A STRATEGY FOR SPORTS VISION ASSESSMENT

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An awareness of the importance of the optometric examination has grown over the years and has lead to the need to be able to recognise and diagnose pathology.

What seems to have been sidelined is the importance of the optometric routine, including refraction, as a powerful diagnostic tool and a means of clinically justifying an optical appliance.

Optometry needs to be considered as a whole in which dispensing and clinical practice are inextricably linked and ideally carried out in the same place. It is uniquely different from the job that Ophthalmologists do.

The study of visual performance in the healthy eye, through the visual assessment (screening) of elite athletes, illustrates this.

VISION SCREENING

Everything optometry teaches suggests that there is an inherent advantage in;

- Seeing with two eyes.
- Having both eyes appropriately corrected and orthoptically balanced.
- Being protected against trauma and non ionising radiation.
- Maximising contrast sensitivity.
- Avoiding, recognising and treating pathology.

In addition there is an increasing body of data gathered by the Sports Vision Association *(see Table 1 : Elite groups associated with Sports Vision Association assessments.)*, which is shedding new light on the clinical importance of basic optometric tests *(see Table 2 : On site diagnostic screening tests in the Sports Vision Association battery)*.

Table 1 : Elite groups associated with Sports Vision Association assessments.

The British National Archery squad	Ipswich Town Youth Team
British Women's Hockey team.	The Lilleshall School Of Soccer Excellence.
National and Junior Rifle Teams at Bisley.	Leyton Orient Football Club Senior Squad.
British Olympic Yachting Squad. (Atlanta).	Nottingham Forest U14 Squad.
Yorkshire Cricket Team.	Manchester City F.C. Football Academy, U13 players.
The Scottish Cricket Team.	The All England Netball Association Panel Umpires.
Winter Olympics in Lillehammer and the British Olympic Summer training camp Tallahassee (courtesy Bausch& Lomb).	

Table 2 : On site diagnostic screening tests in the Sports Vision Association battery.

TEST	SIGNIFICANCE
Retinoscopy.	Looking for gross errors, anisometropia, astigmatism.
High and low contrast logMAR vision.	Facilitates statistical analysis to give an accurate measure of changing and different performances.
Dominant eye.	Ocular dominance can cause problems in aiming sports where an arrow is aimed at a target or a foot is aimed at a ball (1).
Accommodation and vergence facility	The durability of these systems (2) is more important in sport than a one off measurement in the office of positive relative convergence.
Brock string	Measures fixation disparity in the sporting context. Raises underlying visual problems to a conscious level
Glare recovery	The ability to deal with glare from stadium lights or a low sun varies considerably in normal eyes. The differential effects of UV light on blue and brown eyes (3,4).
Colour vision and colour preference	Optical properties of tints need to be matched with underlying psychological preference. Recent research in dyslexia migraine (5) and colour deficiencies (6) needs consideration
Dynamic Fixation. Measures eyespeed by a combination of vergence and motility	May give a measure of sporting preference and innate ability (7)
Stereopsis	For confirmation of basic ability time taken as well as level achieved.

A STRATEGY FOR ASSESSMENT OF VISUAL PERFORMANCE

Correlating visual performance with sporting achievement is scientifically very difficult; the result, the number of runs or goals scored, depends on too many variables (the coach, the weather, lighting, condition of the court, the opposition, diet, sleep and so on). Achievement in blind sport (8) suggests that in any case vision is not the overriding concern. Indeed research from the Olympic games (9) suggests that up to 20% of elite athletes compete with visual problems. (There is also a parallel here with visual standards and driving).

Interestingly an overall measure of vision performance in U14 Soccer players correlates very highly (p=0.01) with an independent subjective assessment of their playing skill by their professional coaches (10).

It could be hypothesised that this correlation will decrease in the senior players as the visually (as well as physically) disadvantaged youngsters are lost to the game.

It is safer to say that poor visual performance can be a barrier to achievement in sport and that in some sports certain visual skills clearly contribute to success at the game *(see Table 3 : Important visual skills in different sports)*.

Table 3 : Important visual skills in different sports	
Cricket	Anticipation (batting), Hand eye response (fielding)
Football	Foot eye co-ordination, Peripheral awareness
Archery	Visual acuity, Glare recovery
Sailing	Glare recovery, Motility, Peripheral awareness
Table Tennis	Motility, Hand eye reaction time
Snooker	Stereopsis, Vergence facility
Netball	Depth judgement including stereopsis, Peripheral awareness
Skiing	Contrast sensitivity, Dynamic visual acuity
Hockey	Dynamic visual acuity, Hand eye co-ordination
Athletics Track And Field	Visualisation, Peripheral awareness

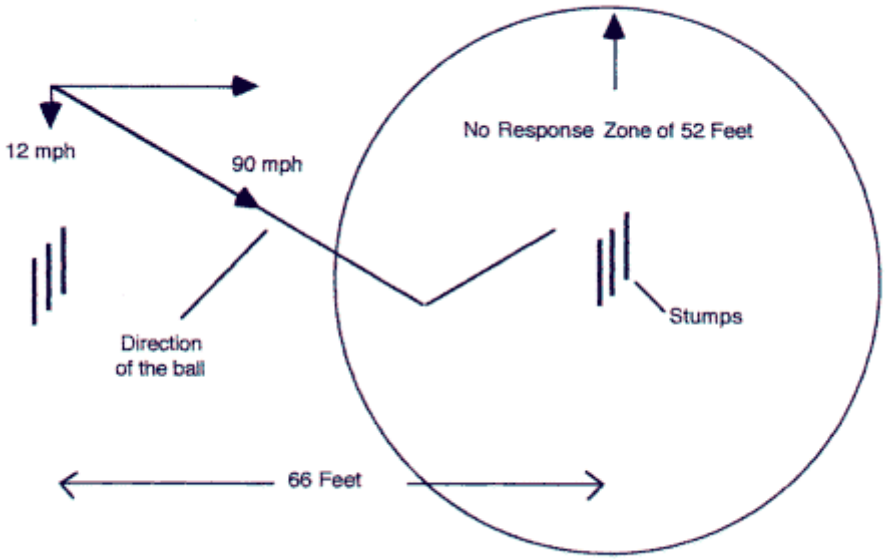
PHYSIOLOGICAL LIMITATIONS

To understand how a visual skill is used in sport, physiological limitations need to be appreciated.

The findings for Hand Eye response time and peripheral awareness (1) have important implications. In cricket for example, response time needs to be related to the speed of the ball and the length of the pitch.

In first class cricket the ball is likely to be delivered by a fast bowler at speeds of up to 90 mph (11). If the pitch is 22 yards long, it takes 0.5 seconds for the ball to travel from one end to the other. For a response time of 0.4 seconds (corresponds to the best response times on the peripheral awareness test and hand eye co-ordination), there will be a zone of 52 feet in front of the batsman (see Fig 2 : Batting zone of no response) where he will not be able to respond to any unexpected change of direction of the ball.

Fig 2. Batting Zone of No Response



ANTICIPATION

By anticipating a course of action, which way the tennis ball will be hit, or the way the cricket ball will turn, response time is improved. Anticipation can make up for the physiological limitations of reaction time and will be affected by visual skills which are amenable to investigation, correction and therapy. *(See Table 4 : Visual skills that facilitate anticipation)*.

Table 4 : Visual skills that facilitate anticipation

VISUAL SKILL	APPLICATION
Eye movements; pursuit; saccade; vergence and motility	Pursuit of the bowlers hand and following the ball
Visual acuity	Bowlers hand grip
Contrast sensitivity	Bowlers hand against the background
Hand eye response time	Reaction to speed and direction of the ball
Accommodation facility	Speed of changing focus
Glare recovery	Dealing with different levels of illumination

MEASUREMENT

Anticipation timing is measured using the Basin Anticipation Timer and a sequenced row of light emitting diodes. Relatively low speeds are used (5, 10and 15 mph) compared with the speed at which the ball is bowled because the apparent speed of the ball moving straight to the batsman is governed by the rate at which it is falling vertically or swerving horizontally.

The components of the speed in these directions are much slower than the actual speed of the ball towards the bat *(see Fig 2 : Batting Zone of No Response)*. The forward movement of the bat may be more of a simple reaction to the release of the ball from the bowlers hand, but sideways and vertical movement in flight can, up to a point, be followed and anticipated.

STRATEGY

Physiologically the human visual system is limited by the rate at which nerve impulses can be transmitted and to a lesser extent by the physical strength of the player. What marks the difference between the novice and the elite player apart from physical development is the ability to anticipate.

Anticipation it would seem depends greatly on rapid interpretation of visual clues. *(See Table 5 : The relevance of visual clues in competitive sport)*.

Table 5 : The relevance of visual clues in competitive sport

VISUAL CLUE	SPORTING RELEVANCE
Ball spin	Cricket. Swing of the ball in the air, direction off the ground. Rugby. Direction of bounce
Direction of gaze	Badminton. Eye movement may signal the competitors intention, or it may be a bluff
Speed and direction of bat	Table tennis. Fast upward movement will impart topspin, fast forward movement a smash
Pattern of play off the ball	Football. Fast movement on the wings would precede a pass from the centre
Body movement	Judo, Football. May indicate nervousness, fluidity, being off balance.
Wind direction	Archery, Rifle Shooting. Direction of wind indicators, flags or trees are critical to the execution of the shot.
Facial expression	Weight lifting. Expressions of defeat or confidence can have a psychological effect on competitors.
Skin colour	Athletics. Excessive redness might be a sign of vulnerability or fatigue
Speed of approach	Cricket. Bowling too fast trying too hard. Too slow has given up
Angle of racket head	Tennis. Direction of the ball after being hit
Hand grip	Cricket. Spin of the ball
Condition of the playing surface	Skiing. At 90mph the quatity of the snow and eveness of the surface are of critical importance

TESTS

Given that visual performance is directly or indirectly important in sport, tests which measure it need to be broadly divided into two *(see Table 6 : Screening strategy)*; those which represent an important visual aspect of the sport (analytical), and those which break down vision into as component parts (diagnostic). If members of the group do badly in the analytical (sport specific) tests compared with their peers, then this could be a reason for poor performance. The results in the diagnostic tests then give an indication of which aspect of visual performance may be at fault.

Table 6 : Screening strategy

TEST	
Analytical	**Diagnostic**
Anticipation Timing Stereopsis	Retinoscopy Dynamic Fixation Vergence Facility Accommodation Facility Contrast Sensitivity Vision logMAR Glare Recovery Eye Hand Dominance Brock String

Using the Scottish Cricket Union as an example (12) anticipation, (which seems important in batting) was taken as the main analytical test. The performance of individual players who did worst on this test, (Mean Anticipation Timing > +/- 10 and / or Standard Deviation >5) are summarised on *Table 7*. Where the same players results in the diagnostic test are below average, these are also shown. The blank spaces are results which are average or above.

Table 7 : Summary of significant data Anticipation Timing at 5mph

	ANALYTICAL			DIAGNOSTIC								
Subject	Anticipation Timing Mean (x100)	Stdev	Stereo	Domin	Brock	Ret	Dyn Fix	Verg	Focus	CS	Vision	Glare
M	10.16		120	L Cross	-0.33	+0.75				L	R	11
D		7.56		R Cross	-1.00			17	8			
B	-11.20			L	1.00			18	10			
G	29.38	21.39		L Cross	-0.11					R	R	
A	11.38	19.33		L Cross	-0.33	+1.5					R	
K	-22.60	23.53	120	L Cross	-0.22		25.76				R	

EXPLANATION OF TERMS AND MEASURES

Anticipation timing
Using the Basin Anticipation timer (see above) a late response (measured to the nearest 100th of a second) is given a positive value and an early response a negative value.

Stereopsis
Measured with the TNO

Dominance
This gives the characteristic for each player. For instance, "L Cross" means left eye dominant but bats or bowls right handed. "L" on its own means left eye dominant and left handed for batting and bowling.

Brock String
It is not possible to quantify individual observations on the Brock String only whether the strings cross in front of, behind, or at the bead. There were three beads on the string which was held in front of the player in three different positions, up, down and straight ahead. If the strings appeared to cross in front of the bead (esophona) this was assigned a value of +1. If it was behind the bead the response was given a value of -1 and at the bead , 0. For each player there were 9 results and to give an indication of overall tendency the average of the assigned values was taken. Someone who always saw the string in front of the bead would have 9 assigned scores of +1 and an average of +1.

Retinoscopy
Estimate of refractive error

Dynamic Fixation (7)
Is a measure of eye speed and is the average in seconds of three sets of three cycles on the instrument.

Vergence Facility
Is the number of times the subject can converge on letters at 6m through a pair of 2 base out lenses, which are repeatedly placed in front of the eyes for a duration of one minute. Focus or

Accommodation Facility
This is the same as Vergence Facility except -2.00 spheres are used instead of prisms.

Contrast Sensitivity
Indicates where an eye is greater than two standard deviations worse than the average for the group in one of the four levels of spatial frequency. (measured on the Vector Vision CVS 1000).

Vision
This is measured as the player presents, as they would be on the field of play. It shows where there is a difference

between the eyes, the eye with the poorer vision at high or low contrast is recorded (all these eyes are within the defined range of average which is between + and - one standard deviation of the mean).

Glare
This is time in seconds to recover, to a 6/9 line of letters, from disability glare caused by a camera flash held at 2/3 of a metre.

INTERPRETATION OF RESULTS

Anticipation

Late anticipation (+) corresponds to exophoria on the Brock string (-) in all but one case. The exception was K whose poor eye speed and inconsistent results (SD 23.53 for anticipation) indicate poor muscle control. Reduced stereopsis and vision (R) may also be significant. Poor timing seems to be associated with reduced stereopsis in two subjects. In the group as a whole 11 subjects (73%) had anticipation times at 5mph which corresponded to the opposite sign in Brock String, this suggests a trend but is not statistically significant.

Ocular Dominance

All the players with poor anticipation were cross dominant (eg right eye left hand or vice-versa) or totally left dominant (left eye left hand). This compares with the remainder of the group (9) with no problems where only 2 (22 %) were cross dominant *(see Table 8a : Incidence of cross dominance with anticipation timing problems)*. The incidence of dominance is different in cricket compared with archery *(see Table 8b : Incidence of Hand-dominance %)*.

Table 8a : Incidence of cross dominance with anticipation timing problems

ANTICIPATION			
Problems		**No Problems**	
Dominance	Incidence	Dominance	Incidence
L Cross	4	R Dom	7
R Cross	1	L Cross	2
L Dom	1		

Table 8b : Incidence of Hand-dominance %

Dominance		**Cricket**	**Archery**		**Meeting Delegates**	
Eye	Hand	Scottish National N=15	Internationals N=16	Coaches N=70	Northern Optical Soc. N=65	SVA Members N=25
Right	Right	46.7	62.5	84.3	78.5	48
Left	Left	6.6	18.75	10	1.5	12
Right	Right	6.6	6.25	2.85	0	8
Left	Left	40	12.5	2.85	20	32
% Cross Dom		46.6	18.75	5.7	20	40

In the National squad of fifteen players, all four of the specialist batsmen were right eye, right hand dominant (uncrossed) and favoured a full on stance and straight head. (Unlike the sideways stance favoured in base ball). It seems that binocular vision is important in batting and that the dominant right eye should not be hindered by facial features or head tilt (13) as it would be in a sideways stance. The incidence of cross dominant players (46.7%) compared with archery (18.7%), suggests that at least one aspect of the game favours this configuration (the side on delivery of the bowler?)

Implications
Using the cricketing example the results suggest that binocular vision and eye dominance are important and that the diagnostic data will indicate which elements of visual function are defective. Poor vergence or focus facility which could affect anticipation timing, might need exercises to improve them using exercises with stereo vectograms or prism and sphere flippers.

In two subjects problems may be solved by correcting hyperopia with contact lenses to reduce esophoria, correct anisometropia and improve vision. Anisometropia and hyperopia can affect stereopsis.

Susceptibility to discomfort glare because of hypo-pigmentation in the iris and retina (14), aberrations from a large pupil, or fluorescence of blue and UV light in the ocular media, could be helped with an appropriate tint (15). A course of action would be confirmed after a full eye examination. Poor recovery from disability glare may not be associated with eye colour. In fact a blue eye which is used dealing with light seems to recover more quickly than a brown eye in subdued light, which is suddenly surprised by a camera flash (1).

DISPENSING CONSIDERATIONS

Seeing as clearly as possible can make up for the physiological limitations of the human nervous system. This has important clinical implications in the dispensing of sports vision appliances.

TYPE OF SPORT

The type of appliance varies considerably with the sport for which it is needed. Sports can be divided roughly into two types *(see Table 9 below)*....

Table 9 : Sport Type

Dynamic	Non-dynamic
Athletics	Archery
Soccer	Bowls
Yachting	Shooting
Squash	Darts
Hockey	Snooker

As the balance in a sport shifts from the dynamic to the non-dynamic, from the physical to the cerebral, so dispensing considerations change. In sports like ice hockey and tennis, things

happen very quickly and there is a great risk of trauma. In chess there is very little movement and a lot of thought, so less risk of eye injuries. The intensity of competition in both these sports however should not be underestimated.

In chess for example, what are the effects of prolonged concentration at the near focal point, how does the light reflect off the board, what is the effect of the ambient light, is it harsh fluorescent or tungsten. What is the level of illumination. Information about muscle balance, individual ocular refraction, eye colour and age become very important. These considerations occur to varying degrees in all sports.

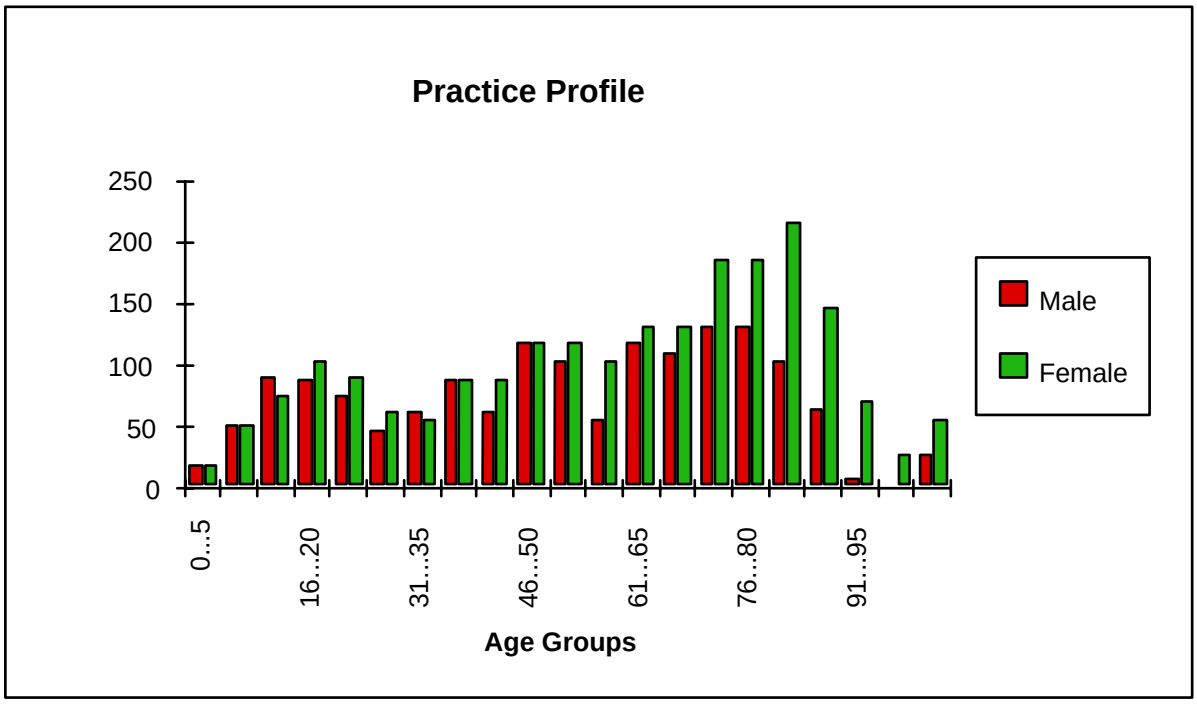
50% of the population is involved in sports in some way or other (17) and the most active age group, 15 - 39 (18), is the least likely to attend for an eye examination. *See Fig 3.*

SPORTS VISION APPLIANCES

Safety is a primary concern in sport and although there is resistance from players to wearing eye protectors most optometrists have no difficulty justifying them. The problems arise when practitioners are unaware of their patients sporting interests and the potential hazards in specific sports. The new British Standard in squash and racket sports (16) makes an interest in sport and close questioning during history and symptoms even more important.

The ophthalmological significance of eye injuries is self evident. Optometrically is could be said that good vision and peripheral awareness helps to avoid them. Seeing the cricket ball early gives time to take evasive action, seeing the movement of a squash racquet in peripheral vision might help to avoid serious injury. It follows that a post injury reduction in visual performance will make subsequent injury more likely and diminish future enjoyment of the sport (poorer performance seems to encourage reduced participation in competitive sport).

Fig 3 : Practice Profile (courtesy Debbie Burns 21.9.95)



CLINICAL CONSIDERATIONS

The shape, size and type of appliance may be governed by the overriding safety requirements and the risks should be emphasised to the player. Design and cosmesis also play an important part in peer approval. But above all vision in all its different ways need to be maximised. Sport at all levels would logically seem to need sustained, clear and comfortable vision. Refractive findings become important and even small prescriptions may be significant in the sporting context *(see Table 10 : Visual components affected by spectacle Rx)*.

Table 10 : Visual components affected by spectacle Rx

• Contrast sensitivity • Binocular balance • Accommodation vergence facility • Depth perception • Peripheral vision (lens size, material and design) • Glare (inappropriate use or non use of tints, scratched lenses) • Asthenopia	• Dominant eye (eg. when the non-dominant eye takes over from a dominant eye, compromised by short sight or obstructions - the string of a bow in archery). • Speed of eye movement (differential prismatic effects caused by poor centration or anisometropia)

VISION IN SPECS

Given the visual requirements of sport and the importance of the refraction, lens materials, coatings and filters become an important consideration *(see Table11 : Clinical reasons for lens specifications)*.

Table11 : Clinical reasons for lens specifications

Multi anti-reflection coat	Increases contrast sensitivity by improving lens transmission and reducing surface internal reflections.
Tint • Contrast discomfort and possibly disability glare. • Visible light	Improve contrast sensitivity, reduce
Scratch resistance	Prolongs good light transmission
Peripheral distortion • Aspherics • Lens size	Maintains peripheral awareness
Water repellent	Maintains lens transmission in rain and spray
Cleaning	Keeps anti reflection coat effective, maintains contrast sensitivity.
Fit	Maintains effective power, keeps appliance stable, prevents vertical prismatic effects.
Comfort	Prevent distractions
Weight	Help to maintain fit and keep comfortable in the active, hot sporting situation
Protection • Trauma • Non ionising radiation	Built in protection with polycarbonate frames and lenses.(16) Address possible hazards to ocular and surrounding tissue health (3,4)

CONTACT LENSES

Contact lenses are usually the correction of choice in sport but their effect on the tear layer and the cornea needs consideration *(see Table 12 : Contact lens considerations)*. In shooting and archery small movements on blinking can be unacceptably distracting.

Table 12 : Contact lens considerations

SPECIFICATIONS	MAINTENANCE
Fit (reduce movement) Aspherics (correct low cyls, Nissel) Bio compatible (comfort) Water content (reduce dehydration) Gas permeable or soft (what are visual replacement requirements?) UV protection (long term health of the eye, compare with specs) Tinting (visual glare, protection. Lunelle)	Wearing Time Stability Protein build up Dehydration Disposable Adaptation Exclusions? • Archery (maximise acuity) • Swimming (keep clean, stick in fresh water*)
* Soft contact lenses stick to the cornea In fresh (hypotonlc) water. This is probably an osmotic effect, not a margInal tightening of the lens. A lens that has been splashed is unsafe to remove for at least 20 minutes after leaving the pool. In salt water (hypertonIc) soft lenses float as freely as they would in a tearing eye (19,20).	

APPLIANCE EXAMPLES

Clinical, cosmetic and functional factors can now be translated into appliances for specific sports. *(See Table 13 : Sports Vision appliances)*.

Table 13 : Sports Vision appliances (21)

SPORT	CONSIDERATIONS
Squash	Safety, weight, peripheral vision, acuity, glare
Archery/ shooting	Eye dominance, occlusion, acuity, Safety
Billiards, snooker	Optical centres, refraction, binocular balance, reflections, frame.
Clay pigeon	Contrast, safety, glare.
Flying	Peripheral vision, UV filters, contrast enhancement.
Skiing	UV protection, visible light reduction, safety, acuity.
Cycling	Sun, optical centres, foreign bodies, wind protection

CONCLUSION

Effective prescribing of sports vision appliances comes from an understanding of the clinical reasons for their use and matching this to the visual needs of sports men and women.

Need for research

Our understanding of the visual performance of the normal eye and the role of optometry in the prevention of eye disease through safe, healthy exercise and good nutrition, is in its infancy. Research in this area would be a natural progression for a mature profession.

ABOUT THE AUTHOR

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