The visual acuity variability during physical efforts in low vision athletes from the athletics Brazilian team*

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ABSTRACT

Introduction and objective: This study had as an objective to evaluate the visual acuity behavior in athletes with low vision, during a continuous effort protocol. Researches point out that visual acuity presents performance varieties when submitted to physical efforts in subjects without visual impairment. **Method:** The studied population was composed by six peoples, who practiced athletics and were part of the Brazilian team in track events. The progressive physical effort test was applied on the first day in a treadmill. On the second day the continuous effort test was applied, which was divided in three levels, each one had a 15 and 30 minutes break between them. To determine the intensities, the results obtained in the progressive physical effort test (60% of VE peak, limiar VE and 90% VE peak) were used. The visual acuity was measured before, during and after each level of intensity in the continuous effort protocol. The *t* Student test was used for statistics analysis ($p < 0.05$). **Results:** The visual acuity presented a decrease in the three levels of effort in its performance. The variety between the initial static visual acuity measure results and the measurement of the same variable in the end of the running phase was 44.5% in the first level, 52.5% in the second and 60% in the third level. The results presented higher degradation of the visual component during the dynamic measurements. The recuperation phases, which succeeded the most intense levels of effort, had the results of the visual acuity, after the deficit found during the exercise. **Conclusion:** It can be inferred that in this specific population there is a decrease in the visual acuity during the effort. This fact implies on the necessity of the visual sportive classification being directed to evaluate the visual functionality of each athlete with low vision during the physical effort, since these varieties can occur during it.

Keywords: Athletics. Visual impairment and visual acuity.

INTRODUCTION

Motor actions occur through interactions and needs created in the relationship of the man with the environment. The information pick up must be suitably performed so that a movement is efficient.

Such condition is built from the environment's stimuli reception as well as a response elaboration in the face of the need. The data processing for these interactions with the environment formation is associated with the repertoire of experiences lived by an individual[1]. The main system of data pick up is the sight; moreover, it is dominant over other sensory capacities[2-3]. Nevertheless, each individual presents a contribution higher or lower than the other systems in the information pick up[1].

Athletes with low vision will have as main sensory characteristic the limitation of visual stimuli from the environment. Thus, their motor efficiency will be associated with better usage of their visual residue, associating it with the other sensory capacities. However, would a temporary alteration in the visual information occur, the response to this stimulus will be differentiated. During sports practice, more specifically in athletics, many athletes with low vision have reported decreased performance in their visual capacity, both in training and competitions[4].

Studies on visual capacity behavior during physical efforts have presented varied results. Visual acuity presents variation according to the intensity and characteristic of the effort; another influential factor is the behavior and kind of object to be visualized in the focusing. Research developed by Ishigaky *et al.*[5] has shown that visual acuity statically tested presented a significant decrease concerning the initial condition in the three continuous effort levels. However, there was no significant variation in refraction neither in the crystalline accommodation during exercise performed in ergometric bicycle. Watanabe[6] performed in his study tests with a focus object in static and dynamic conditions; the results presented a decrease in visual acuity in both cases, except for the mildest static effort in which there was improvement in visual acuity. Visual behavior showed lower variation in results of static tests compared with dynamic ones. The ergometer used for this test was a static ergometric bicycle and the focus object was in dynamic condition. Fleury *et al.*[6] evaluated visual acuity during the dislocation of volunteers on a treadmill in many effort regimens, the results presented decrease in visual acuity in all intensities. In investigations by Bard and Fleury[7], Hancock and McNaughton[8], Aravena *et al.*[9], Oliveira Filho and Almeida[4] the tests were performed with a static focus object and all measured variables presented decrease in final levels of visual acuity compared with the initial parameters, being the aerobic component present in all of them.

Visual acuity is understood as the maximal distance in which an object can be observed and visually defined over the influence of the different refractions and techniques applied in the test[10]. Visual acuity may present two components in its analysis, namely: static or dynamic[6,11]. The former is the capacity to discriminate static objects and the latter refers to the condition to visually define, with precision, moving objects[6].

The process of visually focus a given object is controlled by the effects caused in the accommodation of the crystalline and the pupillary diameter[6,12-13]. The first process is characterized by the crystalline shape, the shape alteration occurs by action of the ciliary muscle, the muscular contraction leads to the crystalline flattening, which allows to more precisely see more distant structures[12-13]. The accommodation has more effective action in objects with distance up to 40 centimeters[6]. The ratio between pupillary diameter and focusing lies on the amount of light which enters the ocular globe[6,12-13]. The more light, the lower the capacity to focus; thus, the pupil's constriction will be an agent for visual acuity. This

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movement is regulated by the sphincter muscle of the iris. Both muscles are stimulated by the parasympathetic autonomous system[12-13].

Sportive practice of individuals with visual impairment has as characteristic the classification of the athletes according to their visual capacity presented in distinct levels. This sports classification is divided in three groups: in B-1 class (B = blind) we have the subjects who present blindness, receiving or not light, but not being able to distinguish the shape of a hand placed in front of their eyes; in B-2 class we have the subjects with low vision who present visual mean of up to 5 degrees and/or visual acuity of up to 2/60 meters; in B-3 class the subject with low vision should present visual mean with boundaries between 5 and 20 degree and/or visual acuity ranging from 2/60 to 6/60 meters. These measurements are done in both eyes, but the result considered will be that one from the eye with better vision, after surgical correction and/or use of corrective lens. This process follows the principles used in the ophthalmologic clinic evaluations[14].

The International Para Olympic Committee (IPC) has tried to improve its classification system. This condition allows the athlete during the evaluation to have a similar condition of movements to which he/she will find at the competitive moment and therefore, to have the efficiency of his/her performance effectively analyzed[15]. The functional sportive classification parameters have improved from medical standards to a movement's analysis perspective, where the clinic standards are used as support for evaluation. In the disability field which presents Para Olympic modalities, this process has settled; however, concerning visual disability, the classification does not use mechanisms for analyzing the functionality of visual capacity during competitions, being based only and exclusively in medical parameters.

This study had the aim to identify the behavior of the visual acuity in athletes with low vision as well as its possible implications in the practice of athletics (training procedures and sportive classification).

METHODS

Sample

The study was developed with a group of 6 athletes with low vision (n = 6), athletics and tracks and field practitioners, of both genders who presented the B-2 sportive classification. Age range was 19-35 years. All of them were Brazilian champions in their specialties and members of the Brazilian team at the time of the evaluation. The research was approved by the Ethics Committee of the State University of Campinas (CEP/UNICAMP 26/2001) and all subjects voluntarily participated in the tests, having all knowledge on their procedures and aims.

Delimitation of the number of subjects in the research – Research conducted with subjects with visual disability present as characteristic a limited number of evaluees due to the population's characteristics[16]. The choice of the specific public to this research implied in greater populational restriction, since besides the issue of the number of visually impaired subjects being reduced, there was also as limitation the number of athletes wit low vision practitioners of high performance athletics.

Evaluation instruments

Each subject was tested on two consecutive days. On the first day, the clinical and the progressive effort ergometric tests were performed in order to obtain the ventilatory peak. On the second, a test with continuous workload protocol in which visual acuity was measured was applied. The results of the first test were used to establish the intensity of the second test so that the visual acuity responses in the different effort levels proposed by the research could be obtained[5-7].

Room temperature presented a variation of 22 to 24 degrees Celsius during the tests.

The cardiorespiratory functions as well as the visual characteristics were evaluated in the clinical tests. Both tests were performed by residents of the Ophthalmology Department of the Medical Sciences College of the Stat University of Campinas – UNICAMP.

Materials – The used materials were namely: *Treadmill Controller Model* 640 Series 90, gas analyzer MMC Horizon™ Systems by SensorMedics, a chart containing the optometric scale by Snellen. Elastic bands were used in order to enable spatial delimitations on the treadmill, with the purpose to better guide the volunteers during the run.

The tests had the following outlining:

Progressive Effort Ergometric Test **–** The adopted protocol in the test[17] was developed using the following outlining[1]: initial velocity of 6 $km.h^{-1}$ and increment of 2 $km.h^{-1}$ at every 2 minutes with steady inclination of 2%, until athlete's physical exhaustion. The recovery, after the end of the test, was of 1 minute with treadmill at 6 $km.h^{-1}$ velocity and 0% of inclination. During the run performance, the ventilatory peak was measured (V_{peak}) as well as the heart rate variables. The result of the V_{peak} allowed that the ventilatory threshold could be measured, as well as the 60 and 90% percentages of the effort intensity of this variable.

The application of two effort tests was crucial for measuring the effects of the continuous workloads with intensity controlled over visual acuity. The results of the applied test on the first day showed the intensity of the continuous work performed in the tests of the second day.

Continuous Effort Ergometric Test – This test was divided in three levels of continuous efforts, with duration of 15 minutes each and specific intensities in each one. The characterization of the workloads was of 60% of the V_{peak} on the first level; the ventilatory threshold was used for the second and the third ones had intensity of 90% of the V_{peak}. On the first minute of each level, a warm-up period at 8 $km.h^{-1}$ was adopted, using constant inclination of 2%. There was a recovery phase of 30 minutes between each intensity level. Had the athlete reached voluntary physical exhaustion, the test would be stopped. The visual acuity measurement occurred during the application of this protocol.

Visual Acuity Evaluation – The optometric scale by Snellen was used for the visual acuity evaluation. The evaluees had an adaptation period for the procedure, in which they would have to show the direction of the optometers opening with their hands, since during the test they could not speak, due to the use of a mouth adapter or gases pick up. Such procedure had the purpose to improve the adaptation process derived from learning, since the results could suffer influence due to the non-incorporated situations[18]. The volunteers had their visual capacity evaluated in the site of the physical test. The results have been represented in decimal values from the scale by Snellen[10].

The visual acuity measurement occurred during the continuous effort protocol, which was divided in 5 stages, namely:

Static Visual Test (SVT) – The first stage was performed on ergometric treadmill, with the subject being already connected to the gas analyzer. Prior to the run, visual tests were performed in order to establish the distance for visual acuity measurement, which was standardized when the subject was able to identify at least 4 different sizes of the pictures on the chart. The results of the distance and reached value on the scale by Snellen were used for the calculation of the initial value of the visual evaluation.

Dynamic Pre-Effort Visual Test (DPE) – During the warm-up phase in the beginning of each stage, measurement of the dynamic visu-

[1] There was a time adjustment of each test stage. The protocol originally presented duration of 3 minutes and has been modified for 2 minutes, considering that the pilot tests presented a much longer duration.

al acuity was performed with the subject in dislocation on the treadmill and the chart with the optometers static. The distance used between the subject and the chart in the movement phases was the same from the static pre-effort test.

Visual Tests During Effort – Two visual tests were performed with the athlete in movement. The adopted times were 7 minutes and 30 seconds (DM), being this the mean effort time, and at 14 minutes and 30 seconds (PoED), the final phase of movement. During the third effort level, intermediate evaluations were performed, depending on the level of fatigue presented by the subject.

Visual Tests at the End of the Effort (PoEE) – at the end of the effort a visual acuity test was applied with the athlete still, respecting the characteristics of the initial test (DPE).

Post-Effort Visual Tests – After each run stage, static visual acuity tests were performed in order to measure the visual capacity variation during recovery. The evaluations were performed at every minute during the first 15 minutes and after this period; the measurement was performed at every five minutes until minute 30.

Statistic Analysis **–** The t-student test was used as instrument for analysis between variables of visual acuity. The relationship of the visual acuity behavior in the different dislocation velocities was analyzed by the Linear Correlation by Pearson. In addition, the arithmetic mean, median and standard deviation were also calculated. The software S-Plus 2000 by Mathsoft, Inc was used for the statistical analyses.

RESULTS

The dislocation mean velocity of the subjects at the moment in which the run was at the half of its total time was equal or higher than the one obtained at the final moment of the test. The dynamic visual acuity presented positive correlations with values between 0.62 and 0.70 in the two first effort levels concerning the dislocation velocity. The highest correlation values occurred in the final measurement of the dynamic phase. On the third level, the correlation result on the half of the dislocation period was of 0.66; the value found in the dislocation final measurement (PoED) was of 0.81.

The analysis of the found values in the three effort levels showed significant statistic difference ($p < 0.05$) among them. In the relationship within each effort level, the results also presented significant statistic difference among variables.

The results of the three initial measurements in which the subject was not in movement (PEE), in each effort level, presented values of 0.45 (1st level), 0.35 (2nd) and 0.40 (3rd).

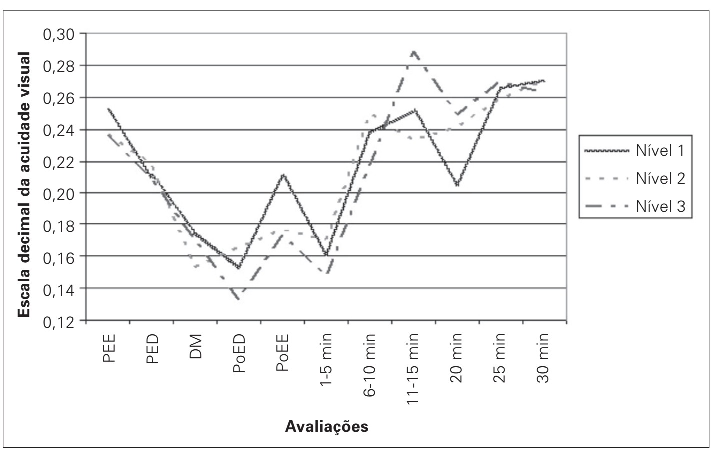

Figure 1 *– Visual acuity values during the three levels of intensity in the effort and recovery phases*

Note: Static Visual Test (EPE). Dynamic Pre-Effort Test (DPE), Visual Tests During effort (DM) and at the end of the effort phase (PoED), Visual Tests at the End of Effort (PoEE). The intervals between minutes 1-5, 6-10 and 11-15 were represented in mean values.

The variation between the initial static measurement (PEE) and the remaining variables presented the highest differences in the most intense effort levels. The visual acuity performance had the highest absolute and percentual degradation concerned with the most intense effort level. Dislocation velocity was related with the effort intensity in each level, among other factors.

In the three effort levels, the visual acuity measurement outcomes presented higher degradation during dynamic conditions. The variation between initial static acuity measurement results (PEE) and its measurement at the end of he run phase (PoED) was of 44.5% on the first level, 52.5% on the second and 60% on the third one. The differences found between the measurement values of the initial (PEE) and final static measurement (PoEE) presented, on the first effort level, a variation of 33.4%. On the second, the mean result was of 42.9% and on the third of 52.5%.

The statistic results showed that during recovery there was significant difference ($p < 0.05$) in the visual acuity values among the different effort levels. In the same effort level, there has been also statistic difference, except for the behavior of the following results of visual acuity: in the measurements occurred in the five first minutes and in the ones from the interval between the eleventh and fifteenth minute, both concerning the measurement in the thirtieth minute from the second effort level; and the values of the period between the eleventh and fifteenth minute also presented the same behavior concerning the thirtieth minute in the third effort level.

During recovery periods, the visual acuity behavior presented improvement in its performance compared with the values found during the effort phase and the initial values of the second and third effort levels. In the recovery of the third effort level, the visual acuity had its highest improvement index compared with the one during the effort phase.

The percentage variation of the visual acuity during recovery behaved inversely proportional to the behavior of this variable during effort. The visual acuity had the highest values of degradation from the highest effort intensities. On the recovery phase though, the highest increase values of this visual capacity were found in the posterior moments to the most intense effort levels. The visual acuity behavior during recovery presents an initial phase with fast improvement in the first 10 minutes. After this period, a decrease of the found values was observed, with an increase of visual acuity again only in the final phase of the recovery time.

TABLE 1
Anthropometric variables of the athletes with visual impairment

	Median	Mean	SD
Age (years)	24.5	26.4	± 6.0
Height (cm)	168.0	169.1	± 7.8
Weight (kg)	65.2	64.7	± 9.9
Fat mass (%)	12.7	11.7	± 6.1
Fat mass (kg)	8.8	9.0	± 2.1

% = percentage, kg = kilogram, cm = centimeter. SD = standard deviation.

TABLE 2
Heart rate variables, ventilatory threshold and dislocation velocity in the initial phase, in the threshold and in the end of the progressive effort test

	Median	Mean	SD
Initial HR (bpm)	62.5	63.3	± 6.7
HR at the ventilatory threshold	177	179	± 8.8
Ventilatory threshold (L/min)	78.0	79.3	± 20.5
Threshold velocity ($km.h^{-1}$)	12	12.3	± 1.5
HR peak (bpm)	198	196	± 31.5
PV peak (L/min)	111.5	109.6	± 31.5
Peak velocity ($km.h^{-1}$)	15	15.3	± 2.4

HR = heart rate, L/min = liters per minute, $km.h^{-1}$ = kilometers per hour. bpm = heart beats per standard minute.

TABLE 3
Monocular visual acuity, low vision cause and subjective behavior of the vision during effort

Subjects	Visual acuity		Medical visual classification	Low vision etiology	Visual behavior during effort*	Gender
	RE	LE				
1	Blur	20/800	Deep low vision	Toxoplasmosis and congenital cataract	Stable	Male
2	20/1440	20/1440	Almost blindness	Congenital toxoplasmosis	Stable	Male
3	20/680	20/680	Deep low vision	Retinitis pigmentosa and nystagmus	Worsening	Male
4	20/1620	20/1620	Almost blindness	Retinitis pigmentosa and nystagmus	Worsening	Female
5	20/3520	20/3520	Almost blindness	Atrophy of the optical nerve	Worsening	Male
6	20/720	20/720	Deep low vision	Congenital cataract, strabismus and nystagmus	Worsening	Female

RE = right eye, LE = left eye, Blur = luminosity and shapes perception without great precision, Visual acuity was expressed in the meter scale and * subjective report of visual behavior during effort.

TABLE 4
Dislocation velocity during the dynamic phases of the continuous effort test

Level	During effort (DPE)	During the final phase of effort (PoED)
1	10.5	9.5
2	10.75	10.75
3	15.65	14.35

Dislocation velocity expressed in km/h.

DISCUSSION

The results found in the ophthalmologic evaluation showed that within the B2 sportive class there is a wide variation of visual acuity, as well as of medical classification. The subjective reports of stability in the visual function during effort have occurred in subjects with the same etiologic condition of disability.

During the exercise in the three effort levels the results showed decrease in performance of visual acuity, which presented in the first and third effort levels, degradation concerned with the effort-time relationship during the movement. In these levels, the velocities have presented, in the final measurement, mean values lower than the ones used in the measurement during effort. In the 2nd level, the visual acuity behavior during measurement occurred in half of the run time (DM) presented greater degradation than the one found in the final measurement of the run phase (PoED). The velocity in this level was equal in the two measurements.

The study by Watanabe[6] showed that the dynamic visual acuity is influenced by the velocity of the focus object. The faster the object is, the smaller is the capacity to recognize its details. The dislocation velocity of the individual is a difficulty factor in the focusing process[11]. The outcomes found in the visual acuity of athletes with low vision showed that the dislocation velocity influences the vision degradation; however, its interference is associated with other factors such as effort intensity. The values of visual acuity and dislocation velocity in the 1st and 3rd effort levels showed that even with the decrease of velocity during the run phase, the degradation of the visual component remained growing.

The outcomes found in this study are similar to the notes of other experimental research[4-6], which presented decrease of visual acuity during exercise, in which the most remarkable decreases occurred in the highest effort intensities. The notes found on athletes with low vision corroborate the data by Watanabe[6] concerning the variation imposed by the dynamic condition of visual acuity, which increased the drop of visual capacity during effort.

The behavior of the visual acuity values measured during the recovery phases did not corroborate the ones found in similar studies[5-6]. Since they have pointed that this visual capacity behavior had a recovery rhythm proportional to the effort intensity, the more exhaustive the stimulus, the slower the recovery was. The results found during recovery were similar to the ones presented by Watanabe[6], since the values during recovery have reached scores higher than the initial ones, a different behavior from what was found in another investigation[5] in which the visual acuity did not return to a similar level to the initial one. The focus objects in other studies[5-6] were dynamic and the subject remained still, contrary to what happened in this research, where the subject was in dislocation and the focus object remained still.

The visual acuity is controlled by structures which have straight influence on the parasympathetic system[6,12-13] and the acetylcholine effects have short duration[19]. During physical exercises practice, the dominant system is the sympathetic, which is characterized by suppressing the parasympathetic and may be able to decrease even more the visual acuity efficiency during exercise. Since the visual acuity accuracy needs constant stimuli of acetylcholine in order to regulate the light entrance through the pupil and the refraction promoted by the crystalline curving, it has limited release during physical exercise practice. The method and instruments used in this research presented limitation in straight measurement of this metabolic influence and the behavior of the visual acuity during effort.

Another factor which influences the decrease in lower extent in visual acuity performance occurred during the second effort level. Compared with the first one, it may be the better adjustment of the visual capacity to collect that kind of information[18].

Even with the limited number of athletes who participated in our research, the profile of the found results has shown the need that the sportive classification for athletes with visual disability occurs more functionally. Since the effort and movement variables are factors which greatly influence the reception of visual information, such needs should be considered during the current evaluation process.

One can also conclude that the pedagogical process in sports should consider that the information transmitted to the athletes during the effort and recovery should be adjusted to the deficit on their reception and therefore, make use of more relevant visual devices, such as structures with better contrast or bigger references, associating them to verbal or kinesthetic information.

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