2013-11

Establishing Normative Data for the Visual Skills of Gaelic Footballers

Valerie Kennelly
Technological University Dublin

ESTABLISHING NORMATIVE DATA FOR THE

VISUAL SKILLS OF GAELIC FOOTBALLERS

Valerie Kennelly B.Sc. M.C.Optom

A thesis submitted to the Dublin Institute of Technology

for the degree of Master of Philosophy

School of Physics

Dublin Institute of Technology

Kevin Street, Dublin 8

Submitted: November 2013

Abstract

Although sports vision procedures have been implemented in many sports worldwide, no rigorous scientific investigation of the visual skills trends of Gaelic Athletic Association (GAA) participants has been carried out in Ireland to date. The aim of this study was to identify the visual skills required to play Gaelic football and to establish normative data for those skills which can be used to classify, superior, above average, average, below average and inferior visual performance. Hardware visual skills including high and low contrast vision, stereo acuity, colour vision, and contrast sensitivity and software skills including eye hand co-ordination, dynamic fixation and anticipation timing were studied.

This work also compared the visual skills of Gaelic footballers playing at county (n=61) and club (n=46) level. With the exception of Wayne Pro-Action, Wayne Reaction, and vision 90% right there was a significant difference in the other visual test results between county and club level players. County players performed significantly better than club players in tests to assess vision 90% left, 90% binocular, 10% right, 10% left, 10% binocular, dynamic fixation and anticipation timing. In contrast, club players performed better than county level players for contrast sensitivity. Approximately 56% of county and club level players had a stereo acuity value of 60 seconds of arc. No recordable stereo acuity was found in 11% and 15% of county and club level players respectively. A larger proportion of club players (6.5%) had a colour deficiency than county level players (1.6%).

Normative data can now be provided to Irish Optometrists, enabling improved visual care for this group of participants, as it provides a frame of reference when interpreting optometric test results carried out on Gaelic footballers and identifies areas of deficiencies that need to be addressed.

Declaration

I certify that this thesis which I now submit for examination for the award of Masters of Philosophy, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for post graduate study by research of the Dublin Institute of Technology and has not been submitted in whole or in part for an award in any other Institution or University.

The work reported on in this thesis conforms to the principals and requirements of the Institute's guidelines for ethics in research.

The Institute has permission to keep, to lend or to copy this thesis in whole or in part, on condition that any such use of the material of the thesis is duly acknowledged.

Signature Date

Valerie Kennelly

Acknowledgements

First and foremost I would like to thank God for giving me wisdom support and guidance throughout my life.

To my husband Alan and son Tom thank you for your endless love support and encouragement throughout this project and always. You make everything worthwhile.

For my parents who instilled in me a work ethic and the desire to be the best I can be for the love and support you always show me I am truly grateful.

I would like to express my deepest gratitude to Professor Mary Mc Namara for the support and kindness she has shown me throughout, without her encouragement professionalism and attention to detail I would have never have been able to complete this thesis.

A special thanks to Dr. Glyn Walsh of Glasgow Caledonian University who lectured me as an undergraduate. Your encouragement throughout my undergraduate degree instilled in me a love for Optometry that I still hold strong today. Your door was always open then and is still open now and for that I owe you a huge debt of gratitude. I strive daily to be the Optometrist you encouraged us all to be.

Sincere thanks to David Gildea who helped with the data collection.

I would also like to thank the managers and players who participated in this study.

Finally I would like to thank the GAA for the difference it makes in so many lives on so many different levels throughout the world.

Abbreviations

AOA	American Optometric Association
B	Binocular
CNS	Central Nervous System
DFT	Dynamic Fixation Timer
ESRI	Economic and Social Research Institute
GAA	Gaelic Athletic Association
I'national	International
LE	Left Eye
LTM	Long Term Memory
Min	Minute
Hr	Hour
N	Number
NTO	National Task Force on Obesity
PHN	Public Health Nurse
PNS	Peripheral Nervous System
RE	Right Eye
Sec	Second
Sec of Arc	Seconds of Arc
SSIA	South African Sports Information and Science Agency
Std dev	Standard Deviation
STM	Short Term Memory
SVT	Sports Vision Trainer
T&F	Track and Field
TNO	The Netherlands Organisation for Applied Scientific Research

UK United Kingdom

US United States of Americia

Yr Year

WHO World Health Organisation

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER I

Introduction

1.1 Background

Eye care has a formative role in the lives of children particularly, in the development of balance, co-ordination, and learning skills. It can affect social skills, confidence and educational potential. Optometrists need to advise clients about when a refractive correction (spectacles or contact lenses) should be worn. There are EU guidelines governing the vision standards required to operate a visual display unit. The driving lice authority outline the vision standards required to drive a car. These standards not only specify what line on a test chart a person must be able to read but also the field of vision required, the binocular status of the eyes and the contrast sensitivity function of the eyes. Optometrists have a responsibility to advise drivers about the legal vision standards required to drive but as yet there are no accepted standards or guidelines for the vision required to play Gaelic games.

It is generally accepted by optometric associations around the world that 80% of learning is performed through vision and that deficiency in the visual system may ultimately result in learning difficulties. In Ireland at present optometrists are not involved in the school vision screening service provided by the Health Service Executive (HSE). According to the American Association of Optometrists 33% of children between 6 months and 5 years 11 months are farsighted and 23% of children between 6 years and 18 years are farsighted.(http://www.aoa.org/patients-and-public/good-vision-throughout-life/childrens-vision?) In many cases even moderate levels of farsightedness will not be identified in the current school vision screening service. Furthermore, moderate levels of anisometropia (unequal refractive error), are undetected unless one eye has become amblyopic prior to the screening. Public health nurses are not trained to carry out refraction and therefore cannot be expected to identify those children requiring attention.

When undertaking an assessment of a child to establish for the presence of dyspraxia details will be required regarding the child's development history, intellectual ability and gross and fine motor skills. Gross motor skills refer to how well the child uses his/her large muscles to co-ordinate body movement. This includes jumping throwing walking running and maintaining balance. Fine motor skills refer to how well the child can use his/her smaller muscles. Activities which require fine motor skills include beading, cutting out shapes with a scissors, colouring, writing, tying shoelaces and doing up buttons. A diagnosis of dyspraxia can be made without a child having to undergo a full sight examination. Anecdotal evidence from educational psychologists, occupational therapists and physiotherapists suggests that the role of vision in balance and co-ordination has not been adequately addressed as part of their professional training.

There is a similar lack of awareness of the importance of vision in sport. Many of the managers approached to take part in this study felt that the players would know themselves if they required an eye examination or ocular intervention. Managers were unaware if any of the panel members wore contact lenses, had a lazy eye or were colour blind. This study attempts to increase the awareness of the importance of vision.

1.2 Introduction to vision

The human eye is the organ that gives us the sense of sight. It is only about 25mm in diameter and it is estimated that it contains about 70% of all the sensory receptors in the body. It is believed that visual skills and their components accounts for 80% of the sensory information that an athlete's brain receives about its sporting environment. (Marieb 1992; Buys 2008)

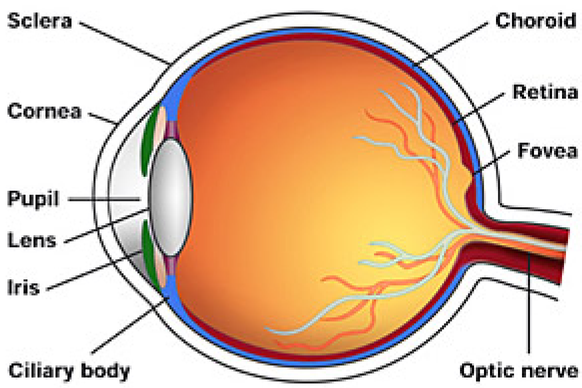


Fig 1.1 Anatomical components of the eye.
The cornea is a clear dome at the front of the eye it is responsible for 2/3 of the focussing power of the eye. The Iris is the coloured part of the eye and the pupil is an aperture in the centre of the iris that regulates the amount of light entering the eye. The crystalline lens is held in position by the ciliary muscle and can increase it's refractive power to enable the eye to focus on a near or distance object. The retina forms the lining at the back of the eye it contains millions of photoreceptors (rods and cones) which convert light rays into electrical impulses that pass along the optic nerve to the brain where they can then be perceived as images.(https://www.google.ie/search?q=diagram+of+the+eye 2014)

Fig 1.1, shows some of the basic anatomical features of the eye. The cornea is a transparent dome shaped window which covers the front part of the eye. It is only about ½ mm thick and is responsible for about 2/3 of the eye's focussing power. It is avascular (without blood vessels) and very sensitive as it has more nerve endings than anywhere else in the body.

1.2.1 The Iris

The iris is the coloured part of the eye the colour pattern is as unique a fingerprint. The aperture in the centre of the iris is called the pupil. It appears black because light rays entering the pupil are absorbed by the tissues of the eye. The iris is embedded with tiny muscles which control the amount of light entering the eye similar to the aperture in a camera.

1.2.2 The Crystalline Lens

The crystalline lens is a transparent biconvex structure which is situated behind the iris. Unlike the cornea whose curvature and therefore refractive power (ability to converge light) is fixed, the lens can change it's curvature becoming steeper for near vision and flatter for distance vision. The lens is held in place behind the iris by the ciliary body and ciliary muscles. When the ciliary muscles contract the lens becomes bore bulbous thereby increasing it's focussing power. The process of increasing the refractive power of the lens is called accommodation.

The retina is a multi layered sensory tissue at the back of the eye. It contains millions of photoreceptors that convert the light rays into electrical impulses which in turn travel along the optic nerve to the brain where they are processed into images. There are two types of photoreceptors rods and cones. There are approximately 125 million rods spread throughout the peripheral retina they are responsible for peripheral vision and low light vision but do not allow one to see colour.

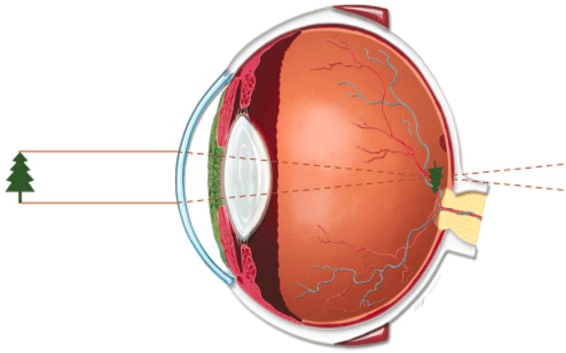


Fig 1.2 Retinal image formation
The eye can be compared to a camera. A camera uses lenses to focus light on a film to create a picture. Similarly the eye focuses light on the retina using the cornea and crystalline lens to create an image.(https://www.google.ie/search?q=camera+and+pencil)

There are approximately 6 million cones in the eye. They are situated in the macula which is responsible for central vision. They are most densely packed at the fovea, the very central portion of the macula. Cones are most sensitive to bright light and enable colours to be perceived.

1.2.3 The Optic Nerve

The optic nerve contains over one million nerve fibres and it connects the eyes to the brain. It is part of the central nervous system (CNS). It carries the electric impulses created when light activates the photoreceptors in the retina to the brain. In turn the brain processes these impulses into images.

1.2.4 The Visual Pathway

The visual pathway illustrated in figure 1.3, is the name given to the neural pathway from the retinal receptors to the visual cortex at the occipital lobe of the brain, via the optic nerve, chiasma optic tract and optic radiations.The right and left optic nerves merge at the chiasma. Here the nasal nerves from each retina cross the midline and enter the optic tract on the other side. The nerve fibres from the temporal half of the retina pass into the optic tract of the same side. The optic tract continues from the chiasm and is thought to terminate largely although not exclusively at the lateral geniculate body the remaining fibres end in the colliculus, diencephalons, midbrain and brainstem. (Missankov 2000)

The electrical impulses continue along the visual pathway along the optic radiations which are nerve fibres arising from nerve cells in the lateral geniculate body and terminate in a fan-shaped manner at the visual cortex at the occipital lobe of the brain.

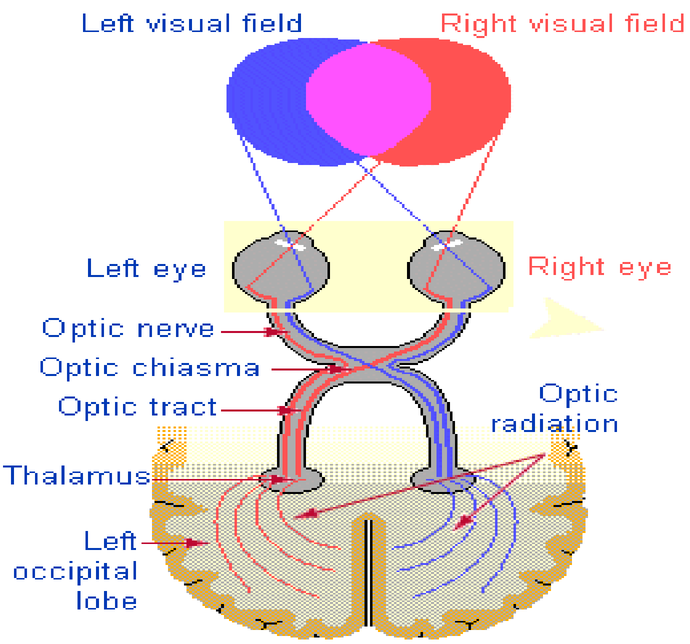
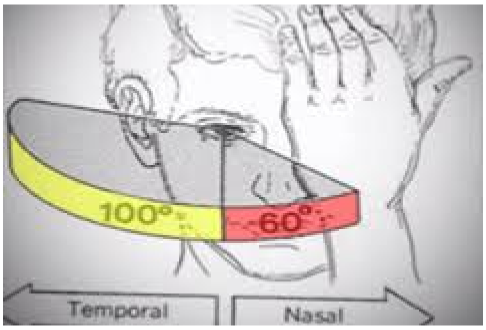


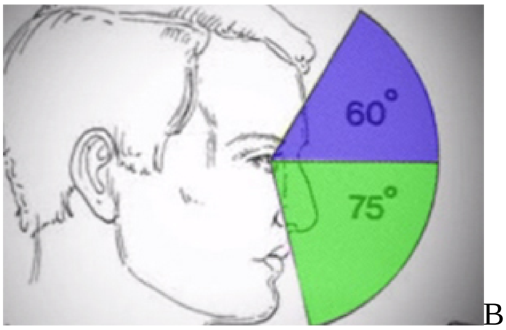
Fig 1.3 The visual pathway
Electrical impulses generated when light activates the photoreceptors in the retina pass along the visual pathway to the visual cortex at the occipital lobe of the brain where they are interpreted as images. The nasal nerves from each eye cross to the opposite side at the chiasma. The temporal nerves pass to the optic tract on the same side.**(https://www.google.ie/search?q=visual+pathway+anatomy)**

1.2.5 The Visual Field

The visual field has been defined as the entire area that can be seen when the eye is directed forward including that which is seen with peripheral vision. (http://www.medterms.com/) The dimensions of the visual field have been recorded as being 60° superiorly (upward) 75° inferiorly (downwards) 60° nasally (to the left in the right eye and to the right in the right eye), and 100° temporally (to the right in the right eye and to the left in the left eye). (Henson) The dimensions of the visual field are illustrated in figure 1.4.



A



B

Fig 1.4 Visual Field
The temporal field of vision in each eye extends 100° temporally, 60° nasally, 60° superiorly, and 75° inferiorly.**(https://www.google.ie/search?q=diagram+showing+fixation+axis+of+visual+field)**

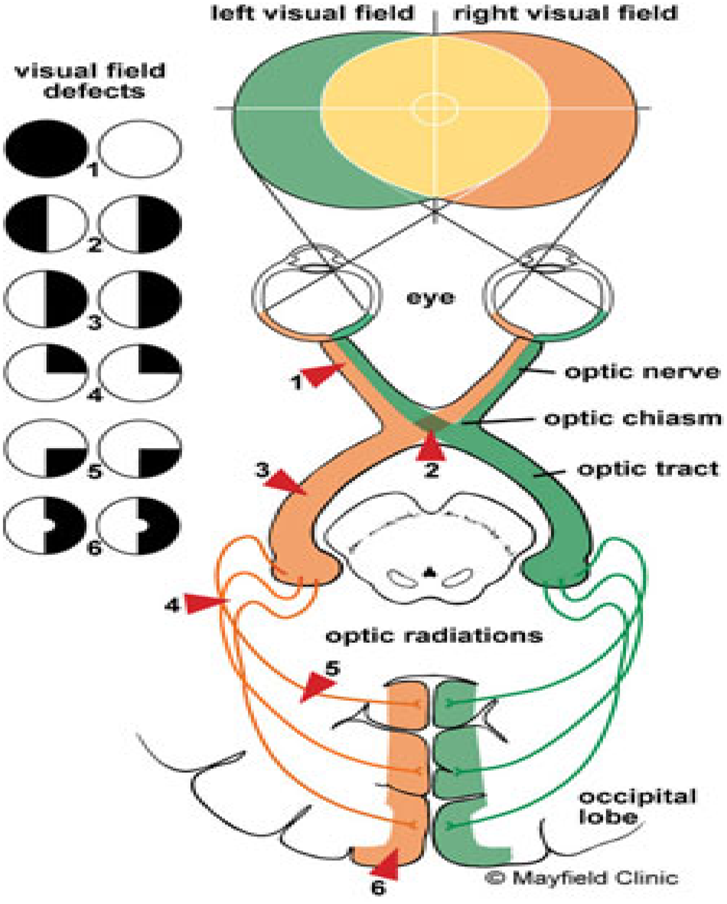


Fig 1.5 Visual Field Loss.
Lesions or damage to the nerves on the visual pathway caused by trauma or disease may result in visual field loss. The type of field loss depends on the position of the lesion. Pre chiasmal lesion on the left optic nerve will only result in a field loss in the left eye whereas post-chiasmal (ie after the chiasma) lesions will affect both eyes.
(https://www.google.ie/search?q=visual+pathway+lesions+and+visual+field+defects)

Lesions (damage) to the visual pathway caused by trauma or disease may result in a visual field loss. The nature and position of the field loss depends on the location if the lesion as illustrated in figure 1.5. Pre-chiasmal lesions on the left hand side of the visual pathway will only affect the visual field of the left eye whereas post chiasmal lesions can affect both sides of the visual field.

Sometimes the image formed on the retina will be out of focus. The most common reasons for retinal blur are myopia (short sightedness) (figure 1.6) hyperopia (far sightedness) (figure 1.7) and astigmatism (figure 1.8).

1.2.6 Myopia

Myopia results from the incoming light coming to focus before the retina.

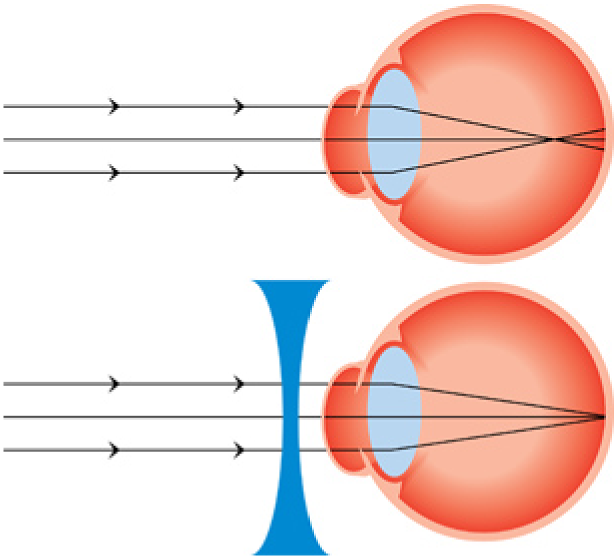


Figure 1.6 Myopia
Myopia occurs when the light comes to focus before it reaches the retina. Myopia is corrected using a bi-concave lens. (http://resource.rockyview.ab.ca/rvlc/physics30)

1.2.7 Hyperopia

Hyperopia is due to the light entering the eye from a distant object not coming to focus by the time it reaches the retina. A bi convex lens is used to converge the light entering the eye bringing it to focus on the retina.

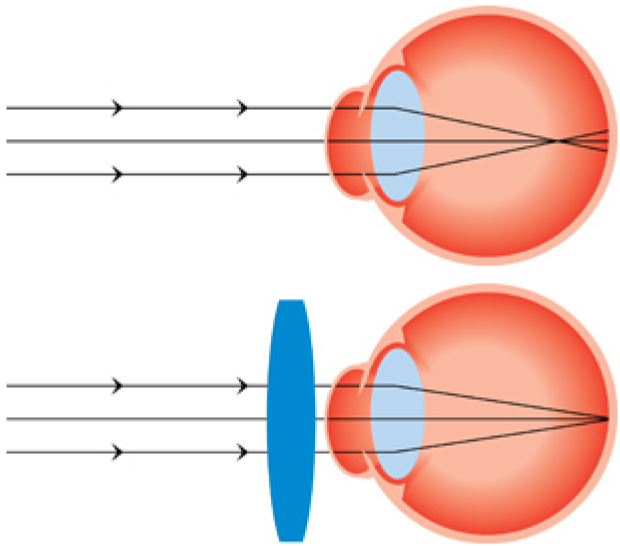


Figure 1.7 Hyperopia
Hyperopia is corrected using a bi-convex lens. The above figure shows a hyperopic eye. The light converges to focus behind the retina on the top illustration resulting in a blurred image being observed. The light can be brought to focus using a bi-convex lens as seen in the bottom illustration. **(https://www.google.ie/search?q=images+for+hyperopia)**

1.2.8 Astigmatism

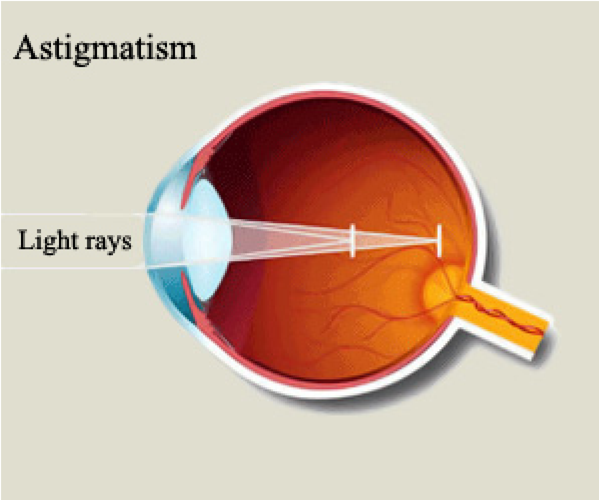


Figure 1.8 Astigmatism
Astigmatism is corrected by using a toric lens. Above showing that light rays come to focus at two different points in an astigmatic eye. This is the most commonly found refractive error. The light can be brought to focus on the retina by using toric lenses.(https://www.google.ie/search?q=definition+of+astigmatism+eye)

Astigmatism results from the cornea or lens being toric instead of being spherical in shape (ie shaped more like a rugby ball than a football). This is the most common type of refractive error.

Anisometropia is the term used for when the refractive (focussing) error is different in each eye.

1.2.9 Extraocular Muscles:

The eyeball is surrounded by layers of soft fatty tissue. These layers allow easy movement and protection of the eyeball. Traversing the fatty tissue are three pairs of extraocular muscles (fig 1.9), the superior oblique, the medial oblique and the inferior rectus muscles. These muscles allow the eye to rotate about its' vertical, horizontal and anterior-posterior axes.

There are six cardinal positions of gaze, up to the right, up to the left, down to the right, down to the left, right and left. These positions allow comparison of the horizontal vertical and diagonal ocular movements produced by the six ocular muscles when both eyes and multiple muscles are working together.

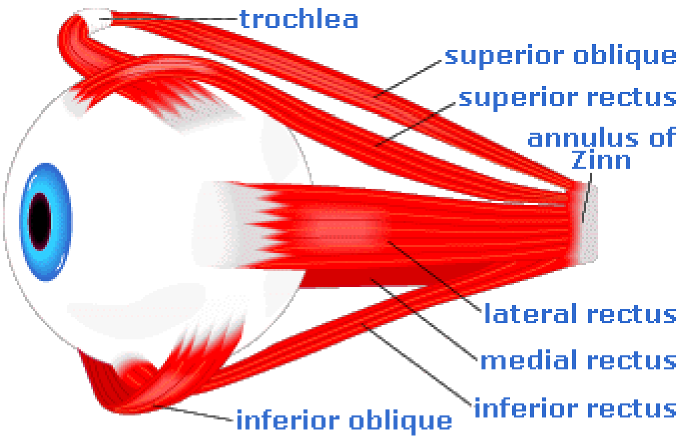


Figure 1.9 Extraocular muscles.
***The eye is surrounded by a layer of soft fatty tissue. Traversing the soft fatty tissue are three pairs of extraocular muscles, the superior oblique, the inferior oblique and the medial rectus muscles. These muscles allow the eye to move about it's vertical, horizontal and antero-posterior axes*.(http://www.tedmontgomery.com/the_eye/eom.html)**

In each position of gaze a muscle of one eye is paired with a muscle of the other eye to move the eyes together in a certain direction.

Figure 1.10 below shows the pairs of muscles involved with moving the eyes to each position of gaze. The diagram also shows three other positions of gaze, up, down and convergence.

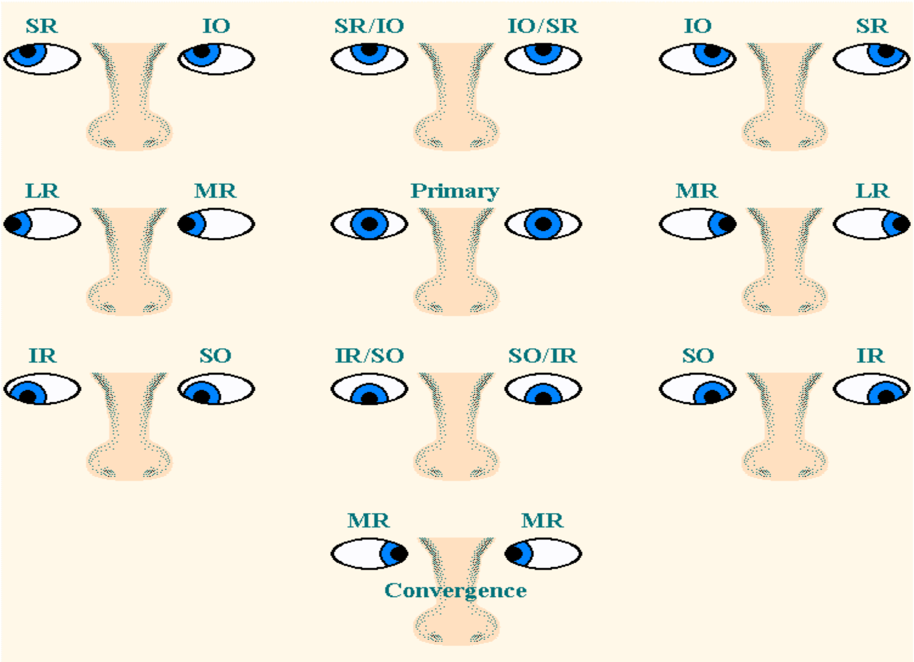


Figure 1.10 Six cardinal positions of gaze.
The six cardinal positions of gaze are illustrated above, up to the right, up to the left, down to the right, down to the left, right and left. For each of these six positions the muscle of one eye is paired with a muscle of the other eye to move the eyes together in a certain direction. Also illustrated is the primary position, upward gaze, downward gaze and convergence. **(https://www.google.ie/search?q=image+of+extra+ocular+muscles)**

1.2.10 Binocular Vision

Binocular vision is defined as the ability to maintain focus on an object with both eyes creating a single visual image. (http://www.medterms.com/) Binocular vision enables stereopsis which is the most precise kind of depth perception. Normal binocular single vision requires relatively well focussed vision in each eye, the ability of the retino-cortical elements to function in association with each other to promote sensory fusion (i.e. the fusion of two slightly dissimilar images) and the precise co-ordination of the two eyes for all directions of gaze enabling motor fusion. A disruption to binocular vision could result in diplopia (double vision). If binocular vision fails to develop normally or if it is interrupted due to, trauma, disease, or unequal retinal image formation could result in a reduced field of vision and a reduction in depth perception. (Bhola 2006)

1.2.11 Colour Vision

Colour Vision is defined as the perception of different colours making up the spectrum of light. (Saunders 2007) the retina has three types of cones with absorption spectra that peak in the long, middle and short wavelength ranges, respectively. By adjusting the activation of the three cone types by normal observers the full spectrum of human colour sensation can be elicited.

1.3 Aims and Objectives

The aim of this work is to identify the visual skills required to play Gaelic football and to establish normative data for those skills which can be used to classify, superior, above average, average, below average and inferior (needs attention) visual performance.

The first objective is to examine Gaelic footballers for

- High and Low Contrast Vision
- Contrast Sensitivity
- Dynamic Fixation
- Co-incident Anticipation Timing
- Eye-Hand Co-ordination
- Stereo Acuity
- Colour Vision

This test selection allows assessment of some hardware skills (high and low contrast vision, contrast sensitivity, stereo acuity and colour vision) and some software skills (co-incident timing, eye-hand co-ordination and dynamic fixation). The tests used to examine these skills are discussed in chapter two. Most of the tests selected are in common use in optometry practice, portable and light and the battery of tests should be completed in 20 min. This allowed two examiners to assess 6 players per hour and a panel of 30 players in 5 hr.

The second objective is to compare and contrast the visual skills of County and Club Gaelic football players using this normative data. Normative data can then be provided to Irish optometrists enabling improved visual care for this group of participants as it will provide a frame of reference when interpreting the results of optometric tests carried out on Gaelic footballers and help in the identification of areas of deficiencies that need to be addressed.

CHAPTER II

Review of Literature

2.1 Social Benefits of Sport

The World Health Organization (WHO) in its European Health Report 2009 estimates that physical inactivity causes 600,000 deaths annually in the European region, is responsible for between 5 and 10 % of the total mortality in each of the 53 European region member countries and that premature mortality and disability results in the annual loss of 5.3 million years of healthy life. (WHO 2009) From studies in the United Kingdom (UK) and Switzerland, insufficient physical activity is estimated to cost European countries between €115 and €230 per person per annum. (WHO 2009) The national taskforce on obesity (NTO) has estimated that 39 % of Irish adults are overweight and 18 % are obese. They estimate that this trend is increasing by 1 % per year. In 2005, it was estimated that 2,000 premature deaths in Ireland were attributed to obesity and that these deaths could be costing the state around €4 billion annually. (Children 2005; WHO 2007; WHO 2009; Executive 2011). Conversely, increased levels of physical activity are associated with lower mortality rates, lower costs to the economy and enhanced psychological well-being. (General 1996)

2.2 History of Sports Vision Research

One of the first published references to vision and its importance in sport was a report in 1921 on the American baseball player, Babe Ruth. The report concluded that his "coordination between eye, ear, brain and muscle is much nearer perfection than that of the normal healthy man." (Fullerton 1921) The optometry profession became more involved with sports vision research in the 1970's with the improvement in soft contact lens technology. A survey carried out by Bausch and Lomb in 1977 found that 86% of professional baseball, football, basketball and ice hockey players who required vision correction used contact lenses and of those 50 % wore soft contact lenses. (Lieblien 1986) It was 1978 before the American Optometric Association (AOA) established a sports vision section, the first organisation of its kind to allow practitioners a venue for continuing education and access to professional materials such as sports vision guidebooks and sports vision bibliography. (Erickson 2007) Subsequently, other organisations dedicated to sports vision and sports vision research were established throughout the world.

The Canadian Association of Optometrists Sports Vision section was established in 1987 followed by the European Academy of Sports Vision in 1989. The Optometrist Association of Australia established a sports vision section in 1992 and the Sports Vision Association was established in 1993 in the UK. (Erickson 2007) To date, Ireland has no sports vision association.

2.3 Norms for Visual Screenings

Visual screenings for athletes were reported in the 1960s. Ferreira in an overview of sports vision research, reported on studies by Bauscher, Martin and Garner. (Bauscher 1968; Martin 1970; Garner 1977; Ferreira 2003) Between 1964-1966 Bauscher (1968) measured visual acuity, refractive error, pathology, tropia, lateral and vertical phorias and depth perception in 368 athletes and concluded that 28% had inadequate vision required to maximise athletic performance. (Bauscher 1968) Martin reported a failure rate of 22% in 809 athletes who underwent similar screening (Martin 1970). Neither Bauscher nor Martin reported on the norms on which the test scores were based.

Sports vision research grew rapidly, particularly in the US, in the 1980s (Christenson 1988; Buys 2008) However, the results were subject to bias and criticism from optometrists due to the lack of standardized scores. Planer (1994) categorised visual skills on an arbitrary basis into five groups of superior, above average, average, ineffective and needs immediate attention. (Planer 1994) Buys and Ferreira (2008) further developed on these five categories and established normative for static and dynamic visual acuity, contrast sensitivity, colour discrimination, stereopsis, focus and fusion flexibility, central-peripheral awareness, eye-hand and -body coordination, visual response time and adjustability data in 64 female and 94 male athletes (Buys 2008). The study participants were selected by the South African Sports Information and Science Agency (SISA) and were classified as emerging talent or established international level athletes. Subjects were not categorised by age, gender or sport as the authors wished to establish an overall picture, which could be useful for comparative purposes.

The mean and standard deviation method is based on the fact that 68% of the values in a normal distribution are within 1 SD of the mean. However, not all data is distributed normally. In addition, the mean and standard deviation method may not be suitable some test results. For example, the maximum possible score for eye-hand reaction using the Wayne Saccadic Fixator is 30. If the mean is 26 and the SD 4 then according to Buys and Ferriera's classification method an individual would require a score >34 (mean + 2 SD) to be classified as having superior eye-hand reaction. Since a score of 34 exceeds the maximum possible score achieveable (30) it would not be possible for any player to be categorised as having superior eye-hand reaction skills. Buys and Ferreira used the percentage method to address this problem. The percentage method classifies individuals as superior if they achieve a score in the top 10 percentile. Above average, average and below average classification is based on achieving scores between the 70^{th} and 90^{th}, 50^{th} and 70^{th} and 50^{th} and 25^{th} percentile, respectively. Individuals scoring in the bottom 25% are classified as requiring attention. Loran and Griffiths (2000) used a similar classification system but with different definitions for each category.

Normative visual scores for archers (Strydom, 2009) were found to be lower than those reported for elite athletes by Buys and Ferreira (Strydom 2010). Many of the studies investigating visual skills in athletes used a correction (spectacles or glasses) during testing only if the correction was worn when participating in sport (Buys 2008; Potgiter 2009; Strydom 2010). A study investigating the difference in visual skills between professional and amateur rugby players did not record the use of correction during testing or provide any information in relation to refractive error. (Ludeke 2008)

Visual categories were based on percentile or standard deviation (SD) scores and are summarised in Table 2.1.

Table 2.1 Categories for sports vision evaluation

	Classification Method		
	Percentage*	**Mean SD***	**Mean SD^**
Superior	Top 10 %	> 2 SD above mean	>3 SD above mean.
Above average	90 - 70 %	1-2 SD above mean	2-3 SD above mean.
Average	70 - 50 %	Mean – 1 SD above mean	+/-1 SD of mean.
Below average	50 - 25 %	Mean – 1 SD below mean	1-2 SD below mean
Needs attention	25 - 0 %	>1 SD below mean.	2-3 SD below mean

*Buys and Ferreira. (2008) ^Loran and Griffiths (2000)

2.4 Visual Skills for Sports

Visual skills have been divided into hardware and software skills. (Abernethy 1986; Williams 1993; Williams 2002) Hardware skills refer to the innate physical and physiological aspects of vision such as static and dynamic visual acuity, peripheral vision, depth perception ocular motilities and heterophorias, contrast sensitivity and stereopsis. Software skills are learned skills such as eye-hand co-ordination and anticipation timing. It is considered that the hardware system may set the potential limit to visual performance in sport. (Abernethy 1987; Ludeke 2008; Potgiter 2009) However, it is thought that it is the software skills that separate the expert players from the non-expert players. (Williams 1993; Venter 2004; Ludeke 2008; Potgiter 2009)

The perceptual mechanism includes the sense of vision, smell, touch and hearing with vision being the dominant sense. An estimated 70 % of all the sensory receptors in the body are located in the eyes. . It is believed that visual skills and their components accounts for 80% of the sensory information that an athlete's brain receives about it's sporting environment. (Marieb 1992; Mc Morris 2004) This information is relayed to the central nervous system (CNS). The amount of information that can be thoroughly processed is limited by the sensory channel capacity. The CNS interprets incoming information by filtering out irrelevant information in favour of relevant cues. This process is referred to as selective attention and information processing theorists claim that memory plays an important role in aiding this process. (Venter 2004)

McMorris (2004) outlines how information is filtered by the CNS. Determination of what information is relevant takes place in short-term memory (STM) which is guided by past experience and information stored in the long-term memory (LTM). This process allows the observer to concentrate only on the relevant information and in-turn makes a decision. Once a decision on how respond has been made the sends information to the peripheral nervous system (PNS) and movement takes place. Once movement starts feedback is processed. In slow movements feedback can be used to refine or alter actions as they are taking place. Feedback to LTM relays information about the success or failure of our actions, and is responsible for learning.

Before an athlete can react to a ball (CNS instructs the PNS as to what movement needs to take place) it must first be sighted and its speed trajectory and susceptibility to factors like wind or deflections off another player, racquet, bat etc., needs to be assessed by the visual system. As LTM and STM also play a role in skill acquisition it seems logical that maintaining an effective visual system throughout an athlete's career is advisable. Indeed, a deficiency in the visual system during childhood may result in difficulties learning sports skills.

2.4.1 Dynamic and Non-Dynamic Sports

The visual skills required for different sports can vary greatly. For example, a golfer will require a steady image to be processed and peripheral awareness is less important. In contrast, a down-hill skier may require exceptional peripheral awareness. Sports can be categorised as either non-dynamic (static) or dynamic (fig 2.2). (Erickson 2007) In a dynamic sport the athlete performs while in motion, whereas in a static sport the athlete remains relatively motionless allowing time to analyse the visual information.

Table 2.2 Examples of non-dynamic and dynamic sports

Dynamic	Non-Dynamic
Football	Archery
Hurling	Golf
Rugby	Shooting
Skiing	Snooker

Intermittent field based sports such as Gaelic football, soccer and Australian Rules are dynamic in that the players and the ball are constantly moving. and as they change he/she must be able to process the different information while also maintaining balance as he/she moves with regular interrupted views of the action. The visual skills required for Gaelic football will be much different to those required for golf. A golfer can take time to consider each shot and has longer to process the visual information required prior to swinging the club.

In order to identify the visual skills required by Gaelic footballers the practitioner must first have an understanding of the game, the pitch dimensions, ball size, jersey colours, and the rules of the game. Gaelic Games

2.5 Gaelic Games

Gaelic football is the most popular sport in Ireland with 12,950 teams registered in 2011. (GAA 2012) Over 1.3 million people attended championship games in 2011. (GAA 2012) Gaelic football is a hybrid of soccer, rugby and basketball, although it predates all of those games. The ball used is similar in size to that used in soccer. It is 69 – 74 cm in diameter and weighs approximately 460 g. The playing area is 130 - 145 m in length and 80 – 90 m and wide. Goalposts are placed 6.5 metres apart in the centre of each end line. A crossbar is attached to each post at a distance of 2.5 metres from the ground. A point is awarded when the ball is played by the hand or foot over the crossbar and between the goalposts. Three points are awarded when the ball crosses the goal-line between the two posts and underneath the crossbar after being played with a foot or hand strike. (www.gaa.ie/coaching-and-games/rules. ; Orejan 2006)The ball is transferred being players with a foot pass or hand pass. A player can take four steps while in possession of the ball. After four steps the ball must be either bounced or dropped onto the foot and kicked backed into hand (solo tap). The ball cannot be bounced twice in succession. (www.phoenixgaels.com Downloaded 01/10/2012)

Fourteen county teams wear jerseys with red or green or a combination of red and green. Two counties wear maroon coloured jerseys. It would be expected therefore that it would be an advantage for players to have normal colour vision to enable them to identify players on their own team from players on the opposing team. Figure 2.1 illustrates the colours worn by each GAA county team. Figure 2.2 gives examples of County teams where red-green colour-blind players or viewers would have difficulties differentiating between both teams.

Figure 2.1 Colour schemes for GAA county teams (http://www.gaa.ie/about-the-gaa/provinces-and-counties/about-county/county-colours/)

(a)

(b)

.(c)

Figure 2.2 Examples of GAA county jerseys

County jerseys as seen with Normal Colour Vision (on the left) and by a dichromat (on the right) for (a) Antrim v Down (https://www.google.ie/search?q=antrim+v+down&source) (b) Meath v Mayo (www.sportsfile.com/737722) (c) Cork v Galway (www.independent.ie)

Many GAA county teams, for example Donegal, Kerry, Leitrim and Meath, share the colours green and yellow in their jerseys and others, for example Fermanagh, Limerick and London, have green and white in common. When playing against teams such as Cork, Derry, Down, Louth, Mayo or Tyrone, all of whom have red in their jerseys, there would be a possibility of colour confusion for colour deficient players and spectators (fig 2.2)

2.6 Visual Task Analysis

Loran and Griffiths (2000) examined visual performance in sixteen elite U- 14 soccer players in the UK. The visual skills recorded were high and low contrast vision using log Mar charts, stereopsis using TNO, vergence facility, accommodative facility, dynamic fixation, eye-hand response time and eye-foot reaction time. Players were categorised according to their visual skills in order to determine the relation between visual performance and playing skill. Mean and standard deviation values were calculated for each visual skill. Each player was then assigned an overall score for their visual skills comparing their scores with the average scores for the squad and players were assigned an overall score. (Loran 2000) Four coaches at the club were asked to grade the skill level of the players subjectively on a scale 1-5, (5 = international player standard 1= not suitable to play soccer at any level). Player's skill level was in turn ranked based on an average of the four coaches' assessment of skill. Spearman's rho statistical test showed the player's ranking based on visual skill to correlate with the coaches' ranking based on football skill ($p=0.01$).

Ward and Williams (2000) undertook a study involving 137 elite and sub-elite male soccer players to examine the relative contribution of visual, perceptual and cognitive skills to the development of expertise. (Loran 2000; Ward 2000) Players were tested in their normal viewing mode (no correction 79 %, spectacles 15 %, contact lenses 6 %). The tests of visual function did not discriminate between skill groups at any age. They found that tests of anticipatory performance and situational probabilities were the best indicators of skill level across the different skill groups. Furthermore, they found that from the age of 9 years, elite soccer players demonstrated superior perceptual and cognitive skills when compared with their sub-elite counterparts.

Savelsbergh *et al*. (2010) examined the visual search ability of goalkeepers of varying levels of experience during penalty kicks. The skilled goalkeepers were found to take longer to make a decision and made fewer corrective movements. They were also found to more accurately predict the direction of penalty kicks and used a more efficient strategy of focusing their vision. The spots they focused on were more similar within their group than in a group of inexperienced goalkeepers. (Savelsbergh 2010)

2.5.1 High and Low Contrast Vision

The most basic visual requirement in Gaelic football is to be able to see the ball. Players need to be able to deal with different contrast conditions, e.g., glare, fog and floodlights due to the fact that the games are played outdoors and at night. Visual acuity is the acuteness or clearness of vision, which is dependent on the sharpness of the retinal focus within the eye and the sensitivity of the interpretive faculty of the brain. (Cline 1997) Duane considered static visual acuity among the most important of visual skills required in sport. (Duane 1997) It is recommended that myopic refractive errors as small as -0.25 should be corrected in individuals participating in sport. (Loran 1995)

The vision required to see a Gaelic football depends on the size of the football and how far away it is from the observer. Using the diagonal Gaelic pitch dimensions and the dimensions of the circumference of the ball the minimum vision required to see the ball when viewed by an observer at the opposite end of the diagonal has been calculated and can be seen in table 2.3.

Table 2.3 Minimum acuity required to resolve a Gaelic football

Pitch Size	Ball Size	Snellen Acuity	Log Mar Acuity
145 m	69 cm	6/15	0.4
130 m	74 cm	6/19	0.5

2.5.2 Contrast Sensitivity

Contrast sensitivity measures the ability of the visual system to process spatial or temporal information about objects and their backgrounds under varying lighting conditions. (Cline 1997) Athletes often have to contend with different contrast conditions. Indeed, it is possible for contrast conditions to change many times throughout a Gaelic football match. It is much easier to view a white football against the background of a blue sky than an overcast and cloudy sky. It is recommended that contrast sensitivity is recorded during a sports vision assessment. (Loran 2003) Previous research has found increased contrast sensitivity across all spatial frequencies for athletes. (Laby 1996; Buys 2002; Erickson 2007; Buys 2008)

2.5.3 Dynamic Fixation

The ability of Gaelic football players to quickly and accurately identify the position of their team-mates, opposition players and the relative position of the goalposts in relation to themselves requires ocular vergence and motility skills.

Dynamic fixation is defined as brief fixation, preceded and followed by saccadic eye movements, in a combination of motility and vergence. (Griffiths 2002) Several types of eye movements are used to view a moving ball. Kluka (1991) classified eye movements into i) saccadic, ii) vestibulo-ocular, iii) vergence and iv) smooth pursuit. (Kluka 1991; Knudson 1997) Saccadic movements are for scanning rapidly and jumping to various points in the visual field. Vestibulo-ocular movements are coordinated with head movement to keep the eyes on a ball. Vergence eye movements allow the eyes to focus on a ball at different distances, while smooth pursuit eye movements are used to follow a slow moving ball. (Duane 1997)

2.5.4 Co-incident Anticipation Timing

The process of adjusting a motor response to the arrival of a ball at a specific time and place is called co-incidence or co-incident anticipation. (Belisle 1963; Williams 1985) Gaelic football players need to be able to respond efficiently when receiving a pass or solo running with the ball. The factors that affect co-incident anticipation timing have been investigated in squash, karate and tennis players. (Abernethy 1990; Mori 2002; Williams 2002) Some studies found that athletes and experts had faster reaction times than non-athletes and novices (Farrow 2005; Gabbett 2007) , while others found no significant difference in the visual motor reaction times between experts and novice athletes. (Welford 1980; Jevas 2001; Mori 2002; Williams 2002; Der 2006; Kosinski 2010)

State of attention including muscular tension also called “arousal” has been found to have a significant effect on reaction time (Welford 1980; Kosinski 2010). Faster reaction times have been found to occur when there is an intermediate level of arousal, and slower reaction times were found when individuals were either too relaxed or too tense as illustrated in figure 2.3. (Welford 1980; Kosinski 2010)

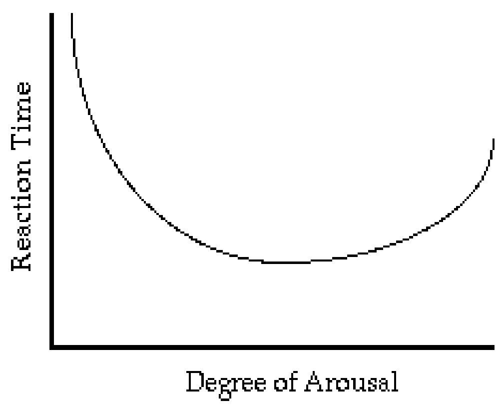


Figure 2.3 Relation between reaction time and degree of arousal
Diagram illustrating that reaction time is fastest with an intermediate level of arousal or state of attention and deteriorates when the subject is either too relaxed or too tense. ***(Kosinski 2010)***

A number of studies have reported a reduction in reaction time with advancing age (Welford A T 1980; Der 2006) that is similar in men and women. (Jevas 2001; Kosinski RJ 2010) Philip *et al.*, found that 24 h of sleep deprivation lengthened the reaction times in 20-25 year old subjects, but had no effect on the reaction times of 52-63 year old subjects. (Welford A T 1980; Philip 2004; Kosinski RJ 2010) Men have faster reaction times than women. (Welford A T 1980; Der 2006) A study by Botwinick and Thompson (1996) found that almost all of the gender difference in reaction time was due to the lag time between the presentation of the stimulus and the beginning of muscle contraction. (Botwinick 1966; Kosinski RJ 2010) The gender imbalance in reaction time may be changing, especially outside the US due in part to the fact that a greater number of women are participating in explosive sports. (Silverman 2006; Kosinski RJ 2010) A study by Szinnai *et al*., (2005) found that gradual dehydration resulting from a loss of 2.6 % of body weight over a 7 d period resulted in a shortened reaction time in men and a lengthened reaction time in women. (Szinnai 2005; Kosinski 2010)

Experts hurlers have been found to have significantly better co-incidence anticipation than novice players. (Lyons 2008)

2.4.5 Eye-Hand Co-ordination

Visual motor reaction time refers to the amount of time that elapses between the initiation of a visual stimulus and the completion of a motor response to that stimulus. (Erickson 2007) A number of studies have used the Wayne Saccadic Fixator to measure pro-action and re-action times. Loran and Griffiths (2000) recorded mean pro-action and re-action times of 26.11 sec and 27.42 sec, respectively. In contrast, Buys and Ferreira (2008) recorded mean pro-action and re-action times of 30.70 sec and 26.91 sec, respectively. The different findings may be due to the fact that the participants in the Loran and Griffiths study were U-14 soccer players whereas the age of the participants evaluated by Buys and Ferreira's ranged from 16-28 years. Previous studies have found that reaction times increase from infancy to the mid 20's and slowly reducing thereafter. (Welford 1980)

2.5.6 Stereo Acuity

Stereopsis is the ability to perceive depth, on the basis of retinal disparity cues. (Grosvenor 2007) When an object fails to stimulate corresponding retinal points for the two eyes but stimulates non-corresponding points (fig 2.4), the result is retinal disparity and stereo acuity. Binocular vision is essential in order to have 3D vision or stereo acuity. A person with one eye can perceive depth using monocular cues e.g., parallax, relative image size, light and shadow etc. Stereo acuity and monocular depth perception have been classified as innate and learned skill skills, respectively. (Loran 1995)

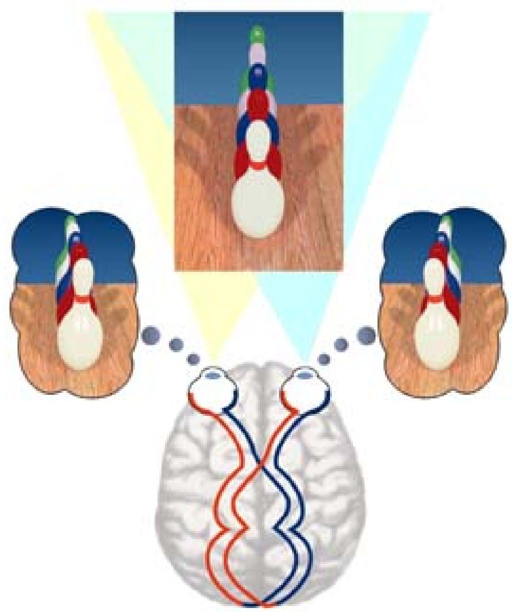


Figure 2.4 Depth perception is perceived due to retinal disparity
(http://www.vision3d.com//images/bb.jpeg)

Transferring the ball with a fist past during Gaelic football match play requires not only good eye-hand co-ordination, but also depth perception and ideally a good level of stereo acuity.

2.5.7 Colour Vision

It is important for players to have normal colour vision given the similarity in jersey colour between large numbers of Gaelic football teams. Colour vision is defined as the perception of different colours making up the spectrum of visible light. (Saunders 2007) The trichromacy theory states that the retina has three types of cones with absorption spectra that peak in the long, middle and short wavelength ranges, respectively. By adjusting the activation of the three cone types, the full spectrum of human colour sensation can be elicited. (Bennett 2007; Beau 2011) A dichromat can match any colour they see with some mixture of just two spectral lights. Protan, deutan and tritan defects are characterised by the absence of a contribution to vision from the long, medium and short cones, respectively. (Neitz 2010) Opia comes from the Greek word meaning "a blindness resulting from a defect in" the first (prot), second (deuter) or third (trit) cone. (Mosby 2009) For the protanope, the brightness of red, orange and yellow is much reduced compared to normal. Reds may be confused with black or dark grey. Violet, lavender and purple may all look the same as various shades of blue because their reddish components are so dimmed as to be invisible. The deuteranope suffers the same hue discrimination problems as the protanope without the abnormal dimming. Fig 2.5 illustrates how a deuteranope may observe the a selection of county jerseys compared to how a person with normal colour vision observes them. The tritanope has reduced sensitivity in the blue sensitive cones and although red and green are unaffected trichromats have difficulty distinguishing between yellow and blue. (Waggoner 2012)

(a)

(b)

Figure 2.5 Selection of GAA county jerseys
County jerseys as observed by people with normal colour vision (a) and adjusted to show how a person with a red-green defect might see them(b).
(https://www.google.ie/search?q=all+ireland+championship+2013)

Colour blindness is either inherited or acquired. Red-green colour-blindness is the most common form and is passed down on the X chromosome and therefore affects more men than women. Colour-blind women must inherit the defective gene from both parents.

The proportion of colour-blind females in a population is generally estimated as a square of the proportion of colour-blind males. It is generally accepted that about 8 % of males are colour-blind. Therefore, it would be expected that 0.64 % of females would have the deficiency. (Fisher 1980; Grosvenor 2007)

2.5.8 Eye Dominance

Eye dominance, ocular dominance or eyedness is defined as the tendency to prefer visual input from one eye over the other. (Porac 1976) Studies have shown that there is no relation between dominant hand/leg and dominant eye. (Papousek 1999; Pointer J 2001) This is not surprising as lateral body dominance may be related to dominance of one cerebral hemisphere, while the right left ocular signals are similarly represented in both hemispheres due to semi-decussation of the visual pathway. There also appears to be little relation between sensory dominance, (i.e., eye with the better visual acuity) and sighting dominance (i.e., eye used when looking through a telescope camera lens or for aiming in rifle shooting). (Bailey 1981; Pointer 2007) It has been suggested that eye dominance switches from one eye to the other with changes in horizontal eye position. (Carey 2001; Khan 2001) In contrast, others studies found that relative image size and not eye position determines eye dominance switches. (Banks 2004; Shneor 2006) Laby (2011) cautioned that the visual system is designed as a binocular system and therefore only tests that allow for maintenance of binocular vision during determination of ocular dominance should be used if accurate evaluation is to be made. (Laby 2011)

A study comparing eye dominance and its importance in different sports found that 80% of archers to be ipsi lateral dominant (dominant eye and dominant eye is on the same side). (Griffiths 2003) It is considered that the effect of the dominant eye in archery is very important as ipsi lateral dominance enables the right handed archer to draw the bow back keeping the peep sight in the string to line up with the right aiming eye. Similar results were found for rifle shooting where 91% of participants were found to be unilateral dominant. Fig 2.4 shows how the incidence of uni-lateral and ipsi-lateral dominance changes depending on the type of sport. The same study found soccer teams are made up of roughly 66% ipsi-lateral dominant players and 33% contra-lateral dominant players. In Gaelic football and soccer the ball is kicked when the foot and aiming eye are in alignment but sometimes players will be required to be equally adept with each foot to be able to score from different positions. In tennis which is considered to require skills of anticipation more than aiming, 43% of players were found to be cross-dominant. Similar results were found for athletes involved in clay shooting which requires the clay to be located before the shotgun is brought to the aiming position, and therefore requires both anticipation and aiming shills.

Table 2.4 Relation between dominant eye and dominant hand Griffiths (2003)

Dominance Eye	Dominance Hand	Archery Internationals N16	Archery Coaches N 70	*Rifle GB N32	Clay Shooters N13	Tennis Players N14	Football N18
Right	Right	62	84	88	46	57	55
Left	Left	19	10	3	8	0	11
Right	Left	6	3	0	15	29	17
Left	Right	13	3	9	31	14	17
%Cross Dominant		19	6	9	46	43	33

Values are percentages. * Junior squad

Using tennis players and clay shooters Griffiths (2003) investigated the effect of partial occlusion of an eye on sporting performance. Shooting performance was recorded and compared according to which eye (dominant or non-dominant) was partially occluded and in turn compared to shooting performance when neither eye was partially occluded. Clay shooters performance was shown to improve when the non-dominant eye was partially occluded. Partial occlusion of the dominant eye resulted in a reduction in performance. Surprisingly, the left dominant clay shooters appeared to score better regardless of which eye was partially occluded. Griffiths suggested that left dominant players may have better powers of adaptation due to their need to cope with right-sided equipment thus enabling them to better cope with adversity.

In the same study partially occluding the dominant eye of tennis players had little effect on performance, whereas partial occlusion of the non-dominant eye negatively affected performance. Again, the left eye dominant players appeared to be unaffected regardless of which eye was partially occluded. Each player in the study was right handed. It was suggested that the study findings could be due to the dominant eye being better able to cope with a degraded image compared with the non-dominant eye. Results may also have been influenced by the fact that the study design required the tennis players to hit a forehand to their left in order to hit the target and therefore the left eye would receive valuable information with regard to accuracy of the task.

It is not clear whether these athletes self-select to these sports because of their eye-hand dominance or whether eye-hand dominance changes or adapts according to the requirements of the sport played. It is clear that eye-dominance has an important role in sport but much more research is required before its full implications can be understood.

The basic Porta's test is a very popular method of testing sighting dominance. The subject aligns a finger with a distant point while keeping both eyes open. This manoeuvre produces conflicting images and the subjects align the finger with one of their eyes. Handedness has been shown to influence the result of the Porta test. (Porac 1976; Valle-Inclan 2008) The ABC test requires monocular viewing through a hole. Subjects aim at a distant point with a truncated cone covering their faces. The cone is aligned with one of the subject's eyes without the subject's awareness. A more popular version of this test involves the subject looking at a distant point through a triangle made with their hands. Alternating the position of the hands will help reduce the effect of handedness on the result. (Griffiths 2003; Valle-Inclan 2008)

CHAPTER III

Methodology

3.1 Participant Selection

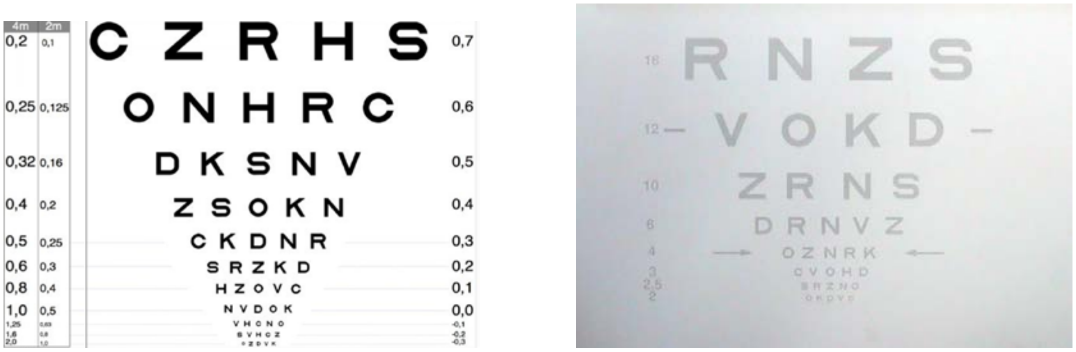
Several county and club level managers were contacted by e mail or phone to inquire about their willingness to participate in the study. Managers and selection committee members attended a meeting where the aims and objectives of the study were explained, and they were encouraged to ask questions relating to the nature of the study. These were explained to the players in turn by the manager. Players gave permission and signed consent forms signed allowing the battery of tests to be carried out (Appendix 1).

Two county level (n = 61) and two club level (n = 46) Gaelic football teams agreed to participate. Participants were male and were between age of 18 and 38 years. Visual testing was undertaken at an agreed venue by two optometrists. Players were tested as they habitually played Gaelic football, wearing corrective contact lenses if wore during match play (County = 4.9% and Club = 10.9%) or without refractive correction (County = 95.8% and Club = 89.1%). No player wore a spectacle correction during match play.

3.2 High and Low Contrast Vision

High and low contrast vision was assessed using the Bailey Lovie 90% and 10% log Mar charts (Figure 3.1 (A) and (B)). This method of testing is more reliable than the Snellen chart and more sensitive to inter ocular differences in visual acuity. The log Mar can also record visual acuities of better than 20/20. This is a benefit when analysing athletes whom may have superior visual skills. Each letter represents 0.02 log Mar units and compared to the Snellen chart allows more precise measurements of acuity when a individual fails to read every letter on a line correctly. Mean and standard deviation (SD) results of visual acuity were calculated from the logMar values. (Sloan 1951; Holladay 1997; Rosser 2001)

The test was undertaken in a room with standard lighting and a lux meter was used to ensure that the test chart was illuminated to between 80 and 320 cd/m². The participants were standing and the chart was mounted on a wall at a distance of 6 m. Unaided vision was first recorded in the weaker eye (if known), to avoid errors caused by memorisation. Otherwise, vision was recorded in the right eye first. Participants were encouraged to read as many letters as possible. Each additional correct letter identified reduced the score by 0.02 log Mar units. A score of 20/20 corresponds to 0.00 log Mar units. For each additional letter correctly identified beyond 20/20 vision the assigned score was reduced 0.02 log Mar units. Prior to the test participants were given the following instructions “I would like you to cover your left eye with your hand taking care not to push against the eye and read the smallest line you can read.” The measurement was repeated for each eye and binocularly and results were recorded. .



A B

Figure 3.1 High and low contrast vision charts
90% contrast vision test chart illustrated on the left and 10% contrast vision test chart is illustrated on the right. The logMAR scoring values are displayed on the right hand side of the chart.(https://www.google.ie/search?q=high+and+low+contrast+vision+charts)

3.3 Contrast Sensitivity Testing

A large number of tests are available to measure contrast sensitivity of which the most commonly used is the Pelli-Robson chart. This chart (fig 3.2) determines the contrast required to read large letters of a fixed size. (Pelli 1988; Owsley 2003) It consists of eight rows of letters with two triplets of letters per row. The three letters within each triplet have constant contrast, whereas the contrast across triplets, reading from left to right, and continuing on successive lines, decreases by a constant factor (1/√2). The contrast of the test letters decreases from 100% at the top to < 1% at the bottom of the chart in 0.15 log unit sensitivity steps for each triplet of letters. (Owsley 2003) Each letter subtends a visual angle of 2.86 at 1 m test distance. Letters are 5.08 cm x 5.08 cm in size. Testing was carried out at 1 m as per the manufacturer's instructions and corresponded to a spatial frequency of 1 cycle per degree (1.5 logMAR). (Mantyjarvi 2001)

The test was undertaken in a room with standard lighting and a lux meter was used to ensure that the test chart was illuminated to a minimum of 85 cd/m^2. Participants were standing and the test chart was mounted on a wall at a distance of 1 m. The participant read the letters across and down the chart, as in standard letter acuity measurement. The final triplet at which the participant read two of the three letters correctly, determined the log contrast sensitivity, which was read off a score sheet that relates each triplet to a log contrast sensitivity value (Appendix A). Prior to the test participants were given the following instructions; "I would like you to cover your left eye with your hand taking care not to push against it. The letters in this chart decrease in contrast from top to bottom, please read as many letters as you can see." The test was initially performed on the weaker eye (if known), to avoid errors caused by memorisation. Otherwise, vision was recorded in the right eye first. The measurement was repeated for the left eye and binocularly and the results were recorded.

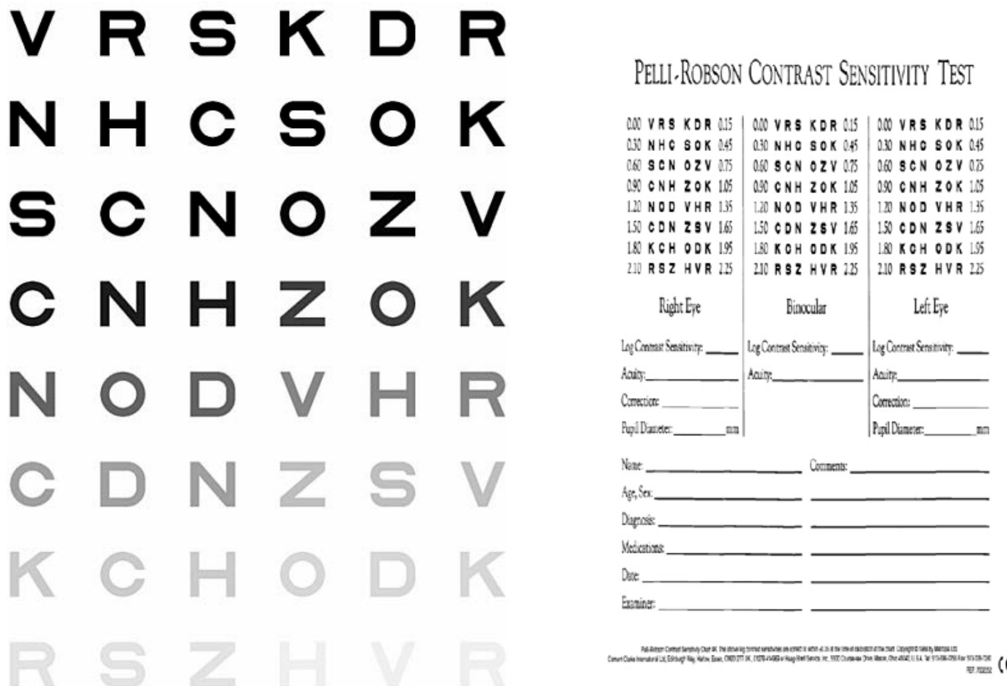


Figure 3.2. The Pelli Robson test chart
The chartconsists of triplets of letters. All letters on the chart are equal in size (1.5 logMAR) but the triplets reduce in contrast from top to bottom. The last triplet which the participant could read at least two out of three letters was recorded as log contrast sensitivity value. This value was read off a score sheet seen on the right. (http://www.scribd.com/doc/59085894/Pelli-Robson-ETDRS-Score-Sheet-Instructions)

3.4 Eye-Hand Co-Ordination

The Wayne Saccadic Fixator (fig 3.3) is a two dimensional panel with an array of lighted buttons was used to assess eye-hand co-ordination. The panel dimensions are 71.12 cm x 74.93 cm x 2.86 cm and it weighs 5 kilo. The test involved pressing LED lights as they appeared at random for a set time period. This test was undertaken in a dimly lit area. Participants stood 75 cm from the Wayne Saccadic Fixator which was mounted on a stand and were positioned to ensure the centre of the instrument was at eye level allowing them to reach the top and bottom of the instrument without changing distance. The task was demonstrated by allowing the subject to press 5 lights correctly. Two pre-programmed tests were undertaken. Test 1 and test 2 assessed pro-action and re-action, respectively. During both tests the lights were illuminated randomly for duration of 30 sec. During test 1, the light remained lit in the same position until pressed by the participant and then moved to the next position. Prior to test 1, the participants were given the following instructions "This test records your re-action time. Please touch the lights with either hand. This time each light remains on for one second and then moves to the next position whether you touch it or not. Try to touch as many lights as you can." The number of lights correctly identified in 30 sec was recorded.

In contrast, during test 2 each light remained illuminated for 1 sec and then moved to the next position regardless of whether or not it was touched by the study participant. Prior to test 2 the participants were given the following instructions "This instrument measures eye-hand co-ordination and hand speed. For the first test, touch the lighted circles with either hand. As soon as you touch one, another circle will light up in another random position. Touch as many circles as you can in 30 seconds." The number of lights correctly identified in 30 sec was recorded.

Fig 3.3 Wayne Saccadic Fixator
This is a two dimensional panel with an array of lighted pads. It can be used to measure eye-hand pro-action and re-action co-ordination.(https://www.google.ie/search?q=wayne+saccadic+fixator)

3.5 Dynamic Fixation

Participants were timed for 24 vergence and motility cycles to measure dynamic fixation. A dynamic fixator consists of a near and distant chart. The participant holds the near chart so that all the numbers on the distant chart may be viewed through the aperture as shown in figure 3.4

The test was undertaken in a room with standard lighting and a lux meter was used to ensure that the test chart was illuminated to between 80 and 320 cd/m^2. The player was standing 1 m from the distant chart which was mounted on a wall. The near chart was held at a distance of 20 cm from the face to enable the numbers on the distance chart to be viewed through the aperture. Each participant had one practice trial and 2 recorded trials. The participant is asked to call the numbers out starting with 1 on the near chart then going to 4 on the distance chart and back to 7 on the near and 2 on the distance chart and continuing in a clockwise direction until 3 full circuits (24 cycles) are completed. The time taken to complete three cycles starting and finishing with number 1 was recorded. Prior to the test participants were given the following instructions; "This test measures how quickly and accurately your eyes can change focus from a near to a distant target. It does this by making your eyes adjust focus from the near chart to the distant chart and in different directions. Please hold the near chart before your face so that you can view all the numbers on each chart without moving your head or the card. Now I would like you to call the numbers starting with 1 on the near card back to 4 on the distance chart then back to 7 and continue this in a clockwise direction until you complete three full cycles starting and finishing with number 1. Try to complete the three cycles as quickly and accurately as possible."

Figure 3.4 The Dynamic Fixator
A near chart with an aperture and a distance chart. The near chart is held at a distance of 20cm to enable all the numbers on the distance chart to be viewed **(Griffiths)**

3.6 Co-Incident Anticipation Timing

The Bassin Anticipation Timer was used to measure co-incident anticipation timing. This test apparatus consists of a platform mounted runway with LED lights as shown in figure 3.5. There is an LCD timer attached to the runway at the operators end and a push botton control at the participants end. The participant was stationed at one end of the apparatus. When activated, each light was sequentially illuminated starting with the light furthest from the participant. Participants were instructed to continuously view the light as it travelled down the runway at a predetermined velocity of 2.23 $m.sec^{-1}$ and press a pushbutton coinciding with the illumination of the final light.

Figure 3.5. The Bassin Anticipator .
A mounted platform with an LED display. It has a LCD timer at the operating end and push button at the participants end. Participants are requested to follow LED lights as they approach from the operator's end of the runway lighting up sequentially and to push the button to coincide with the final light illuminating. (patients@kirschen.net)

This test was performed in a dimly lit area of the room. Participants were relaxed and standing 1 m from the end of the runway with the track perpendicular to their shoulders. Each participant had one practice trial and 2 recorded trials. Prior to the test participants were given the following instructions; "The row of lights represents a target approaching you. Stop the light exactly at the end of the track by pushing the handled trigger." A plus sign was recorded if the participant pushed the bottom prior to the illumination of the final LED light. A minus sign was recorded if the participant pushed the bottom after the illumination of the final LED light.

3.7 Stereo Acuity

The Netherlands Organisation (TNO) for Applied Scientific Research test has been designed primarily for screening children of 2.5 to 3 yr of age for defects of binocular vision. It consists of seven plates (to be viewed with red green glasses) that carry figures that can be seen only when binocular vision is present (fig 3.6). The first four plates provide a qualitative assessment of stereo acuity as the disparity is large. The next three plates, present images that are graded for stereo acuities from 480-15 sec of arc. For each test level two discs are presented with a sector missing in different orientations. (Elliott 2007) In this study only the first, fifth, sixth and seventh plates were shown. If the player saw two butterflies in plate 1, he was shown plates 5, 6 and 7. If he failed to see the two butterflies in plate 1 he was not shown any more plates.

The test was undertaken in a room with standard lighting and a lux meter was used to ensure that the test chart was illuminated to between 80 and 320 cd/m². The player sat and held the book at 40 cm. Care was taken to eliminate shadow. If the subject was hesitant about an answer, plenty of time was allowed. If only one of the two tests for each acuity level was stated correctly, a second attempt was allowed at the incorrect one, but if called incorrectly again, or if the subject could not see a shape, the stereo acuity was recorded as the previously correctly identified level. Each player was given the following instruction "I am now going to test your 3D vision. Please put on the red/green spectacles." For Plate 1 the player was asked "How many butterflies can you see on the page? Can you point to them?” For Plates 5 6 and 7, the player was asked “Can you see a pac man in each square? Can you point or tell me what direction he is pointing, up, down, left or right?” Player’s stereo acuity was recorded in seconds of arc or having no stereo acuity if the second butterfly was not observed in plate 1.

Figure 3.6 TNO
Plates are viewed through red and green spectacles .containing images that can only be seen when both eyes combine to provide stereoscopic vision. This test provides information about the presence of stereo-acuity and the sensitivity of the stereo-acuity of the observer.
(https://www.google.ie/search?q=tno+stereoacuity+test)

3.8 Colour Vision Testing

Ishihara plates for colour vision testing were used in this study as it is a portable test that could be quickly preformed. Each plate contains a number which is composed of dots of one colour and the background is composed of dots of a different colour. Observers will need to be able to distinguish between the two colours in order to be able to decipher the number.The first plate was for demonstration. It showed the number 12 and could be observed by colour normal and colour deficient observers. Only every other plate was shown (2,4,6 etc…) between plates 2-15. The final two plates shown were plates 16 and 17 and identifiy colour deficient observers as either protanopic or deuteranopic. Observers with normal colour vision will see the number 26 and 42 on plates 16 and 17 respectively. Protanopic observers will only be able to see numbers 6 (plate 16) and 2 (plate17). Observers with a mild version of protanopia will see a faint 2 (plate 16) and 4 (plate 17). Conversely deuteranopic observers will only be able to identify numbers 2 and 4 on plates 16 and 17 respectively. Observers with a mild version of deuteranopia may also see a faint 6 and 4 on plates 16 and 17 respectively.

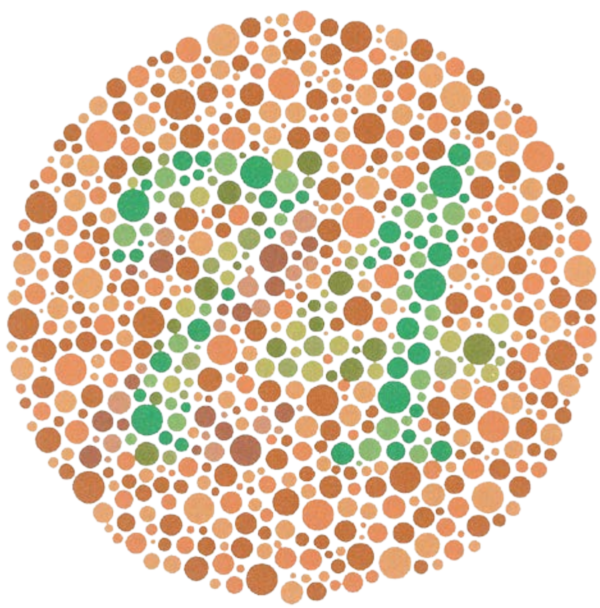


Figure 3.7 Ishihara Test Plate
Each plate contains a number which is composed of dots of one colour and the background is composed of dots of a different colour. Observers will need to be able to distinguish between the two colours in order to be able to decipher the number. (https://www.google.ie/search?q=ishihara+colour+vision+test+plate)

The test was undertaken in a room with standard lighting and a lux meter was used to ensure that the test chart was illuminated to between 80 and 320 cd/m².The player sat and held the book at 50 cm. Each player was given the following instruction “Look at the plates and tell me what number the dots form.” Players were recorded on as having normal colour vision or being protanopic, deuteranopic or being totally red-green colour deficient. (Erickson 2007)

3.9 Eye Dominance Testing

To identify the dominant eye the player was standing 6M from the examiner. Each player was given the following instruction: “I am going to establish which eye is your dominant eye Please place your right hand over your left hand and make a triangle between the apex of your fingers and thumbs. Now stretching your hands towards me until your arms are straight, I would like you to look at my nose through the triangle. Please repeat by putting your left hand over your right hand.” The measurement was repeated with the left hand over the right hand and twice more right over left and left over right. The examiner recorded the eye which can be seen through the gap. Strong right dominance was recorded as RRRR, weak right dominance was recorded if the left eye was used to view the nose on one occasion i.e. RRLR. Equal dominance was recorded for results that showed RLRL, RRLL, LRLR or LLRR.

Figure 3.8 Eye Dominance Testing
The eye used by the player to view the examiners nose was recorded as the dominant eye.(https://www.google.ie/search?q=eye+dominance+test+triangle)

3.9 Analysis of Results

Two methods were used to categorise the visual skills of the players into superior, above average, average, below average and needs attention, the mean and standard deviation method and the percentage method as reported by Buys and Ferreira. (Buys 2002; Buys 2008) A summary of the tests used, together with the supplier or manufacturer of the equipment and analysis method is given in Table 3.1.

Table 3.1 Summary of tests used to assess the visual skills of Gaelic footballers

Visual Task	**Analysis**	**Test Used**	**Manafacturer**
High and Low Contrast Vision	Mean and Std Dev	90% and 10% log Mar Charts	Sports Vision UK
Contrast Sensitivity	Mean and Std Dev	Peli Robson	Precision Vision
Ocular Vergence and Motility	Mean and Std Dev	Dynamic Fixator	Sports Vision UK
Anticipation Timing	Percentage	Bassin Anticipator	Sports Vision UK
Eye- Hand Co-Ordination	Percentage	Wayne Saccadic Fixator	Sports Vision UK
Stereopsis	Percentage	TNO	Topcon
Colour Vision		Ishihara Test Plates	Topcon

CHAPTER IV

Results

With the exception of Bassin absolute error scores for club and county level players and DFT scores for county level players none of the other measured visual skills were normally distributed. It appeared that a few extreme scores had a disproportionate effect on the overall distribution of scores for most of the visual tests. The majority of visual test scores failed to meet the normality assumption even after undergoing a number of transformation procedures. Individual data for each visual test was converted to a corresponding Z score (tables 3.2 3.x) and Z scores ≥ 1.96 were deleted from subsequent analysis. Table 4.1 summarizes the number and percentage of participants with Z scores ≥ 1.96.

Table 4.1: Number of county and club level players with z scores ≥ 1.96

Variable	**County n (%)**	**Club n (%)**
Vision 90% Right Eye logMAR	3 (4.9%)	3 (6.5%)
Vision 90% Left Eye logMAR	2 (3.3%)	2 (4.3%)
Vision 90% Binocular Vision logMAR	1 (1.6%)	3 (6.5%)
Vision 10% Right Eye logMAR	2 (3.3%)	3 (6.5%)
Vision 10% Left Eye logMAR	3 (4.9%)	2 (4.3%)
Vision 10% Binocular Vision logMAR	1 (1.6%)	2 (4.3%)
Contrast Sensitivity Right Eye log	0 (0.0%)	1 (2.2%)
Contrast Sensitivity Left Eye log	0 (0.0%)	1 (2.2%)
Contrast Sensitivity Binocular log	0 (0.0%)	0 (0.0%)
Eye-Hand Pro-Action Number	0 (0.0%)	1 (2.2%)
Eye Hand Re-Action Number	0 (0.0%)	0 (0.0%)
Dynamic Fixation_Average Seconds	1 (1.6%)	6 (13.0%)
Co-Incident Timing Seconds *	0 (0.0%)	5 (10.7%)

* Co-Incident Timing Values are mean absolute error values

Descriptive statistics summarizing the mean, SD and median for each visual test for county level, club level and club and county level players combined are outlined in table 4.2. Table 4.3 summarizes the descriptive statistics for county level, club level and combined summarizing the mean, SD and median for adjusted visual test scores with Z score values ≥ 1.96 removed. Comparison of vision test results between club and county level players shown in table 4.4. With the exception of Wayne Pro-Action, Wayne Pro-Reaction, and vision 90% right there was a significant difference in the other visual test results between county and club level players (table 4.4). County players performed significantly better than club players in tests to assess vision 90% left, 90% binocular, 10% right, 10% left, 10% binocular, dynamic fixation and anticipation timing (table 4.4). In contrast, club players performed better than county level players for contrast sensitivity in the right eye ($p<0.001$), left ($p<0.001$) eye and binocular ($p<0.01$). Stereoacuity results for county and club level players are shown in table 4.5. Approximately 56% of county and club level players had a steroacuity value of 60 seconds of arc. No recordable stereoacuity was found in 11% and 15% of county and club level players respectively. Colour vision test results for county and club level players are summarized in table 4.6. A larger proportion of club players (6.5%) had a colour deficiency than county level players (1.6%).

Number and percentage of county and club level players in each assigned category for 90% and10% contrast right eye, left eye and binocular vision are shown in tables 4.7 and 4.8. Similar data for dynamic fixation is provided for county and club level in table 4.9. There was no significant difference between county and club level players for the pro-action and re-action eye-hand coordination results. The data was combined to generate the number and percentage of county and club level players in each assigned category shown in tables 4.10 and 4.11.. Percentile mean absolute error scores for anticipation timing are shown in table 4.12. Table 4.13 and 4.14 shows the number of percentage of county and club players with contralateral and ipsilateral eye hand dominance and eye foot dominance, respectively. Normative data (based on the categories of Buys and Ferriera) for selected visual skills of Gaelic football players are shown in table 4.15.

Table 4.2: Mean, SD and median for each visual test for county level, club level and club and county level players combined

	Group					
	County		Club		Combined	
	Mean ±SD	**Median**	**Mean ±SD**	**Median**	**Mean ±SD**	**Median**
Vision 90% Right Eye logMAR	0.02±0.22	0.00	0.06±0.21	0.00	0.04±0.22	0.00
Vision 90% Left Eye logMAR	0.00±0.16	-0.02	0.04±0.14	0.00	0.02±0.16	0.00
Vision 90% Binocular logMAR	-0.08±0.10	-0.08	0.03±0.13	0.00	-0.05±0.12	-0.08
Vision 10% Right Eye logMAR	0.23±0.25	0.20	0.31±0.29	0.22	0.23±0.25	0.20
Vision 10% Left Eye logMAR	0.22±0.20	0.18	0.27±0.16	0.23	0.24±0.19	0.20
Vision 10% Binocular logMAR	0.12±0.13	0.12	0.17±0.16	0.12	0.14±0.14	0.12
Contrast Sensitivity Right Eye log	1.72±0.12	1.80	1.79±0.18	1.80	1.76±0.15	1.80
Contrast Sensitivity Left Eye log	1.72±0.11	1.65	1.81±0.12	1.80	1.76±0.12	1.80
Contrast Sensitivity Binocular log	1.77±0.13	1.80	1.83±0.78	1.80	1.79±0.12	1.80
Eye-Hand Pro-Action Number	36.84±4.34	37.00	36.04±4.55	36.00	36.43±0.12	37.00
Eye Hand Re-Action Number	27.26±2.29	28.00	27.14±2.49	28.00	27.63±4.42	28.00
Dynamic Fixation Average Second	16.99±2.79	16.89	19.68±3.90	25.95	18.15±3.56	17.60
Co-Incident Timing Seconds *	0.05±0.04	0.04	0.14±0.90	0.13	0.07±0.07	0.05

* Co-Incident Timing Values are mean absolute error values

Table 4.3: Mean, SD and median for adjusted visual test scores for county level, club level and club and county level players combined**

	Group					
	County		Club		Combined	
	Mean ±SD	**Median**	**Mean ±SD**	**Median**	**Mean ±SD**	**Median**
Vision 90% Right Eye logMAR	-0.02±0.12	-0.06	0.06±0.21	0.00	0.00±0.13	-0.04
Vision 90% Left Eye logMAR	-0.02±0.10	-0.06	0.04±0.15	0.00	-0.01±0.09	-0.04
Vision 90% Binocular logMAR	-0.08±0.10	-0.09	0.03±0.13	0.00	-0.05±0.10	-0.08
Vision 10% Right Eye logMAR	0.20±0.16	0.20	0.31±0.29	0.22	0.23±0.18	0.18
Vision 10% Left Eye logMAR	0.18±0.12	0.17	0.27±0.16	0.23	0.21±0.12	0.15
Vision 10% Binocular logMAR	0.11±0.12	0.12	0.17±0.16	0.12	0.12±0.11	0.12
Contrast Sensitivity Right Eye log	1.73±0.08	1.80	1.79±0.18	1.80	1.75±0.15	1.78
Contrast Sensitivity Left Eye log	1.73±0.08	1.65	1.82±0.12	1.80	1.75±0.12	1.75
Contrast Sensitivity Binocular log	1.78±0.11	1.80	1.83±0.79	1.80	1.79±0.12	1.87
Eye-Hand Pro-Action Number	36.84±4.34	37.00	36.04±4.55	36.00	36.71±4.02	37.00
Eye Hand Re-Action Number	27.51±1.85	28.00	27.14±2.49	28.00	27.51±1.80	28.00
Dynamic Fixation Average Second	16.86±2.60	16.88	18.53±2.48	18.33	17.53±2.67	17.35
Co-Incident Timing Seconds *	0.05±0.04	0.04	0.11±0.05	0.13	0.06±0.04	0.05

* Co-Incident Timing Values are mean absolute error values **Z score values $\geq$ 1.96 removed

Table 4.4: Comparison of vision test results between club and county level players*

	Group		
	County	**Club**	**P Value**
Vision 90% Right Eye logMAR	-0.02±0.12	0.06±0.21	0.070
Vision 90% Left Eye logMAR	-0.02±0.10	0.04±0.15	0.040
Vision 90% Binocular logMAR	-0.08±0.10	0.03±0.13	0.040
Vision 10% Right Eye logMAR	0.20±0.16	0.31±0.29	0.040
Vision 10% Left Eye logMAR	0.18±0.12	0.27±0.16	0.001
Vision 10% Binocular logMAR	0.11±0.12	0.17±0.16	0.050
Contrast Sensitivity Right Eye log	1.73±0.08	1.79±0.18	0.001
Contrast Sensitivity Left Eye log	1.73±0.08	1.82±0.12	0.001
Contrast Sensitivity Binocular log	1.78±0.11	1.83±0.79	0.010
Eye-Hand Pro-Action Number	36.84±4.34	36.04±4.55	0.350
Eye Hand Re-Action Number	27.51±1.85	27.14±2.49	0.480
Dynamic Fixation Average Second	16.86±2.60	18.53±2.48	0.001
Co-Incident Timing Seconds *	0.05±0.04	0.11±0.05	0.001

Values are mean ± SD. *Adjusted data with Z score values ≥ 1.96 removed

* Co-Incident Timing Values are mean absolute error values

Table 4.5 Stereoacuity results for county and club level players

Sec of Arc	County Players (%)	Club Players (%)
15	4 (6.56%)	01 (2.17%)
30	10 (16.39%)	03 (6.52%)
60	34 (55.74%)	26 (56.52%)
120	03 (4.92%)	05 (10.87%)
240	02 (3.28%)	04 (8.70%)
480	01 (1.64%)	00 (0.00%)
No Butterfly	07 (11.47%)	07 (15.22%)

Values are number (percentage)

Table 4.6: Colour vision test results for county and club level players

	Group	
	County	**Club**
No Defect	60 (98.4%)	43 (93.5%)
Red-Green Colour Defect	1 (1.6%)	3 (6.5%)

Values are number (percentage)

Table 4.7a:Number and percentage of county and club level players in each category for vision right eye 90% logMar*

	<- 1 SD <-0.14	<Mean to -1 SD <-0.02 to -0.14	Mean -0.02	> Mean to 1 SD > -0.02 to 0.10	> 1 SD to 2 SD > 0.10 to 0.22	> 2 SD > 0.22
County (n=61)	8	22	0	20	6	5
Percentage	(13.1%)	(36.1%)	(0.0%)	(32.8%)	(9.8%)	(8.2%)
Club (n=46)	1	15	0	19	7	4
Percentage	(2.2%)	(32.6%)	(0.0%)	(41.3%)	(15.2%)	(8.7%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.7b: Number and percentage of county and club level players in each category for vision left eye 90% logMar *

	<- 1 SD < -0.12	<Mean to -1 SD <-0.02 to -0.12	Mean -0.02	> Mean to 1 SD > -0.02 to 0.08	> 1 SD to 2 SD > 0.08 to 0.18	> 2 SD > 0.18
County	7	23	1	17	8	5
(n=61)	(11.5%)	(37.7%)	(1.6%)	(27.9%)	(13.1%)	(8.2%)
Club	0	12	0	21	9	4
(n=46)	(0.0%)	(26.1%)	(0.0%)	(45.7%)	(19.6%)	(8.7%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.7c: Number and percentage of county and cub level players in each category for binocular vision 90% logMar *

	<- 1 SD < -0.18	<Mean to -1 SD < -0.08 to -0.18	Mean -0.08	> Mean to 1 SD > -0.08 to 0.02	> 1 SD to 2 SD > 0.02 to 0.12	> 2 SD > 0.12
County-R	7	23	10	13	6	2
(n=61)	(11.4%)	(37.7%)	(16.4%)	(21.3%)	(9.8%)	(3.3%)
Club-R	4	15	2	18	4	3
(n=46)	(8.7%)	(32.6%)	(4.3%)	(39.1%)	(8.7%)	(6.5%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.8a: Number and percentage of county and cub level players in each category for vision right eye 10% logMar *

	<- 1 SD < 0.04	<Mean to -1 SD < 0.20 to 0.04	Mean 0.20	> Mean to 1 SD > 0.20 to 0.36	> 1 SD to 2 SD > 0.36 to 0.52	> 2 SD > 0.52
County (n=61)	8	18	10	6	3	6
Percentage	(13.1%)	(29.5%)	(16.4%)	(26.2%)	(4.9%)	(9.8%)
Club (n=46)	0	16	7	8	10	5
Percentage	(0.0%)	(34.8%)	(15.2%)	(17.4%)	(21.7%)	(10.9%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.8b: Number and percentage of county and cub level players in each category for vision left eye 10% logMar *

	<- 1 SD < 0.06	<Mean to -1 SD < 0.18 to 0.06	Mean 0.18	> Mean to 1 SD > 0.18 to 0 .30	> 1 SD to 2 SD > 0.30 to 0.40	> 2 SD > 0.40
County-R	8	21	2	20	6	4
(n=61)	(13.1%)	(34.4%)	(3.3%)	(32.8%)	(9.8%)	(6.6%)
Club-R	0	13	0	18	12	3
(n=46)	(0.0%)	(28.3%)	(0.0%)	(39.1%)	(26.1%)	(6.5%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.8c: Number and percentage of county and cub level players in each category for binocular vision 10% logMar *

	<- 1 SD < -0.01	<Mean to -1 SD < 0.11 to -0.01	Mean 0.11	> Mean to 1 SD > 0.11 to 0.23	> 1 SD to 2 SD > 0.23 to 0.35	> 2 SD > 0.35
County-R	5	23	0	24	5	4
(n=61)	(8.2%)	(37.7)	(0.0%)	(39.3%)	(8.2%)	(6.6%)
Club-R	0	20	0	15	8	3
(n=46)	(0.0%)	(43.5%)	(0.0%)	(32.6%)	(17.4%)	(6.5%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.9: Number and percentage of county and cub level players in each assigned category for dynamic fixation*

	<- 1 SD **< 14.20**	**<Mean to -1 SD** **< 16.99 to 14.20**	**Mean** **16.99**	**> Mean to 1 SD** **> 16.99 to 19.78**	**> 1 SD to 2 SD** **> 19.78 to22.57**	**> 2 SD** **> 22.57**
County-R	10	21	1	23	3	3
(n=61)	(16.4%)	(34.4%)	(1.6%)	(37.7%)	(4.9%)	
Club-R	1	9	0	17	11	8
(n=46)	(2.2%)	(19.6%)	(0.0%)	(37%)	(23.9%)	(17.4%)

*Mean and SD calculated using data from county players (n=61) only

Table 4.10: Number and percentage of players in each assigned category for eye-hand pro-action

Wayne Pro-Action	< -2 SD	< - 1 SD to -2 SD	< Mean to -1 SD	Mean	> Mean to 1 SD	> 1 SD to 2 SD	> 2 SD
Score	**< 27**	**31 to 27**	**35 to 32**	**36**	**37 to 40**	**41 to 45**	**> 45**
Combined N=107	2 (1.87%)	14 (13.08%)	23 (21.49%)	13 (12.15%)	38 (35.51%)	16 (14.95%)	1* (0.93%)

(Adjusted Data*) = All Data With Values > 2SD (Z values > 1.96) Removed Only one value was removed prior to calculating the mean and Standard Deviation Values. (n=107)

Table 4.11: Number and percentage of players in each assigned category for eye-hand re-action*

Wayne Re-Action	< - 1 SD to -2 SD	< Mean to -1 SD	Mean	> Mean to 1 SD	> 1 SD to 2 SD
Score (n)	**22 to 23**	**24 to 26**	**27**	**28 to 29**	**30**
Combined N=105	7 (6.7%)	22 (21%)	17 (16.2%)	48 (45.7%)	11 (10.5%)

*Based on combined county and club level data

Table 4.12: Percentile scores for the mean Absolute error for co-incident timing (sec)

	Percentiles						
Bassin Absolute Error	**5th**	**10th**	**30th**	**50th**	**70th**	**90th**	**95th**
County (sec)	**0.00**	**0.02**	**0.03**	**0.04**	**0.06**	**0.11**	**0.14**
Club (sec)	**0.03**	**0.03**	**0.08**	**0.13**	**0.19**	**0.28**	**0.35**

Table 4.13: Eye- hand dominance for county and club Gaelic football players

			Football		Football & Hurling
			County (n=61)	Club (n=46)	Club (n=20)
Dominant Eye	**Dominant Hand**				
Right	Right	Number	36	27	9
		Percentage	59	59	45
Left	Left	Number	4	5	0
		Percentage	7	11	0
Right	Left	Number	1	1	1
		Percentage	2	2	5
Left	Right	Number	20	13	10
		Percentage	33	28	50
Cross Dominance			35	30	55

Table 4.14: Eye-hand dominance for county and club Gaelic football teams

			Football		Football & Hurling
			County (n=61)	**Club (n=26)**	**Club (n=20)**
Dominant Eye	**Dominant Hand**				
Right	Right	Number	36	18	9
		Percentage	59	69	45
Left	Left	Number	4	5	0
		Percentage	7	19	0
Right	Left	Number	1	0	1
		Percentage	2	0	5
Left	Right	Number	20	3	10
		Percentage	33	12	50
Cross Dominance			35	12	55

Table 4.15: Summary of normative data for visual skills of Gaelic footballers

Visual Skills	Superior	Above Average	Average	Below Average	Needs Attention
90 % Log Mar					
Right Eye	< -0.14	-0.02 to -0.14	> -0.02 to 0.01	> 0.01 to 0.22	> 0.22
Left Eye	< -0.12	-0.02 to -0.12	> -0.02 to 0.08	> 0.08 to 0.18	> 0.18
Binocular	< -0.18	-0.08 to -0.18	>-0.08 to 0.02	>0.02 to 0.12	> 0.12
10 % Log Mar					
Right Eye	< 0.04	0.20 to 0.04	> 0.20 to 0.36	> 0.36 to 0.52	> 0.52
Left Eye	< 0.06	0.18 to 0.06	> 0.18 to 0.30	> 0.30 to 0.40	> 0.40
Binocular	<-0.01	0.11 to -0.01	> 0.11 to 0.23	> 0.23 to 0.35	> 0.35
Dynamic Fixation (sec)	< 14.20	16.99 to 14.20	> 16.99 to 19.78	> 19.78 to 22.57	> 22.57
Co-Incident Timing	<0.01	0.01 to 0.03	> 0.03 to 0.04	>0.04 to 0.07	> 0.07
Pro-action (no. lights)	> 40	36 to 40	35 to 32	31 to 27	< 27
Re-action (no. lights)	30	27 to 29	26 to 25	24 to 23	< 23
Stereo Acuity (sec arc)	15	30	60	----------	>60

CHAPTER V

Discussion

The aim of this research study was to identify the visual skills required to play Gaelic football and to establish normative data to classify these skills into superior, above average, average, below average and inferior (needs attention) visual performance. The objective was to provide normative data to Optometrists that can be used as a frame of reference when testing Gaelic footballers.

5.1 High and Low Contrast Vision

Vision is our dominant sense. It has been estimated that 80% of the sensory information about the environment is visual. The first step in the visual process is the formation of a clear, focussed image at the back of the eye. Monocular and binocular vision scores were adjusted my removing z scores ≥ 1.96. This resulted in a 50% reduction in SD for the monocular test scores whereas the binocular test scores remained unaltered. This suggests that binocular vision is more critical to a player's performance than monocular vision.

With the exception of right eye monocular high contrast vision, county players had significantly better high and low contrast vision monocularly and binocularly than club players. It is worth noting that the difference in right eye monocular high contrast vision between county and club level players almost reached statistical significance ($p = 0.07$). A number of factors may help to explain the better visual performance in county than club level players. Firstly, county players may self-select due to their innate higher standard of vision. Secondly, county level players may be more diligent about wearing a refractive correction, if required. It is also a possibility that playing football at county level may enable vision to develop to a higher level. Considering that only 5% of county players wore contact lenses compared with 11% of club players it is possible a higher standard of vision is essential to play Gaelic football at county level. A reduced visual acuity may have an immediate and detrimental effect on player and goal recognition resulting in a knock-on effect on anticipation and reaction time (Ward 2000).

Static visual acuity has been identified among the most important of visual skills required in sport. (Ward 2000) A study involving Nepalese football and cricket players found that 93% had available distance vision of 6/6 (log Mar 0.0) when wearing their optimum refractive correction. (Sapkota 2004) Loren and Mc Kewen (1995) recommend that myopic refractive errors as small as -0.25 should be corrected in athletes. (Loran 1995) There is anecdotal evidence to suggest that many children who have been identified as requiring a refractive correction have either been advised to or choose not to wear their glasses while participating in sport to avoid breakage or injury. If clear comfortable vision is an essential requirement in developing sports skills, then it is possible that the sporting progress of these children may be delayed simply because they should be wearing sports glasses or contact lenses.

It is possible that uncorrected moderate and high levels of hyperopia in childhood may prevent delay or retard balance, co-ordination, and depth perception, important learned visual skills especially for invasion field-based team sports. Inability to catch or kick a ball with ease is likely is likely to discourage a child from participating in ball sports. This may have a serious negative psychosocial effect on a growing child/adolescent. An essential part of growing up is learning how to be a team player, how to cope with success and failure and developing leadership skills. Involvement in sport can help to develop these skills while promoting physical and emotional well being. Inability to participate in sports may result in a child/adolescent feeling inadequate or isolated.

Although the IRFU currently prohibits the wearing of glasses or goggles when participating in the contact format of rugby they offer no guidelines as to the minimum vision a player should have before being allowed to participate. Children with the same chronological age can differ by 3-4 years in biological maturation. A collision between two children of similar chronological age and large differences in biologically maturation could be potentially very dangerous. This is an area that should be given more careful consideration when developing guidelines for eligibility to participate in invasion team based sports.

Overall, the vision results for club players are skewed more to the right (poorer results) than for county players. According to Buys and Ferriera's (2008) the "needs attention" category represents players with a relatively poor score (1 SD above the mean). As county level players had better vision than club players, vision can be considered to be an important attribute for optimal performance in Gaelic football and therefore, optometrists should try to maximise the vision of each player and not just those scoring >1 SD above the mean value. Optimising each player's vision could result in a shift in the distribution to the left. Regardless of unaided vision the present results indicate that an improvement of 0.2 log units achieved monocularly or binocularly with a refractive correction or by improving a refractive correction should be considered for all Gaelic football players.

Near induced transient myopia (NTIM) is defined as a short-term myopic far point shift immediately following a sustained near visual task.(Ong 1995) Previous research has found both early and late onset myopes to be particularly susceptible to this accommodative shift (Ciuffreda 1998). The NITM effect has also found to be additive following long periods of uninterrupted sustained close work (Vasudevan 2008) and rest periods may prevent a cumulative or additive effect (Arunthavaraja 2010). It has also been speculated that residual NITM may contribute to the progression of permanent myopia following repeated cycles of near work (Ciuffreda 2008).

Pre-match work and recreational visual tasks may affect the accommodative status of the visual system. Prolonged periods involving near vision can cause a temporary myopic shift resulting in blurred distance vision. Athletes who work at a computer should be aware of the effect that prolonged exposure to a near visual task has on their vision. They should also be aware of how long it takes distance vision to return to normal after ceasing computer work. Athletes should be advised about working distance, as increased working distance may reduce the myopic shift and shorten recovery time. Athletes should be encouraged to avoid using hand held devices like computers and tablets, to prevent a temporary blur to distance vision when travelling long distances to match venues. .

Elliott *et al*., (2007) found that the mean log Mar visual acuity improved from -0.13 in 18-24 year olds to -0.16 in 25-29 year olds, reducing gradually with age to a mean value of -0.02 for subjects over 75 yrs of age. The findings indicate that to draw useful conclusions from measures of acuity of normal healthy eyes, the test methods must record acuities of better than 0.00 log Mar. (Elliott 1995)

Contrast sensitivity measures the ability of the visual system to process spatial or temporal information about objects and their backgrounds under varying lighting conditions. (Cline 1997) This was the only test in which club players out-performed county players. The reason(s) for this difference is unclear but may be related to the significant age difference between county and club players (p=0.02). The club players were on average 5 years older than the county players. Previous research found that contrast sensitivity improves until approximately 40 years of age and then reduces slightly, thereafter.(Mantyjarvi 2001)

4.2 Dynamic Fixation

Dynamic fixation is defined as a brief fixation, preceded and followed by saccadic eye movements, in a combination of motility and vergence. One (1.6%) county player and 6 (13%) of club players had a dynamic fixation z score ≥ 1.96. Gaelic football is a dynamic sport, requiring players to quickly and accurately follow a moving ball, while at the same time being aware of the position of players on their own team and players on the opposing team and the exact location of the goal. The fact that county players had a faster dynamic fixation scores than club players is not surprising. The most likely reason for this difference is that county games are played at a faster pace than club games and therefore requires superior dynamic skills. It is also likely that playing at inter-county level helps to improve dynamic fixation skills.

The Dynamic Fixator is an easy test to administer and perform and appears to easily identify players of different playing ability. Griffith (2002) found that athletes who participated in the more dynamic track and field events had significantly faster eyes than the archers. This suggests that not only is it advantageous for sports people involved in dynamic sports to have fast eyes but it is perhaps equally important for athletes involved in more static sports like archery darts and shooting to have slow eye movements and steady fixation. Future studies should investigate the effect of introducing pre-match warm up routines including exercises that require fast eye movements for football players and slow steady gaze exercises for individuals participating in more static sports.

4.3 Eye-Hand Co-Ordination

Eye-Hand Co-Ordination refers to the amount of time that elapses between the initiation of a visual stimulus and the completion of a motor response to that stimulus.(Erickson 2007) It is measured using the Wayne Saccadic Fixator. Only one club player had a z score ≥ 1.96 for eye-hand pro-action co-ordination and no player had a z score ≥ 1.96 for eye-hand re-action co-ordination. Since there was no difference in either pro-action or re-action eye-hand co-ordination between the county and club players their results were combined for analysis. Ludeke and Ferreira (2006) compared the eye-hand pro-action co-ordination between professional, amateur and club rugby players. (Ludeke 2008) There was no difference in the eye-hand pro-action scores between the different groups. A single sample t test was used to compare the pro-action results in the present study with the results of Ludeke and Ferreira (2006). The rugby players in all groups performed better ($p<0.001$) in the pro-action test than Gaelic football players indicating that eye-hand co-ordination skills appear to be more developed in rugby players.. It appears that pro-action eye-hand co-ordination may not be a good indicator of talent within a particular sporting discipline. This may be due to the difference in movement patterns and decision making requirements between the two sports. It would be worthwhile investigating the effect of rugby specific drills on eye-hand co-ordination abilities of Gaelic football players.

4.4 Anticipation Timing

The process of adjusting a motor response to the arrival of a ball at a specific time and place is called co-incidence or co-incident anticipation. (Belisle 1963; Williams 1985) The analysis of the co-incidence or co-incident anticipation raised a few challenges. Late results were recorded with a minus sign and early results with a plus sign. For the purpose of analysis in this study the absolute error results were used. This means that the magnitude of the error was used with no consideration of anticipation timing being early or late. The best possible score for this test was 0 and if using the mean and SD method of analysis for categorising players it would place all in the average group. The percentage method provided more useful information. Buys and Ferreira (2006) recommended that the top 10% of scores should be categorised as superior. They also recommended that the next best 20% of scores should be categorised as above average and the following 20% as average. The remaining 50% of scores are divided evenly and categorised as below average and needing attention (the bottom 25% being categorised in the needs attention group). (Buys 2002) None of the county player had a z score ≥ 1.96 whereas 5 club players (10.7%) had a z score ≥ 1.96. County players had better co-incident timing scores than the club players. A previous study involving 137 elite and sub-elite soccer players concluded that the tests of anticipatory performance and situational probabilities were the best indicators of skill across the different skill groups. (Ward 2003)

It is difficult to compare co-incidence or co-incident anticipation results with previous studies due to difference in protocols employed. A study by Lyons (2008) involving expert and novice hurlers recorded co-incident anticipation timing immediately following acute bouts of exercise at 70% and 90% heart rate reserve. Each player performed 20 trials, following each exercise intensity. Expert hurlers had significantly better anticipation timing results across all intensity levels than the novice hurlers. There was no significant difference in co-incident anticipation timing among the expert hurlers across the exercise intensities. Novice hurlers had the best co-incident anticipation timing scores following moderate intensity exercise suggesting that the pre-match warm-up should involve this intensity of exercise. As co-incident timing appears to be a differentiating factor identifying expert players from novice players managers should consider co-incident timing exercises as part of their training routines. Ball machines similar to that used in tennis or baseball may have a positive effect on co-incident timing. Future research should investigate how dynamic fixation, co-incident timing and eye-hand co-ordination skills are affected by fatigue, dehydration and alcohol consumption.

4.5 Stereo Acuity

Stereo-acuity is a measure of the ability to perceive depth, on the basis of retinal disparity cues. (Grosvenor 2007) Approximately 56% of county and club level players had a stero acuity value of 60 seconds of arc. No recordable stereo acuity was found in 11% and 15% of county and club level players respectively. It would be interesting to determine the effect of wearing optimum refractive correction on stereo acuity values and the stereo acuity of players relative to their playing position and their role in the team. Taking a penalty kick is primarily an aiming task. It may be an advantage for the player taking the penalty not to have stereo acuity. Indeed, many air rifle shooters and archers choose to occlude an eye when competing.

The high percentage of club and county level players with no stereo-acuity makes it difficult to assess differences between groups. Stereo-acuity results for the county and club players, including individuals with no recordable scores are illustrated in Figure 5.1.

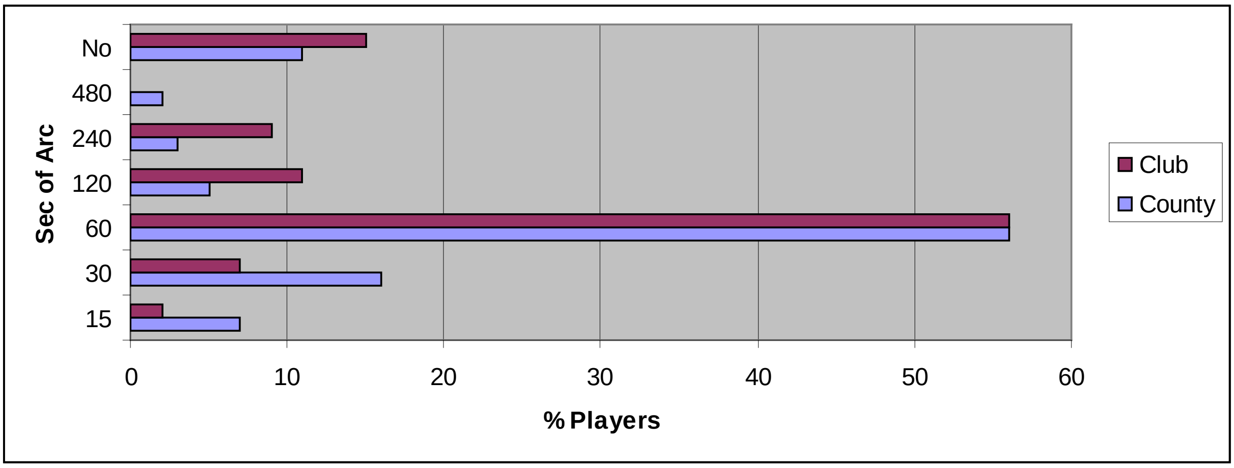


Figure 5.1. Stereo acuity scores for county and club level Gaelic football players
No = No level of stereo acuity was recorded.

The majority of players recorded a stereo acuity of 60 sec of arc. 23% of county compared to 9% of club players had a score < 60 seconds of arc. Conversely, 35% of club players had stereo acuity results > 60 seconds of arc compared to 21% of county levels players. Factors that would lead to a reduction in stereo acuity, for example, uncorrected anisometropia, should be taken into consideration during the sight examination of Gaelic football players.

4.6 Colour Vision

Colour Vision is defined as the perception of different colours making up the spectrum of visible light (Saunders 2007) and was evaluated using the 24 plate Ishihara colour vision test. Similar to the normal population 6.5% of club level players () were found to be red-green colour deficient. In contrast, only 1.6% of county players presented with red-green colour deficiency. However, this difference did not reach statistical significance. Having a red-green colour deficiency may impede enjoyment and performance in spectators and players respectively. Colour confusion can be minimised by careful jersey design. For example, the use of red and green could be minimised to stripes and yellow and white could be maximised to improve colour deficient player and spectator enjoyment. When Donegal and Down play against each other there is a risk of red green confusion for dichromats. This effect is reduced if Donegal wear predominantly yellow and minimise the colour green in their jersey. It can be seen in Figure 4.10 that by careful jersey design, the yellow portion of Donegal's jersey can be easily distinguished from the red worn by Down


(a)


(b)

Figure 5.2 Reducing the effect of red green confusion.
Donegal v Down as seen (a) with Normal Colour Vision and (b) by the Dichromat **(www.donegaldemocrat.ie)**

Similarly Figures 4.11 and 4.12 shows how clever jersey selection can minimise the colour confusion experienced by a dichromat when two teams are wearing red and white or when a team wearing red plays against a team wearing maroon.

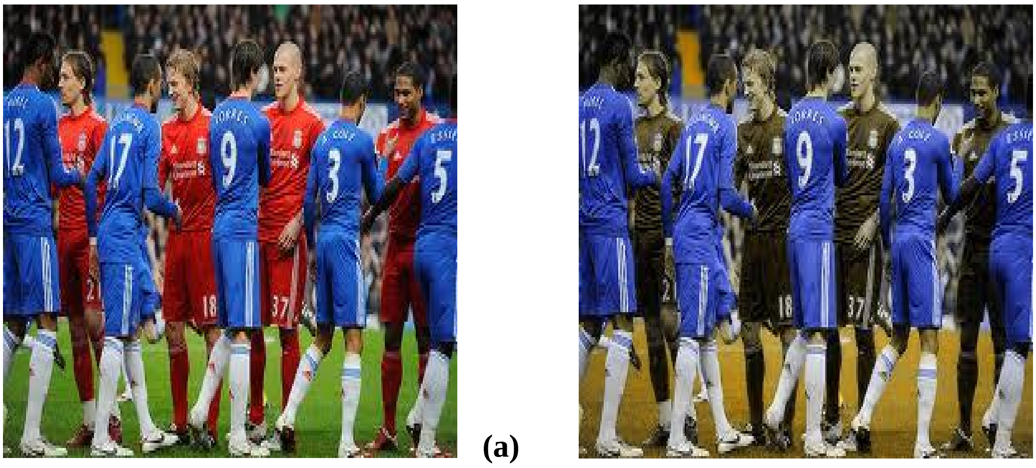
(a) **(b)**

Figure 5.3 Clever jersey selection when both teams wear red and white
As seen (a) with Normal Colour Vision and (b) by the Dichromat (www.donegaldemocrat.ie)

(a) **(b)**

Figure 5.4 Clever jersey selection to reduce the effect of maroon red confusion
As seen (a) with Normal Colour Vision and (b) by the Dichromat (www.independent.ie)

In addition the larger the block of colour, the easier it is for players and spectators to distinguish. In Figure 4.13 Liverpool players are wearing red long-sleeved jerseys, red shorts to the knees and red socks pulled up to the knees. This results in almost a complete block of unbroken red and therefore has the effect of increasing the size of the player so as to be easily distinguished by the viewer. Chelsea players are wearing long blue-sleeved jerseys, long blue shorts to the knee, and white socks pulled up to the knee. For the deuteranopic viewer, Liverpool players (in red) become almost dark grey but when viewed against the bright blue Chelsea players there is no difficulty differentiating one team from another.



(a) (b)

Figure 5.5 Colour blocking: Chelsea v Liverpool
As seen by normal observer (a) and by the dichromat (b)
(httpswww.google.iesearchq=chelsea+v+liverpool)

Classification of visual skills into five categories may in hindsight not have been ideal method of analysis. The mean and SD values for each visual skill is it itself useful information. However, the results for all visual skills were distributed normally after z scores ≥ 1.96 were removed. This means that 68.27% of the values were within one SD of the mean, 95% were within two SD of the mean and 99.73% were within three standard deviations of the mean. Knowing the mean and SD values will provide optometrists with norm reference criteria. The five categories could prove to be misleading. For example, when examining high and low contrast vision results, it would be preferable to provide refractive correction or improve the existing refractive correction for all players who could achieve 0.2 logMAR improvement. Results for dynamic fixation and anticipation timing have shown county players to perform significantly better than club players. It may be more useful to consider drills that improve anticipation timing and dynamic fixation as part of the training of Gaelic football teams as a whole rather than concentrating only on players who have a score > 1 SD above the mean.

The Wayne Saccadic Fixator is a test for examining eye-hand co-ordination, a skill which is undoubtedly necessary in Gaelic football. Surprisingly, there was no difference in hand-eye coordination skills between county and club players and therefore is not a useful test to identify between Gaelic football players of different ability. It is doubtful if players scoring below one SD from the mean require attention anymore than players classified in the superior group. Further research should examine the relation between eye-hand co-ordination and Gaelic football talent, factors which affect eye-hand co-ordination, drills to improve eye-hand co-ordination and the necessity if any for employing those drills.

Eye-hand dominance has been found to affect sporting skill.(Griffiths 2003) Uni-lateral dominance appears to be advantageous in aiming sports like archery and rifle shooting and contra-lateral dominance appears to be more prevalent amongst athletes involved in anticipatory sports like tennis and clay pigeon shooting. Similar to the county level Gaelic football, approximately 33% of soccer players have been identified as cross dominant (Griffiths, 2003). The club players in this study were sub-divided into players who played Gaelic football only, and those who played both hurling and football. Only 12% of club football players were cross dominant as opposed to 55% of club hurlers and football players. Although the sample size of each group is quite small it appears that due to the different skills required between Gaelic football and hurling cross dominance appears to be advantageous to hurlers. As hurlers would be expected to hold the hurl in their dominant hand scoring a point or goal would mean that the opposite eye would be in line with the goal-post. Further research needs to establish if cross dominant players self-select in hurling or if eye dominance changes depending on the sport played.

CHAPTER VI

Limitations, Recommendations and Conclusions

6.1 Limitations

When providing normative data it would be preferable to use the results from a visual skills analysis using members of the team of the County team who won the All Ireland Gaelic Football Championship as they can be considered to be the "most elite" in a given year. Indeed given time, an assessment of panel members from several annual championships could provide more insightful data. Such a study could include data from a visual skills analysis of winners of the minor, under 21 and senior championships, across several years, providing information on the visual skills of players from different age categories.

Assessment of high and low contrast vision was undertaken with refractive correction only if worn by players during training and games to maximise vision. High and low contrast vision was assessed without knowing what prescriptive glasses would be required to maximise vision. The accommodative effort required to undertake the test and the difference in the accommodative effort required by each eye was not measured. The Dynamic Fixator is a relatively new tool for the sports vision optometrist and currently lacks a standardized protocol

The Bassin Anticipator is cumbersome to use. It requires considerable time to assemble and dismantle. It had to be frequently re-set during testing as the slightest knock caused it to malfunction. It is difficult to compare results with previous findings due to the lack of a standardized protocol. The Wayne Saccadic Fixator test may not have a high enough sensitivity to detect reaction eye hand coordination due to equipment design issues and the fact the period of time during which the lights were illuminated was too long. The values recorded may not have been a record of each individual's maximal achievable stereo acuity as players may not have been assessed with optimum refractive correction. The Ishihara colour vision test did not test for blue-yellow deficiency. However, this is not a major limitation considering that only 0.01 % of humans are thought to have blue-yellow colour deficiency.

6.2 Recommendations

6.2.1 Increase Visual Skill Awareness in Sport

The Association of Optometrists should increase the awareness of the importance of vision in sport. GAA managers should include sports vision screening as part of their team management strategy. Ideally, Ireland should have an association of sports vision practitioners responsible for catering for the visual requirements of Irish athletes at all levels.

6.2.2 Guidelines and Standards

Collisions between children of different size and weight could occur due to a child playing with reduced vision resulting in possible serious injury. Indeed this is true for many team sports. At every level of the GAA, from nurseries (that cater for children from 4 years of age) to senior county level players, routine screening of visual skills should be standard practice. This will ensure that any reduction in vision will be picked-up early and allow correction to take place to prevent reduction in sporting performance.

Optometrists should play a more important role in pre-school screening for a visual defect and should be part of the primary care team that includes occupational therapists, psychologists and physiotherapists. To date, the school vision screening is undertaken by public health nurses. This screening places great emphasis on distance monocular log Mar vision results but does not include refraction, stereo acuity testing or colour vision testing. It is not uncommon for children with significant hyperopia/farsightedness (*i.e,* > 3Ds) or significant amisometropia (*i.e.* > 2Ds) to pass a school screening. This could result in a breakdown in binocular vision resulting in poor stereo acuity and problems with visual skills required in school or sport. Sporting organisations should be aware of the importance of vision in their sport and provide visual screenings routinely.

There is currently no uniform standards for eyewear that can be worn when playing Gaelic football. If players, especially children too young to wear contact lenses, require a refractive correction, there should be guidelines and safety standards governing the sports glasses that can be worn.

6.2.3 Jersey Design

The complications resulting from poor jersey colour selection and design have been highlighted. Careful jersey colour design could improve player and spectator enjoyment especially for the colour deficient population. It is recommended that team managers and sporting organisations investigate the choice of jersey colours worn by competing teams with a particular emphasis on the requirements of colour deficient players and spectators.

6.2.4 Statistical Analysis:

Classification of Visual skills into five categories Superior, above average, average, below average and needs attention, may not in hindsight not be an ideal method of analysis. The mean and SD values for each visual skill is useful information but considering that the results for all visual skills was were distributed normally after z scores ≥ 1.96 were removed data then follows the empirical rule. This means that 68.27% of the values lie within one SD of the mean, 95% of values lie within two SD of the mean and 99.73% of the values lie within three standard deviations of the mean. By providing mean and SD values, optometrists will now have a reference. The five categories could prove to be misleading. For example, when examining high and low contrast vision results, it would be preferable to provide refractive correction or improve the existing refractive correction for all players who could achieve 0.2 logMAR improvement. Results for dynamic fixation and anticipation timing have shown county players to perform significantly better than club players. These tests would be useful in identifying talent. It may be more useful to consider drills that improve anticipation timing and dynamic fixation as part of the training of Gaelic football teams as a whole rather than concentrating only on players who have a score more than one> 1 SD worse than the mean.

The Wayne Saccadic Fixator is a test for examining eye-hand co-ordination, a skill which is undoubtedly necessary in Gaelic football but as no significant difference was found between county and club players it is not a useful test to identify between players of different ability and as such it is doubtful if players scoring below one SD from the mean require attention anymore than players classified in the superior group. Further research should examine the relationship between eye-hand co-ordination and Gaelic football talent, factors which affect eye-hand co-ordination, drills to improve eye-hand co-ordination and the necessity if any for employing those drills.

6.2.5 Future studies

Several players may have the same result for vision but the refractive effort required could vary greatly. Future research should examine refractive status and what improvement if any, can be achieved for all visual skills post refractive correction. Studies should also investigate the link between refractive error development of balance and co-ordination skills.

A study to investigate the incidence of ipsi-lateral dominance in hurlers of different ages and standards would be insightful. Previous studies have shown uni-lateral dominance to be an advantage in predominantly aiming sports like archery and rifle shooting and contra-lateral dominance to be more prevalent in sports that require anticipation like hurling and tennis. A longitudinal study should examine eye-hand dominance in children over a five year period and ascertain and determine if changes are sport specific. If eye-hand dominance changes according to the sport played this may have significant impact on reading ability and academic performance. Future studies should examine the visual skills of Gaelic football players in relation to the position and role they have to play on the team with particular attention given to the role of stereo acuity.

6.3 Conclusions

Table 6.1 Frame of Reference for optometrists

Visual Skill	**Mean ±SD**
Vision 90% Right Eye logMAR	-0.02±0.12
Vision 90% Left Eye logMAR	-0.02±0.10
Vision 90% Binocular logMAR	-0.08±0.10
Vision 10% Right Eye logMAR	0.20±0.16
Vision 10% Left Eye logMAR	0.18±0.12
Vision 10% Binocular logMAR	0.11±0.12
Eye-Hand Pro-Action Number	36.84±4.34
Eye Hand Re-Action Number	27.51±1.85
Dynamic Fixation Average Second	16.86±2.60
Co-Incident Timing Seconds *	0.05±0.04

Notes to optometrists:

1. Refractive correction should be provided or existing refractive error should be changed if 0.02logMAR improvement can be achieved either monocularly or binocularly.

2. Measurements of eye-hand co-ordination are not good indicators of talent and will not identify discriminate elite Gaelic football players from amateur Gaelic football players

3. Both the Dynamic Fixator and Anticipation Timer are good tests for identifying talent amongst Gaelic footballers

4. Gaelic footballers should have a colour vision test as part of their routine sight examination. Players found to have a red-green colour deficiency should be informed about possible resulting difficulties they may experience when playing football.

Appendix 1

Table 1: Vision 90% logMAR right eye raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
1	1.10	4.883	1	0.02	-0.080	1	-0.10	-0.631
2	0.90	3.964	1	0.02	-0.080	1	-0.10	-0.631
1	0.80	3.504	1	0.02	-0.080	1	-0.10	-0.631
1	0.62	2.677	1	0.02	-0.080	1	-0.10	-0.631
2	0.60	2.585	1	0.02	-0.080	1	-0.10	-0.631
2	0.58	2.493	1	0.02	-0.080	1	-0.10	-0.631
2	0.40	1.666	1	0.02	-0.080	1	-0.10	-0.631
1	0.30	1.207	1	0.02	-0.080	1	-0.10	-0.631
1	0.30	1.207	2	0.02	-0.080	2	-0.10	-0.631
1	0.22	0.839	2	0.02	-0.080	2	-0.10	-0.631
1	0.20	0.747	1	0.00	-0.172	2	-0.10	-0.631
1	0.20	0.747	1	0.00	-0.172	2	-0.10	-0.631
2	0.20	0.747	1	0.00	-0.172	2	-0.10	-0.631
2	0.20	0.747	1	0.00	-0.172	2	-0.10	-0.631
2	0.14	0.472	1	0.00	-0.172	2	-0.10	-0.631
1	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
1	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
1	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
2	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
2	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
2	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
2	0.12	0.380	2	0.00	-0.172	2	-0.10	-0.631
1	0.10	0.288	2	0.00	-0.172	1	-0.16	-0.907
1	0.10	0.288	1	-0.06	-0.447	1	-0.18	-0.999
1	0.10	0.288	1	-0.06	-0.447	1	-0.18	-0.999
2	0.10	0.288	1	-0.06	-0.447	1	-0.18	-0.999
2	0.10	0.288	1	-0.06	-0.447	1	-0.18	-0.999
2	0.10	0.288	1	-0.08	-0.539	1	-0.20	-1.091
2	0.10	0.288	1	-0.08	-0.539	1	-0.20	-1.091
2	0.10	0.288	1	-0.08	-0.539	2	-0.20	-1.091
2	0.10	0.288	1	-0.08	-0.539	1	-0.22	-1.183
2	0.10	0.288	1	-0.08	-0.539			
2	0.10	0.288	1	-0.08	-0.539			
1	0.04	0.012	1	-0.08	-0.539			
1	0.04	0.012	2	-0.08	-0.539			
1	0.04	0.012	1	-0.10	-0.631			
2	0.04	0.012	1	-0.10	-0.631			
1	0.02	-0.080	1	-0.10	-0.631			

1= County level; 2= Club level

Table 2: Vision 90% log MAR left eye raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
1	0.80	5.046	2	0.02	0.025	1	-0.08	-0.618
1	0.60	3.758	2	0.02	0.025	1	-0.08	-0.618
2	0.60	3.758	2	0.02	0.025	1	-0.08	-0.618
2	0.56	3.501	2	0.02	0.025	1	-0.08	-0.618
1	0.22	1.313	1	0.00	-0.103	1	-0.08	-0.618
2	0.22	1.313	1	0.00	-0.103	2	-0.08	-0.618
1	0.20	1.184	1	0.00	-0.103	2	-0.08	-0.618
1	0.20	1.184	1	0.00	-0.103	1	-0.10	-0.747
2	0.20	1.184	1	0.00	-0.103	1	-0.10	-0.747
2	0.18	1.055	1	0.00	-0.103	1	-0.10	-0.747
2	0.14	0.798	1	0.00	-0.103	1	-0.10	-0.747
1	0.12	0.669	1	0.00	-0.103	1	-0.10	-0.747
1	0.12	0.669	1	0.00	-0.103	1	-0.10	-0.747
1	0.12	0.669	2	0.00	-0.103	1	-0.10	-0.747
1	0.12	0.669	2	0.00	-0.103	2	-0.10	-0.747
2	0.12	0.669	2	0.00	-0.103	2	-0.10	-0.747
1	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
1	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
1	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
1	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
2	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
2	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
2	0.10	0.540	2	0.00	-0.103	2	-0.10	-0.747
2	0.10	0.540	2	0.00	-0.103	2	-0.12	-0.876
2	0.10	0.540	2	0.00	-0.103	1	-0.14	-1.005
2	0.10	0.540	2	0.00	-0.103	1	-0.16	-1.133
2	0.06	0.283	1	-0.02	-0.232	1	-0.16	-1.133
1	0.04	0.154	1	-0.06	-0.490	1	-0.16	-1.133
1	0.04	0.154	1	-0.06	-0.490	1	-0.16	-1.133
1	0.02	0.025	1	-0.06	-0.490	1	-0.18	-1.262
1	0.02	0.025	1	-0.06	-0.490	1	-0.18	-1.262
1	0.02	0.025	1	-0.06	-0.490			
1	0.02	0.025	1	-0.06	-0.490			
1	0.02	0.025	1	-0.08	-0.618			
1	0.02	0.025	1	-0.08	-0.618			
2	0.02	0.025	1	-0.08	-0.618			
2	0.02	0.025	1	-0.08	-0.618			
2	0.02	0.025	1	-0.08	-0.618			

1= County level; 2= Club level

Table 3: Vision 90% logMAR binocular raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	0.60	5.4636	2	0.00	0.4541	2	-0.10	-0.3808
1	0.30	2.9589	1	-0.04	0.1202	2	-0.10	-0.3808
2	0.20	2.1240	1	-0.06	-0.0468	2	-0.10	-0.3808
2	0.18	1.9570	1	-0.06	-0.0468	2	-0.10	-0.3808
1	0.14	1.6230	1	-0.06	-0.0468	2	-0.10	-0.3808
1	0.12	1.4560	1	-0.06	-0.0468	2	-0.10	-0.3808
1	0.12	1.4560	1	-0.06	-0.0468	2	-0.10	-0.3808
1	0.12	1.4560	2	-0.06	-0.0468	2	-0.10	-0.3808
2	0.12	1.4560	1	-0.08	-0.2138	2	-0.10	-0.3808
1	0.10	1.2890	1	-0.08	-0.2138	2	-0.10	-0.3808
1	0.10	1.2890	1	-0.08	-0.2138	2	-0.12	-0.5478
2	0.10	1.2890	1	-0.08	-0.2138	1	-0.16	-0.8817
1	0.04	0.7881	1	-0.08	-0.2138	1	-0.18	-1.0487
2	0.04	0.7881	1	-0.08	-0.2138	1	-0.18	-1.0487
2	0.04	0.7881	1	-0.08	-0.2138	1	-0.18	-1.0487
1	0.02	0.6211	1	-0.08	-0.2138	1	-0.18	-1.0487
1	0.02	0.6211	1	-0.08	-0.2138	1	-0.18	-1.0487
1	0.02	0.6211	1	-0.08	-0.2138	1	-0.18	-1.0487
2	0.02	0.6211	2	-0.08	-0.2138	1	-0.18	-1.0487
2	0.02	0.6211	2	-0.08	-0.2138	1	-0.18	-1.0487
2	0.02	0.6211	1	-0.10	-0.3808	1	-0.20	-1.2157
1	0.00	0.4541	1	-0.10	-0.3808	1	-0.20	-1.2157
1	0.00	0.4541	1	-0.10	-0.3808	1	-0.20	-1.2157
1	0.00	0.4541	1	-0.10	-0.3808	2	-0.20	-1.2157
1	0.00	0.4541	1	-0.10	-0.3808	2	-0.20	-1.2157
2	0.00	0.4541	1	-0.10	-0.3808	2	-0.20	-1.2157
2	0.00	0.4541	1	-0.10	-0.3808	2	-0.20	-1.2157
2	0.00	0.4541	1	-0.10	-0.3808	1	-0.22	-1.3827
2	0.00	0.4541	1	-0.10	-0.3808	1	-0.24	-1.5497
2	0.00	0.4541	1	-0.10	-0.3808	1	-0.26	-1.7166
2	0.00	0.4541	1	-0.10	-0.3808	1	-0.26	-1.7166
2	0.00	0.4541	1	-0.10	-0.3808			
2	0.00	0.4541	1	-0.10	-0.3808			
2	0.00	0.4541	1	-0.10	-0.3808			
2	0.00	0.4541	2	-0.10	-0.3808			
2	0.00	0.4541	2	-0.10	-0.3808			
2	0.00	0.4541	2	-0.10	-0.3808			
2	0.00	0.4541	2	-0.10	-0.3808			

1= County level; 2= Club level

Table 4: Vision 10% logMAR right eye raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	1.80	5.6712	1	0.24	-0.1003	2	0.12	-0.5442
1	1.30	3.8214	1	0.24	-0.1003	2	0.12	-0.5442
1	1.28	3.7474	2	0.24	-0.1003	2	0.12	-0.5442
2	0.84	2.1195	1	0.22	-0.1743	2	0.12	-0.5442
2	0.80	1.9716	1	0.22	-0.1743	1	0.10	-0.6182
2	0.72	1.6756	1	0.22	-0.1743	1	0.10	-0.6182
1	0.70	1.6016	1	0.22	-0.1743	1	0.10	-0.6182
1	0.62	1.3056	1	0.22	-0.1743	1	0.10	-0.6182
1	0.60	1.2316	1	0.22	-0.1743	1	0.10	-0.6182
1	0.54	1.0096	1	0.22	-0.1743	1	0.10	-0.6182
2	0.54	1.0096	1	0.20	-0.2483	1	0.10	-0.6182
2	0.50	0.8617	1	0.20	-0.2483	1	0.10	-0.6182
1	0.44	0.6397	1	0.20	-0.2483	1	0.10	-0.6182
2	0.42	0.5657	1	0.20	-0.2483	2	0.10	-0.6182
2	0.42	0.5657	1	0.20	-0.2483	2	0.10	-0.6182
2	0.42	0.5657	1	0.20	-0.2483	2	0.10	-0.6182
1	0.40	0.4917	1	0.20	-0.2483	2	0.10	-0.6182
1	0.40	0.4917	1	0.20	-0.2483	2	0.10	-0.6182
2	0.40	0.4917	1	0.20	-0.2483	1	0.06	-0.7662
2	0.40	0.4917	1	0.20	-0.2483	1	0.04	-0.8402
2	0.40	0.4917	2	0.20	-0.2483	1	0.04	-0.8402
2	0.40	0.4917	2	0.20	-0.2483	2	0.04	-0.8402
2	0.40	0.4917	2	0.20	-0.2483	2	0.04	-0.8402
2	0.40	0.4917	2	0.20	-0.2483	1	0.02	-0.9142
1	0.32	0.1957	2	0.20	-0.2483	1	0.02	-0.9142
1	0.32	0.1957	2	0.20	-0.2483	1	0.02	-0.9142
1	0.32	0.1957	2	0.20	-0.2483	1	0.02	-0.9142
1	0.30	0.1217	1	0.16	-0.3963	1	0.00	-0.9882
1	0.30	0.1217	1	0.14	-0.4702	1	0.00	-0.9882
1	0.30	0.1217	1	0.14	-0.4702	1	-0.02	-1.0622
2	0.30	0.1217	1	0.14	-0.4702	1	-0.06	-1.2102
2	0.30	0.1217	2	0.14	-0.4702			
2	0.30	0.1217	2	0.14	-0.4702			
2	0.30	0.1217	1	0.12	-0.5442			
2	0.30	0.1217	1	0.12	-0.5442			
2	0.30	0.1217	2	0.12	-0.5442			
2	0.30	0.1217	2	0.12	-0.5442			
1	0.26	-0.0263	2	0.12	-0.5442			

1= County level; 2= Club level

Table 5: Vision 10% logMAR left eye raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
1	1.30	5.654	1	0.24	0.008	1	0.12	-0.631
2	0.82	3.097	2	0.24	0.008	1	0.12	-0.631
2	0.80	2.991	2	0.24	0.008	1	0.12	-0.631
1	0.78	2.884	1	0.22	-0.099	1	0.12	-0.631
1	0.62	2.032	1	0.22	-0.099	1	0.12	-0.631
1	0.54	1.606	1	0.22	-0.099	2	0.12	-0.631
2	0.52	1.499	1	0.22	-0.099	2	0.12	-0.631
1	0.42	0.967	1	0.22	-0.099	2	0.12	-0.631
2	0.42	0.967	1	0.22	-0.099	2	0.12	-0.631
1	0.40	0.860	1	0.22	-0.099	2	0.12	-0.631
1	0.40	0.860	1	0.22	-0.099	2	0.12	-0.631
1	0.40	0.860	1	0.22	-0.099	1	0.10	-0.738
2	0.40	0.860	2	0.22	-0.099	1	0.10	-0.738
2	0.40	0.860	1	0.20	-0.205	1	0.10	-0.738
2	0.40	0.860	1	0.20	-0.205	1	0.10	-0.738
2	0.40	0.860	1	0.20	-0.205	1	0.10	-0.738
2	0.38	0.754	2	0.20	-0.205	2	0.10	-0.738
2	0.36	0.647	2	0.20	-0.205	2	0.10	-0.738
1	0.34	0.540	2	0.20	-0.205	2	0.10	-0.738
2	0.34	0.540	2	0.20	-0.205	2	0.10	-0.738
1	0.32	0.434	2	0.20	-0.205	2	0.10	-0.738
2	0.32	0.434	2	0.20	-0.205	2	0.10	-0.738
2	0.32	0.434	2	0.20	-0.205	1	0.08	-0.844
2	0.32	0.434	2	0.20	-0.205	1	0.04	-1.057
2	0.32	0.434	2	0.20	-0.205	1	0.04	-1.057
1	0.30	0.327	1	0.18	-0.312	1	0.02	-1.153
1	0.30	0.327	1	0.18	-0.312	1	0.02	-1.164
1	0.30	0.327	1	0.16	-0.418	1	0.00	-1.270
1	0.30	0.327	1	0.16	-0.418	1	0.00	-1.270
1	0.30	0.327	1	0.14	-0.525	1	0.00	-1.270
2	0.30	0.327	1	0.14	-0.525	1	-0.06	-1.590
2	0.30	0.327	1	0.14	-0.525			
2	0.30	0.327	2	0.14	-0.525			
2	0.30	0.327	1	0.12	-0.631			
2	0.28	0.221	1	0.12	-0.631			
1	0.26	0.114	1	0.12	-0.631			
1	0.26	0.114	1	0.12	-0.631			
2	0.26	0.114	1	0.12	-0.631			

1= County level; 2= Club level

Table 6: Vision 10% logMAR binocular raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	0.80	4.607	1	0.16	0.128	1	0.04	-0.712
2	0.66	3.628	1	0.14	-0.012	1	0.04	-0.712
1	0.50	2.508	1	0.14	-0.012	1	0.04	-0.712
1	0.42	1.948	1	0.14	-0.012	1	0.04	-0.712
1	0.40	1.808	2	0.14	-0.012	2	0.04	-0.712
1	0.40	1.808	2	0.14	-0.012	2	0.04	-0.712
2	0.40	1.808	1	0.12	-0.152	2	0.04	-0.712
1	0.32	1.248	1	0.12	-0.152	1	0.02	-0.852
2	0.32	1.248	1	0.12	-0.152	1	0.02	-0.852
2	0.32	1.248	1	0.12	-0.152	1	0.02	-0.852
2	0.32	1.248	1	0.12	-0.152	1	0.02	-0.852
1	0.30	1.108	1	0.12	-0.152	2	0.02	-0.852
2	0.30	1.108	1	0.12	-0.152	2	0.02	-0.852
2	0.30	1.108	1	0.12	-0.152	2	0.02	-0.852
2	0.30	1.108	1	0.12	-0.152	2	0.02	-0.852
2	0.30	1.108	1	0.12	-0.152	1	0.00	-0.992
2	0.28	0.968	2	0.12	-0.152	1	0.00	-0.992
1	0.26	0.828	2	0.12	-0.152	1	0.00	-0.992
1	0.26	0.828	2	0.12	-0.152	1	0.00	-0.992
1	0.24	0.688	2	0.12	-0.152	1	0.00	-0.992
2	0.22	0.548	2	0.12	-0.152	1	0.00	-0.992
1	0.20	0.408	1	0.10	-0.292	1	0.00	-0.992
1	0.20	0.408	1	0.10	-0.292	1	0.00	-0.992
1	0.20	0.408	1	0.10	-0.292	2	0.00	-0.992
1	0.20	0.408	1	0.10	-0.292	2	0.00	-0.992
2	0.20	0.408	1	0.10	-0.292	2	0.00	-0.992
2	0.20	0.408	1	0.10	-0.292	1	-0.06	-1.412
2	0.20	0.408	2	0.10	-0.292	1	-0.06	-1.412
2	0.20	0.408	2	0.10	-0.292	1	-0.08	-1.551
2	0.20	0.408	2	0.10	-0.292	1	-0.10	-1.691
2	0.20	0.408	2	0.10	-0.292	1	-0.10	-1.691
1	0.18	0.268	2	0.10	-0.292			
1	0.18	0.268	2	0.10	-0.292			
2	0.18	0.268	2	0.10	-0.292			
1	0.16	0.128	2	0.10	-0.292			
1	0.16	0.128	2	0.10	-0.292			
1	0.16	0.128	2	0.10	-0.292			
1	0.16	0.128	1	0.06	-0.572			

1= County level; 2= Club level

Table 7: Contrast Sensitivity Right eye log units. raw score and Z score for each Participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	2.10	2.279	1	1.80	0.310	1	1.65	-0.675
1	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
1	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	1	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.95	1.295	2	1.80	0.310	1	1.65	-0.675
2	1.90	0.966	2	1.80	0.310	1	1.65	-0.675
2	1.90	0.966	2	1.80	0.310	1	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	1	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	1	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	1	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.65	-0.675
1	1.80	0.310	2	1.80	0.310	2	1.50	-1.660
1	1.80	0.310	1	1.65	-0.675	1	1.05	-4.614
1	1.80	0.310	1	1.65	-0.675	2	0.90	-5.599
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			
1	1.80	0.310	1	1.65	-0.675			

1= County level; 2= Club level

Table 8: Contrast Sensitivity Left eye log units raw score and Z score for each Participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	2.10	2.749	1	1.80	0.321	1	1.65	-0.892
1	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
1	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	1	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.95	1.535	2	1.80	0.321	1	1.65	-0.892
2	1.90	1.131	2	1.80	0.321	1	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	2	1.80	0.321	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	2	1.65	-0.892
1	1.80	0.321	1	1.65	-0.892	1	1.20	-4.534
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			
1	1.80	0.321	1	1.65	-0.892			

1= County level; 2= Club level

Table 9: Binocular Contrast Sensitivity log units. raw score and Z score for each Participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
1	1.95	1.318	1	1.80	0.105	1	1.65	-1.108
1	1.95	1.318	1	1.80	0.105	1	1.65	-1.108
1	1.95	1.318	1	1.80	0.105	1	1.65	-1.108
1	1.95	1.318	1	1.80	0.105	2	1.65	-1.108
1	1.95	1.318	1	1.80	0.105	1	1.20	-4.746
1	1.95	1.318	1	1.80	0.105			
1	1.95	1.318	1	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
1	1.95	1.318	2	1.80	0.105			
2	1.95	1.318	2	1.80	0.105			
2	1.95	1.318	2	1.80	0.105			
2	1.95	1.318	2	1.80	0.105			
2	1.95	1.318	2	1.80	0.105			
2	1.95	1.318	2	1.80	0.105			
1	1.80	0.105	2	1.80	0.105			
1	1.80	0.105	2	1.80	0.105			
1	1.80	0.105	2	1.80	0.105			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			
1	1.80	0.105	1	1.65	-1.108			

1= County level; 2= Club level

Table 10: Eye-Hand Pro-Action (No. of Lights) raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	46	2.148	2	39	0.566	1	34	-0.564
1	44	1.696	2	39	0.566	1	34	-0.564
1	44	1.696	1	38	0.340	1	34	-0.564
1	44	1.696	1	38	0.340	2	34	-0.564
2	44	1.696	1	38	0.340	2	34	-0.564
2	43	1.470	2	38	0.340	2	34	-0.564
1	42	1.244	2	38	0.340	2	34	-0.564
1	42	1.244	2	38	0.340	2	34	-0.564
1	42	1.244	2	38	0.340	2	34	-0.564
1	42	1.244	1	37	0.114	2	34	-0.564
1	42	1.244	1	37	0.114	2	33	-0.790
2	42	1.244	1	37	0.114	1	32	-1.016
2	42	1.244	1	37	0.114	1	32	-1.016
2	42	1.244	1	37	0.114	2	32	-1.016
1	41	1.018	1	37	0.114	2	32	-1.016
1	41	1.018	2	37	0.114	1	31	-1.242
1	41	1.018	2	37	0.114	2	31	-1.242
1	40	0.792	2	37	0.114	1	30	-1.468
1	40	0.792	1	36	-0.112	1	30	-1.468
1	40	0.792	1	36	-0.112	1	30	-1.468
1	40	0.792	1	36	-0.112	2	30	-1.468
1	40	0.792	1	36	-0.112	1	29	-1.694
1	40	0.792	1	36	-0.112	1	29	-1.694
1	40	0.792	1	36	-0.112	1	29	-1.694
1	40	0.792	2	36	-0.112	1	29	-1.694
1	40	0.792	2	36	-0.112	1	29	-1.694
2	40	0.792	2	36	-0.112	1	28	-1.920
2	40	0.792	2	36	-0.112	2	28	-1.920
2	40	0.792	2	36	-0.112	2	27	-2.146
2	40	0.792	2	36	-0.112	2	26	-2.372
1	39	0.566	2	36	-0.112	2	25	-2.598
1	39	0.566	1	35	-0.338			
1	39	0.566	2	35	-0.338			
1	39	0.566	2	35	-0.338			
1	39	0.566	2	35	-0.338			
1	39	0.566	1	34	-0.564			
1	39	0.566	1	34	-0.564			
2	39	0.566	1	34	-0.564			

1= County level; 2= Club level

Table 11: Eye-Hand Re-Action (No. of Lights) raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	1	26	-0.51
1	30	1.18	1	28	0.33	2	26	-0.51
2	30	1.18	1	28	0.33	2	26	-0.51
2	30	1.18	1	28	0.33	2	26	-0.51
2	30	1.18	1	28	0.33	1	25	-0.93
1	29	0.76	1	28	0.33	2	25	-0.93
1	29	0.76	2	28	0.33	2	25	-0.93
1	29	0.76	2	28	0.33	2	25	-0.93
1	29	0.76	2	28	0.33	2	25	-0.93
1	29	0.76	2	28	0.33	2	25	-0.93
1	29	0.76	2	28	0.33	1	24	-1.36
1	29	0.76	2	28	0.33	1	24	-1.36
1	29	0.76	2	28	0.33	1	24	-1.36
1	29	0.76	2	28	0.33	2	24	-1.36
1	29	0.76	2	28	0.33	2	24	-1.36
2	29	0.76	1	27	-0.09	2	24	-1.36
2	29	0.76	1	27	-0.09	1	23	-1.78
2	29	0.76	1	27	-0.09	1	23	-1.78
2	29	0.76	1	27	-0.09	1	23	-1.78
2	29	0.76	1	27	-0.09	1	22	-2.20
2	29	0.76	1	27	-0.09	2	20	-3.04
2	29	0.76	1	27	-0.09	1	18	-3.89
2	29	0.76	1	27	-0.09	2	18	-3.89
2	29	0.76	1	27	-0.09			
2	29	0.76	1	27	-0.09			
2	29	0.76	1	27	-0.09			
2	29	0.76	2	27	-0.09			
2	29	0.76	2	27	-0.09			
1	28	0.33	2	27	-0.09			
1	28	0.33	2	27	-0.09			
1	28	0.33	2	27	-0.09			
1	28	0.33	2	27	-0.09			

1= County level; 2= Club level

Table 12: Dynamic Fixation (sec) raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	32.22	3.95	2	18.61	0.13	1	16.35	-0.51
2	28.27	2.84	2	18.50	0.10	1	16.30	-0.52
2	26.98	2.48	1	18.42	0.07	1	16.20	-0.55
2	25.88	2.17	1	18.19	0.01	2	16.18	-0.55
2	25.62	2.10	2	18.16	0.00	2	16.15	-0.56
2	25.50	2.06	2	18.11	-0.01	2	15.88	-0.64
1	25.14	1.96	1	18.02	-0.04	1	15.74	-0.68
1	24.90	1.90	2	18.00	-0.04	1	15.72	-0.68
2	24.10	1.67	1	17.88	-0.08	2	15.63	-0.71
1	24.07	1.66	1	17.85	-0.09	1	15.58	-0.72
2	23.76	1.58	1	17.83	-0.09	2	15.53	-0.74
2	23.42	1.48	1	17.76	-0.11	1	15.36	-0.78
1	21.69	0.99	1	17.71	-0.12	2	15.24	-0.82
2	21.37	0.90	2	17.71	-0.12	1	15.10	-0.86
2	21.25	0.87	1	17.61	-0.15	1	14.95	-0.90
2	21.11	0.83	1	17.60	-0.16	1	14.83	-0.93
2	20.79	0.74	2	17.49	-0.19	1	14.71	-0.97
2	20.75	0.73	2	17.41	-0.21	1	14.55	-1.01
2	20.50	0.66	2	17.38	-0.22	1	14.52	-1.02
1	20.47	0.65	2	17.33	-0.23	2	14.35	-1.07
1	20.44	0.64	1	17.22	-0.26	1	13.92	-1.19
2	20.29	0.60	1	17.19	-0.27	1	13.81	-1.22
2	19.95	0.50	1	17.17	-0.28	1	13.77	-1.23
2	19.94	0.50	1	17.17	-0.28	1	13.53	-1.30
2	19.82	0.47	2	17.10	-0.30	1	13.17	-1.40
1	19.77	0.45	2	17.08	-0.30	2	13.15	-1.41
1	19.63	0.41	1	17.05	-0.31	1	12.99	-1.45
2	19.59	0.40	1	16.99	-0.33	1	12.91	-1.47
2	19.47	0.37	1	16.89	-0.35	1	12.74	-1.52
1	19.41	0.35	1	16.86	-0.36	1	12.67	-1.54
1	19.37	0.34	1	16.75	-0.39	1	11.85	-1.77
2	19.05	0.25	1	16.71	-0.41			
2	19.04	0.25	1	16.66	-0.42			
1	18.99	0.24	2	16.64	-0.43			
1	18.95	0.22	1	16.57	-0.44			
1	18.83	0.19	1	16.52	-0.46			
1	18.80	0.18	2	16.51	-0.46			
2	18.78	0.18	1	16.46	-0.48			

1= County level; 2= Club level

Table 13: Co-Incident Timing absolute error (sec). raw score and Z score for each participant

Group	Score	Z Score	Group	Score	Z Score	Group	Score	Z Score
2	0.352	4.163	1	0.057	-0.271	1	0.012	-0.956
2	0.287	3.192	1	0.054	-0.324	1	0.012	-0.956
2	0.223	2.229	1	0.051	-0.369	1	0.01	-0.986
2	0.221	2.191	1	0.050	-0.376	1	0.009	-0.994
2	0.216	2.123	1	0.049	-0.391	1	0.008	-1.009
2	0.193	1.777	1	0.049	-0.391			
2	0.181	1.596	1	0.046	-0.436			
1	0.162	1.303	1	0.045	-0.459			
2	0.159	1.257	1	0.045	-0.459			
2	0.158	1.242	1	0.044	-0.467			
1	0.147	1.084	1	0.042	-0.489			
2	0.145	1.054	1	0.042	-0.497			
1	0.144	1.032	1	0.042	-0.497			
1	0.137	0.934	1	0.042	-0.504			
2	0.124	0.738	1	0.041	-0.504			
1	0.122	0.700	1	0.040	-0.527			
2	0.114	0.580	1	0.040	-0.527			
1	0.110	0.527	1	0.037	-0.572			
2	0.107	0.482	2	0.036	-0.595			
1	0.101	0.392	1	0.033	-0.632			
1	0.094	0.286	1	0.032	-0.655			
1	0.092	0.249	2	0.030	-0.677			
1	0.087	0.181	2	0.030	-0.685			
1	0.085	0.151	1	0.028	-0.700			
2	0.085	0.151	1	0.027	-0.730			
1	0.084	0.136	1	0.024	-0.768			
2	0.080	0.068	1	0.022	-0.798			
1	0.078	0.045	1	0.022	-0.798			
2	0.076	0.008	1	0.022	-0.805			
2	0.076	0.008	1	0.022	-0.805			
1	0.075	-0.007	1	0.021	-0.813			
1	0.067	-0.120	1	0.020	-0.828			
1	0.067	-0.120	1	0.017	-0.873			
1	0.066	-0.143	1	0.016	-0.888			
1	0.065	-0.158	1	0.016	-0.888			
1	0.059	-0.241	1	0.016	-0.896			
1	0.058	-0.248	1	0.016	-0.896			
1	0.059	-0.248	1	0.015	-0.903			

1= County level; 2= Club level

Appendix 2

Subject Information Sheet

A Visual Skills Analysis of Gaelic Football Players

Dear Gaelic Football Player

You are being invited to take part in a research project being conducted by Valerie Kennelly (Sports vision Optometrist and post graduate researcher DIT). Please be informed that your participation in this project is voluntary, that is, you can choose not to participate in part or all of the research and therefore you can withdraw at any stage without giving any reasons. Before you decide to participate, please read all of the information provided below as it is important for you to understand why the research is being done and what it will involve.

Purpose of the study

Research has shown that vision influences the capacity of an athlete to perform the tasks of a sport. Sports vision is defined as the study of visual abilities required in competitive and recreational sports, and the development of visual strategies to improve performance, consistency, accuracy and stamina of the visual system. It therefore involves the optimisation and promotion of safe and efficient vision of sports participants at all levels of participation. Sports vision is gaining increasing international recognition as a sub-specialty of optometry, sports science and medicine.

This study is being conducted as a research project to analyse the visual skills of Gaelic footballers which will provide a better understanding of the range of players' visual performance. Much research has been carried out elsewhere in the world on a range of sports, but to date no published research exists on the visual skills testing and norms of participants in GAA games. Identification of the visual skills important in GAA games and the level of performance of GAA participants in the skills tested, will allow the optometrist and team management to provide improved visual care for sports participants. The results will be compared with those from an identical study of Hurlers and also with the visual skills of the general population. This study has received ethical clearance from the Dublin Institute of Technology's Ethical Research Committee and will take place from 2010- 2013.

Data gathering

You will be asked to fill out a questionnaire outlining your current and previous visual history and the visual requirements and concerns associated with your sport. You will then be required to complete a range of visual tests which will take approximately 20 minutes. These tests can all be carried out at your training ground/ clubhouse. You will receive a report on your performance and be advised of your results and their implications. Please note that the screening tests that you are consenting to do not constitute a full eye examination and you are advised to have a routine eye examination at regular intervals to ensure that you receive the appropriate visual and ocular health checks. After the visual screening has been completed, recommendations will be made as to what action should be taken and if a full sports vision assessment is advisable. This full visual assessment would fall beyond the scope of the research study being undertaken and would be subject to a professional assessment fee. If you authorise us to discuss your results with your team management, a report will be provided advising them of which players will benefit most from visual correction and training.

Data storage and presentation

The questionnaire and the test results will be viewed only by Valerie Kennelly and her associate Sports vision Optometrist David Gildea. The results will be stored in a locked filing cabinet. Most of your responses to the questionnaire and your test results will need to be recorded in an electronic format, but your name will not be used for this recording. Your data will be identified by a unique number assigned to you for the purposes of this study only.

Please contact Valerie Kennelly should you wish to seek any further clarification concerning this research. Your time and assistance in participating in this study is welcomed. Many Thanks,

Yours Sincerely,

Valerie Kennelly,B.Sc. (Optom), MCO

Trim Optical Centre, Patrick St. Trim Co. Meath

Tel: 046 9436223 Email: valerie.kennelly@sportsvision.ie

CONSENT FORM

Access to Data – Patient Consent Form

Valerie Kennelly, and David Gildea are qualified sports vision practitioners. Information entered on your personal record in the patient record database during the course of the eye examination/screening may subsequently be used for research/or teaching purposes. Information used for this purpose will be anonymous. This means that anyone who is not involved in your examination/screening will not have access to information that would make it possible to identify you personally. In publications or presentations Valerie Kennelly/David Gildea will not include any information that will make it possible to identify you as a subject.

I have read and understood all the above information and give my consent to the use of data for teaching/research purposes.

Name of Gaelic Football Player ____________________________________

Signature of Gaelic Football Player

Date _ _/_ _/_ _

For sports people who are examined as part of a team.

I agree that the optometrist(s) who examined my eyes can discuss any findings relating to me with my coach/management team.

Signature of Gaelic Footballer

Date--/--/--

Sports Vision Clinical Assessment Form

This evaluation is designed specifically for sportspeople. The purpose is to evaluate the efficiency of those visual skills necessary for peak sports performance and to establish normative values for Gaelic footballers and hurlers. Sportsvision.ie, aim to help you to achieve your full sporting potential.

(ALL INFORMATION WILL BE TREATED AS CONFIDENTIAL)

Date__ __/__ __/__ __

Name ………………………………………………………………………………

POSTAL ADDRESS:…………………………………………………………………..

……………………………………………………………………………………….

Phone (H) (M)

D.O.B.__ __/___ ___/__ __/ Gender M F

SPORT PLAYED	FOOTBALL	HURLING
CLUB TEAM	__________________	____________________
COUNTY TEAM	__________________	____________________

Please ask Valerie or David for clarification should you have any queries concerning the questions in this document.

OCULAR HISTORY

1. Have you ever had a complete eye/visual examination? YES/NO

If YES when was your most recent eye examination?---------------------

2. Have you ever been involved in a visual training programme? YES/NO

If YES, when and for what reasons? ……………………………………

If YES, did you feel it was successful? YES/NO

EXPLAIN……………………………………………………………………………….

3. Do you wear glasses? YES/NO

If YES how long do you have them?----------- Are they satisfactory? YES/NO

When do you use them? For seeing far away/T.V./Driving

For close work/Computer/Reading

For Distance and near vision.

Do you wear them when playing sport?

If you do not wear glasses at present, have you ever had glasses in the past? YES/NO

If YES, when and why did you stop wearing them?……………………………………

4. Do you wear contact lenses? YES/NO

If YES what type?

SOFT Daily Monthly Extended Wear

OR

Gas Permeable

If YES do you wear them during sport participation? YES/NO

Do you wear them all day?   YES/NO

When did you have them last checked by your Optometrist?…………………………

List any problems with your current contact lenses…………………………………….

If NO, have you ever worn contacts in the past?   YES/NO

If you have had contact lenses in the past, when and why did you stop wearing them?

……………………………………………………………………………………….

5.Do you ever see blur?   YES/NO

If YES, when: Looking Far/Looking Near

How Often……………………………………………………………………………

Describe………………………………………………………………………………

6. Do you ever see double? YES /NO

If YES when? Looking Far/Looking Near

How often?…………………………………………………………………………...

If YES, do you see double when playing sport? YES/NO

Describe…………………………………………………………………………….

7. Do you ever feel you have a difficulty keeping your eye on a moving object?

YES/NO

If yes give examples and describe…………………………………………………….

8. Do you notice variations in your performance during a game or event? YES/NO

Would you think that your performance is affected by lighting conditions e.g. Sun Glare/Overcast conditions/Floodlights?

If so which conditions have the greatest negative affect?………………………………

9. Performance most consistent Early/Late/Equal Throughout a match.

10. Is performance consistent during critical competition situations? YES/NO

11. Do you notice loss of concentration during critical competition situations? YES/NO

If Yes Explain……………………………………………………………………..

12. Do you ever notice a difficulty with your perception of depth or judging how far something (ball/sloither/goalpost) is from you? YES/NO

If YES

Discuss trying to identify if tiredness/stress/ plays a big part with these difficulties

or

Do you have depth perception difficulties at all times?

13. Do you ever notice reduced peripheral vision or awareness of objects to either side of you during a game? YES/NO

14. Give Examples relating to questions 9-13

15. Are you experiencing any Visual Difficulties? YES/NO

If YES Describe……………………………………………………

16. Please rate your feeling regarding the importance of vision in your sport:

Not Important Very Important

1 2 3 4 5 6 7 8 9

How do you feel vision is important in your particular sport?…………………………

17. Do you use visualisation /imagery techniques? YES/NO

If yes describe…………………………………………………………………

18. Have you ever suffered an eye injury, surgery, infection or disease involving your eyes? YES/NO

If YES explain…………………………………………………………………………

19. List any other visual performance concerns you may have e.g. miss hitting a ball, difficulty in catching a ball on one side or other of the body

……………………………………………………………………………………..

20. If you have any further concerns about your vision please discuss………………

……………………………………………………………………………………..

References

Abernethy, B. (1986). "Enhancing Sports Performance Through Clinical and Experimental Optometry." Clinical and Experimental Optometry **69**(5): 186-196.

Abernethy, B. (1987). "Selective attention in fast ball sports II: Expert Novice Differences." Australian Journal of Science and Medecine in Sport **19**(4): 7-16.

Abernethy, B. (1990). "Anticipation in squash: Differences in Advance Cue Utilization between Expert and Novice Players." Journal Of Sport Science **8**(1).

Arunthavaraja, M. V., B; & Ciuffreda, KJ. (2010). "Nearwork- Induced Transient Myopia (NITM) Following Marked and Sustained, but Interrupted, Accommodation at Near." Ophthalmic and Physiological Optics **30**(6): 766-775.

Bailey, N., Ed. (1981). Statistical Methods in Biology. London,Sydney, Auckland and Toronto.

Banks, M. G., T. & Hills J. (2004). "Relative Image Size not Eye Position Determines Eye Dominance Switches." Vision Research **44**: 229-234.

Bauscher, W. (1968). "Vision and the athlete." Optom, Wkly **59**(19): 21-25.

Beau, L., *et. al*. (2011). "Seeing in Colour." Optics and Lazer Technology **43**: 261-269.

Belisle, J. J. (1963). "Accuracy, Reliability and Refractoriness in a Coincident Anticipation Task
" Research Quarterly for Exercise and Sport **34**: 271-281.

Bennett, A., & Thery M. (2007). "Avian Color Vision and Coloration: Multidiscilpinary Evolutionary Biology." The American Naturalist **169**(Supplement): S1-S6.

Bhola, R. (2006). "Binocular Vision." Retrieved 12/09/2014.

Botwinick, J., & L. W., Thompson. (1966). "Components of Reaction Time in Relation to Age and Sex. ." Journal of Genetic Psychology **108**: 175-183.

Buys, H. (2002). The development of Norms and Protocols in Sports Vision Evaluations. Faculty of Science. Johannesburg, Rand Afrikaans University.

Buys, J., & Ferriera, J.T. (2008). "The Development of Protocols and Norms for Sports Vision Evaluations." S African Optometry **67**(3): 106-117.

Carey, D. (2001). "Vision Research: Loosing Sight of Eye Dominance." Current Biology **11**: R828-R830.

Children, D. o. H. a. (2005). Obesity The Policy Challenges The Report of the National Taskforce on Obesity.

Christenson, G., & Winkelstein, A. (1988). "Visual Skills of Athletes Versus Non-Athletes: Development of a Sports Vision Testing Battery.
." Journal of the American Optometric Association **59**(9).

Ciuffreda, K. V., B. (2008). "Nearwork-Induced Transient Myopia and Permanent Myopia Is There a Link?" Ophthalmic and Physiological Optics **28**(2): 103-114.

Ciuffreda, K. W., DM. (1998). "Myopes Show Increased Susceptibility to Nearwork Aftereffects." Investigative Ophthalmology & Visual Science **39**(10): 1797-1803.

Cline, D., Hofsetter H.W., & Griffin J.R. (1997). Dictionary of Visual Science. Butterworth-Heinemann. Boston.

Der, G., & Deary, I. (2006). "Age and Sex Differences in Reaction Time in Adulthood: Results from the United Kingdom Health and Lifestyle Survey." Psychology and Aging **21**(1): 62-73.

Duane, V., Knudson, C., & Morrison, S. (1997). "The Impact of Vision and Vision Training on Sports Performance."

Elliott, D., Ed. (2007). Clinical Procedures in Primary Care.

Elliott, D. Y., K & Whitaker D. (1995). "Visual Acuity Changes Throughout Adulthood in Normal, Healthy Eyes: Seeing Beyond 6/6." Optomerty and Vision Science **72**(3): 186-191.

Erickson, G., Ed. (2007). Sports Vision Vision Care For The Enhancement Of Sports Performance, Butterworth-Heinemann, an imprint of Elsevier.

Executive, H. S. (2011). HSE framework for action on obesity 2008-2012.

Farrow, D. Y., W; & Bruce, L. (2005). "The Development of a Test of Rective Agility for Netball: A New Methodology." J Sci Med Sport **8**: 52-60.

Ferreira, J. (2003). "An Overview of Research in Sports Vision: Its History and an Optometric Perspective." South African Optometry **62**(4): 142-149.

Fisher, C., & Simmonds M. (1980). "A Note on the Incidence of Colour Blindness in Cook Island Males." New Zealand Psychologist **9**: 34.

Fullerton, H. (1921). "Why Babe Ruth Is The Greatest Home Run Hitter: Popular Science Monthly test in the Laboratory His Brain, Eye, Ear and Muscle and Get his Secret." Popular Science Monthly **99**(19).

GAA, A. C. (2012).

Gabbett, T. B., D. (2007). "Reactive agility of rugby leage players." Journal of science and medicine in sport. **12**(1): 212-214.

Garner, A. (1977). "Visual Aid Prescribing for the Athlete." Californian Optometry **3**(6): 18-19.

General, U. S. (1996). In Physical Activity and Health.

Griffiths, G. Dispensing for Sport-Eye Dominance. Continuing Education and Training Course Code C8954

Griffiths, G. (2002). "Eye-speed, Motility and Athletic Potential." Optometry Today **42**(12): 34-37.

Griffiths, G. (2003). "Eye Dominance in Sport A Comparitive Study." Optometry Today: 34-40.

Grosvenor, T., Ed. (2007). Primary Care Optometry. Missouri, Elsiver.

Henson, D. Visual Fields, Butterworth Heinemann.

Holladay, J. (1997). "Proper Method For Calculating Average Visual Acuity." Journal of Refractive Surgery **13**: 388-391.

http://resource.rockyview.ab.ca/rvlc/physics30. Retrieved 09/09/2014.

http://www.aoa.org/patients-and-public/good-vision-throughout-life/childrens-vision? 2013.

http://www.gaa.ie/about-the-gaa/provinces-and-counties/about-county/county-colours/.

http://www.medterms.com/. Retrieved 11/09/2014.

http://www.medterms.com/. Retrieved 12/09/2014.

http://www.scribd.com/doc/59085894/Pelli-Robson-ETDRS-Score-Sheet-Instructions. Retrieved 26/09/2014.

http://www.tedmontgomery.com/the_eye/eom.html. Retrieved 19/09/2014.

http://www.vision3d.com//images/bb.jpeg. Retrieved April 2013.

https://www.google.ie/search?q=all+ireland+championship+2013.

https://www.google.ie/search?q=antrim+v+down&source. Retrieved 03/10/2013.

https://www.google.ie/search?q=camera+and+pencil. Retrieved 09/09/2014.

https://www.google.ie/search?q=definition+of+astigmatism+eye. Retrieved 09/09/2014.

https://www.google.ie/search?q=diagram+of+the+eye (2014). Retrieved 12/09/2014.

https://www.google.ie/search?q=diagram+showing+fixation+axis+of+visual+field (12/09/2014).

https://www.google.ie/search?q=eye+dominance+test+triangle. 2014.

https://www.google.ie/search?q=high+and+low+contrast+vision+charts. 2014.

https://www.google.ie/search?q=image+of+extra+ocular+muscles. Retrieved 09/09/2014.

https://www.google.ie/search?q=images+for+hyperopia. Retrieved 11/09/2014.

https://www.google.ie/search?q=ishihara+colour+vision+test+plate. 2014.

https://www.google.ie/search?q=tno+stereoacuity+test. 2012.

https://www.google.ie/search?q=visual+pathway+anatomy (11/09/2014).

https://www.google.ie/search?q=visual+pathway+lesions+and+visual+field+defects (11/09/2014).

https://www.google.ie/search?q=wayne+saccadic+fixator. 2014.

httpswww.google.iesearchq=chelsea+v+liverpool. Retrieved 03/10/2013.

Jevas, S., & Yan, J. (2001). "The Effect of aging on Cognitive function: A Preliminary Quantitative Review. ." Research Quarterly for Exercise and Sport **72**.

Khan, A. C. J. (2001). "Ocular Dominance Reverses as a Function of Horizontal Gaze Angle." Vision Research **41**: 1743-1748.

Kluka, D. (1991). "Visual Skills: Concicerations for Learning Motor Skills for Sport." Asahperd **14**(1): 41-43.

Knudson, D., & Kluka, D. (1997). "The Impact of Vision and Vision Training on Sporting Performance." Journan of Physical Education, Recreation and Dance.

Kosinski, R. (2010) A Literature Review on Reaction Time.

Kosinski RJ (2010) A Literature Review on Reaction Time.

Laby, D., & Kirschen, D. (2011). "Thoughts on Ocular Dominance: Is it actually a Preference?" Eye and Contact Lens: Science and Clinical Practice **37**(3): 140-144.

Laby, D. R., A & Kirschen D. (1996). "The Visual Function of Professional Baseball Players." American Journal of Ophthalmology **122**: 476.

Lieblien, J. (1986). "The Athlete's Choice: Contact Lenses." Contact Lens Spectrum. **1**(9): 55-58.

Loran, D. (2003). Sports Vision:For The On Site Screening of Visual Performance in Sport. Leicester, Sports Vision Services Ltd.

Loran, D., & Griffiths, G. (2000). "Visual Performance and Soccer Skills in Young Players." Optometry Today: 32-34.

Loran, D., & Mac Ewen, C., Ed. (1995). Sports Vision: Vision Requirements in Sport. Oxford, Butterworth Heinemann.

Ludeke, A. (2008). The Visual Skills of Professional and Amateur Rugby Players. Optometry. Johannesberg, University of Johannesberg. **M Phil**.

Lyons, M., Al-Nakeeb, Y., & Nevill, A. (2008). "Post-Exercise Coincidence Anticipation in Expert and Novice Gaelic Games Players: The Effects of Exercise Intensity." European Journal of Sport Science **8**(4).

Mantyjarvi, M., & Laitinen, T. (2001). "Normal Values for the Pelli-Robson Contrast Sensitivity Test." Journal of Cataract and Refractive Surgery **27**(2): 261-266.

Marieb, E., & Mallat, J., Ed. (1992). Human Anatomy. California.

Martin, W. (1970). "What the Coach Should Know About the Vision of Athletes." Optometry Weekly **61**(25): 538-560.

Mc Morris, T., Ed. (2004). Acquisition and Performance of Sports Skills. Chichester, John Wiley & Sons, Ltd.

Missankov, A., Ed. (2000). Basic Anatomy of the Central Nervous System and the Cranial Nerves., New Standard Printing.

Mori, S., Ohtani, Y. & Imanaka, K. (2002). "Reaction Times and Anticipatory Skills of Karate Athletes." Human Movement Science **21**(2): 213-230.

Mosby (2009). Mosby's Medical Dictionary, Elseiver.

Neitz, J., & Neitz, M. (2010). "The Genetics of Normal and Defective Color Vision." Vision Research **51**(7): 633-651.

Ong, E. C., KJ; (1995). "Nearwork Induced Transient Myopia a Critical Review." Doc Ophthalmology **91**(1): 57-85.

Orejan, J. (2006). "The History of Gaelic Football and the Gaelic Athletic Association." The Sport Management and Related Topics Journal **2**(2): 45-50.

Owsley, C. (2003). "Contrast Sensitivity." Ophthalmology Clinics of North Americia **16**: 171-177.

Papousek, I. S. G. (1999). "Quantative Assessment of Five Behavioural Laterality Measures: Distributions of Scores and Intercorrelations Among Right Handers." Latreality **4**: 345-362.

patients@kirschen.net. Retrieved 28/04/2012.

Pelli, D., Robson, J., & Wilkins, A. (1988). "The Design of a New Letter Chart for Measuring Contrast Sensitivity." Clinical Vision Science **2**: 187-199.

Philip, P., *et al*. (2004). "Age, Performance, and Sleep Deprivation." Journal of Sleep Research **13**(2): 105-110.

Planer, P. (1994). Sports Vision Manual. Harrisburg International Academy of Sports Vision. Harrisburg.

Pointer, J. (2007). "The Absence of Lateral Congruency Between Sighting Dominance and the Eye with Better Visual Acuity." Ophthalmic and Physiological Optics **27**: 106-110.

Pointer J (2001). "Sighting Dominance, Handedness and Visual Acuity Preference: Three Mutually Exclusive Modalities." Ophthalmic and Physiological Optics **21**(2): 117-126.

Porac, C. C., S. (1976). "The Dominant Eye." Psychological Bulletin **83**: 880-897.

Potgiter, K., & Ferreira, J. (2009). "The Effects Of Visual Skills on Rhythmic Gymnastics." South African Optometry **68**(3): 137-154.

Rosser, D., Laidlaw, D., & Murdoch, I. (2001). "The Development of a" Reduced log Mar" Visual Acuity Chart for Use in Routine Clinical Practice." British Journal of Ophthalmology **85**: 432-436.

Sapkota, K. *e. a.* (2004). Visual Status of Nepalese Football and Cricket Players.

Saunders (2007). Dorland's Medical Dictionary for Health Consumers. Dorland's Medical Dictionary for Health Consumers, Elseiver.

Savelsbergh, G., *et a*l. (2010). "A Method to Identify Talent: Visual Search and Locomotion Behavior in Young Football Players." Human Movement Science **29**: 764-776.

Shneor, E. H., S. (2006). "Eye Dominance Effects in Feature Search." Vision Research **46**: 4258-4269.

Silverman, I. W. (2006). "Sex Differences in Simple Visual Reaction Time: A Historical Meta-Analysis (Sports Events)." Sex Roles: A Journal of Research **54**(1-2): 57-69.

Sloan, L. (1951). "Measurement of Visual Acuity.
." Arch Ophthalmol **45**: 704.

Strydom, B., & Ferreira JT. (2010). "The Role of Vision and Visual Skills in Archery." South African Optometry **69**(1): 21-28.

Szinnai, G., *et. al*. (2005). "Effect of Water Deprivation on Cognitive-Motor Performance in Healthy Men and Women." The American Journal of Physiology **289**(1): R275-280.

Valle-Inclan, F. B., MJ; Soto, D; Leiros, L. (2008). "A New Method to Assess Eye Dominance." Psicologica **29**: 55-64.

Vasudevan, B. C., KJ. (2008). "Additivity of Near Work-Induced Transient Myopia and its Decay Characteristics in Different Refractive Groups." Investigative Ophthalmology & Visual Science **49**(2): 836-841.

Venter, S., & Ferreira J. (2004). "A Comparison of Visual Skills of High School Rugby Players of Two Different Age Groups." South African Optometry **63**(1): 19-29

Waggoner, T. (2012). "Testing Color Vision.Com." What is Colourblindness and the Different Types?
. Retrieved April 8th 2012.

Ward, P., Williams, A., & Loran, D. (2000). "The Development of Visual Function in Expert and Novice Soccer Players." International Journal of Sport Vision. **6**: 1-11.

Ward, P. W. M. (2003). "Perceptual and Cognative Skill Development in Soccer: The Multidemsional Nature of Expert Performance." Journal of Sport & Exercise Psychology **25**: 93-111.

Welford, A., Ed. (1980). Reaction Times. Choice Reaction Time: Basic Concepts. New York, Academic Press.

Welford A T, Ed. (1980). Reaction Times. Choice reaction time: Basic concepts. New York, Academic Press.

WHO (2007). The Challenge of Obesity in the WHO European Region and the Strategies for Response.Summary. Copenhagen.

WHO (2009). The European Health Report 2009: Health and Health Systems.

Williams, A., *et. al.* (1993). "Visual Search and Sports Performance." Australian Journal of Science and Medecine in Sport **25**(2): 55-65.

Williams, A., *et. al*. (2002). "Anticipation Skill in a Real-World Task: Measurement, Training and Transfer in Tennis." Journal of Experimental Psychology: Applied, **8**(4): 259-270.

Williams, K. (1985) Age Differences on a Coincident Anticipation Task: Influence of Stereotypic or "Preferred" Movement Speed. Journal of Motor Behaviour **17**, 389

www.donegaldemocrat.ie.

www.gaa.ie/coaching-and-games/rules.

www.independent.ie. Retrieved 02/10/2013.

www.phoenixgaels.com (Downloaded 01/10/2012).

www.sportsfile.com/737722. Retrieved 02/10/2013.