A Practitioner’s Guide
Module 2 – Diagnosis and Vision Correction

In the second of three CET-approved modules, sports vision specialist Martin Cardall looks at the visual skills involved in popular sports, the options for vision correction and eye protection, and how to tailor these to individual sports.

Performance Vision Training will be discussed in Module 3, along with some of the specialist equipment this requires, but it is important to understand that eye exercises and vision training are not the only solution to improving sporting performance. These are only appropriate for enhancing visual performance once a full optical correction has been prescribed and dispensed. Module 2 will therefore outline appropriate vision correction methods for athletes, with the emphasis on specific sports.

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What are the visual considerations for individual sports?

Key sensory information needed by athletes during competitive sporting activities is provided by the visual system. It has been suggested that 95% of all physical movement is controlled visually and that this is the trigger mechanism for the first movement of the athlete.1,2 Hence choosing the most appropriate method and requirements of visual correction is essential in sport.

It is important to identify from the outset the key visual requirements for the athlete’s given sport. These should be established during the history taking and visual task analysis, as described in Module 1, and need to be taken into consideration when choosing both the battery of tests included in the Performance Vision Evaluation and the correction prescribed.

Table 1 outlines some important visual skills required for a variety of popular sports and examples of basic and specialist tests to include or equipment to use to assess these skills. Many of these techniques that can also be used for vision training purposes will be discussed in Module 3. Although a little prior knowledge of the sport goes a long way, the visual requirements of many popular sports are easily understood. Footballers, for instance, require a good level of foot-eye coordination and peripheral awareness and these measures of vision should be included in their evaluation. For football, spectacle wear may be impractical making contact lenses the most likely choice of correction. Snooker players, on the other hand, require good stereopsis and vergence control, so these should be carefully assessed. Here spectacles are an option or may even be a necessity if prismatic correction is required.

The use of static and dynamic visual acuity and contrast sensitivity testing has been discussed in Module 1. Again, the tests selected must reflect the real-world demands of the given sport. Static visual acuity testing assesses the visual acuity of a non-moving target at a fixed distance, usually with a Snellen chart. Static tests are especially relevant to sports such as archery and shooting. Dynamic visual acuity testing is important in sports where either the target or the player is in motion. Examples here include skiing, tennis and cycling. Whether using static or dynamic techniques, it is important that these tests are carried out with the visual correction athletes wear for their sport.

Computer-based assessment can be very usefully employed when attempting to measure performance in some of the areas set out in Table 1. The Visual Performance Enhancement program (VPE) from Home Therapy Systems is a useful tool to enable the clinician to rapidly make an estimate of the athlete’s ability to perform in the following areas: dynamic visual acuity, short presentation times (Tachistoscope), peripheral awareness, saccadic fixations and visual scan. Performance in the areas of divergence, convergence, jump vergence and accommodative rock can also be assessed. The use of computer-based programmes for visual skills training will be covered in Module 3.

Additionally, assessment of the athlete’s contrast sensitivity is highly desirable since many sports involve visual discrimination of contrasting targets. Contrast sensitivity testing has also been proven to be important in athletes wearing contact lenses since it has been shown that if the lens performance is not optimal, contrast sensitivity may be reduced, even though Snellen acuity may be adequate.

Table 1: Visual skills required in some popular sports and examples of tests to include or equipment to use in the Performance Vision Evaluation (after Griffiths)  

<table>
<thead>
<tr>
<th>Sports</th>
<th>Visual skills</th>
<th>Basic tests employed in eye examination</th>
<th>Specialised equipment/tests that can be used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cricket</strong></td>
<td>Ocular alignment, ocular motility, accommodation, convergence, stereopsis</td>
<td>Cover test, pen torch, saccadic/refixation tests, near point rule (preferably free space target), random dot tests, oculomotor balance tests</td>
<td>Howell Phoria Cards, Brock String, Flipper Accommodation Test (Module 1)</td>
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<tr>
<td></td>
<td>Anticipation (batting)</td>
<td></td>
<td>Bassin Anticipation Timer, Sports Vision Trainer (SVT)</td>
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<tr>
<td></td>
<td>Hand-eye response (fielding)</td>
<td></td>
<td>Wayne Saccadic Fixator, SVT</td>
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<tr>
<td></td>
<td>Accuracy of fixation and binocular stability</td>
<td>Mallet unit</td>
<td></td>
</tr>
<tr>
<td><strong>Football</strong></td>
<td>Foot-eye coordination</td>
<td>Confrontation test</td>
<td>Modified Saccadic Fixator, SVT</td>
</tr>
<tr>
<td></td>
<td>Peripheral awareness</td>
<td>Confrontation test, Peripheral fields</td>
<td>Peripheral Awareness Trainer (Module 3), SVT</td>
</tr>
<tr>
<td><strong>Sailing</strong></td>
<td>Ocular motility</td>
<td>Pen torch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peripheral awareness</td>
<td>Confrontation test, Peripheral fields</td>
<td>Peripheral Awareness Trainer, SVT</td>
</tr>
<tr>
<td><strong>Snooker</strong></td>
<td>Ocular alignment, stereopsis</td>
<td>Cover test, Maddox rod, random dot test, Mallet unit, pencil-to-nose test</td>
<td>Eye dominance, Brock String</td>
</tr>
<tr>
<td></td>
<td>Vergence control</td>
<td></td>
<td>Vectograms and tranaglyphs (Module 3)</td>
</tr>
<tr>
<td><strong>Netball</strong></td>
<td>Depth perception (incl. stereopsis)</td>
<td>Random dot tests</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peripheral awareness</td>
<td>Confrontation test, Peripheral fields</td>
<td>Peripheral Awareness Trainer, SVT</td>
</tr>
<tr>
<td><strong>Skiing</strong></td>
<td>Contrast sensitivity</td>
<td>High and low contrast LogMAR charts</td>
<td>Pelli-Robson Chart</td>
</tr>
<tr>
<td></td>
<td>Dynamic visual acuity</td>
<td>DVA-Test</td>
<td></td>
</tr>
<tr>
<td><strong>Hockey</strong></td>
<td>Dynamic visual acuity</td>
<td>DVA-Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hand-eye coordination</td>
<td>Wayne Saccadic Fixator</td>
<td></td>
</tr>
<tr>
<td><strong>Athletics - track and field</strong></td>
<td>Peripheral awareness</td>
<td>Confrontation test, Peripheral fields</td>
<td>Peripheral Awareness Trainer, SVT</td>
</tr>
<tr>
<td><strong>Tennis</strong></td>
<td>Dynamic visual acuity</td>
<td>DVA-Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peripheral awareness</td>
<td>Confrontation test, Peripheral fields</td>
<td>Peripheral Awareness Trainer, SVT</td>
</tr>
<tr>
<td></td>
<td>Hand-eye coordination</td>
<td>Wayne Saccadic Fixator</td>
<td></td>
</tr>
</tbody>
</table>
What refractive error do I correct?

Athletes often have high visual demand and the literature has indicated that optimal vision correction can enhance sporting performance even with corrections as small as -0.25D. Hypermetropia over +1.00D should be corrected as this may relieve fatigue, especially for near and intermediate targets. Correcting small amounts of astigmatism (starting from 0.50DC) and anisometropia (0.50D and more) may also be beneficial.

In everyday life, correcting very low levels of refractive error or changing a correction by just 0.25D may not always be worthwhile but, in elite athletes, optimum vision can provide an extra edge in competition. Consider the fact that of the five time-based Gold medals won by British athletes during the Athens 2004 Olympic Games, the cumulative time difference these athletes achieved collectively over the Silver medal winners was just 0.545 seconds. Any advantage, though seemingly small, can make a big difference to performance at this level.

However, it is important to ascertain from athletes if they feel the prescription benefits their vision and helps maximise their sporting potential. Correcting a small refractive error on the test chart may enhance their visual acuity but it may not be essential for their given sport. Any vision correction will need to be tested under sporting conditions to determine whether it is beneficial. For some sports these conditions may first be simulated in the practice, but ultimately all correction needs to be tested in real-life sporting situations.

Lighting conditions play an important part in determining the refractive correction. When prescribing for sports that are played in twilight and recessed lighting conditions, this needs to be taken into account during visual assessment and refractive compensation incorporated in the final correction. Similarly, for sports played under stadium lighting, which tends to have higher blue wavelength, extra minus may benefit the athlete of around -0.25D.

Working distance is another factor to consider in some sports. For example, an extra +0.25D to +0.75D overcorrection may be beneficial to pistol shooters’ performance as they generally prefer to keep the front sight in focus as opposed to the distance target, although the amount of overcorrection will depend on the patient’s own accommodative ability and target distance. Efron suggested adding at least -0.25D to the correction for young sports participants for optimum acuity at far distance.

At the other end of the age range, choice of bifocal spectacle design or contact lens is important when prescribing for the presbyopic athlete. Consideration should again be given to the requirement of the athlete’s given sport; for golfers for example, offsetting the bifocal segment in the temporal or superior aspect of spectacle lenses may be beneficial.

When fitting athletes with any form of new correction it is advisable for them to train using the new appliance rather than fitting immediately before an important event. For a first prescription, three to six weeks may be needed to adapt to visual perceptive changes.

Finally, it is imperative to remember that, regardless of refractive error, some sports require protective sports eyewear and this should always be worn by all participants, including emmetropes. Protective eyewear will be described in detail later in this module.
What factors will influence the choice of vision correction method?

The three options for visual correction are spectacles (including protective sports eyewear), contact lenses and refractive surgery. When deciding on which method of correction is needed for a particular athlete, it is important to establish some background information by careful questioning. In some sports, a combination of appliances may be needed to cover a variety of environmental conditions and visual tasks.

Firstly, the practitioner needs to discover whether there are any recommendations or mandatory requirements for sports eye protection and if contact lenses or spectacles can be worn for a given sport. This is important as safe practice is always recommended. Secondly, ocular health plays an integral part when deciding whether contact lenses or spectacles are the mode of choice. Previous problems with contact lenses may contraindicate contact lens wear and, for a neophyte, it may be difficult to identify potential problems with contact lenses when worn for sport. Thirdly, determine the environment in which the athlete is participating. Dust and other environmental factors may influence your choice of correction; for example, a patient may indicate that they require correction for netball but it is important to establish if this is to be played outside or indoors so that lighting conditions and UV protection can be taken into account.

Finally, consider the visual requirements needed for a given sport in relation to method of correction. Many sports, for instance, require a wide field of view, where contact lenses may be an advantage, although they may not provide adequate protection alone. It is now possible for some prescriptions to glaze sport frames that have a ‘wrap-around’ design, thus increasing the field of view.

Polycarbonate lenses in an appropriate housing can provide eye protection during sporting activities, unlike contact lenses that provide no protection against trauma. UV protection can be incorporated in sports spectacles and is especially effective in wrap-around frame designs. UV-absorbing contact lenses protect the cornea and limbus, but not the whole conjunctiva and adnexa. Unlike spectacles, however, they may protect against peripheral and obliquely incident radiation in a way that is difficult to achieve with sun spectacles. Thus although contact lenses are not substitutes for UV-protective eyewear, they can act as an additional barrier to UV while wearing sports spectacles.

What benefits do contact lenses have over spectacles?

There are many advantages to wearing contact lenses as opposed to spectacles for sport. Table 2 summarises the main benefits. Contact lenses have also been found to provide a significant psychological advantage over spectacles which may enhance overall sports-oriented visual performance.9

A study in 2005 investigating contact lens wearing trends discovered that 95% of contact lens wearers who play sport use their lenses during sporting activities.10 Recent research demonstrated that over 25% of patients reported sports as a primary motivating factor for wearing contact lenses.11 These studies indicate that there are many patients wearing contact lenses for sports. Practitioners should therefore offer correct advice on optimum lens choice, wearing schedule and hygiene when lenses are used for this purpose.

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Reason</th>
</tr>
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<tbody>
<tr>
<td>Wider field of view</td>
<td>Limitation on edge position of spectacle lens design, restricted visual field</td>
</tr>
<tr>
<td>Less minification/magnification</td>
<td>Object size more constant ('real-world')</td>
</tr>
<tr>
<td>Less adaptation may be required</td>
<td>After initial adaptation, changes in contact lens Rx require very little adaptation</td>
</tr>
<tr>
<td>Greater stability</td>
<td>Lower risk of dislodgement during wear</td>
</tr>
<tr>
<td>Enhanced depth perception</td>
<td>Allow more stable vision and enhanced depth perception due to less magnification difference between eyes</td>
</tr>
<tr>
<td>Fewer aberrations</td>
<td>Move with the eyes</td>
</tr>
<tr>
<td>Fewer reflections</td>
<td>Lenses in contact with tears</td>
</tr>
<tr>
<td>Not affected by fogging up or rain</td>
<td>Lenses in contact with tears and not exposed to environmental conditions</td>
</tr>
<tr>
<td>Less susceptible to dirt</td>
<td>Spectacle lenses susceptible to smearing and dirt</td>
</tr>
<tr>
<td>Allow protective eyewear or sunglasses to be worn</td>
<td>Bulk of spectacle frame often interferes with wearing of protective goggles</td>
</tr>
<tr>
<td>Protect against peripheral and obliquely incident UV</td>
<td>Offer additional protection when used with sun spectacles</td>
</tr>
<tr>
<td>Low risk of damage to lens during wear (soft lenses)</td>
<td>High risk of damage to spectacle lenses during wear (excluding polycarbonate lenses) and potential trauma from lenses and frames</td>
</tr>
<tr>
<td>Disposability viable</td>
<td>Lost or damaged spectacles costly to replace</td>
</tr>
</tbody>
</table>

When choosing the most appropriate type of contact lens for sport many factors need to be taken into account. General considerations are the length of time it takes to play the sport, the environment in which it is played and the general physical demands of the sport, including extreme body movement, body contact and gravitational forces. You will also need to select the appropriate wearing modality, material, design and fitting characteristics.

**Wearing modality**
Many practitioners tend to fit daily disposable contact lenses as the lens of choice for sport due to the many advantages of this modality of wear. This is dependent on prescription and availability of the lens material a particular patient requires. Many sports are played in dirty environments with the potential for lens contamination and handling problems. The daily disposable modality allows the player to discard the contact lenses after each use and is particularly suited to part-time wear. Daily disposables are also convenient as athletes do not need to carry cleaning solutions, spare lenses can be readily available and relatively inexpensive to replace if the lens is lost.

Where re-usable lenses are necessary for prescription or other reasons, it is especially important to discuss lens care procedures. Athletes wearing lenses on an occasional basis must be instructed to disinfect their lenses before each use.

An alternative for some athletes might be the technique of accelerated orthokeratology, where individually designed RGP lenses are worn overnight. In this system, lenses are worn during the hours of sleep and removed during the day. By altering corneal curvature there is a reduction in myopia and some forms of astigmatism that is sustained during waking hours. To date, this technique has not been widely utilised and there is no publication that addresses the quality of vision and athletic performance after the orthokeratology procedure. However, it may be an option for those athletes unable to tolerate modern contact lenses or prohibited from wearing them during competitions.

For some endurance events - such as mountaineering, ocean racing and rally driving - and in environments where lens handling is impractical, extended wear lenses may be the best solution. Where this is the case, high oxygen permeability (Dk) silicone hydrogel lenses should be used and, again, the patient carefully instructed on lens wear and care.

**Lens material**
Generally soft contact lenses are the material of choice when fitting for sports as these tend to move less on the eye compared to rigid gas-permeable (RGP) lenses and are less likely to be dislodged. In sports, dust or debris can get trapped under the RGP lens which can result in damage to the cornea and marked discomfort to the wearer as the lens moves. In sports which are dynamic (e.g. tennis) the extra stability of soft contact lenses is advised to reduce lens movement. For outdoor sports, contact lenses that incorporate UV protection should be recommended.

The oxygen transmissibility (Dk/t) of the contact lens is important. Generally a low Dk/t hydrogel lens will provide less oxygen to the anterior surface of the cornea in the open eye condition compared to a high Dk/t silicone hydrogel lens. Therefore the duration of the sporting activity needs to be taken into consideration to minimise hypoxia of the cornea. Since low Dk lenses may be unsuitable for use at high altitudes due to reduced corneal oxygenation, silicone hydrogels are advisable for skiing and mountaineering.

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Soft lens water content is also a factor in some sports. For indoor or arena sports, where the environmental conditions promote lens dryness, moderately thick, low water content lenses have traditionally been preferred to high water lenses to control dehydration. However, a recent study showed that conventional hydrogel lens wearers refitted with a second-generation silicone hydrogel lenses show improved comfort in challenging environments, such as dry, dusty conditions and high altitudes. Soft lens dehydration may also be a problem in sports that expose the eye to increased airflow, such as cycling, sailing and wind surfing, where additional protective eyewear is advisable.

Lens design and fitting characteristics
Most practitioners fit spherical soft contact lenses for patients with astigmatism of 0.25D and 0.50D and only tend to fit toric contact lenses with astigmatism of 1.00D or above. As optimum correction is important in many sports, it may be worth fitting toric lenses at lower levels of astigmatism to maximise the athlete’s vision.

Aberration-controlled contact lenses are becoming more widely available and claim to control aberrations across the lens thus improving quality of vision. It has been shown that there is no statistically significant difference between spherical and aspheric design lenses for high or low-contrast visual acuity, although some patients may prefer aspheric over spherical design contact lenses. Superior vision can be achieved for low astigmatic contact lens wearers using toric soft rather than aspheric lenses. Customised contact lenses that utilise wavefront technology to correct higher order aberrations of the eye may ultimately provide the elite athlete with levels of visual acuity higher than spherical lenses alone.

Fitting contact lenses to the presbyopic athlete requires special consideration and is strongly dependent on the sport involved. Contact lenses can be a hindrance for such patients as depth perception can be reduced or even lost with monovision and bifocal contact lenses. Where static visual acuity is critical, such as in snooker, darts or archery, spectacles may be preferred to contact lenses. Single-vision distance contact lenses with bifocal or near addition spectacles can be appropriate in some sports.

Lens stability on the eye is the key fitting characteristic for athletes, particularly in sports involving extreme body movements or body contact. For soft lenses, this suggests a large diameter, relatively tight fitting, good centration and minimal movement.

For sports where RGP lenses are acceptable, try to minimise the risk of the lens dislodging by fitting a larger diameter (10-10.5mm) with central alignment and reduced edge lift. A back-surface aspheric design that conforms more closely to the cornea may be preferred.

On-eye stability is even more crucial with toric soft lenses in order to avoid fluctuating vision. However, toric lenses are now available that use a technology known as Accelerated Stabilisation Design to orientate more quickly and consistently, and remain unaffected by gravitational forces compared to prism ballast lenses. Rotational stability is important in most sports, and particularly in cycling, skiing and motorbike racing.

What about refractive surgery?

Sport is a factor influencing the patient’s choice to opt for refractive surgery although convenience is the main motivation. Athletes may perceive surgery as offering greater convenience, improved vision and avoiding the risk of lenses becoming dislodged, drying out or causing irritation. However, as with any choice of vision correction method, it is important to consider the pros and cons and to ensure that patient expectations are realistic.

With laser-assisted in situ keratomileusis (LASIK), the most commonly performed refractive surgery procedure, potential complications affecting the athlete are dry eye symptoms, visual disturbances (glare and haloes) and possible flap dislocation in those susceptible to trauma. Dry eye occurs in most post-LASIK patients although it is usually mild, resolves within 3-9 months after surgery and can be treated with lubricating eye drops and other therapies. Glare and haloes can be experienced in mesopic or scotopic environments. In the first 6-9 months and athletes performing at night or in dim indoor conditions need to be made aware of this. However, wider treatment zones and wavefront-guided ablation have reduced this complication.

To reduce the risk of flap dislocation, athletes who have had LASIK are advised to wear protective eyewear for at least a year after refractive surgery. Incisional surgery such as radial keratotomy (RK) weakens the cornea and eye protection should be recommended indefinitely in this group.

However, it should be said that most athletes find the side-effects of LASIK minimal and easy to tolerate. Contrast sensitivity usually decreases after surgery, but improved treatment delivery systems have led to better visual outcomes in recent times. Whether LASIK can improve sporting performance remains unclear; one US study among professional baseball players found no significant improvement in on-field performance following refractive surgery.

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What type of correction is appropriate for the major sports?

Swimming
There are around 7 million regular swimmers in the UK and swimming is regarded as one of the most common recreational activities. Vision is important in swimming as, during a competitive race, knowing when to turn is critical for success. It is also important from a social and safety aspect as the ability to recognise faces, especially your child's, in a busy swimming pool is crucial.

There has been debate surrounding the use of contact lenses while swimming and the literature can be contradictory. The current school of thought is that contact lenses should be used with caution. Most contact lens manufacturers do not recommend contact lenses for swimming as pool contaminants may remain in a soft contact lens. Rigid contact lenses can also easily be lost in the water.

Eye Care Practitioners should caution wearers as to the potential increased risk of infection, and advise on how to minimise the risk.

Wearing contact lenses while swimming has also been associated with Acanthamebol and bacterial infections, outdoor swimming pools posing a higher risk of infection compared to indoor swimming pools. A study investigating the very rare but serious condition of Acanthamebol corneal infection in the UK demonstrated that 91% of infections could have been eliminated by the use of suitable lens care products, regimes and avoiding swimming in contact lenses. Studies have demonstrated that salt water and chlorine can affect the adhesion properties of soft contact lenses and that lenses exposed to these conditions are more likely to tighten on the eye.

Quevedo et al found that the tear film in swimmers reduces after training and thus recommended that swimming goggles should be worn with contact lenses to prevent evaporation. (Figure 1)

Figure 1: Swimming goggles

Detailed instructions should also be given on lens care. Based on the findings of studies in Australia and New Zealand of risk factors for microbial keratitis, the Vision CRC in Sydney has launched the ‘Take care with contacts’ campaign in which they advise on the use of contact lenses when swimming. Their recommendations are that if contact lenses are to be worn whilst swimming, wearers should be advised to wear tight fitting swimming goggles and effective cleaning and disinfection of lenses is important. Some practitioners may recommend that daily disposable lenses are used under swimming goggles and discarded afterwards.

Due to the potential risks of swimming with contact lenses, a safer option is to use prescription tight fitting swimming goggles. There are many different types of swimming goggles on the market today; a study in 2003 concluded that 76% of UK practitioners stock such appliances, including plano and prescription goggles.

Other facilities within leisure centres also need to be taken into account. Contact lenses should be avoided in saunas and in hot tubs. Spectacle manufactures usually do not recommend wearing spectacles in saunas as this can affect the frame and spectacle lens material and lens coatings.
Racket sports

The importance of eye protection in racket sports such as squash and badminton cannot be over-emphasised. Serious eye injuries can occur from the ball, racket and opponent. There are many types of sports spectacles available on the market today which can provide essential protection against eye injuries (Figure 2). The correct use of such appliances is vital.

Figure 2: Sports protective eyewear for squash

Always recommend that spectacle wearers who play racket sports wear impact resistant lenses and note this advice on the record card. During such sports, a wide field of view is important and ‘wrap-around’ sport spectacles can deliver this provided they comply with BS 7930-1:1988 safety standard.

Many players wear contact lenses for such an activity and because they do not provide protection against injury it is recommended that sport eye protection is worn over the top.

In tennis players, the tear film has been shown to be reduced after training, possibly due to dehydration and the sympathetic reduction in tear flow. This should be taken into consideration when fitting contact lenses for tennis. As players have to repeatedly look up when serving, it has been suggested that soft contact lenses should be the lenses of choice since they show less vertical lag. Soft lenses also provide better stability and centration compared to RGP lenses, which may drop when the eye moves up.

Contact sports

Contact sports are those that involve any form of physical contact or impact and include football, rugby, boxing and many martial arts. Impact to the head can occur frequently in football and rugby and these popular sports have been shown to be major contributors to sports eye injuries. RGP contact lenses are not recommended for contact sports as these can fracture in the eye or dislodge on impact. Soft contact lenses should be the lenses of choice since they offer good stability and centration and cannot easily be dislodged. Careful attention should be paid to lens design and fitting characteristics. A potential problem in these and other physically demanding sports is sweat from the forehead entering the eyes and causing stinging and discomfort. The use of an absorbent head band to prevent perspiration entering the eyes may be recommended.
Boxing is a contact sport that poses a significant risk to ocular health. A study of eye injuries in boxing concluded that after five losses a boxer had a 20% chance of a retinal detachment and a 95% chance of a retinal tear after 75 bouts.\textsuperscript{33} The sport vision standards section of the Association of Optometrists’ Handbook\textsuperscript{34} states that amateur boxing participants are not allowed to wear contact lenses or spectacles. It also states that in karate, soft contact lenses are the only contact lenses of choice.

Running
Track athletes are exposed to many environmental factors such as changes in air velocity and temperature, which can lead to eye dryness. However, Quevedo et al\textsuperscript{35} demonstrated that there was no difference in tear quality in these athletes before and after training. Running is a dynamic sport and, where correction is necessary, requires the extra stability of soft contact lenses to provide minimal movement on blinking. For long-distance and marathon runners, protection from dust and debris is also an issue and participants often wear protective eyewear (Figure 3). UV eye protection is essential for runners as with any sport performed outdoors in direct sunlight.

Cycling
Cyclists frequently report problems with dust and flying debris, causing eye irritation.\textsuperscript{1} Increased airflow is also an issue and may cause dryness. Cycling spectacles are advisable as they can eliminate many of these problems by providing adequate coverage and protection. If choosing contact lenses as the mode of correction, protective spectacles are also advisable (Figure 4). UV protection is again recommended and polarised lenses can be useful when cycling on wet surfaces to suppress reflected glare from the road surface.\textsuperscript{26}

Shooting / Marksmen
There are many myopic shooters who wear contact lenses as these provide good peripheral vision. Soft contact lenses are the lens of choice for shooters as they may be subjected to windy conditions making rigid contact lens wear uncomfortable.\textsuperscript{36} However, movement of the lenses on blinking could be off-putting and may impede performance.\textsuperscript{37} In this sport, a difference in tear quality and quantity has been found before and after training, attributed to a reduction in blink rate.\textsuperscript{28} High water content hydrogel lenses should therefore be avoided and low water content hydrogel or second-generation silicone hydrogel lenses prescribed. Additionally, lubricant eye drops can be recommended where necessary. An alternative to contact lenses is the use of specialist shooting spectacles (Figure 5) to eliminate these potential problems.

\begin{itemize}
\item\textsuperscript{33} Giovinazzo VJ, Yannuzzi LA, Sorenson JA et al. The ocular complications of boxing. Ophthalmo 1987;94(6):887-96.
\item\textsuperscript{34} AOP Handbook, Section C, 2006. www.assoc-optometrists.org.
\item\textsuperscript{36} Breedlove HW. Prescribing for marksmen and hunters. Optom Clin 1993;3:1 77-90.
\item Griffiths G. The clinical application of sports vision appliances Optom Today 1999; March 20:36-42.
\end{itemize}
Eye protection is essential for shooters, whether contact lenses are worn or not. It has also been suggested that for pistol shooters occluding the non-dominant eye may be beneficial.36

Contact lenses can also reduce the amount of oxygen available to the cornea so careful consideration is needed as to the type of vision correction applied. High Dk silicone hydrogels are the best soft lens option for altitudinal sports. Cold weather influences the method of correction, as very low temperatures can cause corneal staining.39 In downhill skiing increased airflow may also be an issue. Protective eyewear should therefore be recommended over contact lenses for all skiers.39 A wide range of ski masks (Figure 6) and goggles are available. Some allow spectacles to be worn underneath and others can be glazed or a prescription insert added.

UV radiation exposure increases with altitude and cases of photokeratitis have been reported due to UV-B reflecting from snow. A sensible resolution for all skiers/climbers would be the use of skiing goggles or masks with UV protection.40 Previous literature has suggested that contact lenses can be worn by skiers without problems as long as protective eyewear with suitable UV protection is used to protect from the wind and glare. For additional protection, UV-absorbing contact lenses should be worn.

Hygiene is an important aspect of contact lens wear for altitudinal sports, especially for long expeditions. Butler38 reported that contact lens storage solution could freeze overnight in extreme cold temperatures and suggested that storage cases containing contact lenses be kept in the sleeping bag at night.

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Sub-aquatic sports (e.g. scuba diving, snorkelling)

If there is a sudden drop in atmospheric pressure, for example while resurfacing after diving, bubbles can form in the body, including the eye. Contact lenses, and especially RGP lenses, can be a contraindication in these conditions. Small bubbles can be observed in the tear film when wearing RGP lenses, resulting in injury to the cornea.\(^{41}\) Similarly, bubbles have been noted under soft and RGP lenses at altitudes of only 6,000 feet.\(^{42}\) Various designs of diving mask are also available (Figure 7), including prescription masks which incorporate the correction in or on the mask window, or in an insert that sits behind it.

Fishing and sailing

Fishing is a very popular recreational activity. Perhaps surprisingly for a seemingly peaceful pursuit, it is also a major cause of eye injury. A US study investigated 143 patients with fishing-related injuries and found that corneal laceration, globe rupture, and hyphaema were the most common injuries.\(^{44}\) These were caused by fish hooks, fishing weights, and fishing poles. The study concluded that fishing-related ocular injuries represented a high proportion of sports-related trauma in the US and that protective eyewear should be worn.

Polarised filters are recommended for both fishing and sailing as these can suppress reflected horizontal light, reducing reflections from the water surface. As with all outdoor sports, it is recommended that they are supplied with UV protection.

Motor sports (e.g. motor cycling, motor racing, rallying)

The Motor Sports Association UK, the body responsible for medical standards in most UK motor sports, recommends that spectacles should be fitted with ‘shatterproof lenses’. It suggests that soft contact lenses can be worn for motor cycling but under a full face visor or goggle, and RGP contact lenses are not recommended.\(^{34}\)

When dispensing vision correction for sub-aquatic sports it is important to remember the difference in refractive index of water compared to air. Brown and Siegal discussed the effect of this difference on underwater images, e.g. fish appear nearer and larger, requiring greater accommodation. These authors suggested that presbyopic contact lens-corrected myopes may require near additions in their diving masks.\(^{43}\)

41. Simon DR and Bradley ME. Adverse effects of contact lens wear during decompression. JAMA 1980;244:11 1213-4.
What tints and coatings are available for sport?

Different coloured tints have been prescribed to enhance vision and aid visual comfort for many sports. Sunglasses are extremely important in sports as they reduce glare and protect against harmful UV radiation. There are different sun protection categories defined by the British Standards Institute (BS EN 1836:1997) and there are many sport-specific sunglasses available today.

The starting point when dispensing tints and coatings is a careful visual task analysis to determine the ambient light levels and conditions (artificial or natural), and factors such as the colour of the target and background, and the contrast of the target against the background. Visual skills specific to the given sport need to be taken into account in order to select the most appropriate tint or coating. Filter types can be broadly divided into: neutral grey, polarising, yellow-brown, green range, red range and photochromic. (Figure 8) shows the effect of different types of tint on different sporting conditions (left without tint and right with tint).

The principle of neutral grey filters is that they filter all wavelengths equally and keep colours more natural than do other coloured filters. Neutral grey filters have potential sports applications where subtle colour differences matter, such as in golf, mountaineering or skiing. Polarising filters (Figure 8) are useful where reflected light may be a hazard, such as fishing, water sports, driving or cycling (on wet surfaces). However, they may remove important details in some sports such as skiing or golf.

Yellow filters have been used in the past to increase contrast by blocking the blue end of the visible spectrum resulting in a reduction of blue light scatter. These filters may enhance differences in contour and have a brightening effect in low light levels. Potential applications are in shooting, snow sports, driving or cycling. Green range filters can be used for background enhancement and may be recommended for golf, tennis and some forms of shooting. Red range filters enhance objects at the red end of the spectrum and may be applicable in clay shooting where the target is orange, in skiing to contrast changes in reflected light, or in motor sports to reduce glare reflected from asphalt.

Figure 8: Polarising filters reduce glare from reflective surfaces such as water
Among the speciality filters available are mirror coatings, which limit glare, increase absorption and reduce infra-red, thus reducing heat build-up. These may be useful in snow sports, water sports, cycling and running. Anti-reflective coatings minimise lens reflections, especially from the back surface, and are recommended for racquet sports, fishing, shooting and archery.

In photochromic filters the transmission characteristics change, most commonly between approximately 20% to 80% transmission, and the usual tint is neutral grey or brown. Photochromic lenses have potential applications in sports played in changing light levels, such as golf or tennis.

It is important to remember when dispensing any sport-specific tints that the patient must be advised about their use for driving. Caution should be exercised when recommending photochromic lenses for use in low levels of illumination. The Department of Transport is currently examining the safety of photochromic lenses in transport situations.

Other coloured filters are often used in sports spectacles and spectacle manufacturers have gone to great lengths to design sport-specific tints. Table 3 summarises some of the coloured tints that have been recommended by various spectacle manufacturers for specific sports.

<table>
<thead>
<tr>
<th>Sport</th>
<th>Example colour/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skiing</td>
<td>Brown, red/orange, neutral grey</td>
</tr>
<tr>
<td>Shooting</td>
<td>Reddish brown, orange, yellow to brown, green</td>
</tr>
<tr>
<td>Golf</td>
<td>Green, neutral grey, yellow to brown</td>
</tr>
<tr>
<td>Water sports</td>
<td>Polarising brown or grey</td>
</tr>
<tr>
<td>Football (and fast-moving ball sports)</td>
<td>Amber</td>
</tr>
<tr>
<td>Cycling</td>
<td>Polarising, yellow</td>
</tr>
<tr>
<td>Tennis</td>
<td>Green</td>
</tr>
<tr>
<td>Fishing</td>
<td>Polarising</td>
</tr>
<tr>
<td>Running</td>
<td>Green, neutral grey</td>
</tr>
<tr>
<td>Motor sports</td>
<td>Polarising, yellow, red</td>
</tr>
</tbody>
</table>
More recently, sport-specific tints have been incorporated into contact lenses. Nike Maxsight® (Bausch and Lomb) low water content hydrogel contact lenses are available in two different colours and eliminate part of the visual spectrum especially at the blue end. The amber lens is recommended for fast-moving sports such as football and tennis. The grey-green lens is for bright conditions and is designed for golf and running.

There is no hard-and-fast rule as to the colour of tint to use for a given sport. Griffiths researched colour preference among elite athletes and found that preference was specific to individuals and their sports; this led to the development of the Eye Bright Test (Figure 9). The test consists of six different coloured and one grey spectacle lenses ranging from blue to red, incorporating colours that may enhance contrast (e.g. yellow) to colours that may help for light sensitivity (e.g. grey). The lenses are introduced in front of the patient’s vision under test conditions that simulate the sporting environment and the preferred colour is chosen.

When prescribing tints, practitioners should always be mindful of the potential to reduce visual performance in certain circumstances. The colour of the ball or target may have been carefully chosen to contrast against the sky or surface on which the sport is played, or to be most visible overall (e.g. tennis), and an inappropriate tint may reduce this visibility. Thus consideration should be given as to the effect of the tint on target/ground discrimination as well as on enhancing variations in the terrain on which the sport is played.

46. www.sportvision.co.uk
Sports-related eye injuries account for only around 2.3% of all eye injuries that attend a hospital Accident and Emergency department but as many as 41% of cases requiring hospital admission. Sport is therefore regarded as the most common cause of severe eye injuries.

A wide variety of ocular injuries are associated with different sports. The most common injuries from football, for instance, are peri-orbital, corneal, hyphaema, and trauma to the posterior segment of the eye. In comparison, corneal and conjunctival injuries are associated with swimming.

The sports most likely to be implicated in eye injury also vary between countries largely reflecting the relative popularity of the sport.

In the UK, football is the most common cause of sport-related injuries, accounting for 12% of cases. This trend runs in Norway, Portugal and Britain but in the US baseball and basketball have been implicated in most sport injuries. With new extreme sports, such as bungee jumping and paintball becoming more popular, increased numbers of eye injuries are being reported.

The use of polycarbonate lenses for ocular protection is well documented and these are clearly the lenses of choice for sport eye protection. Polycarbonate has high impact resistance, and is one of the lightest lens materials available. It is available in a wide range of lens types, including polarising, progressive power and photochromic lenses.

Failure to prescribe the appropriate lens material could be considered as negligent. It is possible that an athlete might bring a legal claim against a practitioner for failing to provide the correct eyewear or advice and thus increasing the risk of a sports-related eye injury.

Squash has been recognised as posing a particular risk of eye injury as the squash ball is the perfect size to fit within the orbit. Eye protection is considered important in squash by England Squash which collaborated with ophthalmologists, doctors, optical bodies and the British Standard Institution to publish the 1988 British Standard for Eye Protectors for Racket Sports (Part 1, Squash, BS 7930-1). England Squash states: "Players are reminded that it is their responsibility to ensure that their eye protector has a recognised Standard."

The wearing of eye protectors is now mandatory for doubles and for specific events for junior players (i.e. under 19), and advised for all players, especially beginners. Yet surprisingly, a study in Australia demonstrated fewer than 10% of adult squash players voluntarily wear appropriate protective eyewear. This study concluded that many squash-related eye injuries could have been prevented by the use of protective eyewear.

Although other ball sports may not specify eye protection, it is important to remember that injuries can happen and eye protection for these sports should be considered. It is likely that, in due course, British Standards for other racket sports will follow.

Athletes who have undergone eye surgery or eye trauma in the past require eye protection and are recommended to consult their ophthalmologist before playing sports.

Table 4 indicates recommendations by regulatory organisations or controlling bodies for participants in some popular sports. For a more comprehensive list see Section C of the Association of Optometrists members’ handbook.
Table 4: Examples of recommendations for eye protection in some popular sports (extracted from AOP Handbook34)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Can spectacles be worn?</th>
<th>Can contact lenses be worn?</th>
<th>Safety lenses mandatory?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soccer</td>
<td>Yes but must not be danger to other players</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Lawn Tennis</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Rugby</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Water-skiing</td>
<td>No but prescription goggles may be worn</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Squash</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes for doubles and &lt;19 yrs Protective eye wear recommended for all other players</td>
</tr>
<tr>
<td>Boxing (amateur)</td>
<td>No</td>
<td>No</td>
<td>N/A but headguard must be worn</td>
</tr>
<tr>
<td>Netball</td>
<td>Yes</td>
<td>Yes</td>
<td>No but guidelines issued</td>
</tr>
<tr>
<td>Shooting</td>
<td>Yes</td>
<td>Yes</td>
<td>No but eye protection is recommended</td>
</tr>
</tbody>
</table>

51. England Squash, www.englandsquash.co.uk
What sports eye protection should I stock?

With a wide range of protective eyewear available for a variety of sports, choosing what to stock may seem a daunting prospect. A useful approach is to start with the sports that are most likely to be encountered in everyday practice, remembering that patients with little or no prescription require adequate eye protection for sport as well as ametropic players. As your sports vision practice increases, you can then expand the range of eyewear stocked and introduce specialist appliances, particularly if you intend to specialise in specific sports or offer your services to elite sports groups.

Although it may not be obvious, swimming goggles can be thought of as protective eyewear. These are relatively inexpensive to the patient and come in a variety of prescriptions. Ski masks are an important aspect of eye protection and can easily be stocked in optical practice during the ski season. Depending on your location and customer base you may also wish to stock diving masks. Squash players are another obvious group to cater for, given that the need for eye protection is well recognised.

Most optical practices stock sunglasses but you may want to extend your range to include specialist designs for sports such as running or cycling where it is important that adequate coverage around the eyes is achieved.

Technology is changing all the time and ‘wrap-around’ eyewear can now be glazed to most prescriptions, including presbyopic correction. Table 5 lists some suppliers of sports spectacles and lenses that can provide more detailed information of the range of protective eyewear available.

It is important to recognise when prescribing and dispensing for sport that a single mode of correction may not be sufficient to cover all requirements; a combination of vision correction and eye protection is often needed. Table 5 presents some examples of how individual athletes can be helped by a careful visual task analysis and Performance Vision Evaluation, followed by appropriate prescribing and dispensing decisions.

### Table 5: Some suppliers of equipment used in sports vision practice

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Website</th>
<th>Contact details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adidas</td>
<td><a href="http://www.silhouette.com">www.silhouette.com</a></td>
<td>020 8889 9997</td>
</tr>
<tr>
<td>Bollé</td>
<td><a href="http://www.bolle.com">www.bolle.com</a></td>
<td>020 8770 1766</td>
</tr>
<tr>
<td>Hilco Europe</td>
<td><a href="http://www.hilco.com">www.hilco.com</a></td>
<td>01969 667688</td>
</tr>
<tr>
<td>Inland</td>
<td><a href="http://www.inland.co.uk">www.inland.co.uk</a></td>
<td>020 8863 9248</td>
</tr>
<tr>
<td>Nike</td>
<td><a href="http://www.marchon.com">www.marchon.com</a></td>
<td>01483 302882</td>
</tr>
<tr>
<td>Nike Maxsight</td>
<td><a href="http://www.bausch.com">www.bausch.com</a></td>
<td>020 8781 2900</td>
</tr>
<tr>
<td>Norville</td>
<td><a href="http://www.norville.co.uk">www.norville.co.uk</a></td>
<td>01452 528686</td>
</tr>
<tr>
<td>Oakley</td>
<td><a href="http://www.oakley.com">www.oakley.com</a></td>
<td>01462 475475</td>
</tr>
<tr>
<td>Rodenstock</td>
<td><a href="http://www.rodenstock.com">www.rodenstock.com</a></td>
<td>01474 325555</td>
</tr>
<tr>
<td>Rupp and Hubrach</td>
<td><a href="http://www.rh-lenses.co.uk">www.rh-lenses.co.uk</a></td>
<td>0870 2250033</td>
</tr>
</tbody>
</table>
Table 6: Examples of visual correction for a given sport

**Rugby Female, age 28**
Patient’s Rx was R-1.50D and L -1.25D. Wearing conventional replacement soft contact lenses but found they moved too much on the eye when playing rugby. Prescribed daily disposable lenses with optimum fitting characteristics for reduced movement and incorporating a UV filter. Wayne Saccadic Fixator used to test hand-eye co-ordination with habitual lenses and with new lenses. Found improved reaction time with new lenses.

**Cyclist Male, age 33**
Myope with Rx R-4.50D and L-5.00D complaining of dry eyes when wearing contact lenses for cycling. No sports spectacles used. Refitted with silicone hydrogel two-weekly replacement contact lenses with UV filter. Checked preferred tint with Eye Bright Test and dispensed plano polycarbonate wrap-around yellow tinted spectacles with UV filter to wear over contact lenses.

**Fishing Male, age 61**
Reported glare from water when fishing during the day, especially in sunny conditions. Patient was plano for distance and R and L +2.50D for near. Fitted with low-set bifocal polycarbonate polarised lenses to reduce glare from the water and enable him to see at distance and, for baiting the hook, at near.

**Squash Male, age 24**
Patient complaining that vision in spectacles (not protective) was slightly better than with spherical monthly contact lenses. Wearing R-2.25/-0.50x93 and L-2.50/-0.75x108 with VA of 6/4.8 R and L. Contact lens Rx was R-2.25D and L-2.75D with VA 6/6 R and L. Refitted patient with two-weekly replacement toric soft contact lenses R-2.25/-0.75x90 and L-2.50/-0.75x110 resulting in improvement of VA to 6/4.8 R and L. Lenses fitted with optimum fitting characteristics to minimise lag on up-gaze. Polycarbonate eye protection dispensed to wear over contact lenses.

The aim of this second module on Performance, Vision and Sport is to provide an overview of the types of correction required for different sports. It is clear that there are many factors to take into consideration when choosing the optimum method of correction and that each athlete needs to be considered individually. It is important to note that with any appliance provided for sports it is the practitioner’s responsibility to ensure the patient’s suitability for any particular product. The final module of this series will examine specialist sports vision testing equipment and techniques for enhancing vision performance.
About the author

Optometrist Martin Cardall is a clinical demonstrator at Aston University and undertaking a PhD in the Ophthalmic Research Group, School of Life and Health Sciences. His PhD area is investigating changes in ocular physiology in response to exercise. He is particularly interested in contact lens usage during sports and physiological changes that can occur as a result of variations in contact lens type and wearing modality. In 2005, Martin completed a Diploma in Sports Vision Practice and co-supervised a summer studentship on contact lens use for sports among university students, funded by the College of Optometrists.

Acknowledgements

Thanks to Norville Optical Group, Kodak and Sport Vision for supplying images.
Multiple-choice questions

To submit your answers to these questions simply log on to www.bethebestyoucanbe.org and follow the instructions for each module. After completing your answers you will be asked to submit your personal details. If you have answered correctly your CET points will be awarded within 10 days. You may resubmit answers if at first you are unsuccessful.

1. Which of the following advantages do contact lenses have over spectacles for visual correction in sport?
   a. Wider field of view, fewer aberrations and reduced depth perception
   b. Wider field of view, more aberrations and reduced depth perception
   c. Wider field of view, increased depth perception and not affected by fogging up or rain
   d. Protection of the cornea from damage caused by trauma and UV radiation

2. In which of the following three sports may athletes benefit from the use of a green range filter?
   a. Shooting, tennis and golf
   b. Skiing, tennis and golf
   c. Water sports, fishing and shooting
   d. Running, tennis and cycling

3. Which of the following statements is correct?
   a. Sport is regarded as the most common cause of eye injury
   b. There are no ocular risk to the eye when playing sports
   c. Sport is the most common cause of severe eye injury
   d. Sports injuries are not detrimental to vision

4. Which of the following statements is incorrect?
   a. Vision is important in swimming
   b. Pool contaminants can remain in soft contact lenses
   c. Acanthamoeba keratitis is a sight-threatening condition
   d. There are no risks to wearing contact lenses when swimming

5. Which of the following statements is correct?
   a. RGP lenses are advised to be fitted for contact sports
   b. Generally RGP lenses do not move down when a player looks up
   c. RGP lenses are advised not to be fitted for contact sports
   d. There are no risks wearing RGP lenses when swimming

6. For which of the following sports should contact lenses not be worn?
   a. Shooting
   b. Amateur boxing
   c. Netball
   d. Rugby

7. Which of the following spectacle lens types can be used for cycling?
   a. Polarised
   b. Polycarbonate
   c. Tinted lenses
   d. All of the above

8. For altitudinal sports, which of the following statements is correct?
   a. Generally, more oxygen is available to the cornea at high altitudes
   b. Generally, less oxygen is available to the cornea at high altitudes
   c. As we ascend, the oxygen available to the cornea stays the same
   d. All of the above

9. Which of the following types of contact lens is advisable in challenging environments, such as dry, dusty conditions?
   a. Rigid gas-permeable
   b. Low water content conventional hydrogel
   c. High water content conventional hydrogel
   d. Second-generation silicone hydrogel

10. For dynamic sports such as tennis, soft contact lenses should be:
    a. Fitted with good corneal coverage to aid stability
    b. Fitted with poor centration
    c. Fitting not recommended generally
    d. All of the above

11. When deciding on the optimum method of vision correction for athletes:
    a. Environmental factors play an important role
    b. Ocular health plays an important role
    c. Sport regulation requirements play an important role
    d. All of the above

12. Which of the following statements is correct?
    a. Sport eye protection is only advised when it is mandatory
    b. Sport eye protection should only be considered for ametropic patients
    c. Sport eye protection should be recommended, when appropriate, to all patients regardless of spectacle prescription
    d. Sports eyewear is not important over contact lenses
Notes