AN INTRODUCTION TO

SPORTS VISION

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INTRODUCTION:

The visual system plays a critical role in sports performance, as it does in the performance of virtually all perceptual-motor skills. To improve sports performance through improving vision an understanding of the visual demands of different sports is required. One also needs to consider the extent that different visual parameters can be modified through vision training. However the ultimate question is whether training certain aspects of the visual system can be translated into improvements with on field performance.

Defining Sports Vision in a clinical environment

Sports vision testing incorporates:

1. Vision screening and testing of athletes
2. The prescription of sunglasses and protective eyewear
3. The management of eye injuries
4. Vision enhancement to improve performance.

THE RELATIONSHIP OF VISION AND SKILLED MOVEMENTS

Skilled movement is not a spontaneous muscular response but represents a sequence of complicated processes within the central nervous system. An athlete absorbs information from the surrounding sporting environment and processes this information. The final output produces a movement response. This model of humans as information processing systems is commonly used to explain the role of vision in producing and controlling skilled movement. The human performance model was originally presented by Welford (1960).

The model assumes that perceptual-motor performance occurs when sensory input information is converted into a purposeful output action. In between the input and output actions information passes through 3 hypothetical central processing mechanisms.

1. Perceptual mechanism

This mechanism receives information from receptors such as the retina for visual information and the inner ear for balance information. The perceptual mechanism reorganises and interprets the information. The selection of information can be influenced by the athlete's previous experiences.

2. Decision mechanism

Information from the perceptual mechanism is passed through to the decision mechanism, which decides the appropriate action. This mechanism is concerned with response selection and strategy formation. This can also be influenced by the athlete's previous experience.

3. Effector mechanism

If the decision mechanism selects a motor response, the relevant information is passed onto the effector mechanism, which controls and organises the sequence

of the desired movement. Neural commands pass from the central nervous system to muscle groups required for the movement. Through feedback this mechanism can control a movement during its execution and evaluate the final result in a way, which allows changes to be made in the future.

"HARDWARE" AND "SOFTWARE" ASPECTS OF VISION

The perceptual mechanism is made up of 2 different levels of visual information.

1. Hardware

The first type of visual information processing involves the reception of visual information; this is affected by the ocular characteristics of the athletes visual system. The hardware components of the visual system can be measured using Orthoptic or Optometric tests and forms the basis for a sports vision eye examination e.g. a snellens chart to measure static visual acuity.

2. Software

The second type of visual information processing involves the perception of visual information this is influenced by the strategies an athlete develops through experience, which results in processing the incoming information more efficiently. Software aspects of sports vision includes information processing strategies, encoding and retrieving perceptual information from memory, extracting relevant information from both advance cues and ball flight cues and the use of anticipatory skills.

SPORTS VISION EYE EXAMINATION

A sports vision eye examination includes a battery of about 20 tests designed to detect visual and/or visual-motor deficiencies that could be effecting athletic performance. Different sports require different visual skills. A cricket player has different visual demands to that of a basketball player.

Examination procedure

1. Static visual acuity,

Visual acuity is the degree of detail the eye can discern in an object. The object can be stationary (static) or moving (dynamic). Static visual acuity (SVA) can be measured on the traditional snellens eye chart where the subject and test object is stationary. However this does not reflect the inherent demands of an open sporting environment where the demand on the eyes are essentially dynamic in nature.

2. Contrast sensitivity

Contrast sensitivity provides a measure of the visual sensitivity to various sized objects at different contrasts. The measurement indicates the least amount of contrast required to detect a visual stimulus. For example a cricket batsmen is subjected to changing lights conditions during day/night games. Picking up the ball in certain lighting conditions is influenced by contrast sensitivity.

Visual Fatigue and ocular muscle balance (tests 3 to 9)
3. Cover test
4. Prism bar cover test or a maddox wing
5. Convergence
6. Accommodation
7. Fusion ranges
8. Ocular movements
9. Stereopsis
Stereopsis is the binocular appreciation of depth. It is a crucial visual parameter in sports where the athlete has to judge distance. For example a golfer must use depth perception when assessing the distance from the fairway to the green which assists in determining which club to use.

10. Eye movements.
Quick and accurate eye movements are essential for surveying the location and movement of the surrounding environment. There are 4 basic types of eye movements.
(A) Saccades
A saccade is a rapid eye movement between two points in space usually at a speed of between 400 and 700 degrees per second. The spectrum of saccadic reaction times exhibits four different modes.

- Long latency regular saccades with reaction times of about 230 milliseconds (ms).
- Short latency regular saccades with reaction times of between 150- 200 ms.
- Express saccades, with reaction times of between 90-130 ms.
- Anticipatory saccades, with reaction times of less than 80 ms.

(B) Smooth Pursuit
Smooth pursuit produces slow eye movements and allows continuous foveation of moving targets. The reaction time between target movement and the initiation of smooth pursuit is 125 - 135 ms. Maximum pursuit velocity to an accelerating target is about 30 to 70 degrees per second. Constant velocity targets can be accurately tracked to velocities approaching 100 degrees per second.
(C) Vestibular system
The vestibular system generates slow eye movements in response to head movement (the vestibulo-ocular reflex (VOR)). The purpose of the VOR is to enable eye position to be maintained during movement of the head and body. **(D)**
(D) Vergence system
The vergence system is responsible for convergence and divergence eye movements.

11. Peripheral vision

Peripheral vision is the ability to maintain an awareness of what is happening outside the direct line of vision. There are physiological limitations to human's peripheral vision. The normal monocular visual field extends to 50-60 degrees superiorly, 60 degrees medially, 70-75 degrees inferiorly and 90-110 degrees temporally. The binocular field is made up of overlapping monocular fields extending to about 200 degrees horizontally and 130 degrees vertically. The blindspot is a physiological area of blindness in the retina, which corresponds with the optic nerve head. The blind spots are compensated by the overlap occurring between each eye.

Therefore peripheral vision training does not make an athlete's peripheral vision larger but merely improves the awareness of the surrounding environment. The faster a player runs the less he is able to process information utilising peripheral vision.

12. Eye-hand dominance

Information from one eye may arrive at the cortical level of the brain earlier than the other eye. If this occurs the information will get processed more rapidly through one eye. Theoretical it may be advantageous to place an athlete where the dominant eye can receive information more quickly. The relationship between the hands and eyes is described as either:

- **Uncrossed eye-hand dominance** (i.e. right eyed and right handed or left eyed and left handed).
- **Crossed eye-hand dominance** (i.e. right eyed left handed or left handed right eyed)
- **Central dominance** (i.e. central eyed and right handed or central eyed and left handed).

A common belief is that crossed dominant baseball batters have a batting performance advantage over uncrossed batters. This belief is based on the theory that the dominant eye has a better angle for viewing the incoming ball and is able to process visual information up to 21 milliseconds faster than the non-dominant eye.

13. Colour vision and general ocular health

VISUAL-MOTOR ASSESSMENT

1. Eye hand coordination.

Eye-hand coordination is defined as a perceptual-motor skill involving the integration and processing in the central nervous system of visual and tactile information so that purposeful motor movements can be made. (Paillard, 1990)

2. Peripheral awareness reaction time

Peripheral awareness reaction time measures how quickly an athlete is aware of an object in his peripheral vision. In team sports peripheral awareness is a crucial skill.

3. Total reaction time
This represents the measurement of reaction time plus movement time based on responses from the visual, auditory and motor systems. First step explosiveness and the ability to get off the mark quickly is an important component of visual-motor performance.

4. Eye/foot coordination
Eye/foot coordination is the ability of the feet to respond in a smooth and coordinated manner as a result of information provided by the visual system.

5. Coincidence anticipation
Coincidence anticipation is the ability to make a motor response coincident with the arrival of an object at a designated point e.g. predicting the arrival of a pitched ball in baseball.

How do coaches/vision therapists train the visual system?
Vision training techniques that are currently conducted by coaches and vision therapists can be divided into 4 categories.

(a) Classical vision training
(b) Visual-motor performance
(c) Visual awareness training
(d) Perceptual training

(a) Classical vision training is based on deficiencies detected during a sports vision eye examination. Orthoptic vision training therapies are proven methods based on scientific principles. Success rates vary from 61.9% (Birnbaum et al 1999), to 91% 9Grisham 1988) to 100%(Wicks 1994). The important question is;

(b) Visual-motor performance
An important component in sports vision testing is the assessment of visual-motor performance. Investigating the processing of visual information and its link to motor output enables sports vision practitioners to test sports specific functions. This includes eye-hand coordination, peripheral awareness reaction time, eye-foot coordination, coincidence anticipation and total reaction time.

(c) Visual awareness coaching
Calder, 1998 has provided scientific evidence for this form of vision training. Calder advocates the use of on field sports specific visual coaching to maximize the athletes use of their visual system. In her research she showed that a combination of classical vision training and visual awareness coaching improved 12 of 22 hockey skills tested

(d) Perceptual training
This is based on developing visual search strategies and effective decision making. Abernethy 1999 showed that a novice could be trained to produce similar anticipatory skills to an expert.

In the complex area of training visual perceptual skills this model of vision training provides coaches with a better understanding of the role of eye-hand coordination in sports performance.