0.075 for the right eye, and 0.070 for the left

✓ the upper line corresponds to the maximum value and is equal to 0.084 for the right eye, for the left – 0.073.

In order to determine the effect of loads on the visual acuity of the studied female athlete, all training loads were distributed according to the magnitude and direction according to the Platonov classification (2017). The athlete performed loads of various sizes with a primary focus on speed, strength, speed-strength and coordination abilities and endurance.

Figure 2 shows the variation in the visual acuity of an female athlete with visual impairment, taking into account the magnitude of the load during the TC.

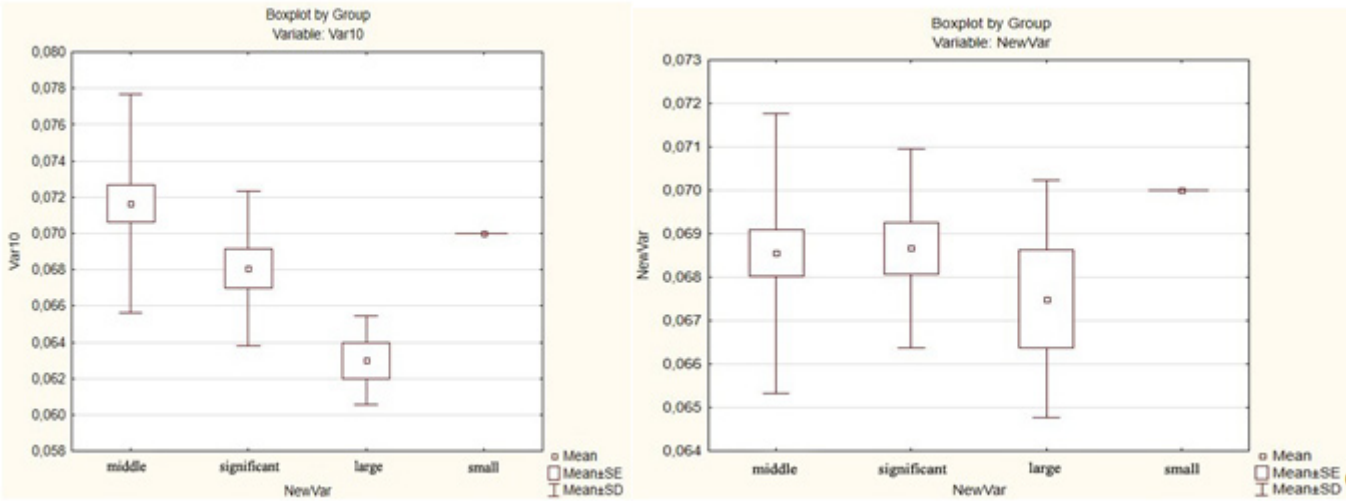
The Kruskal-Wallis (H) test was used to identify the significance of differences between visual acuity indices under the influence of loads of different magnitudes.

Analysis according to the Kruskal-Wallis test was carried out separately for the right and left eyes. It was established that there are significant differences between the indicators of visual acuity of the right eye at different loads H (N=60) =13,60 ($p<0.05$).

Significant differences are observed between the indicators of visual acuity of the right eye under the influence of a large load in comparison with a significant, medium and small one. At the same time, the indicators of visual acuity of the right eye under the influence of significant, medium and small loads do not have a significant difference between themselves (Table 2).

There were no significant differences between the indices of visual acuity of the left eye under loads of different magnitudes H (N=60) =1.96, ($p>0,05$).

The relationship between the magnitude of the load and visual acuity was determined by the Gamma correlation coefficient. This coefficient is used to study the relationship between



a b

Fig. 2. Comparison of visual acuity indicators under the influence of loads of different magnitudes during TC. (a - right eye, b - left eye)

Table 2. Pairwise comparison of indicators of visual acuity of the right eye under the influence of training load of different magnitudes according to the Kruskal-Wallis criterion (H)

Loading value	Small (n=3)	Medium	Significant
Medium (n=36)	H=0,17 p =0,68		
Significant (n=15)	H=0,61 p =0,43	H=3,43 p =0,06	
Large (n=6)	H=5,84 p =0,02	H=10,56 p =0,001	H=6,034 p =0,01

data presented in metric and rank scales. It was established that there is a significant average relationship between the load and visual acuity of the right eye (p<0,05), and the left eye has a weak relationship. (p>0,05).

Analysis of visual acuity indicators of the right eye under the influence of training load of different directions showed the existence of a significant difference between them (Table 3). According to the average rank and the arithmetic mean value, the highest indicators of visual acuity were observed during the work of strength and coordination orientation, complex speed endurance and strength work on the muscles of the upper limbs; the lowest indicators - during complex work on speed endurance and speed-strength abilities, speed-strength abilities and coordination, strength work on the muscles of the lower extremities.

A significant difference between the indicators of visual acuity of the right eye was found when performing the work of the following direction:

– strength - with all other types of work, except for the complex for speed endurance and strength for the muscles of the upper extremities;

– speed-strength - with complex work on speed endurance and strength on the muscles of the upper limbs, endurance and coordination;

– coordination - with speed-strength, complex speed-strength and coordination, speed, power for the muscles of the lower extremities, complex for speed endurance and speed-strength, complex power for the muscles of the upper limbs and coordination, complex for endurance;

– speed - from complex for speed endurance and speed-strength, complex for speed endurance and coordination;

– complex for speed endurance and strength of the muscles of the upper limbs - with a complex speed-strength and coordination, speed, power for the muscles of the lower extremities, complex for speed endurance and speed-strength;

– complex for endurance and coordination - with a complex speed-strength and coordination, speed, power for the muscles of the lower extremities, a complex for speed endurance and speed-strength.

Analysis of visual acuity indicators of the left eye under the influence of training load of different directions showed the existence of a significant difference between them (Table 3). According to the average rank and the arithmetic mean, the highest indicators of visual acuity were observed during the work of a strength orientation, complex for endurance and coordination, endurance and flexibility, speed endurance and speed-strength abilities; the lowest indicators in complex work on speed-strength abilities and coordination, power work on the muscles of the upper limbs and coordination. Analysis of the relationship between the average ranks of the right and left eyes according to the Spearman rank coefficient showed that there is a positive relationship of medium strength between them (r=0,48). This fact indicates the presence of a general tendency to respond to the load of different directions with the right and left eyes.

Discussion

In the scientific and scientific-methodical literature, there is evidence that physical activity has a positive effect on the physiological parameters of the eye. Most of the studies have

Table 3. Comparison of indicators of visual acuity under the influence of a training load of different directions according to the Kruskal-Wallis criterion (H)

Nature of work	Right eye			Left eye		
	N	Average ranks	Arithmetic mean	N	Average ranks	Arithmetic mean
Coordination	3	53,83	0,078	3	26,00	0,068
Strength	3	57,67	0,081	3	51,83	0,072
Speed-strength	12	22,42	0,067	12	24,00	0,068
Speed endurance, strength on the muscles of the upper extremities	3	51,17	0,077	3	28,50	0,068
Endurance, coordination	9	40,44	0,073	9	37,50	0,070
Speed-strength, coordination	3	14,50	0,065	3	7,50	0,063
High-speed	9	26,83	0,068	9	34,50	0,069
Strength on the muscles of the lower limbs	6	15,67	0,065	6	24,00	0,068
Speed endurance, speed-strength	3	6,83	0,062	3	37,50	0,070
Speed endurance, coordination	3	43,33	0,073	3	44,67	0,071
Hand strength, coordination	3	26,83	0,068	3	16,50	0,065
Endurance, flexibility	3	33,00	0,070	3	37,50	0,070
Kruskal-Wallis test (right eye): H (N= 60) =39,09 p =0,0001						
Kruskal-Wallis test (left eye): H (N= 60) =27,78 p =0,003						

been conducted with athletes without visual impairments and usually studies have been devoted to the study of the effect of exercise on the intraocular pressure of athletes. Unlike previous scientific studies, we analyzed the indicators of visual acuity of a highly qualified athlete with visual impairments.

As a result of the study, the exiting opinion was confirmed that the basis of the training of visually impaired sprinters is the use of various exercises of a speed, speed-power and strength nature.

In the course of the study, the information of Alekseev, Suhr Thukjaer, Lundberg and Grauclund on the effect of small loads on the state of the visual analyzer was supplemented and expanded. But, unlike the above authors, we studied the influence of loads of various magnitudes and directions. We found that with an increase in the load, visual acuity indicators decrease.

In the course of the study, results were obtained that contradict the opinion of Arutunova A.V. and Kiseleva T.M. In contrast to the studies of the above-mentioned authors, in our study, all the loads that were used during training were performed with an arterial pulse not higher than 174 beats / min (on the recommendation of an ophthalmologist). We found that loads performed with an arterial pulse up to 175 beats/min can also lead to a decrease in visual acuity. This can be explained primarily by the congenital pathology of the studied athlete and the level of adaptation to physical activity.

According to the results of a study of a highly qualified female athlete with visual impairments, the relationship between visual acuity indicators and loads of different directions was revealed. The load of strength, complex endurance, coordination and flexibility of orientation contributed to the increase in visual acuity. At the same time, loads aimed at speed endurance and speed-strength abilities led to a decrease in visual acuity.

Conclusions

1. Physical activity is considered as a means of preventing and improving the condition of the visual analyzer. However, no information on the influence of loads of different magnitudes and directions on the functional state of the visual analyzer of highly qualified Paralympic athletes has been found in modern literature.

2. The results of the study indicate that there are significant differences between the indicators of visual acuity of the right eye and the magnitude of the load ($p<0.05$). It was found that with an increase in the load, the visual acuity of the right eye decreases. At the same time, no significant differences were found between the visual acuity indices of the left eye under loads of different magnitudes ($p>0.05$). That is, it can be argued that large loads adversely affect the functional state of the visual analyzer.

3. The general tendency of the response of both eyes to the load of different directions was established. So, loads on strength, coordination, endurance and flexibility have a positive effect on visual acuity. Loads of a speed-strength nature and speed endurance lead to a decrease in visual acuity and negatively affect the functional state of the visual analyzer.

4. The results of the study will allow planning the amount, magnitudes and directions of loads in the training process of visually impaired sprinters. In our opinion, this can lead to further prevention descrease in visual acuity of para-athletes.

Author Contributions

Leilia Adzhametova: collection, data entry, data analysis, manuscript preparation, statistics.

Liudmyla Shesterova: design, data interpretation, research planning.

Conflicts of Interest

The authors declare no conflict of interest.

Funding

This article didn't receive financial support from the state, public or commercial organizations.

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