

Environmental Vision (OPT 6051)  
Sports and Driving Vision

### INTRODUCTION TO SPORTS VISION

In the past, whole courses have been devoted to the optometric specialty of sports vision, so it is impossible to completely cover this topic in the limited time available in this Environmental Vision course. The purpose of this lecture is to introduce you to some of the general principles of sports vision, so you will be able to ...

1. Provide basic sports vision care for your patients;
2. Have the basic knowledge from which to learn more about sports vision, and
3. Know which references to seek when you need more specific information on sports vision.

Sport vision is defined as an optometric specialty that uses the doctor's skills and knowledge to enhance an athlete's *level of athletic ability* and *consistency* of performance.

### EYE PROTECTION IN SPORTS

About 10% of all eye injuries occur during sports. So, an important basic principle of sports vision is providing eye protection your patients who participate in sports. This is the topic of the first video, entitled, *Eye Protection in Sports* (produced by the American Academy of Ophthalmology).

### MAJOR ASPECTS OF SPORTS VISION

Sports vision begins with a complete basic eye examination to assess the ocular health, refractive and binocular status of the athlete. Besides eye protection, sports vision is also concerned with ...

- **Vision correction** usually by contact lenses or refractive surgery. Can you think of any famous professional athletes who have had refractive surgery?
- **Screening visual skills** essential to a specific sport
- **Vision enhancement training**. This is, basically, the application of vision therapy to the specific visual requirements of the athlete.

Besides the common vision tests, some of the visual skills screened and/or trained in a sports vision specialty are:

- Contrast sensitivity
- Dynamic visual acuity—Kirschner rotator (rotating mirror on VA projector), letter on phonograph or motorized disk, Marsden ball, letter ball catch
- Visual memory—tachistoscope, flash numbers, letters or sports scenes
- Eye-hand coordination—Wayne saccadic fixator, catching balls, rotating peg board
- Depth perception—especially at distance. Howard-Dolman apparatus or vectograph slides
- Central / peripheral awareness—Wayne Peripheral Awareness Tester, swinging Marsden ball while facing up, letter on fan
- Visual reaction time—*Reaction Plus* device
- Balance—balance beam, 2x4 walk

Vision is obviously absolutely essential to most sports, but the specific kinds of visual skills required can vary greatly depending on the sport. Table 1 summarizes the importance of certain visual skills for different sports. Even within one sport, certain positions may have different visual demands.

**Table 1.** Examples of visual skills that are important in certain sports.

<i>Sport</i>	<i>Very important skills</i>	<i>Less important skills</i>
<i>Archery</i>	VA, eye-hand coordination	Dynamic VA, visual reaction time
<i>Baseball (hitting)</i>	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, visual reaction time, peripheral vision	
<i>Baseball (pitching)</i>	Peripheral vision, eye-hand coordination	Dynamic VA, visual reaction time
<i>Cycling</i>	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, visual reaction time, peripheral vision	Accommodation
<i>Football (lineman)</i>	Peripheral vision, visual reaction time	VA, accommodation, vergence
<i>Golf</i>	Oculomotor, eye-hand coordination, depth perception, VA	Dynamic VA, visual reaction time,
<i>Gymnastics</i>	Hand-eye coordination, depth perception, peripheral vision	VA, accommodation, vergence
<i>Running</i>	Peripheral vision	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, accommodation
<i>Shooting (skeet)</i>	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, visual reaction time, peripheral vision	
<i>Shooting (target)</i>	VA, eye-hand coordination	Dynamic VA, visual reaction time
<i>Sküing</i>	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, visual reaction time, peripheral vision	
<i>Swimming</i>	Peripheral vision	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, accommodation
<i>Tennis</i>	VA, dynamic VA, oculomotor, eye-hand coordination, depth perception, visual reaction time, peripheral vision	

To prescribe the appropriate care for the athlete, you should have a knowledge of the sport and the unique visual requirements of that activity. For example, in any sport you should consider

- primary angle of gaze— Look up? Looking down? Examples: hockey, basketball, billiards, cycling.
- focal distance—boxing, lineman in football, deer hunting, golf
- binocular or monocular correction—target vs trap shooting
- tinted lenses—polarized lenses for fishing, yellow tint for shooting, UV protection for baseball
- soft or rigid contact lenses—swimming, motocross, basketball

Frame considerations:

- strength—polycarbonate frames and lenses
- fit and comfort
- peripheral vision / side protection
- optical axis—shooter’s glasses ride high on nose
- sports adaptive—scuba mask inserts, outfielder’s flip up/down tinted lenses

### AOA SPORTS VISION GUIDEBOOKS

In order to become more knowledgeable in the visual requirements of a particular sport, a useful set of references are the **Sports Vision Guidebooks** produced by the Sports Vision Section of the AOA. The guidebooks come in multiple volumes, each of which covers several sports. A chapter is devoted to each sport, and each includes a summary of,

- Background - history, terminology and other useful background information
- Visual skills important for that sport
- Visual screening or testing procedures indicated
- Vision therapy techniques that can benefit that sport

- Sports vision problems and solutions often encountered
- Common injuries, recommended eye protection and emergency first aid
- Ocular supplies that should be in the trainer’s first aid kit
- Reference list

**Table 2.** AOA Sports Vision Section Guidebook Series

<i>Volume number</i>	<i>Sport</i>
<i>I</i>	archery, basketball, canoeing/kayaking, figure skating, boxing, volleyball
<i>II</i>	golf, team handball, soccer, table tennis, tennis
<i>III</i>	auto racing, baseball, racquetball, water skiing, wrestling
<i>IV</i>	fishing, hockey, rugby, sailing, scuba diving
<i>V</i>	badminton, football, indoor swimming, judo, snow skiing

**Example from the AAOA Sports Vision Guidebook, Volume II: Golf**

1. Golf overview

The Roman and Chinese civilizations from 200 BC played a “club and ball” type game which might have been an early form of golf. The modern game of golf originated in Scotland over 400 years ago and has become popular internationally among men and women of all ages. It is much more difficult than it may appear to a non-player and requires excellent concentration, relaxation, visualization and many visual skills. The Guidebook contains a list of references for more information on golf and a summary of golf terminology. For example terms such as, duffer, hacker, sandbagger and St. Andrews are listed.

2. Visual skills important in golf, and how they can be tested and trained:

- visual acuity
  - distance static visual acuity is important to judge distance and find the ball in a distance. Presbyopes also must be able to read the scorecard at near.
  - Normal Snellen chart.
  - Correct with spectacles or contact lenses for best VA. Consider angle of gaze in bifocal designs and be aware that optical distortion with new prescriptions can distort space perception and hurt performance.
- depth perception
  - important in selecting the correct club and for putting.
  - Vectograph slides for far or stereo tests for near. Be aware of binocular problems, such as suppression, which may be different at far and near.
  - BI and BO training while maintaining binocular fusion. Use vectograph cards, anaglyphs, stereoscopes, Brock string, etc.
- ocular motility
  - Smooth pursuits help you follow a flying ball; saccades are less important.
  - Test with eye tracker, Wayne Saccadic Fixator.
  - Train with pegboard rotators, Wayne Saccadic Fixator, ceiling fan, Marsden ball.
- eye / body coordination
  - These, along with balance, rhythm and head posture are very important to consistent performance.
  - Test and train with Wayne Saccadic Fixator. Also balance board, 2x4 walk, strobe lights.
- visualization
  - Since the player has adequate time to prepare to hit the ball, this is particularly important. Visualization may help the golfer in putting, teeing off, sending the ball on the desired trajectory or in deciding which club to choose.
  - No test, but teach principles. It can be broken down into several steps: analyze the scene, visualize the action, find center of fixation, execute action, playback.

- accommodative facility
    - must be able to shift focus quickly.
    - Test and train with +/- flipper lenses, Wayne Saccadic Fixator, accommodative rock, Marsden ball.
  - glare recovery
    - may hit and follow ball into the sun. Quality sunglasses may be important while cheap low quality sunglasses may compromise vision at a critical time.
    - Patients with certain kinds of cataract may be more subject to glare and this can be evaluated with the Brightness Acuity Tester (BAT).
  - ocular endurance / fatigue
    - 18 holes of golf could require 4 hours of heavy concentration and visualization, which can fatigue the eyes.
    - Test visual skill before and after a long game or training session.
    - Train by teaching and emphasizing visualization.
  - fixation
    - especially important during putting
    - Test with eye track.
  - visual memory
    - Memory of past swings and the results can be important in improving performance and consistency. This is closely related to visualization.
    - No test, but principle can be taught.
  - central / peripheral awareness
    - eye on the ball but aware of the target down range.
    - Test and train with the Wayne Saccadic Fixator. The telephone-pole game.
    - Take time to train.
  - spatial localization
    - critical to know where you are in relation to the intended target. Some have suggested that eso or exo phorias can lead to systematic error in golf shots.
    - Normal Von Graffe phoria testing,
    - Brock string, analgyph and vectograph trainers.
3. Visual skills that are less important in golf
- dynamic visual acuity
  - peripheral vision
  - high speed recognition
  - color perception
4. Sport vision problems (See Table 3).
5. Most common eye injuries in golf
- relatively rare
  - corneal abrasions from sand, etc.
  - blunt trauma or lacerations from ball ricocheted off tree, etc.
  - UV overexposure

**Table 3.**

<i>Problem</i>	<i>Suggested remedy</i>
<i>Wind and dust</i>	Visor, spectacles, soft contact lenses
<i>Glare</i>	Visors, sunglasses
<i>Fogging, misting of lenses</i>	Contact lenses
<i>Presbyopia</i>	Right handed golfers: Small round seg rotated toward lower temporal field of right lens only. Left-handed golfers=opposite. Keep any bifocal seg low so it won't obstruct vision during teeing off. Or design a high-set executive bifocal with the lower focal power set for the ground distance.
<i>Dirt, sand, tree branches, bugs in eyes</i>	Sunglasses, soft contact lenses
<i>Overcast, hazy weather</i>	yellow tinted lenses may enhance contrast

#### 6. Protective eye wear

- Brimmed hat
- Impact resistant spectacles and / or sunglasses
- Contact lenses—soft preferred
- Head sweatbands to keep sweat out of eyes

#### 7. Supplies for trainer's first aid kit

- Sterile saline eyewash
- Artificial tears
- Cotton swabs
- Hard contact lens remover
- Fluorescein strips and black penlight
- Regular penlight
- Broad-spectrum antibiotic ointment (Polysporin, Gentamycin, etc.)
- Eye patches and tape, Fox shields.
- Spare disposable contact lenses for all athletes
- Small mirror
- Blue ice

#### 8. First aid techniques for the athletic trainer

- Eye irrigation
- How to use all of the above supplies
- How to handle and remove contact lenses
- How to bandage and protect and injured eye

## PRINCIPLES OF VISION AND DRIVING

(Reference: Sheedy Je, Bailey II. Vision and Motor Vehicle Operation (Chapter 14) in Environmental Vision, Pitts DG, Kleinstein RN eds. Butterworth-Heinemann, Boston, 1993.)

Vision is obviously critical for driving and is clearly the most important of our senses when it comes to driving. But what level of vision is needed for driving? Is the 20/40 requirement mentioned in the Federal laws for commercial drivers sufficient to establish that vision is adequate for safe driving?

Studies have been done to look for a correlation between vision and driving performance. For example, in the most comprehensive studies of vision and driving, Burg (1967, 1968, 1971) tested 17,500 drivers over a three-year period. The following aspects of vision were tested:

- Standard VA
- Dynamic VA
- Horizontal phoria
- Horizontal visual field
- Glare testing
- Visual recognition in low light

These were compared to the number of traffic accidents among the same population, and interestingly there was not a clear-cut statistical correlation between any of these measures of vision and accident rate.

Other scientists have found the same thing—that most common vision tests do not correlate with or predict the likelihood of traffic accidents. Because of that, researchers Katherine Ball and Cynthia Owsley developed another way to analyze vision called the **UFOV (useful field of vision)**. This is primarily a test of visual attention for objects in both the central and peripheral field of view, with and without distractors. The UFOV has been receiving much attention in recent years. For a summary, see: <http://www.safety.gmu.edu/litreview.htm>

Obviously vision is required for driving, but this is hard to prove statistically. One reason that persons with poor vision do not have many traffic accidents is because they realize the danger and often avoid driving.

Another reason that it is difficult to find a clear mathematical correlation between certain visual skills and driving is that driving is a very complex task that requires many other skills besides good vision. Examples include, cognitive function, motor coordination, familiarity with the roads, weather conditions, distractors, traffic congestion, etc.

We will consider some specific visual functions and their relation to driving next.

### **Visual acuity and driving**

Although it may be difficult to find a statistical correlation between visual functions and traffic accidents, from task analysis it is obvious that specific aspects of vision are important for vision.

For one thing, maximum visual acuity is critical to provide drivers with the reaction time to avoid dangers or to see road signs far enough in advance to prepare for them.

Some studies have indicated that dynamic visual acuity is an important visual skill to evaluate, but there is no clinical standard for measuring dynamic acuity.

We normally test only high contrast, high luminance visual acuity, but some researcher have suggested that it would be better to test visual acuity using low contrast targets or even to test contrast sensitivity rather than visual acuity.

For patients with cataracts, it may be more informative to test visual acuity with a glare source, such as the BAT.

The vision standards for obtaining a driver's license vary from state to state, but 41 states require a visual acuity (monocular or binocular) of 20/40 to pass. Twenty-seven states also require a horizontal visual field of at least 70 degrees. This does not necessarily mean that there is a clear cut-off between safe and unsafe driving at 20/40. It is quite feasible that a driver with 20/100 visual acuity might be a safer driver than one with 20/20. It is however necessary to establish some standard for vision, and 20/40 is used in most states.

One of the benefits of requiring 20/40 vision is that it prompts people who fail the 20/40 screening test to seek an eye examination. Most people who fail the vision screening and seek optometric care can be corrected to 20/20, and they also receive a complete check for other eye problems. The 20/40 screening standard therefore helps improve the overall vision and eye health of the driving population.

Quoting from Sheedy,

The evidence in the literature does not support the idea that a person whose visual acuity is 20/40 or better is adequately equipped for driving but that any person with poorer visual acuity is not. It is not possible to establish a single visual acuity standard that would perfectly distinguish between "visually safe" and "visually unsafe" drivers. Safe driving performance is dependent upon many non-visual factors including attentiveness, mental state, judgment, reaction time, general health, sensory or motor disorders, and so on. To the argument that vision measurements cannot provide a distinct "black and white" criteria for driving licensure, Bailey and Sheedy have brought the recommendation that a "grey zone" be established and suggested 20/40 as a criterion for referral and 20/200 for licensure denial. Applicants whose visual acuity falls within the intermediate "grey zone" would receive special screening and individual consideration. ... For those individuals who cannot meet the vision standards, special consideration should be given to the following:

- driving test results
- driving experience
- driving record
- driving needs
- anticipated driving patterns
- other vision disabilities
- other sensory disabilities
- causative disorder and prognosis
- variability of vision

Sheedy suggests that a person with slightly reduced visual acuity might be able to have a limited license, such as driving restricted to daylight hours and on local roads only. Oklahoma law allows for such a restricted license.

Conversely, certain drivers should be required to meet more stringent vision requirements. These include school bus drivers, taxi drivers, truck drivers, ambulance drivers, etc. These drivers are required to meet the Federal regulations in 49 CFR § 391.41.

### **Visual field and binocular vision**

One study of 10,000 drivers by Johnson and Keltner (1983) showed no significant correlation between monocular field loss and accidents, but those with binocular field loss had about twice as many accidents or traffic violations as normals.

Another study suggested that persons with monocular vision have a greater risk for traffic accidents than persons with normal binocular vision. Some might suggest that because of this, patients with monovision may have a slightly higher risk for traffic accidents.

### **Color vision**

Color vision is most important for correct interpretation of traffic signals. In order to help color deficient drivers, the green light on traffic signals has been standardized to a bluish-green color. Color vision anomalies have not been shown to increase the risk of traffic accidents.

### **Elderly drivers**

- Cataracts and other age related eye problems
- Other non-visual problems

## **VISION STANDARDS IN OKLAHOMA**

### **Oklahoma Administrative Code (OAC 595:10-3-6)**

(b) **Vision Screening.** Applicant's eyesight shall be screened by means of a vision screener or by the use of a Snellen Chart and must meet the requirements set out in Subchapter 5 of this Chapter, Medical Aspects of Driver licensing and/or Section 391.41 Physical Qualifications for Drivers - Subpart E (10) of the Federal Motor Carrier Safety Regulations. [49 CFR § 391.41].

### (c) **Visual Acuity.**

(1) A person may be considered for a Class D Driver License, or for a Commercial Driver License if exempt from Subpart E (10) of the Federal Motor Carrier Safety Regulations under 49 CFR § 391.41, if visual acuity is:

(A) Twenty-sixty (20/60) or better, both eyes, (may pass with or without corrective lenses.)

(B) Twenty-fifty (20/50) or better in one eye (with or without corrective lenses.)

(2) A person who is not exempt from Subpart E (10) of the Federal Motor Carrier Safety Regulations under 49 CFR § 391.41, may be considered for a Commercial Driver License if distant visual acuity is at least twenty/forty (20/40) in each eye without corrective lenses or visual acuity separately corrected to twenty/forty (20/40) or better with corrective lenses, distant binocular acuity or at least twenty/forty (20/40) in both eyes with or without corrective lenses, field of vision of at least 70 degrees in the horizontal meridian of each eye, and if he demonstrates the ability to recognize the colors of traffic signals and devices showing standard red, green and amber.

(3) Applicants for a Class D license and applicants for a Commercial Driver License who are exempt from Subpart E (10) of the Federal Motor Carrier Safety Regulations under 49 CFR § 391.41, not meeting the requirements of (c) of this Section, may apply for a Restricted License provided that the vision is no worse than twenty-one hundred (20/100).

(4) The Department of Public Safety may impose restrictions on those persons whose visual acuity is twenty-fifty (20/50) or worse, restricting the operation of a motor vehicle to specified area, time of day, streets and highways, speed limits and any other restrictions deemed necessary by the Commissioner of Public Safety for the safe operation of a non-commercial motor vehicle. An extended skills test may be conducted to determine the appropriate restriction.

(5) Persons with visual acuity worse than twenty-thirty (20/30) in one eye and no reading in the other eye shall be directed to a vision specialist of their choice for evaluation.

(6) Persons with visual acuity worse than twenty-one hundred (20/100) will not be considered for licensing.

(7) Persons with visual acuity worse than twenty-fourty (20/40) shall be directed to a vision specialist of their choice for evaluation.

[Source: Amended at 10 Ok Reg 3189, eff 6-25-93]

## **SUBCHAPTER 5. MEDICAL ASPECTS**

### **595:10-5-7 Visual problems**

(a) **Acuity.** A person may be considered for licensing if visual acuity is:

(1) Twenty/sixty (20/60) or better in both eyes with corrective lenses

(2) Twenty/fifty (20/50) or better in both eyes with corrective lenses.

(3) Persons not meeting the requirements in (1) or (2) of this Subsection may apply for restricted licenses with such restrictions as area and time, if the visual acuity is no worse than 20/100.

(b) **Field of vision.** A person may be considered for licensing if the field of vision is at least 70 degrees on the temporal side and 35 degrees on the nasal side in at least one eye. Persons not meeting the requirement in this Subsection may apply for restricted licenses with such restrictions as area and time, if the field of vision is not narrower than 30 degrees to the right and 30 degrees to the left.

(c) **Eye diseases.** A person with progressive eye disease such as cataract, glaucoma, nystagmus, iritis, iridocyclitis, retinitis pigmentosa, choroiditis, retinal detachments, macular degenerations, inflammatory vascular, eye ground diseases, optic atrophy, or other disease affecting vision or visual fields shall not be licensed unless they meet the visual standards set forth in (a) and (b) of this Section. If licensed, future periodic vision reports may be required to be submitted to the Department by an ophthalmologist or optometrist.

(d) **Telescopic lenses.** A person wearing telescopic lenses shall not be licensed.

## **Federal Highway Administration, DOT, 49 CFR Ch.10 (10-1-99 Edition)**

### **49 CFR § 391.41 Physical qualifications for drivers.**

(10) Has distance visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses, field of vision of at least 70° in the horizontal meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green and amber;

## **SUMMARY OF OKLAHOMA VISION STANDARDS**

### **1. Unrestricted non-commercial driver license**

Best corrected distant visual acuity of 20/60 or better in OD and OS or 20/50 or better in either OD or OS.

A monocular horizontal field of vision of at least 70 degrees temporal and 35 degrees nasal in either eye.

### **2. Restricted non-commercial driver license for those who cannot meet these standards if they meet the following:**

Best corrected visual acuity is 20/100 or better.

Visual field is not narrower than 30 degrees to the right and 30 degrees to the left.

The regulation is unclear whether it refers to monocular or binocular vision.

### **3. Commercial driver license**

Best corrected distant visual acuity of 20/40 or better OD, OS and OU

A horizontal visual field of at least 70 degrees (unclear if it is monocular, binocular, nasal, temporal).

Be able to recognize the colors of a traffic signal.

### **4. Low vision devices: Persons requiring low vision devices (telescopes) cannot be licensed to drive in Oklahoma.**