5-2006

A new device to measure dynamic visual acuity: Data for athletes and non-athletes

William Alexander Bercha
Pacific University

Douglas Dean Stefanyk
Pacific University

A new device to measure dynamic visual acuity: Data for athletes and non-athletes

Abstract

PURPOSE: DVA is a crucial asset in competitive dynamic sports where the playing environment is in constant flux and changes from moment to moment. Prior to the current study, most attempts to measure DVA in optometry required the subject's head to remain stationary while a moving target was presented. By using the recently developed invisionTM device (NeuroCom International) for this study, it is now possible to measure the vestibular and visual components of dynamic visual acuity. The purpose of this study was to obtain data for athletic subjects using the invisionTM device, and to determine whether athletes have superior dynamic visual acuity than non-athletic subjects.

METHODS: A total of 18 athletes (aged 18-42 years) from three different sports, ice hockey, baseball and basketball, participated in this study. The results for the athlete sample were compared against previously-acquired data for a sample of age-matched non-athletes. The invisionTM device which consists of a headborne accelerometer, a posturography platform, a desktop computer and monitor, was used to measure dynamic visual acuity (constant head velocity of 120 degrees per second with gradual stimulus size reduction), gaze stabilization (increasing head velocity with constant stimulus size), sensory interaction and balance (CTSIB), and limits of stability.

RESULTS: The combined left-right average head velocity during dynamic visual acuity testing differed (pc0.05) between the groups. Athletes were found to have a DVA speed of 156.0 degrees per second versus the non-athletic group's 125.1 degrees per second. The combined left-right average maximum head velocity during gaze stabilization was significant at the pc0.05 level, with the athletic subject group averaging 121.4 degrees per second versus 100.0 degrees per second attained by the non-athletic subject group.

CONCLUSION: The promising results of this study should invite further testing and investigation with the inVisionTM device in the athletic setting.

Degree Type
Thesis

Degree Name
Master of Science in Vision Science

Committee Chair
Bradley Coffey

Subject Categories
Optometry

A NEW DEVICE TO MEASURE DYNAMIC VISUAL ACUITY: DATA FOR ATHLETES AND NON-ATHLETES

By

WILLIAM ALEXANDER BERCHA

DOUGLAS DEAN STEFANYK

A thesis submitted to the faculty of the

College of Optometry

Pacific University

Forest Grove, Oregon

for the degree of

Doctor of Optometry

May 2006

Advisor:

Bradley Coffey, O.D., FAAO

A NEW DEVICE TO MEASURE DYNAMIC VISUAL ACUITY: DATA FOR ATHLETES AND NON-ATHLETES

SIGNATURES

William Alexander Bercha, B.Sc.

Douglas Dean Stefanyk, B.Sc.

Bradley Coffey, O.D., FAAO
Advisor

BIOGRAPHIES

Douglas Stefanyk, B.Sc.

Douglas is originally from Lamont, Alberta, Canada, a small farming community east of Edmonton. After completing high school, Douglas attended the University of Alberta, earning a Bachelor of Science degree with specialization in evolutionary biology. It was during his undergraduate education that he developed a strong interest in ocular development and physiology. He moved to Forest Grove during the summer of 2002, where he began his optometric career at Pacific University College of Optometry. Following graduation, he plans to enter a multi-disciplinary private practice in central California.

William Alexander Bercha, B.Sc.

William hails from Calgary, Alberta, Canada. He grew up on an acreage outside of Cochrane, Alberta. Upon completion of high school with instruction in English and French, he attended the University of Calgary, where he received a Bachelor of Science with a major in exercise and health physiology. Throughout his education, he has always been fascinated with human physiology and the visual process. In the summer of 2002, he began his optometric education at Pacific University College of Optometry. Upon graduation, William plans to join a private practice located in Toronto, Ontario, which specializes in behavioural and developmental optometry and vision therapy.

A NEW DEVICE TO MEASURE DYNAMIC VISUAL ACUITY: DATA FOR ATHLETES AND NON-ATHLETES

ABSTRACT

PURPOSE:
DVA is a crucial asset in competitive dynamic sports where the playing environment is in constant flux and changes from moment to moment. Prior to the current study, most attempts to measure DVA in optometry required the subject's head to remain stationary while a moving target was presented. By using the recently developed *in*Vision™ device (NeuroCom International) for this study, it is now possible to measure the vestibular and visual components of dynamic visual acuity. The purpose of this study was to obtain data for athletic subjects using the *in*Vision™ device, and to determine whether athletes have superior dynamic visual acuity than non-athletic subjects.

METHODS: A total of 18 athletes (aged 18-42 years) from three different sports, ice hockey, baseball and basketball, participated in this study. The results for the athlete sample were compared against previously-acquired data for a sample of age-matched non-athletes. The *in*Vision™ device which consists of a headborne accelerometer, a posturography platform, a desktop computer and monitor, was used to measure dynamic visual acuity (constant head velocity of 120 degrees per second with gradual stimulus size reduction), gaze stabilization (increasing head velocity with constant stimulus size), sensory interaction and balance (CTSIB), and limits of stability.

RESULTS: The combined left-right average head velocity during dynamic visual acuity testing differed ($p<0.05$) between the groups. Athletes were found to have a DVA speed of 156.0 degrees per second versus the non-athletic group's 125.1 degrees per second. The combined left-right average maximum head velocity during gaze stabilization was significant at the $p<0.05$ level, with the athletic subject group averaging 121.4 degrees per second versus 100.0 degrees per second attained by the non-athletic subject group.

CONCLUSION: The promising results of this study should invite further testing and investigation with the inVision™ device in the athletic setting.

Acknowledgements

The authors would like to thank NeuroCom International, Inc. for its generous support of this project through donated equipment. In particular, we would like to thank Dr. Jon Peters for his technical support and communication. We extend our thanks and gratitude to all the subjects who participated in this study.

INTRODUCTION

In the last 60 years, there has been relatively limited research conducted in the assessment of a particular type of visual function known as dynamic visual acuity (DVA). DVA refers to the visual resolution capability of an observer when there is relative motion between the object of interest and the observer [1]. Over the past 120 years, there has been much progress related to correcting and measuring static visual acuities, but it was not until the early 1940's that research into the field of DVA began. Many of the early principles of DVA are still widely accepted today. These fundamental principles state that: as the object velocity increases, the subject's visual acuity substantially decreases; a subject's static visual acuity is not correlated to nor can it be used to predict their DVA; DVA remains sensitive to changes in target energy even after static visual acuity has reached a plateau and, unlike static visual acuities, dynamic visual acuities are more closely related to real world environments than their static counterparts [2]. This is evident when one considers the demands athletes place on their visual system. DVA is a crucial asset in competitive dynamic sports where the playing environment is in constant flux and changes from moment to moment. Many professors of physical education as well as athletic coaches have acknowledged that athletic performance depends on many factors including strength, endurance, speed, agility, coordination and determination. Yet, a critical factor in assessing athletic performance, the athlete's sensory function, particularly vision, has been virtually ignored until the past two decades [3]. It is a reasonable assumption that all the previously mentioned attributes may not provide an accurate gauge of a player's potential on the playing field. When coaches speak of a player having a natural ability or an innate "sixth sense" on the playing field, they may just be referring to the athlete's sensory function. Several authors, Sanderson and whiting[4], Beals et al[3], Sherman[5], Stine et al[6], and Morris and Kreibaum[7], have described DVA as being a critical factor in an athlete's overall performance. Previous studies by Demer et. al.[8], Rouse et. al.[9] found that DVA is significantly better among athletes than non-athletes, and that among elite basketball players, oculomotor control and gaze behaviour related to DVA differed significantly from their near-elite level counterparts [10]. Ishigaki and Miyao[11] measured the DVA of 53 university athletes and 46 non-athlete university students using a Landolt ring as a target. The target moved from left to right on the screen initially at a velocity of 300 degrees of second. The speed of the target was gradually decreased until the subject was able to correctly identify the direction of the gap. When the sizes of the gap were 14 min arc and 8 min arc, the athletes were able to recognize the gap at significantly higher velocities than non-athletes, thus demonstrating superior dynamic visual acuity in athletes.

Prior to the current study, most attempts to measure DVA in optometry required the subject's head to remain stationary while a moving target was presented. This technique allowed the researcher a relatively simple but somewhat flawed measure of the subject's DVA. DVA measured in this manner only account for the visual component and does not incorporate the vestibular component of DVA. The vestibular system has a significant influence on the oculomotor system especially when the head is in motion.

Recently, there have been many attempts to measure DVA with the subject's head in motion while viewing a stationary target, but all methods used to evaluate DVA have had the same confounding inadequacies in theory and protocol. These include the inability to maintain control with head on torso rotation as well as whole body rotation [12] and an inability to extrapolate a subject's ability to resolve a moving target from eye movement recordings [2]. The ability of a study design to reliably ascertain the true DVA resolution ability is still limited. Reasons for this include poorly or not at all monitored head velocity and frequency of the subject; continuous presentation of the target, use of non-uniform optotype from line to line and no means to control subjects from memorizing the content of the charts and then recalling the correct sequence of optotypes directly from memory without any clearly resolvable visual input from DVA [8].

In the current investigation, three sports were selected that place the athlete under significant dynamic visual acuity demands. Ice hockey, baseball and basketball athletes were selected based on the inherent high level of visual demand found in these sports. All three sports rely on the athlete's ability to acquire and track high velocity targets during extended periods of intense physical and mental exertion.

The visual demands of basketball include static and dynamic visual acuity, peripheral vision, depth perception, eye motility, speed of recognition, speed of focusing, fixation ability and central and peripheral awareness. All of these skills are necessary for accurate passing and shooting, particularly depth perception. Speed of recognition and central/peripheral awareness contribute to evaluating and anticipating the opponents' offensive and defensive strategies. Visual memory and spatial localization along with dynamic visual acuity are critical skills in basketball since all players are constantly in motion in different directions and the playing conditions are continually changing within the confines of the court. The ability to withstand eye fatigue while maintaining performance is crucial as the basketball player must maintain high levels of performance over long periods of time in a visually demanding and fatiguing environment [13].

Baseball players require a set of visual skills similar to basketball. These include static and dynamic visual acuity, peripheral vision and awareness, depth perception, eye motility, speed of recognition, speed of focusing and fixation ability. These visual skills allow the baseball player to track and hit a pitch that can travel up to 90 miles per hour, to localize, track and catch a baseball after it has been hit or thrown, and maintain overall field awareness. Peripheral vision is employed by pitchers as they monitor base runners while pitching. Base runners rely on peripheral vision to gain input regarding the position of the ball, the pitcher, the bases, base coach and stadium walls. Eye motility and tracking ability is critical to the batter, as hitting a moving fastball is one of the most visually demanding tasks in sport [14].

Ice hockey is a very dynamic sport that features quick changes from offense to defense. Hockey places the athlete in a highly visually stressful environment and calls upon several critical visual skills. The pace of play in hockey is among the fastest of any sport and the players from opposing sides are in constant motion along with the puck and officials. Exceptional static binocular distance visual acuity and dynamic visual acuity is needed for success in ice hockey. Puck tracking, passing, shooting, shot stopping, body-checking and defending are activities that place high demands on the athlete's dynamic visual acuity ability. Eye motility is crucial for tracking the puck and movement of players on both teams. Eye-handlbodylfoot coordination is essential for players to be able to coordinate skating with puck movement and puck control. Depth perception is vital for a player's ability to judge the distance between themselves and the puck, the goal, the boards, the officials and other players. Speed of recognition is particularly important for goaltenders, as they face the task of stopping shots that can approach at 100 mph. Speed of focusing requires the hockey player to discriminate fine details in order to abide by the rules of the game while successfully completing plays. Peripheral vision, spatial localization, visual memory, central-peripheral awareness and fixation ability are all necessary in order to localize and fixate the puck amongst players on the ice. In particular, players must use central vision to shoot and pass the puck. Goaltenders experience intense visual demands as they require acute peripheral vision and spatial awareness, combined with rapid reaction time and eye-hand-foot coordination. Peripheral vision aids to localize other players' position on the ice. Forwards, defensemen and goaltenders require all the skills outlined above [15].

NeuroCom® International, Inc, founded in 1984 and based in Clackamas, Oregon has developed a novel computerized means to accurately and consistently measure DVA while minimizing the problems associated with historical measurement techniques [16]. Their *in*Vision™ device, a computer-based instrument for measuring DVA, was developed in 2003 and is in use worldwide for assessment of visual-vestibular interaction. Measuring DVA with *in*Vision™ allows for an accurate, real world assessment of a subject's DVA while the subject makes voluntary head movements. Previous studies using the inVision™ device have demonstrated generally consistent test-retest results for DVA and GST in non-athletic subjects. Work by Coffey et al [16, 17] showed that nearly all subjects were within 95% confidence intervals for DVA and GST test-retest scores for non-athletes. The *in*Vision™ protocol has never been applied to athletics, and we hypothesize that the *in*Vision™ device will yield results similar to those found in previous studies. It is hypothesized that athletes will have better dynamic visual acuity than non-athletes as measured by the inVision™ device [17].

METHODS

Nine collegiate level basketball players, five collegiate level baseball players and four experienced hockey players volunteered to participate in this study. The athletes ranged in age from 18 to 42 years with at least three years experience (range 4-32 yrs; mean 14.2 yrs) in their respective sport. Each participant completed a written consent form to participate in the study in accordance with the Pacific University Institutional Review Board (see Appendix). Each participant completed a personal and family health history questionnaire before any subsequent testing began (see Appendix). Questions pertained to family and/or personal history of diabetes, hypertension, heart disease, cancer, thyroid dysfunction, crossed eyes, amblyopia and dyslexia. If the subject reported a positive response to any of these questions, they were questioned further to determine eligibility in the study. Subject inclusion criteria consisted of athletes with a minimum of 3 years playing experience in their respective sports, normal habitual visual acuity, and an absence of strabismus or amblyopia. Participants also were encouraged to report and record any medications, nutritional supplements, vitamins or any other drugs that they were using at the time of the study, but none of their reports excluded them from the study.

Each participant was then screened for any visual or binocular dysfunction that might confound the results of the study (see Appendix). The screening consisted of 4 meter monocular visual acuity using a Bailey-Lovie logMAR chart, Pelli-Robson contrast sensitivity test chart [18] at 3 meters, cover test at 4 meters and 40 centimeters, an ocular sighting preference test, 40 centimeter stereo acuity, and eye-hand reaction/response time measurement. To determine the ocular sighting preference of each subject the following protocol was used: the subject's right hand was placed on top of their left hand so that a triangular opening was created between the index finger and thumb. The subject was asked to fixate on the examiner's right eye and simultaneously raise their hands (that are overlapped creating a triangular opening) and sight thru the opening while continually fixating the examiner's right eye. The subject then lowers their hands and fixates the examiner's left eye and again raises their hands and fixates thru the opening at the examiner's left eye. The subject is then asked to switch the orientation of their hands so that their left hand is on top of their right hand creating a small opening. The procedure is repeated fixating the examiner's right and then left eye as before. This will produce four ocular sighting trials and will determine how strong is the ocular sighting preference (50%, 75% or 100% preference). The subject is instructed to keep their elbows extended so that the arms are straight at all times during the sequence. Stereo acuity is measured using a Randot nearpoint stereo test (available from Bernell Corporation at www.bernell.com) at 40 centimeters with stimuli being presented down to 20 sec arc.

The last screening test to be administered to each subject is measurement of eye-hand reaction time using the ReactionPlus® device [19]. Each subject is positioned with the midline of the body centered above the left button. To begin the test, the right hand depresses the button on the right. At this point the reaction time test is ready to begin. A delay varying from 2 to 4 seconds, set by the examiner, is given before the left button is illuminated. Once illuminated the subject must release the right button and depress the left button. The subject's reaction time is measured by the instrument the instant they have removed their right hand palm from the button after the left button has lit up. The subject's motor response time is then measured as the time taken to move the right hand from the right button to depress the left button. The subject is given two practice trials before five test trials are administered. The overall reaction time is calculated by averaging the five trials.

All testing was performed in the same room with ambient light of 100 lux generated by overhead fluorescent tube ceiling lamps.

The *in*Vision™ device requires a standard PC desktop computer with a flat 17" LCD screen, the software specifically developed to run the *in*Vision™ device, a posturography platform and a headborne accelerometer (the Inertia Cube™).

The first test performed by each subject is a modified clinical test of sensory interaction and balance (CTSIB). The CTSIB establishes a baseline for vestibular function and balance. The subject is asked to remove their shoes and stand straight and tall, with arms at their side, on the posturography platform while fixating straight ahead (see Figure 1). This is repeated three times at ten seconds per trial, then repeated again with eyes closed for three trials. The CTSIB test is then repeated immediately, following the same protocol outlined above except the subject is now asked to stand on a 45 cm X 45 cm X 12.5 cm thick foam rubber block placed on top of the posturography platform (see Figure

2). The purpose of this test is to establish a baseline postural sway of each athlete. The subject is allowed to proceed to the next battery of tests only when their postural sway is determined to be within normal limits.

Figure 1: Modified clinical test of sensory interaction and balance (CTSIB) with foam block.

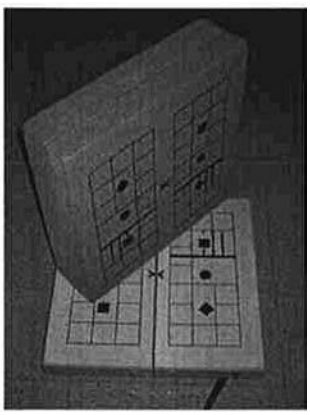

Figure 2: Thick foam rubber block and posturography platform used in the modified CTSIB.

Following the CTSIB, each subject performed the Limits of Stability test. This test measures the subject's ability to maintain functional balance and control when their body weight is unequally distributed over their feet. The subject begins the test by standing, properly aligned, on the posturography platform facing the computer monitor. The test screen is composed of a 1.5cm X 1.5cm central black square with eight identical squares, equally spaced, surrounding the central square in a circular fashion and a small 1.0cm X 1.0cm black stick figure man that is controlled by how the subject distributes his weight on the posturography platform (see Figure 3). The goal of testing is to determine how quickly, accurately and smoothly the subject can manoeuvre the little man from the central square to each of the outer squares in the allotted time of 8 seconds. Before each trial is run, a demonstration is given to allow the subject to practice moving to each of the outer squares. The first of eight test trials begins with the subject maintaining full control of the little man within the central black square. If the subject demonstrates inadequate control or if any part of the little man is outside the box, the test will not proceed and will default back to the demonstration. The purpose of this test is to determine the subject's range of stability and body coordination while undergoing postural changes.

Figure 3: Limits of Stability test screens.

Next, one of two tests was performed. The order of the Gaze Stabilization Test (GST) and the Dynamic Visual Acuity (DVA) was pre-assigned to each athlete in an alternating fashion. For the DVA test, the subject wore the head borne accelerometer and was seated ten feet away facing the computer screen. The subject was instructed to move the head shoulder to shoulder about the yaw axis as if shaking their head saying "no," all the while keeping their eyes on the screen (see Figure 4). During the demonstration period, the subject received

Figure 4: Gaze Stabilization Test

feedback on how fast he was moving his head. A long, sweeping head motion was preferred and encouraged over a rapid, small angle rotation of the head. The subject was required to reach a minimum head velocity of 120 degrees per second in order to elicit the stimulus. When the subject was comfortable moving the head at the required side to side rhythm and velocity, the test began. During the flash presentation of the stimulus, the actual head velocity and direction of motion (rightward or leftward) were recorded and the subject was instructed to maintain or slow down the head motion. If the velocity slowed below 120 degrees per second, the test would pause and the demonstration screen would appear. During the test, the screen consisted of a large, thin black circle on a white background.

When the subject's head reached a minimum velocity of 120 degrees per second, a tumbling E stimulus was presented in the middle of the circle for 75msec. The subject then had to make a four alternative forced choice decision about the stimulus orientation (see Figure 5). The test continued with progressively smaller and smaller stimuli until a threshold DVA was reached (3 of 5 incorrect trials). A threshold DVA was recorded for both leftward and rightward head movement independently to ascertain any discrepancy between the two directions. The results of DVA testing are presented as the DVA threshold acuity, DVA loss (difference between DVA and static visual acuity), and actual DVA velocity (the actual velocity of head rotation; all subjects moved their head at some velocity greater than the minimum 120 degrees per second).

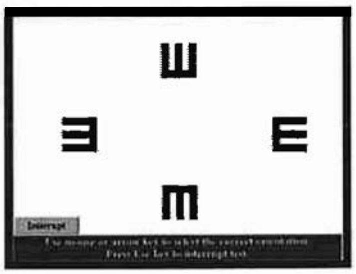

Figure 5: The four alternative forced choice decision screen following stimulus presentation during the GST and DVA testing sequences.

Gaze Stabilization Test (GST) was performed in a similar manner as the DVA test. However, the size of the stimulus was held constant at 0.2 logMAR larger than the subject's static VA threshold and the subject's head velocity was progressively increased to elicit the stimulus. As the subject responded correctly, the minimum velocity needed to elicit the stimulus was increased in 10 degrees per second increments until the subject's threshold was reached. Maximal head velocity reached was recorded for both the rightward and the leftward direction. The results of GST testing were recorded as a threshold head velocity, in degrees per second, while maintaining a visual acuity 0.2 logMAR greater than the static visual acuity threshold.

The CTSIB test was re-administered at the conclusion of testing to determine whether or not the testing battery administered to the athlete had an effect on balance ability.

RESULTS

The inVision™ data for athletes versus a non-athletic age-matched subject population (see Table 1) were analyzed using t-testing (significance level of $P<0.05$). The comparison data for non-athletes were taken from a previous study.[16] The initial visual screening produced no significant differences between the athletic and the non-athletic subject groups when comparing static monocular visual acuities, stereo acuity and distant phoric posture. However, a significant difference ($p<0.05$) was found when near phoric postures were compared. The athletic subject group was found to have a mean near phoric posture of 5.8 prism diopters of exophoria versus the 1.6 prism diopters of exophoria found in the non-athletic subject group.

Variables measured to compare the subject groups consisted of gaze stabilization and dynamic visually acuity. During gaze stabilization, the stimulus size used (0.2 logMAR larger than the SVA threshold) by the athletic and non-athletic sub groups did not differ.

A significant difference ($p<0.05$) was found for maximum leftward head GST velocity reached at threshold acuity. The athletic population reached an average maximum leftward head velocity of 122.8 degrees per second compared to the non-athletic average maximum leftward head velocity of 101.3 degrees per second. Maximum rightward head velocity did not differ between the two subject groups. However, the average leftward and rightward average maximum head velocity was significant, with the athletic subject group averaging 121.4 degrees per second versus the 100.0 degrees per second attained by the non-athletic subject group.

Dynamic visual acuity thresholds were not found to differ significantly between the groups. However, maximal head velocity reached at acuity threshold was different ($p<0.05$) for both the rightward, leftward and combined average velocity. The athletes' rightward head velocity was 153.5 degrees per second versus the 123.9 degrees per second achieved by the non-athletic subjects. Similarly, the leftward head velocity for athletes was 158.6 degrees per second compared to 125.6 degrees per second in the non-athletic group. The combined left-right average head velocity for athletes was 156.0 degrees per second versus 125.1 degrees per second achieved by the non-athletic group.

During the DVA testing, both subject groups exhibited a decrease in dynamic visual acuity threshold when compared to their static acuity threshold levels. Losses recorded in leftward, rightward and combined average loss were not significantly different between the two subject groups.

Variable	Unit	Athlete		Non-Athlete		t-Value	Significance
		mean	s.d	mean	s.d		
VA OD	logMAR	-0.089	0.176	-0.037	0.140	-1.062	0.2946
VA OS	logMAR	-0.134	0.135	-0.042	0.185	-1.786	0.0818
CT Dx	Prism diopter	-0.222	0.943	-0.435	1.973	0.420	0.6766
CT Nr	Prism diopter	-5.778	4.545	~~-1.609~~	~~4.943~~	~~-2.775~~	~~**0.0084**~~
Stereo Acuity	Sec of arc	31.11	18.114	28.696	10.468	0.536	0.5948
NCM SVA	logMAR	-0.19	0.021	-0.184	0.037	-0.602	0.5503
L GST	Deglsec	122.8	35.94	101.3	30.26	2.105	**0.0416**
R GST	Deg/sec	120.0	44.59	98.75	28.33	1.885	0.0666
L GST logMAR	logMAR	0.01	0.021	0.016	0.037	-0.602	0.5503
R GST logMAR	logMAR	0.01	0.021	0.016	0.037	-0.602	0.5503
L+R/2 GST vel.	Deglsec	121.39	37.76	100	27.187	2.136	**0.0388**
Req. velocity	Deglsec	120	0	99.583	17.63	4.9	**0.0001**
L DVA	logMAR	0.013	0.141	0.004	0.099	0.248	0.8053
R DVA	logMAR	0.014	0.154	0.047	0.145	-0.712	0.4810
L DVA vel	Deglsec	158.56	18.734	125.63	22.79	4.991	**0.0001**
R **DVA vel**	Deg/sec	153.5	14.73	123.96	19.95	5.29	**0.0001**
L+R/2 DVA vel	Deg/sec	156.03	15.43	125.13	20.66	5.325	**0.0001**
L DVA loss	logMAR	-0.206	0.136	-0.188	0.088	-0.499	0.6208
R DVA loss	logMAR	-0.207	0.151	-0.232	0.132	0.571	0.5710
L+R/2 loss	logMAR	-0.206	0.137	-0.210	0.096	0.108	0.9140
Sample size		18 Men	3 Women	24 Men	17 Women		

Table 1: Results for athletes and non-athletes with the *in*Vision™ device.

Outcome variables legend:

- L GST: terminal leftward head velocity during GST measurement
- R GST: terminal rightward head velocity during GST measurement
- GST logMAR: the visual acuity demand of the target used for GST measurement.
- L+R/2 GST Vel: average head velocity for both directions
- Req velocity: the minimum initial head velocity required for GST measurement
- L DVA: threshold DVA for leftward head movement
- R DVA: threshold DVA for rightward head movement
- L DVA Vel: actual leftward head velocity when the L DVA threshold is measured
- R DVA Vel: actual rightward head velocity when the R DVA threshold is measured
- L+R/2 DVA Vel: average head velocity for both directions
- DVA loss: the difference between the static and dynamic VA thresholds for each direction of head movement
- L+R/2 loss: the average difference in static and dynamic thresholds for both directions of head movement

DISCUSSION

The results from this study represent initial findings for measuring dynamic visual acuities in the athletic population using the *in*Vision™ device developed by NeuroCom.

As hypothesized, the data show that athletes have significantly better dynamic visual acuities when compared to the non-athletic population. This finding is consistent with the previous studies that have attempted to measure dynamic visual acuities in athletes. This study, in particular, found that the athletic sample significantly outperformed the general population non-athlete sample on the speed or velocity-related tasks involved in dynamic visual acuities. The required minimum GST velocity for athletes was 120 degrees per second and all athletes were able to meet this minimum velocity. A previous study by Coffey et al[16] demonstrated that a velocity of 120 degrees per second was very difficult to achieve within the non-athletic population. However, the athletic population performed no better on the skills pertaining to threshold sensitivities (target size). It is worth noting that the athletes all began the GST task with an initial velocity of 120 degrees per second versus the non-athletic subjects who started at varying target velocities averaging 99.6 degrees per second (See Table 1). The athletes were able to move their heads 20 degrees per second faster than the non-athletes, AND see a target that was slightly (but not significantly) smaller than that seen by the non-athletes (0.01 vs. 0.015 logMAR).

Similarly, the DVA thresholds did not differ between the groups. However, the athletes achieved essentially the same threshold DVA, but at significantly higher terminal velocities (the actual head velocity at the time threshold DVA was reached) than the non-athletes. Stated another way, the athletes were able to perform the task using a similar DVA target size, but with heads moving at a significantly higher angular velocity. These findings suggest that dynamic aspects of vision are developed to a higher level for athletes.

While the inVision™instrument was developed for use by ENT's and vestibular specialists, we believe it has significant potential application with coaches, athletes, optometrists and sports team officials. Static visual acuity measure was not particularly predictive of the dynamic measures assessed using *in*Vision™. The instrument provides potentially useful assessment measures that are not currently part of the athlete recruitment process and standard medical exam for the athletes. It is possible that this instrument could prove to be a valuable predictor in athletic performance.

If the human sensory system cannot accurately and efficiently process visual information during dynamic sports such as ice hockey, basketball and baseball, the athletes' performance will suffer. As the *in*Vision™ technology developed by NeuroCom becomes more widely available, this would provide another means in predicting and evaluating visual aspects of athletic performance. In addition, if the link between dynamic visual acuities and competitive performance can be ascertained via player, a tailored, comprehensive sports vision therapy program might be developed to complement an athlete's daily training regimen.

The preliminary nature of this study invites further testing and investigation with the *in*Vision™ device developed by NeuroCom. For example, in the case where a coach feels that a player is not playing to his potential, the *in*Vision™ device could be used in conjunction with a full vision examination to determine if vision is a limiting factor for the player's performance. The promising results of this study should invite further testing and investigation with the *in*Vision™ device in the athletic setting.

REFERENCES

[1] Long GM, Penn DL. Dynamic visual acuity: Normative functions and practical implications. Bulletin of the Psychnomic Society. 1987;**25** (4):253-256.

[2] Long GM, Crambert RF. The nature and basis of age-related changes in dynamic visual acuity. Psychology and Aging. 1990;**5**:138-143.

[3] Beals RP, Mayyasi AM, Templeton AE, Johnston WL. The relationship between basketball shooting performance and certain visual attributes. Am J *Optom* Arch Am Acad *Optom.* 1971;**48** (7):585-590.

[4] Sanderson FH, Whiting HTA. Dynamic visual acuity and performance in a catching task. J of Mot Behavior. 1974;**6**:87-94.

[5] Sherman, A. Overview of Research information regarding vision and sports. Journal of the American Optometric Association. 1980;**51**:661-665.

[6] Stine D, Arterburn MR, Stern NS. Vision and Sports: A review of the literature. Journal of the American *Optometric* Association. 1982;**53**:627-633.

[7] Morris GSD, Kreighbaum E. Dynamic visual acuity of varsity women volleyball and basketball players. Res Q Am Assoc Health *Phys* Educ. 1977;48(2): 480-483.

Demer JL, Honrubia V, Baloh RW. Dynamic visual acuity: A test for oscillopsia and vestibule-ocular reflex function. The American Journal of Otology. 1994;**19**:790-796.

[9] Rouse MW, Deland P, Christian R, Hawley J. A comparison study of dynamic visual acuity between athletes and non-athletes. J Am *Optom* Assoc. 1988;**59**(12):946-950.

[10] Vickers JN. Visual control when aiming at a far target. J Exp *Psychol* Hum Percept Perform. 1996;**22**(2):342-354.

[11] Ishigaki H, Miyao M. Differences in dynamic visual acuity between athletes and non-athletes. Perceptual *Motor* Skills. 1993;77(3 Pt 1): 835-839.

[12] Tian JR, Shubayev I, and Demer JL. Dynamic visual acuity during passive and self-generated transient head rotation in normal and unilaterally vestibulopathic humans. Experimental Brain Research. 2001;**142**(4):486-495.

[13] AOA Sports Vision Guidebook: Basketball. www.aoa.org, Sports Vision Section, American Optometric Association, St. Louis, MO. 1984.

[14] AOA Sports Vision Guidebook: Baseball. www.aoa.org, Sports Vision Section. American Optometric Association, St. Louis, MO. 1984.

[15] Greene LM, Johnson TJ, Berman A. Hockey: A sports vision guide for the optometrist. American Academy of Optometry. 1994.

[16] Coffey B, Richards L, Olmschenk S, Peters JF. Preliminary Normative Data for a New Device to Measure Dynamic Visual Acuity 2004 Conference proceedings of the 2004 American Academy of Optometry Annual Meeting, Tampa, FL.

[17] Coffey B, Buchholz J, Miller K, Peters JF. Test-Retest Reliability for a New Device to Measure Dynamic Visual Acuity 2005 Conference proceedings of the 2005 American Academy of Optometry Annual Meeting, San Diego, CA.

[18] Pelli DG, Robson JG, Wilkins AJ. The design of a new letter chart for measuring contrast sensitivity. *Clin.* Vision Sci. 1988;**2**(3): 187-199.

[19] Coffey B, Reichow AW. Optometric Evaluation of the Elite Athlete: The Pacific Sports Visual Performance Profile. Problems in Optometry. 1990 1(2):32-58.

Appendix

Pacific University
Informed Consent to Act as a Research Participant
Dynamic Visual Acuity Sport Specific Normative Data

Investigator Contact Information:
Dr. Bradley Coffey, principle investigator — coffeyb@pacificu.edu
Pacific University College of Optometry — 503.352.2880
William Bercha — berc6321@pacificu.edu
Douglas Stefanyk — stefanyk@pacificu.edu

1. Introduction & Background Information

You are invited to participate in a research study of normative data for a new method of measuring dynamic visual acuity, the ability to see small targets when in motion. You were selected as a possible participant after communication was made with your team head coach. Please read this form carefully and ask any questions you may have before agreeing to be in this study. This study is being conducted by Dr. Bradley Coffey. The purpose of this study is to develop normative data for trained athletes for a new method of measuring dynamic visual acuity.

2. Procedures

If you agree to participate in this study, we will ask you to perform three tests that are widely used in clinics and research labs: computerized posturography, gaze stabilization, and dynamic visual acuity. The first task involves attempting to stand still and maintain balance on both a firm surface and a foam pad, both with eyes open and with eyes closed. For the gaze stabilization test, you will sit in a chair ten feet from a computer screen wearing lightweight headgear while moving your head back and forth horizontally (as if to say "no"). When your head is moving fast enough, a Snellen tumbling "E" (an E that is oriented normally or rotated 90, 180, or 270 degrees) will appear on the screen and you will be asked to identify the correct orientation verbally. If you identify the orientation correctly, the rate of head movement is incrementally increased until you are unable to correctly identify the stimulus of constant size. The dynamic visual acuity test consists of the same setup as the gaze stabilization test. For this test, the rate of head movement remains constant while the size of the stimulus letter is incrementally decreased until you can no longer correctly identify it. You will spend about 30-40 minutes for the testing and may need to return if post-season testing scheduled.

3. Risks & Benefits

None of the procedures conducted during the dynamic visual acuity study should pose any significant risks. These same tests are used routinely on a daily basis in clinics and laboratories across the United States. During head rotation, there is a small risk that you may experience symptoms of dizziness, nausea, and/or motion sickness. There is also a small risk of neck injury due to head rotation. You will be in full control of your head movement during the entire testing procedure and may report these symptoms at any time to the experimenters and/or request to discontinue the testing. If you are experiencing these symptoms, you should not drive a motor vehicle until the symptoms subside. Results of the study will increase our understanding of dynamic visual acuity in basketball, baseball and ice hockey, and may lead to improved training procedures designed to enhance performance on the court/ field/ice surface. The data from this study will be used as comparative data for NASA astronauts and people who have imbalance who have completed the same testing protocol.

4. Alternatives Advantageous to Participants

Not applicable

5. Participant Payment

You will not receive payment for your participation, but will receive feedback on how your performance compares to other basketball, baseball and ice hockey players.

6. Promise of Privacy

The records of this study will be kept private. The individual data will be kept on a secure computer in the research lab. If the results of this study are presented or published, we will not include any information that will make it possible to identify a participant. Research records will be stored securely and only researchers will have access to the records.

7. Voluntary Nature of the Study

Your decision whether or not to participate will not affect your current or future relations with Pacific University. If you decide to participate, you are free to not answer any question or withdraw at any time without prejudice or negative consequences.

8. Compensation and Medical Care

During your participation in this project you are not a Pacific University clinic patient or client, nor will you be receiving complete care as a result of your participation in this study. If you are injured during your participation in this study and it is not the fault of Pacific University, the experimenters, or any organization associated with the experiment, you should not expect to receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the study.

9. Contacts and Questions

The experimenters will be happy to answer any questions you may have at any time during the course of the study. Dr. Coffey can be reached at 503.352.2880 or by email at coffeyb@pacificu.edu. If you are not satisfied with the answers you receive, please call the Institutional Review Board Chair, Dr. Karl Citek, at 503.352.2126 to discuss your questions or concerns further. Although Dr. Citek will ask for your name, all calls will be kept in confidence.

10. Statement of Consent

I have read and understand the above. All my questions have been answered. I am either 18 years of age or over, or my parent I guardian has given consent for my participation. I have been given a copy of this form to keep for my records.

Participant's Signature ______________________________ Date ____________

Participant's printed name ______________________________

Parent / Guardian's Signature ______________________________ Date ____________
(if *under* 18 *years* of *age)*

Participant's Address and Phone Number ______________________________

____

____

Investigator's Signature ______________________________ Date ____________

Appendix

Participant Information:

Name: ____

DOB: ____________ Birthplace: ___________

Height: ________ Weight: _______lbs.

Race: ________________

Dominant Hand: L R Dominant Foot: L R

Position: _________________

Experience (# of **years playing):**_______

Do you wear **glasses** or contact lenses? Y N

If you wear contact lenses, what kind? Soft Rigid

Personal **History:**

Please read and answer the following questions by circling Y or N.

1.	Have you ever experienced difficulty tracking a moving object?	Y N
2.	Have you noticed variations in your performance during a game?	Y N
3.	Is your performance consistent during critical competition situations?	Y **N**
4.	Do you experience loss of concentration during games?	Y N
5.	Have you noticed variations in your performance over an extended period of time, such as during a tournament?	***Y*** N

Please circle *any of the following that you have experienced:*

Headaches	**Eye** injuries	**Eye surgery**
Motion sickness	Ear infections	**Head** and **Neck** trauma
Double Vision	Dizziness	**Sinus** infections

Appendix

Medical History:

Please indicate below if you have any of the following conditions:

Diabetes	Yes	No	Unknown
High Blood Pressure	Yes	No	Unknown
Heart Problems	Yes	No	Unknown
Thyroid Problems	Yes	No	Unknown
Cancer	Yes	No	Unknown
Glaucoma	Yes	No	Unknown
Cataracts	Yes	No	Unknown
Breathing problems (asthma)	Yes	No	Unknown
Crossed eyes (strabismus)	Yes	No	Unknown
Amblyopia (lazy eye)	Yes	No	Unknown
Reading difficulties (dyslexia)	Yes	No	Unknown
Nerve problems	Yes	No	Unknown
Other:	Yes	No	Unknown

Do you **have** any allergies to **any** medications or other allergies? *Y* N

If **yes,** please list: ____

Are you currently taking any medications, vitamins or supplements? Y N

If **yes,** please list: ____

____

Participant Signature: ____________________________

Examiner Signature: ______________________________ Date: ______________

Appendix

Entrance Skills:

VAs: OD: OS: OU:

Contrast Sensitivity (Bailey-Lovie): OD: OS: OU:

Cover Test: DistCT: NearCT:

EOMs: **FTB** OU or **Other:**

VF: FTFC **OU** or Other:

Pupils: P E R R L ___ APD

Dominant Eye: L R 100% **75%** **50%**

Stereopsis:	20"	25"	30"	40"	50"	70"	100"	140"	200"	400"
	R	***M***	***R***	***L***	***M***	***R***	*M*	***L***	***R***	***L***

(Randot circles stereotest key)