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Experimental study of visual training effects in shooting initiation

Lluïsa Quevedo*† OD
Joan Solé** PhD
Joan Palmi** PhD
Antoni Planas**
Carlos Saona* OD
* Department of Optics and Optometry, Polytechnical University of Catalonia
† Sports Vision Center at the CAR (Olympic Training Center) of Sant Cugat (Spain)
** National Institute of Physical Education (INEFC Lleida)

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Introduction: The present study was conducted to investigate the influence of specific visual training in shooting initiation performance.
Methods: Seventy-one first-year university students were divided randomly into two groups. The experimental group followed a nine-session shooting training program that included technical, physical and psychological components, along with specific visual exercises. The control group followed the same program with one difference: this group received theoretical lectures on psychological training techniques instead of doing visual exercises. Pre- and post-test results were obtained for shooting, concentration, saccades and visual acuity.
Results: Statistical analysis indicated significant gains in the four mentioned variables for the experimental group. The control group also showed significant differences in the three first variables but no significant improvement in visual acuity. No significant differences in shooting performance were observed between groups.
Conclusions: The effect of vision training on sports initiation performance is still not clear. It cannot be assumed that the improvement is transferable to the performance of precision shooting at the stage of sports initiation.
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Key Words: pistol shooting, sporting initiation, sports vision, visual training

Vision is the process of reacting to what we see, and thus, an essential part of most human activities, including sports.[1]

The discipline of sports vision is a relatively young and growing area of optometry that studies the importance and repercussion of the visual system during one's athletic performance. Based on the current literature,[2-5] sports vision is conceived by the authors as a group of techniques directed to preserve and improve the visual function, with the goal of incrementing sports performance through a process that involves teaching the visual behaviour required in the practice of different sporting activities.

There is little evidence to demonstrate that a visual training program will achieve an improvement in the visual skills of athletes. Although there have been some reports of enhanced visual abilities following visual training[6-9] and optometric procedures have been shown to improve athletic performance when functional visual problems have been eliminated and refractive errors corrected,[10] it has been demonstrated in few cases that the enhanced visual skills can be transferred to producing a better performance in sports.[11,12] Assuming visual ability is normal, numerous factors still affect the ultimate performance of an athlete at any particular time. These include the technical-tactical level as well as physical and psychological abilities. Thus, there is great difficulty in assigning a cause directly to the effect produced by vision training and sports vision care.[13]

With regard to the research related to the sportive modality analysed in the present study, precision shooting, the primary scientific references are the studies of Howard[14] and Gregg.[15] Both researchers emphasise the importance of visual ability in shooting and describe some rules

for refraction. Hamilton[16] designed and applied a visual training program based on audiovisual games and found significant improvements in performance. Dwyer and Coletta[17] established the importance of accommodative function in pistol shooting. Carkeet and colleagues[18] investigated the effect of plus lenses on the performance of nine experienced shooters. Their results showed that lower plus lenses (+0.50 D, +0.75 D) produced the best performance. Long and Haywood[19] established the visual profile of archers. They reported high values of static visual acuity at distance and at near.

More recently, De Teresa[20] used auditory bio-feedback to train experienced shooters. She found significant improvements in visual acuity and accommodative facility, which led to improved shooting performance. Quevedo and Solé[21] conducted a three-month visual training program on 11 elite shooters, members of the Catalan Government Special Intervention Squad. Statistical analysis indicated significant gains in visual function and pistol shooting scores after the program, while the psychological and physical conditions remained the same. The results led the authors to consider a possible causal relationship between visual skills improvement and gains in shooting scores, which demonstrated transference into performance.

With reference to the other area of knowledge of this study, sports, it is observed that nowadays athletic performance is assumed to be the result of the combination and integration of technical, tactical, physical, psychological and visual elements. The authors believe that the visual aspect is critical when designing the global training programs and specifically the visual training program.

Furthermore, in the process of athletic training, there are three different levels of sportive preparation: initiation (novices), specialisation (intermediate) and high performance (elite).[22] These stages correspond to the phases of training of an athlete throughout his or her sporting career. The first, initiation, is the beginning of a systematic process of a sport modality.[23] At this stage the bases needed to develop the sports performance are established and the main objectives can be summarised as the basic learning of specific techniques and the general development of physical condition. Later, at the specialisation stage, a progressive and systematic increment of the training is observed. At the end of the training process, when the athlete achieves his or her peak personal performance, the goal will be to maintain it as long as possible.

As specialists in vision and sports, the authors are mainly concerned with finding the level of performance (initiation, specialisation or high performance) at which it is optimal to follow a visual training program in order to develop visual skills related to sports. There are few experimental studies that can offer guidelines or conclusions and most of the literature reviewed is focused on the high performance and the specialisation areas.[12,20,24] In our opinion, visual training in sports would mainly be a high performance or even a sports specialisation tool. At initiation level the sports vision contribution would be devoted primarily to providing ocular protection, optimal refractive correction and general visual training to eliminate visual functional deficits. At the first stages it may be more beneficial to provide the young athlete with the means to improve his or her technical performance qualities. This is not to say that vision is not important but its role may be greater for its implication in learning than in performance.

In order to answer this last question, the main goal of a previous study[21] by the authors was to assess the sole influence of specific visual training in the area of high performance in sport. Here, our efforts were directed towards visual training in a sample of 71 students, who had never had previous contact with precision shooting, which means that they were at the initiation stage.

Thus, the purpose of this investigation is focused on two clearly differentiated but strongly related aspects:

1. To discover the influence of a specific visual training program on sports performance during sports initiation, by comparing the application of two training programs, with and without visual training exercises.
2. To design a specific visual training method that could be included and adapted to the modern methodologies of sports training.

METHODS

Experimental design

A pre-test/post-test inter-group design with two experimental conditions was followed. This consisted of a shooting training program with specific visual training exercises and a shooting training program without visual training exercises.

The following variables were studied:

1. the independent variable, with two types of training (two categories with and without visual training)
2. the dependent variable, with precision shooting performance, monocular visual acuity and distance-near saccadic monocular fixations.

Subjects

Ninety first-year university students enrolled in INEF (Institute of Physical Education) Lleida. Nineteen of them dropped out. The sample was randomly divided into two groups: group A, which followed a training program with specific visual exercises; and group B, which followed a training program without visual exercises.

Sampling

In the selection of subjects, three characteristics were taken into account

1. they had never belonged to a shooting federation or club
2. they presented neither strabismus nor amblyopia in the shooting eye
3. that on the pre-test shooting exercise, they scored between 1.75 and 8.25.

Materials

Fifteen guns (compressed air) GAMO, standard issue bull's-eye, GAMO pellets, 12 SALTER wristbands, retro-illuminated Snellen Visual Acuity Optotype INOPSA, Hart charts (both distances) and holders, flippers and occluders, minus lenses, Marsden balls, flashlights

and Harris and Harris charts.

A laboratory of motor behaviour at the INEFC at Lleida and a shooting gallery of INEFC Lleida were used.

PROCEDURES

Data on the following tests were collected.
1. The shooting eye was identified by making the subject adopt the aiming position.
2. Static visual acuity of the shooting eye at five metres was measured on a retro-illuminated Snellen Chart. Visual acuity was recorded as the line in which the subject could read more than half of the letters.
3. Distance-near saccadic monocular fixations/accommodative facility were measured by using two Hart Charts, both for distance and for near. The subjects were asked to read alternately one letter at near and one at distance. Omissions and mistakes were penalised by subtracting one point from the final score.
4. Control of concentration was evaluated by using the Harris and Harris procedure,[25] which involves visual searching of series of numbers for one minute.
5. Controls were the mean shooting scores on 20 shoots, with the bull's-eye at five metres. The subjects were asked to shoot 10 times one day and 10 times the next week. The general standard guidelines for precision shooting were followed.

Pre-test data were taken while subjects wore their habitual optical neutralisation. The general lighting was 60 lux.

For the post-test evaluation of visual, psychological and technical abilities, the pre-test protocol was repeated.

Development of the program

Both groups attended the same number of training sessions on the same days but at different randomly selected times (group A: 1600 hours to 1700 hours and group B: 1700 hours to 1800 hours).

Group A (experimental group) followed a precision shooting training program composed of technical, physical, psychological and visual exercises.

Group B (control group) followed the same program, with the exception that they received theoretical lectures on psychological training techniques instead of visual training exercises.

The shooting training program comprised nine weekly 50-minute sessions.

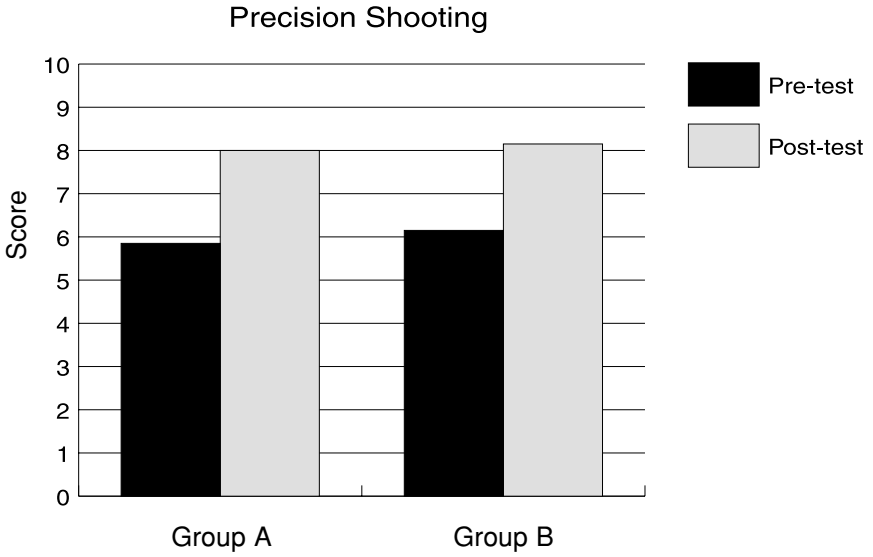

Figure 1. Pre- and post-intervention comparisons

SUMMARY OF THE TRAINING PROGRAM

Visual skills (shooting eye)
- visual acuity: light stimulation[26]
- distance-intermediate-near saccades: Hart charts protocol
- accommodative facility: flipper bar

Shooting technique
- body position
- holding the gun
- aiming
- breathing

Physical capabilities
- muscle endurance of the shooting arm

Psychological skills
- activation control: Jacobson relaxation technique[25]
- concentration: centring technique[27]
- visualisation: Palmi's technique[28]

RESULTS

The pre- and post-test data were statistically analysed using SPSSWIN 5.0.1. The statistical techniques used to verify the hypothesis formulated in this study are shown below. The significance level used on the different statistical tests was $p \leq 0.05$.
1. Descriptive statistics (means, standard deviation and absolute improvement) for precision shooting, visual acuity, saccades and concentration were analysed pre- and post-test, and are presented in Figure 1 and Tables 1, 2, 3 and 4. With reference to the shooting variable, we also analysed the absolute improvement.
2. To verify the efficiency of the two training programs, student t-test for related samples is also featured in Tables 1, 2, 3 and 4.
3. ANOVA one-way of pre- and post-test data was carried out on the variables, precision shooting, visual acuity and saccades. This test yielded non-significant differences for the pre- and post-test on the analysed variables (pre-shooting $p = 0.242$, post-shooting $p = 0.425$, pre-visual acuity $p = 0.851$,

Group	Pre		Post		Absolute improvement	t
A	X	SD	X	SD	X	
n = 37	5.81	1.7	7.96	1.1	2.15	0.000*
B	X	SD	X	SD	X	
n = 34	6.25	1.2	8.1	0.8	1.85	0.000*

* significant at the 0.05 level

Table 1. Precision shooting: pre-and post-intervention comparisons

Group	Pre		Post		Absolute improvement	t
A	X	SD	X	SD	X	
n = 37	0.900	0.14	0.946	0.10	0.046	0.011*
B	X	SD	X	SD	X	
n = 34	0.905	0.12	0.926	0.15	0.021	0.228

* significant at the 0.05 level

Table 2. Visual acuity: pre-and post-intervention comparisons

Group	Pre		Post		Absolute improvement	t
A	X	SD	X	SD	X	
n = 37	33.02	9.2	39.08	6.7	6.06	0.000*
B	X	SD	X	SD	X	
n = 34	35.17	5.8	39.79	5.6	4.62	0.000*

* significant at the 0.05 level

Table 3. Saccades: pre-and post-intervention comparisons

Group	Pre		Post		Absolute improvement	t
A	X	SD	X	SD	X	
n = 37	5.40	2.2	9.08	3.2	3.66	0.000*
B	X	SD	X	SD	X	
n = 34	6.52	2.4	9.4	2.5	2.88	0.000*

* significant at the 0.05 level

Table 4. Concentration: pre-and post-intervention comparisons

post-visual acuity p = 0.525, pre-saccades p = 0.249 and post-saccades p = 0.632).

DISCUSSION AND CONCLUSIONS

Precision shooting training program

Data analysed using the t-test showed statistically significant gains in precision shooting in both the experimental and the control group. These increments were expected as the subjects did not have any shooting experience. By analysing the absolute improvement, we can observe a larger increment on shooting scores in the experimental group. The usefulness of visual training in precision shooting has been repeatedly proved in previous studies such as De Teresa, [20] Hamilton[16] or Quevedo and Solé.[21] However, the post-test ANOVA results showed no statistically significant differences in the shooting improvement of both groups. Thus, from a statistical perspective, the two treatments (precision shooting training with and without specific visual exercises) were equally efficient at the level of sports initiation. These results led the authors to consider that at the stage of sports initiation, specific visual training is not as critical as it can be at the elite or even at the specialisation level. According to Wood and Abernethy,[29] at the sports initiation level the enhancement of visual skills related to sports is not critical to sports performance. However, it is assumed that vision develops a more important role in the learning of the sports technique by allowing faster and more accurate image formation.

Visual variables

With reference to the relationship between visual training and visual skills improvement, the descriptive statistics show a bigger increment in visual acuity and saccades for the experimental group. Also, regarding the standard deviation, it can be observed that visual exercises led to a unification of the values. Furthermore, the student t-test demonstrates that the experimental group has significantly improved visual acuity and distance-near

saccadic fixations. These results are consistent with the conclusions of Cohen[30] after his literature review. However, the same statistical test shows no significant improvement on visual acuity for the control group.

With reference to saccades of the aiming eye, it was observed that they have also improved significantly on the control group. These results could, in the authors' opinion, indicate that distance-near saccades are inherently developed while shooting, and they would also corroborate the reports of Ripoll and Azemar,[31] which emphasise the importance of saccades in precision shooting. The results might also confirm that, depending on the characteristics of the sporting modalities, a 'specialisation' of the visual system is possible. This hypothesis was also maintained by De Teresa.[20]

By comparing the post-test results (ANOVA) of every visual variable, statistical differences between the control and the experimental group were not observed. These results are not consistent with those obtained by De Teresa[20] or Quevedo and Solé,[21] who reported significant differences due to visual training. The authors believe that the visual improvement is not as significant as one could have expected because the length of training was too short, the frequency too low (weekly) and the number of subjects too large to be trained at the same time. Even though all of these facts had previously been considered, the contextual limitations unfortunately prevented modification in any direction.

Psychological variables

The results showed statistically significant gains in the psychological ability for concentration in both groups. In agreement with the contributions of many researchers,[32,33] the authors recognise that concentration is possibly one of the most important psychological abilities for precision shooting performance. As with the saccades, the intrinsic value of concentration is assumed in precision shooting.

After analysing the results obtained, the authors conclude that:

1. Even though the specific visual training of visual acuity and saccadic fixations led to a significant improvement of these abilities, it cannot be assumed that this improvement is transferable to the performance of precision shooting at the stage of sports initiation.
2. Distance-near saccades and concentration seem to be inherently developed while practising precision shooting. The result might also confirm that, depending on the characteristics of the sporting modalities a 'specialisation' of the visual system may be possible.
3. As it is difficult and unwise to generalise from shooting performance to other sports modalities, the effect of vision training on sports initiation performance is still not clear. A greater number of well constructed and controlled studies is required to prove a causal relationship between training and athletic performance at the initiation stage.

Future investigation

We wish to stress the need for further research with the application of a similar study to children aged between 10 and 13 years, ages at which sports initiation generally starts. Similarly, it is necessary to determine the role of vision training in different sporting modalities, using appropriate experimental design and guidelines.

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Author's address:
Professor Lluïsa Quevedo i Junyent
Department of Optics and Optometry
Polytechnical University of Catalonia
Violinista Vellsolá, 37
Terrassa 08299
Barcelona
SPAIN