Academy of Romanian Scientists
Annals Series on Biological Sciences

Volume 14, No. 2, 2025, pp.224-233
Online ISSN 2285 – 4177
REVIEW

OPTIMIZATION OF VISUAL ABILITIES AND PREVENTION OF OCULAR INJURIES AS CONDITIONS FOR HIGH PERFORMANCE IN SPORTS: A REVIEW

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Abstract. *The paper points out on some ocular physiology aspects capable of providing a sportsman the safest means for reaching the highest practice level, with the lowest injury rate. The authors briefly reviewed essential elements of ophthalmology survey in sports, revealing the importance of this concept in improving the visual abilities of sportsmen, thus improving performance and safety. Every sport involves specific characters of visual information. Visual training, similar to physical training, helps high level sportsmen to optimize the ensemble of all their visual sensations. A better knowledge and understanding of each sport's specific visual requirements may provide a better injury control, better health state of sportsmen, thus providing better sports performances and longer lasting abilities in practicing sports.*

Keywords*:* vision, performance, sports-related eye injuries, prevention, safety.

DOI 10.56082/annalsarscibio.2025.2.224

1. Introduction

Considering the eternal struggle of humans for better physical performances and the worldwide researches looking for better training methods, the article briefly reviews the most valuable visual function parameters which condition high performance in sports, considering that the best development and correction of these parameters is an important way to prevent sports-related injuries and to improve sportsmen safety [1]. Knowledge regarding the role of vision in sports injury prevention and sports performance improvement might bridge the gap between eye care and sports medicine health providers, educators and sport managers, providing keys to more effective vision correction and injury control methods in sport, for the best interest of all sports practitioners.

2. Material and Methods

During the last years a new concept has been rising: the absolute necessity of ophthalmology survey in sports, including prevention and correction of eye pathology in sportsmen. Its aim is to improve the visual ability of the sportsman, after having corrected, if necessary, all the deficiencies of visual system and its functions. Certain components and parameters of the visual system and visual function have a most important impact during sports practice, thus influencing the level of performance, the rate of sports-related injuries and of course the longevity of "survival" for sportsmen in high performance sports [2, 3].

All sports involve certain specific characters of visual information, which require specific correction methods [4-7].

Thus, sensorial training, similar to physical training, has to allow to high level sportsmen to optimize the ensemble of all their visual sensations [8].

Such training regarding morphology, color, light and space recognition improves gestures, processes, reflexes, and consequently improves sports safety and performances.

3. Discussions

- The visual sensation appears to be a complex ensemble.
- The visual acuity has three components.
- The first one is the static or angular visual acuity, which allows appraising of the details of objects in the environment.
- Another type of visual acuity is the morphoscopical one, which refers to apparent dimensions.

- The last component is the linear visual acuity, which has to do with estimating limits.

There is a fixation reflex, which means to address the information received in a peripheral point of the visual field towards the center of vision. This is what we call the dynamic visual acuity. It requires an important movement of the eyes which is conditioned by the integrity of the extrinsic eye muscles, and also requires a perfect accommodation mechanism, which depends upon the intrinsic eye muscles integrity. Each muscular systems integrity is required, because of the high speed of the movement. The sports performed with balls and the tennis are the best examples for the value of a good dynamic visual acuity [9, 10].

Another parameter of the visual function is the contrast sensitivity, which is very important because the scenery scenes are sometimes analyzed simply by the sense of contrast, and less by the vision of details. For example, in golf playing the green is better perceived by its contrast than by its shape.

The color vision provides the recognition of the equipment's shades (ball sports, car racing, and referee) and also the evaluation of the environment. Under these circumstances we find useful to point out that 8% of male subjects have color vision deficiencies (dyschromatopsia) compared to only 0, 5% in women.

Binocular vision provides to the subjects the ability to locate themselves in the environment, to follow trajectory and to place themselves in some determined position, in order to catch a ball, for example [11]. The perfect sense of relief and of depth is based on a proper convergence of the eyes. Binocular vision is not equal among humans: 50% of them have a good vision of relief, 40% have a medium one and 10% have a low relief vision.

Speaking of light adaptation ability, the sports the most sensitive to lighting conditions are those sports in which the precision of gestures is fundamental, involving a few factors. These factors are: the precision of perception, the speed of perception, glare and the binocular vision.

Referring to the precision of the perception, the visual acuity varies with the lighting, being proportional with the luminance.

Thus, it is maximal when the luminance of the surrounding space of the sportsman is equal to the one of the backgrounds on which the object is projected and seen.

The notion of contrast is capital, because an object is only perceived by its contrast, either in lighting, either colored in comparison to the background.

Thus, for a target, in order to get a constant visual perception, it is necessary to increase its contrast if the luminance of the background decreases, or opposite way, to increase the luminance of the background if the contrast decreases.

The luminance of the background cannot be indefinitely increased, because it is limited by glare. For example: yellow tennis ball, green tennis court, green court walls.

Another factor with impact on the precision of gestures is the speed of perception, which varies upon the lighting level.

A third element which determine the precision of gestures is glare, which can occur either in natural conditions, as a consequence of a quick passage from shadow to light (in car racing, sports of air flight, with sequences of light-darkness), or it can occur accidentally, such as caused by flash photographers, projectors, sun.

Glare is stronger if the lighted area is larger, brighter, closer to the optic axis and if the background luminance is low.

The light adaptation ability involves also a fourth component, which is represented by binocular vision.

A low illumination environment disturbs fusion. The colour vision is variable in mesopic illumination and photopic illumination (in diving sports).

Myopia and presbyopia vary by 1 dioptre in mesopic light, generating the necessity for high level sportsmen to evaluate the value of nocturnal morphoscopic threshold of the resistance and sensitivity at glare.

Speaking of light adaptation, this is not the only type of visual adaptation that may influence the quality of sports practice. It is also a matter of brain adaptation, which involves a few steps, required for the cerebral interpretation of the surrounding images. These few steps are: fixation – 180 ms, accommodation – 1000 ms, convergence – 200 ms, retina-cortex transfer – 40 ms, identification – 650 – 1000 ms and motricity command – 200 – 1000 ms.

By consequence, the latency of any normal motricity act ordered by vision may be estimated at 1-2 seconds, causing the necessity of anticipating; thus, here comes individual training, which targets to improve the individual visual performance.

The physical activity generates various visual modifications.

There are factors which are characteristic for each sport, responsible for changing the visual function abilities, mostly with negative influences, increasing the injury risks.

Such factors are fatigue, acceleration, vibration. Thus, getting tired leads to a diminished morphoscopic and angular visual acuity, decreased accommodation and decreased visual field sensitivity. Binocular vision worsens, so that heterophoria increase, causing diplopic episodes.

If we consider accelerations, their effect on visual function has to do with intensity, duration, speed of appearance and direction of application of the acceleration.

For example, for an airplane pilot there is acceleration from seat towards head, which is responsible for the appearance of a veil, grey in the beginning and black afterwards, which changes vision and precedes the loss of conscience. And there also exists acceleration from head towards seat, rare, which causes retinal haemorrhages.

In Formula 1 racing there is also transverse acceleration, which causes the perception of a grey veil and a blurred vision. If we have in mind the vibrations, the mechanical ones cause decrease of visual acuity (foot racing, mechanical sports, cycling) and may be transmitted to the devices of optical correction.

There are also sound vibrations, which occur in mechanical sports, ball sports, shooting, and have a mild impact on vision; however, in exchange, these vibrations determine the decrease of space sensation and a slight alteration of colour vision especially in dyschromatopsia subjects. These influences point out on the necessity of hearing protection (earplugs, hearing helmet).

Other factors capable of changing the visual abilities during sports practice are related to the environment. We have in mind altitude, hypoxia and illumination level and type.

High altitude, starting from 5000 m, may cause aeroembolism, followed by reductions of visual field.

Hypoxia may occur by ventilation insufficiency (in long-distance racing) or by low atmosphere pressure (in mountain climbing, airplane flights, parachuting). The results in such situations with hypoxia are decreased visual acuity, disturbances of accommodation, binocular vision, colour vision, low illumination vision and glare.

Training for a good adaptation in high altitude reduces such phenomenon, reducing the injury risk.

In football, which is the most commonly practiced sport in many countries, the dimensions of the playground are about 100m/65m, which means that, even having a normal visual acuity, a player located on one side of the playground cannot perceive the details on the opposite side of it. However, in practice, the game actions are performed in a maximal area of 20-30 m; this is the reason why it is admitted that a visual acuity of 0,5 is enough for playing, except for the goal keeper, who has to see further, of course [12].

The depth of the playground, color vision (for recognizing the opponents and the teammates) must be as good as possible, the glare sensitivity has to be low (for night time matches); the visual field has to be perfect [13]. In cases of refraction errors, the only possible correction is represented by contact lenses, because the head game excludes wearing glasses and injuries pathology risk contraindicates refractive surgery. Monophthalmia and high myopia (ocular protrusion) also contraindicate football practicing.

The eye pathology caused by football playing has an average rate, occurring more often by shocks between players (head game or aggression) than by ball contact (because of its big dimensions). The most involved is the goal keeper.

In cases of refraction errors, the only possible correction is represented by contact lenses. A proper illumination of the stadiums may help preventing mistakes and injuries [14].

The rugby has a lot in common with football from the ophthalmologist's point of view: the same required visual qualities, the same correction options - contact lenses, same absolute contraindication of refractive surgery. A better peripheral vision can make differences among players in tackling. Such research reveals the increased value of certain components of visio-spatial intelligence in rugby, but also shows the reciprocal of this idea: the potential of the practice of such sports to improve the performance of specific visual parameters in population [15]. Instead, ocular morbidity is much higher, more often caused by blocking and tackling between players, with all kind of concussions, mainly involving the orbit [1]. For the forwards, the eye injuries caused by finger nails, with retinal concussions, are the most common. As prevention measures, wearing a helmet was much discussed, but little used; the finger nails must be cut short and wearing rings is forbidden. As a special mention, the ophthalmoscope examination of the fundus of the eye must be performed, by a properly trained ophthalmologist , with special attention on the periphery of the retina.

In handball, basketball and volley ball, the requirements concerning the visual function are alike. The high circulation speed of the ball alleged by these sports requires good visual information, good eye-hand coordination especially in basketball players, also associated with a good binocular vision, which are necessary for the correct estimation of the distance towards the hoop. Referring to the eye pathology associated with these sports, there are eye contusions caused by the ball and by rough contacts between players; thus, correction glasses and refractive surgery are forbidden. In volleyball, the risk of shocking contacts between players is reduced, usually only ball contacts are possible, so that all corrections are possible.

In American football, as a very violent sport, a very high number of injuries occurs, so that wearing a metal helmet is compulsory, protecting the entire face of the player.

Hockey playing also involves severe eye injuries, caused more frequently by players (80%) - shocks, aggression, than those injuries caused by putter or the puck (20%). Fortunately, in hockey on ice, players are very well protected by metal helmet and mask, but this is not the case for field hockey.

The only acceptable correction is provided by contact lenses.

Another type of sports includes those ones involving the use of rackets or other ball handling devices: tennis, table tennis, squash, badminton, golf, ice hockey and field hockey.

In all these sports, the visual information is fundamental and it is received at the departure of the ball (position of the opponent, departure of the kick); the anticipation ability differentiates the champion from the average player. The visual acuity has to be perfect, especially its dynamic component, the visual field also has to be perfect; the contrast sensitivity can be improved by the color of the ball (yellow, white or orange) on the background color (environment, color of players' equipment) [16].

Binocular vision has to be excellent in order to place the kicks according to the lines (detection of heterophorias is capital); thus, amblyopia and strabismus contraindicate practicing such sports at high level.

All corrections for refractive errors are possible, except for progressive and bifocal glasses; refractive surgery is also possible, but the risk of glare and of injury should be considered. Referring to eye pathology, the tennis ball, with a smaller diameter (65 mm) and an average speed of 70- 150 km/h, may hit the eye from upward, fracturing the margin of the orbit, or bounced from downward, causing severe concussions of the eye. The racket can also very frequently cause eye injuries. The proper illumination of the hall or court, good contrasts, the lack of noise and wearing a protective visor for glare may help preventing eye accidents [17].

Considering the ocular pathology caused by ball and racket sports, a special mention has to be done for squash, which causes four major types of injury: musculoskeletal injuries, eyes and head injuries, heat illness and heart injuries-even death [18]. Its practice, exclusively in a hall, with a restricted volume (10 x 7 m), involving two players, with a 40 mm diameter and 25 g weight ball, powered by a 60 cm racket, with a 200 km/h speed, make squash a highly dangerous sport for the eyes . These circumstances generate very often and very severe concussions, with laceration of the eye, caused by the ball, smaller than the

margin of the orbit, or by the racket, in a ratio of 2:1. Prevention includes previous eyes examination regarding the presence of good visual information and the respect of the classical, well-known contraindications, a good physical conditioning and training, compelling screening prior matches, and of course wearing special protection goggles, with flexible anti-shock frames, polycarbonate lenses and anti-fog treatment. Wearing special goggles also has a high potential in control of eye injuries for all racquetball sports players and lacrosse players [19, 20].

Speaking of illumination, it has already been discussed about central scotoma, with a variable duration, loss of colour vision and decreased vision of relief, all of them caused by glare.

Referring to prevention strategies, for indoor sports practice the illumination level, the temperature, the noise, the dust interferes with the visual perception. In order to reduce glare, the projectors must be placed outside the visual field of the players and of the spectators.

A special type of eye pathology is related to playing golf. This pathology is rare, but extremely severe. The common victim of the injury is the spectator, hit by a very small diameter (30 mm) and very tough ball, powered with 100 km/h speed, which induces severe concussions or lacerations of the eyeball. The golf club accidents between players are also frequent. The use of certified protective eyewear should become mandatory by law. Respecting strictly all the rules and etiquette of golf playing is another way to promote safety during practice of this sport [21].

All the previously mentioned aspects point out on the necessity of a rigorous ophthalmological examination. This has to be able to reveal deficiencies of visual apparatus and visual function, which might hinder certain people on practising certain sports, because of the higher injury risk potential. Another quality of a thorough eye examination would be to reveal higher individual parameters of vision, capable of leading to special performances of some sportsmen, in certain types of sports.

Such examination would include basic tests and newest available adequate biomarkers, for visual acuity, refraction errors of the eyes, near vision, but also some specific tests, depending upon the kind of practised sports, such as: binocular visual acuity at far and intermediary distance vision (for ball and combat sports), phorias and fusion tests, space vision test, kinetic visual acuity (for motoring, motorcycling, sky, biking), visual field [22].

The light perception is also very important; it is interesting to evaluate visual acuity in mesopic variable contrast, colour vision (for ball sports, car racing), duration of recovery after glare (in nocturnal sports and ball sports).

Conclusions

The ophthalmological check-up of sportsmen must be done periodically and on demand, after disease or accident, before resuming training or before competitions, as a mandatory safety condition.

A better knowledge and understanding of each sport's specific eye risks may provide a better health state of the sportsman, thus providing better sports performances and longer lasting abilities in practicing certain sports [23,24].

Prevention strategies, such as: proper illumination level, with glare avoidance, proper temperature of the environment, a silent and clean outdoor and indoor location for sports practice, have an important impact on visual function parameters of the sportsmen [25,26].

Thus, by keeping in mind all the previously discussed aspects, visual function can contribute in reaching higher performances under higher safety circumstances. Improvement of the visual function during sports practice might reduce the incidence of eye accidents in sportsmen, leading to better results and longer lasting performances, through more effective injury control policies.

R E F E R E N C E S

[1]. Kung, S.M., Suksreephaisan, T.K., Perry, B.G., Palmer, B.R., Page, R.A. The Effects of Anticipation and Visual and Sensory Performance on Concussion Risk in Sport: A Review. Sports Med-Open, **6**, 54 (2020). https://doi.org/10.1186/s40798-020-00283-6h.

[2]. Krzepota, J., Zwierko, T., Puchalska-Niedbał, L., Markiewicz, M., Florkiewicz, B., & Lubiński, W. The Efficiency of a Visual Skills Training Program on Visual Search Performance. Journal of human kinetics, **46**, 231 (2015). https://doi.org/10.1515/hukin-2015-0051.

[3]. Clark, J. F., Colosimo, A., Ellis, J. K., Mangine, R., Bixenmann, B., Hasselfeld, K., Graman, P., Elgendy, H., Myer, G., & Divine, J. Vision training methods for sports concussion mitigation and management. Journal of visualized experiments: JoVE, **99**, e52648 (2015). https://doi.org/10.3791/52648.

[4]. Bidaux, F, Bourgeois, H. Ceil et sports. Edition Techniques. Encycl. Med Chir. (Paris-France), Ophtalmologie. 1992; 27-710-A-10, 8.

[5]. Chevaleraud, J. L'ceil et le sport. Concours Med., **110**, 3773 (1988).

[6]. Convergence, J. Revue de liaisons avec les ophtalmologistes, 50 (1991).

[7]. Perdriel, G. L'ceil des sports. Encycl. Med Chir (Paris, France). Ophtalmologie. 21710 A10, **9**, 8 (1980).

[8]. Mîndrescu, V.; Popescu, V. The evaluation of sensorial perception dominated through training in sports performances. Annals of "Dunarea de Jos" University of Galati - Fascicle XV: Physical Education and Sport Management, **1**, 91(2017).

[9]. Fleddermann, M. T., Heppe, H., Zentgraf, K. Off-Court Generic Perceptual-Cognitive Training in Elite Volleyball Athletes: Task-Specific Effects and Levels of Transfer. Front. psychol., **10**, 1599 (2019). https://doi.org/10.3389/fpsyg.2019.01599.

[10]. Fleddermann, MT, Zentgraf, K. Tapping the Full Potential? Jumping Performance of Volleyball Athletes in Game-Like Situations. Front Psychol., **9**, 1375 (2018). https://doi.org/10.3389/fpsyg.2018.01375.

[11]. Barrett, B.T., Flavell, J.C., Bennett, S.J., Cruickshank, A.G., Mankowska, A., Harris, J.M., Buckley, J.G. Vision and Visual History in Elite/Near-Elite-Level Cricketers and Rugby-League Players. Sports medicine - open, **3**, 39 (2017). https://doi.org/10.1186/s40798-017-0106-ze.

[12]. Capão Filipe, J.A. Soccer (football) ocular injuries: An important eye health problem. Br J Ophthalmol., **88,** 159 (2004). PMCID: PMC1772023. PMID: 14736758.

[13]. Capão Filipe, J.A., Fernandes, V, Barros, H, Falcão-Reis, F, Castro-Correia, J. Soccer-related ocular injuries. Arch Ophthalmol, **121**, 687 (2003). https://doi.org/10.1001/archopht.121.5.687.

[14]. Harada, T, Hirano, K, Ishii, M., Ichikawa, H. Evaluation of 164 cases of ocular injuries caused by various sports. J Fr Ophtalmol, **8**, 455 (1985). PMID: 4078225.

[15]. King, D., Hume, P.A., Clark, T. Nature of Tackles That Result in Injury in Professional Rugby League. Research. Sports Medicine, **20**, 86 (2012). https://doi.org/10.1080/15438627.2012.660824.

[16]. Beby, F., Kodjikian, L., Roche, O., Donate, D., Traumatismes oculaires perforants de l'enfant. J. Francais d'Ophtalmologie, **29**, 20 (2006). https://doi.org/10.1016/S0181-5512(06)73742-1.

[17]. Quere, M.A., Pietrini P. Accents oculaires et squash. Bull Soc Ophtalmologie, **96**, 1499 (1986).

[18]. Clavisi, O., Finch, C. Striking out squash injuries-What is the evidence? Int J Consum Prod Saf, **6**, 145 (1999).

[19]. McLean, C.P., DiLillo, D., Bornstein, B.H., Bevins, R.A. Predictors of goggle use among racquetball players. Int J Inj Control Safe, **15**, 167 (2008). https://doi.org/10.1080/17457300802296380.

[20]. Otago, L., Adamcewicz, E., Eime, R., Maher, S. The epidemiology of head, face and eye injuries to female lacrosse players in Australia, Int. J. Inj. Control Safe. Promot., **14**, 259 (2007). https://doi.org/ 10.1080/17457300701602381.

[21]. Fradkin, A.J., Cameron. P.A., Gabbe, B.J. Opportunities for prevention of golfing injuries, Int. J. Inj. Control Safe. Promot., **13**, 46 (2006). https://doi.org/ 10.1080/17457300500167693.

[22]. Marinescu, M.C.; Dascalescu, D.M.C.; Stanila, D.; Jurja, S.; Constantin, M.-M.; Coviltir, V.; Alexandrescu, C.; Ciuluvica, R.C.; Burcel, M.G. Axial Length to Corneal Radius of Curvature Ratio (AL/CR) and Refractive Errors in a Single Center Romanian Population. Biomedicines, **13**, 2742 (2025). https://doi.org/10.3390/biomedicines13112742.

[23]. Goldstein, M.H., Wee, D. Sports injuries: an ounce of prevention and a pound of cure. Eye & Contact Lens. Sci Clin Prac. **37**, 160 (2011). https://doi.org/10.1097/ICL.0b013e31821790db.

[24]. Vinger, P.F. A practical guide for sports eye protection. Phys Sportsmed. **28**, 49 (2000).

[25]. Rodriguez, J.O., Lavina, A.M., Agarwal, A. Prevention and Treatment of Common Eye Injuries in Sports. Am Fam Physician, **67**, 1481 (2003). PMID: 12722848.

[26]. Micheli, L.J. Encyclopedia of Sports Medicine. SAGE Publications, **4**, 568 (2010).