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Abstract

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DEVELOPMENT OF NON-ATHLETE NORMS
FOR THE PACIFIC SPORTS VISUAL PERFORMANCE PROFILE

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ABSTRACT

The sports vision discipline within the field of optometry is concerned with visual skills associated with athletic performance. A battery of tests that approximate observed visual skills in sport, entitled the Pacific Sports Visual Performance Profile (PSVVP), was utilized to evaluate 147 subjects. These individuals, each fulfilling criterion defining a non-athlete, completed the series of tests for the purpose of generating normative data. The norms provide a basis of quantitative analysis for purposes such as determining validity of particular optometric tests used in evaluating aspects of vision and sports performance. This study offers normative data for the non-athlete in standardized optometric tests and allows basis for further work in vision and athletics. Statistical analysis of normative data for the non-athlete versus previously generated Olympic Festival athlete data was also performed.

The field of optometry contains elements which cover a large range of interwoven aspects of vision and human performance. Within the human performance concern of optometry lies the discipline of sports vision. The status of sports vision has continued to gain attention from those involved in optometry and many groups involved with athletics.[1,2,3] The attention to athletic performance and visual ability creates a situation in which a number of questions arise. These questions may include: What particular visual skills are being utilized in competitive sport? Are some visual skills more important to particular task performance than others? Do athletes have "better" visual systems than non-athletes? How is it that some visual systems appear to be more finely tuned than others? Are "better" visual abilities developed or genetically inherent? How does the visual system of an elite athlete reach its level of efficiency? These questions demand answers that are yet unquantified or not significantly proven.

Sports vision practioners remain in a position of isolating visual skills that seem to have relationship to athletic performance. It seems that ideally an efficient, effective visual system with these particular skills would yield peak sports performance. Investigating the visual abilities of athletes and non-athletes with clinical tests designed to recreate isolated visual tasks of sport appears to be warranted. An individual's visual system can appear to be better able to carry out the task demands of a specific sport when compared to others. This paper offers the behavioral model of vision as the most probable underlying explanation of apparent visual ability observed in athletes. This model, which considers vision as a process that is improved by learning throughout life, seems to offer a viable explanation of how visual systems can reach various levels of efficiency.

The developmental nature of vision is critical to the formation of abilities to perform in visual motor tasks such as sport. The visual system is malleable, influenced by both genetic determinants and usage throughout life. Authors such as Kavner[4] and Suchoff[5] have discussed the importance of childhood development and interaction in providing a visual system that is capable of efficient, effective vision. In a recent book, *Sports Ophthalmology* [6], it is simply put ,"Vision is a learned experience. It is not automatic." The basis for visual information processing is learned in our childhood years. The abilities of the visual system, including the visual abilities called upon in sport, can increase in effectiveness and efficiency as the individual grows, developing and interacting with the enviroment. Early years of interaction using our visual system appears to be a determinant in being able to more effectively develop many visual skills demanded in athletic endeavours.

The visual system seems to be the dominant sense in humans, but it is not isolated. The integration of auditory, visual, vestibular, and proprioception abilities creates the potential to preplan and execute a motor task. Although these sensory systems are physiologically inherent, the daily interaction with the enviroment using vision and the other sensory processes assists us in interpretation of enviromental stimuli. The opportunity to attain more efficient and sensitive usage of the efferent systems is provided through integration of vision and the other sensory systems.

In order to understand the role of human visual skills in sport, quantification of visual performance with a series of tests is indicated. Rather than presume that various visual skills are inseparable to various athletic abilities, sports vision researchers should work toward accumulating more quantified data on which to base the development of sports vision as an optometric discipline.

There have been several articles which suggest the apparent importance of various visual skills in athletic endeavors.[7-16] Fewer research studies have been done in order to answer questions involving visual abilities of athletes. Abernathy[13] points out that in order to evaluate and improve sports performance we need to be able to evaluate aspects of vision that are important to the task. Optometrically, an initial set of tests that approximate observed visual skills in athletic tasks appears to be a starting point in properly evaluating an athlete.

The Pacific Sports Visual Performance Profile (PSVPP) [17] was originally designed by Drs. Bradley Coffey and Alan W. Reichow at the request of the Sports Vision Section of the AOA for testing athletes at the 1985 National Sports Festival in Baton Rouge, Louisiana. The battery of tests was also used at the 1986 U.S. Olympic Festival in Houston. Normative data were collected from over 600 athletes at these two Festivals. The battery provides strict protocols for instructional set, testing enviroment, and scoring thereby providing a repeatable test battery that evaluates visual skills that seem to be associated with athletic task demand. Five general areas of visual performance are evaluated in the battery: Visual sensitivity, accommodation/vergence, depth perception/eye teaming, central/peripheral visual recognition, and eye/hand/foot/body coordination.

Visual sensitivity refers to tests of an individual's discriminatory ability to detect small visual details. An athlete needs to see as clearly as possible to ensure best performance. Visual clarity as measured by Snellen acuity is accepted as a basic and important visual ability.[7,10] A prominent misconception held by many athletes and practitioners is that once 20/20 acuity is attained, the visual system is in optimum condition. Reaching this level of static acuity does not in fact reveal much about the individual's visual abilities. Some authors go as far as to say " . . . there is no relationship between seeing well in the traditional sense and having good athletic vision." [18] And "attention needs to be given to dynamic tests and to ensuring that target velocities and illumination levels mirror the demands of the sport task." [13] Recognizing and measuring the acuity discrimination of an individual in a dynamic fashion is significant to many authors.[11] Dynamic visual acuity is defined as the individual's ability to resolve detail when there is relative movement between the observer and the target.[18,26] Dynamic visual acuity needs to be considered in visual sensitivity testing, especially given that the human visual system is biased to be a "motion-detecting device."[19]

Studies have shown there is little relation between static visual acuity and dynamic visual acuity. Measuring Snellen visual acuities is not a predictor for the dynamic abilities of the individual.[18-22] This lack of correlation is even more evident when higher speeds of movement are used.[22]

In competitive sport, the visual task of discriminating a target from varying background contrasts under various amounts of illumination is a real and significant demand.[22-24] Assessment of contrast sensitivity, the perception of contrast between different degrees of blackness and whiteness, provides another means to clinically measure a person's ability to detect phase and border contrast. Detection of edges (and thus objects) in our environment is an integral task in everyday life and in sport. Measurement of the athlete's contrast sensitivity function "offers potential for predicting real world performance involving complex visual stimuli."[22] Incorporating its use in testing allows a measure of visual sensitivity involving both low and high spatial frequencies. It differs from static visual acuity in that it not only measures high spatial frequencies but also midrange and low spatial frequencies. It has been shown that visual acuity cannot predict contrast sensitivity to low spatial frequency.[22]

Hoffman, Polan and Powell [23] addressed the question of contrast sensitivity functions associated with college athletes. They demonstrated that college athletes have significantly better contrast sensitivity than non-athletes. This measure of visual sensitivity appears to have some value to offer in a complete evaluation of visual performance.

Our visual system has a basic function in it's ability to efficiently change focus and to aim the eyes. Just as an individual needs to recognize contrast, an athlete needs to find the object in space and efficiently aim and focus upon the target. For example, a pass receiver in football needs to aim and focus upon a thrown ball in order to respond to the ball and make the appropriate motor movements to catch the ball. Ability to use accommodation and vergence effectively in all phases of competitive sport appears to be a required skill. Authors suggest that accommodative facility and amplitude, the individual's speed of focusing and the maximum range of the ability to focus, are important.[24] The athlete's accommodative efficiency should be evaluated in both qualitative and quantitative terms.[9,10] The ability to look from close to the body and then to quickly and accurately change fixation across the court intertwines focusing and pointing. It seems apparent that accommodative and vergence efficiency facilitates optimum visual information processing. Vergence abilities along with other types of eye and motor movements provide the capability to keep the eyes on a ball or localize a target. Any deficiency in these skills provides a basis to detect or suggest reason for deficiency in overall human performance.

A third area evaluated in the PSVPP involves the ability to perceive depth and use two-eyed aiming. The two-eyed ability, binocular visual perception of depth or three dimensional space termed stereopsis[26], appears to be a significant visual ability for any individual responding to the visual demands of sport. Physically, the basis of stereopsis depends upon the occurence of motor and sensory fusion. These two components of stereopsis refer to the relative eye movements needed to obtain simultaneous stimulation in both eyes by the same object. The occurence of motor and sensory fusion allows a single perception of the object for the athlete.[26]

Some authors indicate that two-eyed depth perception may not be as important as other skills [27] or even as strong as monocular depth information reliance when performing visual tasks similar to those present in most sports.[28] Monocular cues can provide much information to the individual. Interpostion of objects, relative position of objects, relative size of objects, and motion parallax are monocular cues used in discerning depth. But, according to Adler[29], "In addition to binocular disparity cues to depth there are many monocular cues . . . Depth estimates based on these secondary cues do not, however, have the same perceptual quality and accuracy as do those cues due to stereopsis."

Many authors list depth perception as an apparently needed skill in competitive sport. This seems hardly debateable when the benefits of stereopsis are related to a given sport. Getz[7] states that the speed with which the eyes are aimed and stereopsis is attained "will indicate how quickly a person develops visual information." Sherman[10] states in his overview that "binocular abilities are necessary to directional properties of vision including perception of depth." He also finds that athletes do have better depth perception in studies considering stereopsis, depth perception, and binocular vision. Blundell[30] found that championship tennis players had significantly better depth perception than did less skilled players. In summary, the ability to use stereopsis and binocular cues to depth and localization seems to be an ability that must be utilized to obtain efficient performance.

Peripheral vision or peripheral awareness, the ability to detect and respond to information from non-foveal points, has been accepted as a visual ability that contributes to athletic ability by a number of authors and researchers. [7,9,10,14,31-33] Task analytic evaluation of the demands of many sports such as basketball and hockey, reveals the visual requirement of the individual being aware of information peripherally. The ability to visually take in peripheral stimuli and then respond with an often complex motor movement allows completion of an athletic task. Evaluating the athlete's peripheral vision properly should incorporate a measurable response to stimuli presented in the peripheral visual field. Peripheral visual response, which entails detecting peripheral stimuli and completing a response to the stimuli, is assessed within the PSVPP.

The ability of an athlete to respond quickly to peripheral visual stimuli seems to be an aspect of athletic performance in many dynamic sports. Buckellew[32] investigated peripheral perception and response time and reported athletes had significantly shorter response times than did non-athletes. The comparison was done while presenting peripheral stimuli from 60 degrees to 105 degrees in multiple steps. Johnson[31] supported the general notion that athletes were significantly better in peripheral perceptual abilities. Blundell[30] also found that there were significantly broader peripheral fields in championship tennis players than all other groups of less skilled tennis players.

The question remains as to whether better peripheral awareness ability is innate or developed, just as it remains with all the general visual categories discussed in this study. In a recent study, support for the possibility that peripheral awareness can be developed was presented. Velenovsky and Prasad[34] concluded in their unpublished study that response time and motor response time to a peripheral stimulus could be improved with training. Improving peripheral awareness, as measured by response to peripheral stimulus, supports the apparent reality that visual abilities can be learned and developed.

A most basic characteristic of sport is speed. In athletics, a common term that surfaces regularly in discussion of speed is "reaction". The participant's reaction and response to other players, the ball, or to game situations creates the primary basis for the outcome of the game. It is evident that often a fraction of a second difference in an athlete's reaction and response times can be the difference between good athletic performance and great athletic performance.

Vision provides the groundwork for any athletic performance. Sherman[10] states, "Vision is a signal that allows muscles to respond in sport activities." Solomon and Zinn[19] support this general statement, " Obviously, the precision and quickness with which the visual system can fulfill the requirements and trigger an appropriate motor response will influence performance." The visual system's driving of the motor system is probed by the measurements of reaction and response times which are included in PSVPP testing.

Reaction time has been investigated in various studies and with many variables.[24,36-39] Within the PSVPP utilized in this study, central reaction/response times and peripheral response time are measured. Response time is broken down into two components, reaction time and motor response time. Reaction time involves the amount of time between the onset of a visual stimulus and the individual's first motor movement. Motor response time is the length of time from starting to completing the movement. Thus response time is simply the total amount of time the individual takes to complete his movement in response to a visual stimulus.

In addition to testing reaction/response time with central visual stimuli, visual recognition is also evaluated. The PSVPP test, which measures an individual's span of recognition, involves visual stimuli that are flashed to the individual in separate and brief presentations. These visual stimuli vary in physical length. Span of recognition refers to the ability the individual has to take in an amount of information within a controlled and brief presentation. This ability reflects an observed task in sport, presentation of visual stimuli containing information that the athlete may need in order to initiate an appropriate response. The athlete often must make decisions quickly when different scenarios present themselves. It seems apparent that the ability to take in more information in a short period of time and the resulting decision of appropriate action can aid performance. This ability has been included in athletic testing[24] and in psychological testing[35] reflecting the observation by researchers that visual recognition plays as much a role in human performance as does simple reflex reaction ability.

The fifth general area of visually-related athletic performance concerns coordination of hands, feet, and body. Movement of the body in response to visual stimuli defines a very basic element of sport. In observation, the athlete's performance seems to be directly related to speed and accuracy of the eye-hand/body coordination. This demand concerning human movement is the most basic underlying component connecting all sport. Obviously coordination of movement in response to sport demands would yield better performance than an uncoordinated eye-hand or eye-body response.

Evaluation of balance with visual tasks are also evaluated in this study. Just as the visual input during the athletic act leads the individual to make coordinated movement, visual input also aids the athlete in maintaining balance. Surrounding cues aid the individual by providing a visual reference for the eyes to take in information in order to solidify balance. The visual system and the vestibular system are linked neurologically to provide feedback information in order that the body's musculature can produce appropriate movement to maintain balance.

This study involves utilizing a test battery, the PSVPP, which includes optometric tests dealing with these five general areas of visual skill: Visual sensitivity, accommodation/vergence, depth perception/eye teaming, central/peripheral visual recognition, and eye-hand/foot/body coordination. A major advantage of the PSVPP is the incorporation of many visual testing procedures which have been offered as optometric tests that each simulate a visual demand in athletics. The availability of such standardized testing and normalized scores offers the opportunity to determine whether these test areas are appropriate for athletic evaluation and, if they are, to determine to what extent subjects excel or show deficiencies. By generating a collection of test scores from individuals who are less involved with athletic activity, the opportunity would then exist to show whether the elite athlete may possess superior visual skills.

The purpose of this study involves accumulating data to provide norms for specific tests for the non-athlete. Statistical comparision will be completed using the data available through this study and previously accumulated data from the 1985 and 1986 Olympic Festival. Significant differences in visual performance, if any, will be reported as they pertain to athlete versus non-athlete samples. The results of this study will hopefully add to our understanding of human performance in isolated visual tasks and contribute to the knowledge base in sports vision.

METHODS

Subjects: The subjects evaluated in this study were individuals who were not associated with a professional athletic organization or a present college sports team, and who did not participate in a sport activity more than two times a week. The subjects wore spectacle or contact lens prescription normally used in recreational pursuits.

The subject sample ranged from 14 to 39 years of age and was 61 percent men and 39 percent women. This range was utilized so that it was possible to approximately age and gender match previously accumulated elite athlete data for purposes of comparing non-athlete to athlete PSVPP data. The sample of non-athletes consisted of three distinct subgroups: optometry students, undergraduate students, and high school students.

Approximately 80 of the subjects were entering optometry students who were tested within six weeks of the beginning of first-year classes. The entering optometry students participated in the study in order to meet a course requirement. The remainder of the subjects received payment at the conclusion of testing. Undergraduate college students received $20 and high school students received $15 which was paid as a donation to their school club. All subjects completed the test battery in approximately one-and-one-half hours.

Undergraduate subjects were acquired by placing flyers in Pacific University mailboxes. The flyers specifically stated the description of individuals sought for the study. A short questionnaire (Appendix C) also was included in the flyer. The questions asked gender, age, phone number, sports participation frequency, and any past sports experience. The questionnaire was to be returned to the investigator's University mail box. Questionnaires were then screened for proper subject definition fulfillment. Subjects were contacted by telephone and testing sessions were planned for specific evenings. High school subjects were contacted through a school club and were screened to insure proper subject definition prior to testing.

Testing: All testing was completed during the period October, 1987, to February, 1988, and was performed after 5:30 p.m. on weekdays in the Vision Therapy Service at Pacific University College of Optometry.

The optometry clinic vision training rooms housed the test instrumentation. Five research assistants and the two principal investigators administered all tests. Each researcher maintained the same stations and administered the tests to all subjects. Throughout the study, special attention was devoted to recreate a testing enviroment similar to the 1985 and 1986 Olympic athlete testing. This involved a casual atmosphere in which the subjects were asked to move into the testing stations as they became available.

Subjects were asked to report to a secretarial assistant at the entrance of the wing of the building housing the vision therapy service, complete all screening questionnaires, and remain there until they could enter a testing station. They returned to the secretary at completion of the battery to insure they had completed all testing stations and to receive their payment if any was to be distributed.

The PSVPP protocols (Appendix B) were strictly followed in all testing. Instrument set up, instructional set, and measurement were completed as determined in the PSVPP.

The five general areas of visual evaluation are subdivided into the following tests; specific test protocols are listed in Appendix B.

A) Visual Sensitivity and Refractive Condition

1) Refractive conditon. Measured with a Canon Auto Refractor. Subjects were classified by most prominant refractive condition.

2) Snellen visual acuity. The subjects were measured monocularly and binocularly at 6m and binocularly at 40 cm with Snellen charts. A general clinic room was used.

3) Vistech Contrast Sensitivity data were taken in accordance with Vistech's published protocol (Appendix D). The subject stood 10 feet away.

4) Dynamic visual acuity. The subject stood 10 feet away watching a rotating Landolt C stimulus of 20/40 demand. A Kirschner Rotator reflected the projected stimulus to a portable movie screen. The subject was to report when they could first correctly identify the orientation of the stimulus. The stimulus was rotated at 100 r.p.m. and speed systematically decreased until the stimulus was correctly identified.

B) Accommodation/Vergence

1) A distance accommodative rock test [40] was used to evaluate the speed with which a subject could call letters alternately on a hand held chart and a wall chart 20 feet away. They were to call out a near letter, look up and report the far letter, return to the card and call a near letter, and repeat. This pattern was continued for 30 seconds. Order of the letters was to be maintained. Two trials were completed. One with a 20/80 demand at far and near and a second trial with 20/25 letter demand at far and near.

2) Vergence range measurements were taken with an AO Ultramatic phoropter while using a single 20/20 letter projected on a screen in an exam room. The subject was to respond to blur, diplopia, and recovery from diplopia when BO, BI, BU, or BD prism was gradually and systematically increased and decreased in power before the eyes.

C) Depth Perception and Eye Teaming

An AO vectographic slide was used to test ability to utilize binocular disparity dependent depth information. The subject sat in an exam chair with polarized glasses. A stimulus line of five circles was presented and the subject was to respond as quickly as possible as to which circle appeared to be closest. Correct or incorrect response and total elapsed viewing time was then recorded for each of the four rows of circles.

D) Central Visual Recognition

The subject was to respond to twelve projected slides, each of which had stimuli of five, six, or seven numbers in a single horizontal line. Each slide was presented ten feet in front of the subject, each letter having a 20/100 demand. The exposure time was 0.10 seconds and the standing subject was preset to look at a fixation point on the movie screen. After the exposure of a slide the subject was to verbally report the numbers in exact order. The number of correct digits called was recorded.

E) Central and Peripheral Response Time

1) Reaction-Plus, eye-hand. The Reaction-Plus(Appendix D) is a table top instrument with illuminated red and green depressable buttons. The subject stands with the dominant hand on the green button and is asked to move the hand across the midline of the body to the red button as quickly as he/she can when it lights up. This technique measures reaction and response times to central visual stimuli based upon visually-guided eye-hand motor response.

2) Reaction-Plus, eye-foot. A Reaction Plus instrument was also utilized to test eye-foot reaction and response times. The subject was seated eight feet from the Reaction-Plus and was instructed to depress the right foot pedal and wait for the red stimulus to light up, at which time the subject quickly moved the right foot to an adjacent pedal on the left.

3) Wayne Peripheral Awareness Tester and Trainer (PATT) (Appendix D)
The PATT is a wall-mounted instrument with eight arms protruding from the center. A small light on the end of one of the arms stays illuminated until the subject moves a hand-held joystick in response to seeing the peripheral stimulus. Then another light on one of the remaining arm lights up and stays illuminated until a response. This continues until the subject has responded to all eight arms. The subject stands with the center of the instrument at eye level at a fixation distance of 20 inches from the wall.

F) Eye-Body/Hand Coordination

1) Wayne/Eyespan (Appendix D)

These instruments measure visual motor response to visual stimuli based upon an eye-hand vertical plane button-pressing task. The subject performs two eye-hand trials with the Wayne Saccadic fixator. In the first 30-second trial, the subject depresses as many of the randomly lighted buttons as possible. Each light remains lit until it is pressed. The second trial has the same instruction but differs in that the light will go off if the subject does not depress the button within the 0.75 second exposure. The same modes are presented to the subject with the Eyespan apparatus.

2) Vision/ Balance

Vision and balance interactions were evaluated to test visual factors involved in maintaining gross motor balance. Two different testing systems were used. The first involved the Wayne Saccadic Fixator. A square rocking balance board is placed on the floor 10 feet away from the Wayne and the subject is instructed to rock the board in 1 of 4 directions to turn off 1 of 4 lights that could light up on the instrument. All trials are 30 seconds long and each subject completes each mode once. The second testing system utilized a 10 foot long 2 X 4 board placed flat on the floor. The subject balanced on the board in stocking or bare feet and was to complete five different tasks, one at a time, by direction of the researcher. First, they were to stand heel to toe for 10 seconds. Second, they were to stand heel to toe with eyes closed for ten seconds. Third, they were to stand heel to toe and complete bead skills (eye movement tasks) which included rotations, saccades, pursuits, and near point of convergence. Fourth, they were to walk forward and backward the length of the board with eyes open. Fifth, they walked forward and backward with their eyes closed. Finally, they were to stand on the end of the board and were given a visualization task. They were told to form an image of the visual cues on the wall in front of them and when they were ready, close their eyes and concentrate on the image while standing on the board for ten seconds. All tasks were objectively scored relating to their stability on the board. A 1 thru 5 point scale was used by the observer to quantify their performance.

The order of testing was random for all subjects. In order to keep the subjects active they were instructed to go to any station that was available and complete the test or tests administered at that station. This was judged to be the easiest and smoothest method of subject flow through the PSVPP. This procedure was stressed throughout testing so that simulation of the Olympic athlete testing atmosphere was approximated.

RESULTS

A number of comparisons can be completed with the data collected through this study and also by using the past Olympic Festival athlete data. Both sets of data were collected while using the PSVPP protocols.

An important goal of this study was to provide non-athlete normalized scores for each of the tests included in the present PSVPP. Before any further statistical analysis concerning elite athlete and non-athlete comparisons can be properly done and considered valid, the non-athlete population must ideally show internal consistency and no significant differences between each of the subgroups evaluated throughout this study. Optometry students (OS), undergraduate students (US), and high school students (HS), all fulfilling the subject qualifications, would hopefully generate a valid and reliable non-athlete data base. The availability of normalized values for each of the tests within the PSVPP for non-athletes will then allow athlete versus non-athlete comparison.

Data were analyzed and comparisons made using ANOVA and post hoc Scheffe test for differences between subgroups. Statistically significant differences are indicated as explained by the legend at the beginning of the tables section of appendix A.

The results of testing the non-athlete population with the battery of tests that comprise the PSVPP showed overall consistency in many areas. Tables 1 thru 6 show means, standard deviation, and other descriptive data for each of the subgroups. The primary goal of this study was to develop a non-athlete criterion level for each of the visual tests. There were 64 separate measurements recorded for each subject. Between subgroup statistical analysis using ANOVA indicated that there were fourteen measurement areas in which significant differences existed between groups.

In visual sensitivity testing the optometry students showed lower right eye static Snellen acuity, yet they also showed significantly better contrast sensitivity in three of the five rows of plates on the Vistech chart ($p<.05$). Analysis of all data within the accommodation/vergence testing showed higher base down duction recovery measures for only the optometry students ($p<.05$).

In the depth perception/ eye teaming task utilizing the AO vectographic slide, the optometry students showed faster recognition time in reporting disparity dependent depth created in the first trial with the vectographic slide ($p<.05$). Central visual recognition testing revealed a significant difference within the subgroups. The high school students showed poorer accuracy than either the undergraduate or optometry students in the tachistoscope task based upon total number of stimuli called correctly ($p<.001$).

The final significant difference in variability between the subgroups of non-athletes was found in the eye-hand motor response time measures with the Reaction-Plus ($p<.05$). The optometry students exhibited faster response times to the central response time task.

Statistical analysis of the data indicates several significant differences between the groups of athletes and non-athletes. 746 Olympic caliber athletes were tested during the Olympic Festivals in 1985 and 1986. Some of these athletes were not tested with all the tests that comprise the updated version of the PSVPP that this study utilized. The number of athletes that did complete each of the tests was still large.

Review of the significant differences show the athletes were more sensitive in visual discrimination ability in the contrast sensitivity task on all rows of stimuli on the Vistech chart ($p<.001$). Athletes also were faster in verbally responding to the percieved float in the AO vectographic chart on row two and line four ($p<.05$). The other two rows revealed no significant differences.

In the distance rock test that represents an accommodative/vergence facility task, the athletes again showed significant superiority in both the 20/80 letter demand ($p<.05$) and 20/25 letter demand ($p<.01$). Vergence range measurements using an AO ultramatic phoropter showed the non-athletes to have higher base-out recovery ($p<.01$), base up break ($p<.01$) and base down break ($p<.01$).

Non-athletes performed significantly better in two of the groupings derived from the tachistoscopic data. Non-athletes correctly called more of the six-digit ($p<.05$) and seven-digit ($p<.01$) stimulus numbers correctly than did athletes.

The athletes' performance in the Reaction-Plus eye-hand task was significantly better in all three measurements ($p<.001$) when compared to the non-athlete population data. In the Wayne saccadic fixator task requiring eye-hand responses, the non-athletes were significantly faster in the first mode ($p<.001$). The athletes were faster in mode two ($p<.01$).

DISCUSSION

This study provides a first look at the wealth of data that now exists for the PSVPP. The PSVPP provides a formal attempt to standardize the visual performance evaluation of the athlete. The PSVPP is designed to test visual abilities significant to performance and to uncover inadequate visual capabilities that may affect an athlete's performance. Now with the non-athlete data which is included in this study, the optometry profession has an improved basis for effective sports vision evaluation. The evolutionary status of the PSVPP has always been emphasized; tests are added or deleted to improve the PSVPP's ability to differentiate visual skill levels among athletes. An important goal of this study is to provide non-athlete normalized scores for each of the tests included in the PSVPP.

Before any further statistical analysis concerning elite athlete and non-athlete data, the non-athlete population should ideally show internal consistency in its subgroup comparison. Analysis of the subgroup population as a whole shows a range of age and background characteristics. However, the subject criteria and student status is common to all subjects. The non-athlete population was solicited in order to provide an approximate age and gender match to the Olympic athlete data. The non-athletes were targeted in the selection process according to age and then, if the opportunity allowed, a proportional number of females and males to match the existing

Olympic data.

First analysis of the subgroups that comprise the non-athlete population showed significant differences in seven of the sixty-four measurements included in the PSVPP. There are some factors that offer a suggestion as to why significant diffences were observed. It is indicated that any subjective observation of the non-athletes be discussed, considering the purpose of this study.

Observations by the researchers indicated the possibility that the optometry students showed a heightened level of attentive interest in the battery of tests. The optometry students had attended few optometry classes prior to participating in the study. They appeared to have a level of interest and curiosity in this battery of tests which reflected interest in their chosen profession. By having a relatively higher level of interest and apparent motivation, the optometry students may show more sensitivity in detecting just noticeable differences within some tests. The significant differences found in contrast sensitivity (three of five rows of Vistech contrast sensitivity plates) and in base down recovery in vergence duction testing could reflect heightened awareness and sensitivity driven by motivational factors. This possibility could be true for any other differences observed.

A trend that is demonstrated by depth perception/eye teaming testing using the AO vectograph slide involves poorer first trial scores (AO1) compared to second trial scores (AO2). In this particular testing there were no demonstration trials allowed. The subjects received the instruction set and then proceeded to complete the first task. Scores for all subgroups were lower for the first trial attempt in discriminating which circle appeared to "float" and then verbally identifying the number of the circle. The first row of circles contained the circle that had the greatest disparity of all four trials and yet the subjects were all slower to respond in this trial than they did in the second. This "practice effect" situation may be a contaminating factor for testing depth perception/eye teaming. Optometry students were significantly better in the first trial scores than were the other subgroups.

The testing enviroment for the non-athletes was considered to be more tightly controlled enviroment than the Olympic Festival testing enviroment. The time demands during the Olympic festivals created a rushed, hectic testing enviroment. Of course, instruction presets, instrument set up, and measurement were all done in accordance to the PSVPP protocol in all data collection. The point here is that the environment surrounding the testing sites was slightly different. In our opinion,the non-athlete testing was more properly controlled. It appeared that the subjects enjoyed the novelty of the tasks encountered in the series of tests and proceeded through the battery of tests in a motivated and enjoyable manner. The testing was unusual and unfamiliar to the non-athlete subgroups, just as it was for the Olympic athletes.

There is another difference in the testing environment for the non-athlete population versus the Olympic population. All non-athlete testing was done in the evening between 5:30 p.m. and approximately 10 p.m.. Olympic testing was done during daytime hours and completed by approximately 7 p.m. This difference may deserve consideration due to the fact that testing in the evening may create a fatigue characteristic for the non-athletes. However, subjective observation of the subgroups did not seem to indicate any fatigue effects.

The question of the elite-athlete being visually superior to the non-athlete, a major motivator in development of the PSVPP, is confronted in a generalized fashion in this study. Significant differences seen in the comparison of athletes versus non-athletes offer some initial support for revealing superior visual abilities in athletes. The Olympic athlete population, when treated as a whole, shows much variability in a number of characteristics. The athlete sample is composed of athletes participating in many different sports and with many different demands. Treating the entire Olympic athlete sample as a simple elite-athlete population is inappropriate, especially when such diverse groups of athletes are involved in different competitive events. Given these factors, any significant differences found in the initial comparison to non-athletes would have to be very robust to be evident in analysis.

The significant differences that were indicated in statistical analysis show obvious patterns. The Olympic athletes were better in contrast sensitivity discrimination for all rows of plates on the Vistech contrast sensitivity chart. The athletic population was also significantly better in both phases of distance rock (accommodative/vergence facility) testing and in all three measurements of Reaction-Plus hand reaction and response speed testing.

As an example of the variability in the Olympic athlete population, it was noted that the 1985 Olympic data contained fourteen and fifteen year-old field hockey players that were relatively young, inexperienced athletes. This segment of athletes was felt to be a contaminating factor in the data. These subjects' maturity and attention were noticeably less during the testing. Unlike the majority of the participants at the Olympic Festivals, these athletes did not appear to be "elite" in athletic ability.

Although comparison of the all Olympic athlete data to the non-athlete data should be completed, it seems to be a very general manner in which to treat the Olympic Festival data. Sports are very diverse in their visual demands of a participant. The PSVPP contains test demands that seem to simulate both reactive and non-reactive sport demands. When considering the Olympic athlete population, very dissimilar sports participation is apparent. The Olympic data included athletes from reactive team sports such as baseball, soccer, and hockey. Non-reactive sports including archery and several Olympic shooting disciplines are also included in the data.

These factors may offer some explanation for the variability seen in the data. The breakdown of the athlete data pool into reactive and non-reactive sports would possibly yield tighter statisical analysis and allow differences in visual ability to surface.

In light of this observation, a proposal for further work with all accummulated data would involve grouping athletes into sport categories based on reactive or non-reactive task demands. Also breakdown of elite-athlete PSVPP data into specific sport, gender, or age characteristics is a viable option. More specifically, the developmental trends relative to age should be considered in athletic visual ability research. The opportunity now exists to better investigate this particular question and many other related questions not included within the investigative scope of this study. The data now accumulated lay the groundwork for considerable analysis of numerous comparisons of various elite-athlete groups with non-athlete data that can be utilized in forthcoming work..

A wealth of data has now been collected under the standardized protocol of the PSVPP developed at Pacific University under the direction of Drs. Coffey and Reichow. Interested and supportive groups such as the United States Olympic Committee, the Sports Vision Section of the American Optometric Association, and sports vision optometrists are now provided a look at preliminary comparisons between proven high caliber athletes and individuals who make athletic activity a recreational venture.

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APPENDIX A- DATA TABLES AND ANALYSIS SUMMARY TABLES

EXPLANATIONS OF ABBREVIATIONS USED IN TABLES

NOF '85, NOF '86	National Olympic Festivals 1985 and 1986
OS	optometry students
US	undergraduate students
HS	high-school students
VA-OD, VA-OS, VA-OU	visual acuities; right eye, left eye, and both eyes
CS1, CS2, . . ., CStot	contrast sensitivity values as per Vistech's system of evaluation
DYN VA mn	the mean value of the three dynamic visual acuity trials
DxRk-80, DxRk-25	distance rock using 20/80 and 20/25 letters respectively
BI bk, BI rec, BO, BU, BD	prism vergence values for breaks and recoveries
AO1 time, . . ., AO4 time	AO vectographic slide rows one thru four
PATT1, . . ., PATT8	Wayne Peripheral Awareness Tester and Trainer value for positions one thru eight
PATTmn	mean value for all eight positions
PATT2-8	mean value for all values except position one
Tach - total 5s	total numerals identified correctly from 5-digit presentations
Tach - total 6s	6-digit presentations
Tach - total 7s	7-digit presentations
Tach - total	total numerals identified correctly from all presentations
Tach - first three	from slides one thru three
Tach - last three	from slides ten thru twelve
RXH mn	mean hand reaction time
RPH mn	mean hand response time
MRH mn	mean hand motor response time
RXF mn	mean foot reaction time
RPF mn	mean foot response time
MRF mn	mean foot motor response time
Wyn 1a	Wayne Saccadic Fixator mode I
Wyn II	mode II
Wyn 1b	balance board
Espn A, Espn B	Eyespan mode A, mode B
VB1, . . .,VBtot	vision and balance

NOTATIONS IN TABLES

a - significantly different than NOF '86 at 95% level
b - significantly different than US at 95% level (US vs. OS)
c - significantly different than HS at 95% level (US vs. HS)
d - significantly different than OS at 95% level (OS vs. HS)
* - significantly different ($p<0.05$)
** - significantly different ($p<0.01$)

GROUP	n	mean	sd	med	mode	range
NOF '86	364	22.41	6.70	21	21	12 - 56
NA	143	21.62	4.60	22	23	14 - 39
OS	86	24.16	3.84	23	23	20 - 39
US	20	20.35	2.11	19	19	18 - 24
HS	37	16.38	1.26	17	17	14 - 18

TABLE 1: Age description of subjects

measure	NOF '85 mean	SD	n	NOF '86 mean	SD	n	OS mean	SD	n	US mean	SD	n	HS mean	SD	n
VA-OD (Snellen Denom	**17.97**	*5.17*	283	**19.71**	*11.81*	363	**23.28**	*9.23*	86	**20.00**	*7.56*	20	**17.24**	*3.77*	37
VA-OS (Snellen Denom	**18.40**	*6.40*	283	**19.49**	*11.54*	363	**21.28**	*5.90*	86	**20.00**	*5.97*	20	**18.05**	*6.15*	37
VA-OU (Snellen Denom	**16.76**	*2.58*	283	**17.52**	*10.40*	363	**18.85**	*4.73*	86	**16.85**	*3.84*	20	**15.73**	*2.38*	37
CS1 (Vistech value)	**6.06**	*0.89*	283	**6.28**	*0.81*	363	**6.22**	*0.73*	86	**5.75**	*0.64*	20	**5.65**	*0.54*	37
CS2 (Vistech value)	**6.89**	*0.84*	281	**6.88**	*0.77*	363	**6.66**	*0.89*	86	**6.35**	*1.14*	20	**6.22**	*0.58*	37
CS3 (Vistech value)	**6.80**	*1.04*	283	**6.73**	*1.10*	363	**6.45**	*1.04*	86	**5.90**	*1.12*	20	**5.76**	*0.90*	37
CS4 (Vistech value)	**6.93**	*1.30*	283	**6.49**	*1.33*	363	**6.09**	*1.05*	86	**5.10**	*1.33*	20	**5.60**	*0.90*	37
CS5 (Vistech value)	**6.22**	*1.21*	283	**5.67**	*1.38*	362	**5.08**	*1.59*	86	**4.50**	*1.64*	20	**5.03**	*1.19*	37
CStot (Vistech value)	**32.95**	*3.96*	283	**31.95**	*4.55*	364	**30.51**	*4.11*	86	**27.60**	*4.67*	20	**28.24**	*3.11*	37
DYN VA mn (r.p.m.)	**48.07**	*10.29*	285	**42.85**	*15.03*	364	**45.47**	*10.01*	86	**40.43**	*7.27*	20	**43.77**	*13.28*	37

TABLE 2: Descriptive data for visual sensitivity.

measure	NOF '86 mean	SD	n	OS mean	SD	n	US mean	SD	n	HS mean	SD	n
DxRk-80	**15.63**	*6.47*	364	**14.05**	*3.20*	85	**14.55**	*2.87*	20	**14.62**	*2.90*	37
DxRk-25	**10.74**	*3.67*	360	**9.48**	*2.75*	79	**10.59**	*2.03*	17	**10.22**	*2.33*	36
BI bk (prism diopters)	**6.86**	*3.31*	358	**6.46**	*2.45*	83	**7.65**	*3.18*	20	**7.95**	*4.68*	37
BI rec (prism diopters)	**2.97**	*2.56*	359	**3.32**	*1.83*	78	**4.75**	*2.77*	20	**2.86**	*2.84*	35
BO bk (prism diopters)	**14.01**	*14.21*	359	**15.22**	*6.75*	85	**13.60**	*7.24*	20	**15.30**	*7.35*	37
BO rec (prism diopters)	**6.15**	*4.53*	357	**7.99**	*4.77*	83	**6.90**	*4.79*	20	**8.63**	*5.44*	35
BU bk (prism diopters)	**2.63**	*1.00*	359	**3.04**	*1.51*	84	**3.20**	*1.24*	20	**2.57**	*0.82*	35
BU rec (prism diopters)	**0.83**	*1.25*	357	**0.79**	*1.15*	84	**0.85**	*0.99*	20	**0.15**	*0.62*	33
BD bk (prism diopters)	**2.38**	*1.04*	360	**2.80**	*0.97*	84	**2.80**	*0.83*	20	**2.91**	*0.87*	34
BD rec (prism diopters)	**0.61**	*0.70*	357	**0.81**	*0.75*	84	**0.45**	*0.61*	20	**0.27**	*0.63*	33

TABLE 3: Descriptive data for accommodativd/vergence ability.

measure	NOF '86 mean	SD	n	OS mean	SD	n	US mean	SD	n	HS mean	SD	n
AO1 time (sec)	3.40	3.50	306	3.25	2.68	83	6.10	5.94	20	4.20	3.73	37
AO2 time (sec)	2.60	2.45	292	3.11	2.01	83	3.75	2.54	20	3.21	2.74	37
AO3 time (sec)	3.04	2.83	300	3.17	2.42	81	4.81	4.16	20	2.79	1.74	35
AO4 time (sec)	4.21	3.67	282	5.35	3.75	81	4.60	3.72	20	4.76	3.73	35

TABLE 4: Descriptive data for depth perception/eye teaming ability.

measure	NOF '85 mean	SD	n	NOF '86 mean	SD	n	OS mean	SD	n	US mean	SD	n	HS mean	SD	n
PATT1 (sec)	39.31	*22.76*	277	50.95	*63.83*	360	59.53	*64.70*	86	35.10	*5.53*	20	36.65	*7.88*	37
PATT2 (sec)	37.12	*12.60*	279	40.40	*21.17*	360	39.69	*9.04*	86	37.73	*7.42*	20	39.78	*12.57*	37
PATT3 (sec)	40.38	*32.47*	279	36.07	*7.38*	360	41.36	*13.70*	86	36.25	*6.95*	20	36.77	*7.45*	37
PATT4 (sec)	35.71	*12.53*	279	34.97	*10.36*	360	36.87	*10.78*	86	34.50	*6.52*	20	36.42	*8.40*	37
PATT5 (sec)	36.72	*21.13*	279	36.27	*12.11*	360	39.47	*13.90*	86	36.70	*8.44*	20	35.16	*10.08*	37
PATT6 (sec)	39.29	*45.66*	279	33.98	*8.32*	360	36.37	*9.29*	86	33.25	*7.74*	20	34.69	*8.06*	37
PATT7 (sec)	38.57	*13.86*	279	35.00	*7.41*	360	38.35	*9.99*	86	35.38	*7.97*	20	35.70	*7.23*	37
PATT8 (sec)	41.03	*30.83*	279	38.82	*17.40*	360	43.16	*17.96*	86	37.00	*8.62*	20	38.04	*9.82*	37
PATTmn (sec)	37.02	*15.46*	290	38.32	*11.50*	360	41.85	*12.97*	86	35.74	*5.02*	20	36.65	*6.55*	37
PATTmn2-8 (sec)	36.95	*15.59*	290	36.50	*7.53*	360	39.33	*8.75*	86	35.83	*5.20*	20	36.65	*6.66*	37
Tach - total 5s	NA	*NA*	NA	16.80	*4.70*	361	16.63	*4.29*	88	17.20	*2.95*	20	14.60	*3.53*	37
Tach - total 6s	NA	*NA*	NA	17.43	*4.60*	362	18.92	*5.20*	88	19.30	*3.20*	20	16.60	*3.93*	37
Tach - total 7s	NA	*NA*	NA	15.28	*4.62*	361	18.01	*5.14*	88	18.00	*4.53*	20	13.30	*4.52*	37

TABLE 5A: Descriptive data for central/peripheral reaction/response time.

measure	NOF '85 mean	*SD*	n	NOF '86 mean	*SD*	n	OS mean	*SD*	n	US mean	*SD*	n	HS mean	*SD*	n
Tach - total	NA	NA	NA	49.53	11.94	360	53.56	13.87	88	54.50	8.66	20	44.49	10.02	37
Tach - first three	NA	NA	NA	12.16	3.82	361	13.28	3.65	88	14.25	2.17	20	10.76	3.24	37
Tach - last three	NA	NA	NA	12.87	3.97	363	14.06	3.66	88	14.40	2.06	20	11.92	3.21	37
RXH mn (sec)	22.63	4.97	278	20.18	7.38	360	24.35	3.62	86	24.40	2.79	20	24.23	2.59	37
RPH mn (sec)	39.89	5.57	278	34.07	12.91	360	43.00	6.21	86	43.97	5.12	20	46.62	7.71	37
MRH mn (sec)	16.55	6.30	290	13.90	6.39	360	18.65	3.97	86	19.57	4.09	20	22.39	6.24	37
RXF mn (sec)	NA	NA	NA	25.70	4.67	360	25.81	2.39	86	26.10	2.65	20	27.21	3.52	37
RPF mn (sec)	NA	NA	NA	40.13	9.46	359	40.18	4.57	86	41.89	6.86	20	44.16	6.80	37
MRF mn (sec)	NA	NA	NA	14.63	9.16	359	14.37	3.74	86	15.79	2.56	20	16.95	5.39	37

TABLE 5B: Descriptive data for central/peripheral reaction/response time.

measure	NOF '85 mean	SD	n	NOF '86 mean	SD	n	OS mean	SD	n	US mean	SD	n	HS mean	SD	n
Wyn 1a	34.84	*6.11*	285	45.05	*6.42*	355	46.08	*6.24*	86	47.80	*6.63*	20	44.16	*7.71*	37
Wyn II	25.67	*6.44*	285	31.86	*4.65*	355	28.13	*5.18*	86	30.35	*4.53*	20	27.38	*4.54*	37
Wyn 1b	32.00	*4.83*	282	36.59	*6.36*	358	33.13	*5.79*	86	34.05	*3.62*	20	31.60	*5.40*	37
Espn A	40.57	*4.64*	145	38.99	*19.03*	356	41.15	*4.70*	86	40.00	*4.16*	20	38.78	*5.30*	37
Espn B	36.30	*6.81*	145	32.92	*7.98*	356	35.99	*9.17*	86	36.25	*8.57*	20	33.57	*9.24*	37
VB1 - static eyes open	4.02	*0.83*	274	4.72	*1.50*	359	4.71	*0.48*	85	4.80	*0.41*	20	4.86	*0.35*	36
VB2 - eye movements	3.59	*1.00*	274	3.85	*0.91*	359	3.27	*0.93*	85	3.50	*0.76*	20	3.17	*0.91*	36
VB3 - static eyes closed	3.71	*0.84*	274	3.36	*0.91*	357	3.73	*0.76*	85	3.50	*0.69*	20	3.72	*0.97*	36
VB4 - dynamic eyes open	3.93	*0.69*	274	3.95	*0.80*	359	3.82	*0.60*	85	3.70	*0.57*	20	3.94	*0.75*	36
VB5 - dynamic eyes closed	3.07	*0.98*	274	2.36	*0.98*	357	2.13	*0.75*	85	2.25	*0.73*	20	1.92	*0.65*	36
VB6 - eyes closed w/image	NA	NA	NA	NA	NA	NA	3.84	*0.81*	85	4.00	*0.73*	20	4.06	*1.04*	36
VBtot	17.30	*5.38*	290	18.16	*3.36*	360	17.66	*2.47*	85	17.75	*2.22*	20	17.14	*3.80*	36

TABLE 6: Descriptive data for eye hand/body coordination.

	ATHLETES (number)	ATHLETES (%)	NON-ATHLETES (number)	NON-ATHLETES (%)
REFRACTION OD				
MYOPES	75	11.66	37	25.87
EMMETROPES	294	45.72	13	9.09
HYPEROPES	167	25.97	9	6.29
ASTIGMATS	106	16.49	84	58.74
REFRACTION OS				
MYOPES	70	10.89	38	26.57
EMMETROPES	294	45.72	27	18.88
HYPEROPES	162	25.19	7	4.90
ASTIGMATS	117	18.20	71	49.65

TABLE 7: Refractive status of athlete and non-athlete populations.

	NOF '86	non-athletes	OS	US	HS
age	22.41	21.62	24.16	20.35	16.38 d
% males	69	61	65	40	62
% females	31	39	35	60	38

d - significantly different from OS at 95% level (OS vs. HS)

TABLE 8: Comparison of age and gender data.

MEASURE	NOF 85	NOF 86	OS	US	HS	ATHLETES	NON-ATHLETES
VA-OD (Snellen denominator)	17.97	19.71	23.28	20.00	17.24 d	18.95 * *	21.26
VA-OS (Snellen denominator	18.40	19.49	21.28	20.00	18.05	19.01	20.27
VA-OU (Snellen denominator)	16.76	17.52	18.85	16.85	15.73	17.19	17.76
CS1 OU (Vistech value)	6.16	6.28	6.22	5.75	5.65 d	6.22 * *	6.01
CS2 OU (Vistech value)	6.89	6.88	6.66	6.35	6.22	6.89 * *	6.50
CS3 OU (Vistech value)	6.80	6.73	6.45	5.90	5.76 d	6.76 * *	6.20
CS4 OU (Vistech value)	6.93 a	6.49	6.09 b	5.10	5.60	6.68 * *	5.83
CS5 OU (Vistech value)	6.22 a	5.67	5.08	4.50	5.03	5.91 * *	4.99
CStot OU (Vistech value)	32.95	31.95	30.51	27.60	28.24	32.38 * *	29.52
DYN VA mn (r.p.m.)	48.07 a	42.85	45.47	40.43	43.77	45.14	44.32

TABLE 9: Comparative data for visual sensitivity

MEASURE	NOF 85	NOF 86	CS	US	HS	ATHLETES	NON-ATHLETES
DxRk 80 (c.p.m.)	NA	15.63	14.05	14.55	14.62	15.63 *	14.27
DxRk 25 (c.p.m.)	NA	10.74	9.48	10.59	10.22	10.74 * *	9.83
BI Bk (prism diopters)	NA	6.86	6.46	7.65	7.95	6.86	7.02
BI Rec (prism diopters)	NA	2.97	3.32	4.75	2.86	2.97	3.41
BO Bk (prism diopters)	NA	14.01	15.22	13.60	15.30	14.01	15.01
BO Rec (prism diopters)	NA	6.15	7.99	6.90	8.63	6.15 * *	7.99
BU Bk (prism diopters)	NA	2.63	3.04	3.20	2.57	2.63 * *	2.94
BU Rec (prism diopters)	NA	0.83	0.79	0.85	0.15	0.83	0.64
BD Bk (prism diopters)	NA	2.38	2.80	2.80	2.91	2.38 * *	2.83
BD Rec (prism diopters)	NA	0.61	0.81	0.45	0.27 d	0.61	0.63

TABLE 10: Comparative data for accommodative/vergence ability.

MEASURE	NOF 86	OS		US	HS	ATHLETES	NON-ATHLETES
AO1 Time (sec)	3.40	3.25	b	6.10	4.20	3.40	3.91
AO2 Time (sec)	2.60	3.11		3.75	3.21	2.60 *	3.23
AO3 Time (sec)	3.04	3.17		4.81	2.79	3.04	3.31
AO4 Time (sec)	4.21	5.35		4.60	4.76	4.21 *	5.09

TABLE 11: Comparative data for depth perception/eye teaming ability.

MEASURE	NOF 85	NOF 86	OS	US	HS	ATHLETES	NON-ATHLETES
PATT1(sec)	39.31	50.95	59.53	35.10	36.65	45.89	50.19
PATT2(sec)	37.12	40.40	39.69	37.73	39.78	38.97	39.44
PATT3(sec)	40.38	36.07	41.36	36.25	36.77	37.95	39.46
PATT4(sec)	35.71	34.97	36.90	34.50	36.42	35.29	36.44
PATT5(sec)	36.72	36.27	39.47	36.70	35.16	36.46	37.96
PATT6(sec)	39.29	33.98	36.37	33.25	34.69	36.30	35.50
PATT7(sec)	38.57 a	35.00	38.35	35.38	35.70	36.56	37.25
PATT8(sec)	41.03	38.82	43.16	37.00	38.04	39.79	40.98
PATTmn(sec)	37.02	38.32	41.85	35.74	36.65	37.74	39.65
PATTmn2-8(sec)	36.95	36.50	39.33	35.83	36.65	36.70	38.15
Tach - total 5s	NA	16.80	16.63	17.20	14.60	16.80	16.20
Tach - total 6s	NA	17.43	18.92	19.30	16.60	17.43 *	18.38
Tach - total 7s	NA	15.28	18.01	18.00 c	13.30 d	15.28 * *	16.81

TABLE 12A: Comparative data for central/peripheral reaction/response times.

MEASURE	NOF 85	NOF 86	CS	US	HS	ATHLETES	NON-ATHLETES
Tach - total	NA	49.53	53.56	54.50 c	44.49 d	49.53	51.37
Tach - first three	NA	12.16	13.28	14.25 c	10.76 d	12.16	12.77
Tach - last three	NA	12.87	14.06	14.40	11.92 d	12.87	13.56
RXHmn(sec)	22.63 a	20.18	24.35	24.40	24.23	21.25 * *	24.33
RPHmn(sec)	39.89 a	34.07	43.00	43.97	46.62	36.61 * *	44.07
MRHmn(sec)	16.55 a	13.90	18.65	19.57	22.39 d	15.08 * *	19.74
RXFmn(sec)	NA	25.70	25.81	26.10	27.21	25.70	26.21
RPFmn(sec)	NA	40.13	40.18	41.89	44.16	40.13	41.45
MRFmn(sec)	NA	14.63	14.37	15.79	16.95	14.63	15.24

TABLE 12B: Comparative data for central/peripheral reaction/response times.

MEASURE	NOF 85	NOF 86	CS	US	HS	ATHLETES	NON-ATHLETES
Wyn 1a	34.84 a	45.05	46.08	47.80	44.16	40.50 * *	45.83
Wyn II	25.67 a	31.86	28.13	30.35	27.38	29.10	28.25
Wyn 1b	32.00 a	36.59	33.13	34.05	31.60	34.57 * *	32.88
Espn A	40.57	38.99	41.15	40.00	38.78	39.44	40.38
Espn B	36.30 a	32.92	35.99	36.25	33.57	33.90	35.40
VB1 - static eyes open	4.02 a	4.72	4.71	4.80	4.86	4.42	4.76
VB2 - eye movements	3.59 a	3.85	3.27	3.50	3.17	3.74	3.28
VB3 - static eyes closed	3.71 a	3.36	3.73	3.50	3.72	3.51	3.70
VB4 - dynamic eyes open	3.93	3.95	3.82	3.70	3.94	3.94	3.84
VB5 - dynamic eyes closed	3.07	2.36	2.13	2.25	1.92	2.67	2.09
VB6 - eyes closed with image	NA	NA	3.84	4.00	4.06	NA	NA
VBtot - 1 thru 5	17.30	18.16	17.66	17.75	19.22	17.78	17.54

TABLE 13: Comparative data for eye hand/body coordination.

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
VA-OD (Snellen denominator)	18.95	9.53	646	21.26	8.31	143
VA-OS (Snellen denominator	19.01	9.64	646	20.27	6.09	143
VA-OU (Snellen denominator)	17.19	7.98	646	17.76	4.32	143
CS1 OU (Vistech value)	6.22	0.85	646	6.01	0.72	143
CS2 OU (Vistech value)	6.89	0.80	644	6.50	0.88	143
CS3 OU (Vistech value)	6.76	1.07	646	6.20	1.06	143
CS4 OU (Vistech value)	6.68	1.34	646	5.83	1.11	143
CS5 OU (Vistech value)	5.91	1.33	645	4.99	1.51	143
CStot OU (Vistech value)	32.38	4.33	647	29.52	4.13	143
DYN VA mn (r.p.m.)	45.14	13.41	649	44.32	10.71	143

TABLE 14: Athlete vs. non-athlete visual sensitivity descriptive data.

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
DxRk 80 (c.p.m.)	15.63	6.47	364	14.27	3.07	142
DxRk 25 (c.p.m.)	10.74	3.67	360	9.83	2.58	132
BI Bk (prism diopters)	6.86	3.31	358	7.02	3.33	140
BI Rec (prism diopters)	2.97	2.56	359	3.41	2.35	133
BO Bk (prism diopters)	14.01	14.21	359	15.01	6.95	142
BO Rec (prism diopters)	6.15	4.53	357	7.99	4.94	138
BU Bk (prism diopters)	2.63	1.00	359	2.94	1.34	139
BU Rec (prism diopters)	0.83	1.25	357	0.64	1.06	137
BD Bk (prism diopters)	2.38	1.04	360	2.83	2.83	138
BD Rec (prism diopters)	0.61	0.70	357	0.63	0.74	137

TABLE 15: Athlete vs. non-athlete descriptive data for accommodation/vergence

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
AO1 Time (sec)	3.40	3.50	306	3.91	3.70	140
AO2 Time (sec)	2.60	2.45	292	3.23	2.29	140
AO3 Time (sec)	3.04	2.83	300	3.31	2.66	136
AO4 Time (sec)	4.21	3.67	282	5.09	3.73	136

TABLE 16: Athlete vs. non-athlete depth perception/eye teaming descriptive data.

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
PATT1 (sec)	45.89	50.57	637	50.19	51.56	143
PATT2 (sec)	38.97	18.00	639	39.44	9.84	143
PATT3 (sec)	37.95	22.24	639	39.46	11.77	143
PATT4 (sec)	35.29	11.36	639	36.44	9.69	143
PATT5 (sec)	36.46	16.65	639	37.96	12.43	143
PATT6 (sec)	36.30	30.89	639	35.50	8.80	143
PATT7 (sec)	36.56	10.85	639	37.25	9.13	143
PATT8 (sec)	39.79	24.20	639	40.98	15.32	143
PATTmn (sec)	37.74	13.42	650	39.65	11.07	143
PATTmn 2-8 (sec)	36.70	11.82	650	38.15	7.93	143
Tach - total 5s	16.80	4.70	361	16.20	4.04	145
Tach - total 6s	17.43	4.60	362	18.38	4.76	145
Tach - total 7s	15.28	4.62	361	16.81	5.29	145

TABLE 17A: Athlete vs. non-athlete descriptive data for central/peripheral reaction/response time.

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
Tach - total	49.53	11.94	360	51.37	12.95	145
Tach - first three	12.16	3.82	361	12.77	3.58	145
Tach - last three	12.87	3.97	363	13.56	3.49	145
RXH mn (sec)	21.25	6.55	638	24.33	3.26	143
RPH mn (sec)	36.61	10.76	638	44.07	6.64	143
MRH mn (sec)	15.08	6.48	650	19.74	4.91	143
RXF mn (sec)	25.70	4.67	360	26.21	2.80	143
RPF mn (sec)	40.13	9.46	359	41.45	5.40	143
MRF mn (sec)	14.63	9.16	359	15.24	4.23	143

TABLE 17B: Athlete vs. non-athlete descriptive data for central/peripheral reaction/response time.

MEASURE	ATHLETES mean	sd	n	NON-ATHLETES mean	sd	n
Wyn I	40.50	8.08	640	45.83	6.75	143
Wyn II	29.10	6.32	640	28.25	4.98	143
Wyn Ib	34.57	6.17	640	32.88	5.47	141
Espn A	39.44	16.24	501	40.38	4.87	143
Espn B	33.90	7.80	501	35.40	9.11	143
VB1 - static eyes open	4.42	1.30	633	4.76	0.45	141
VB2 - eye movements	3.74	0.96	633	3.28	0.90	141
VB3 - static eyes closed	3.51	0.90	631	3.70	0.83	141
VB4 - dynamic eyes open	3.94	0.75	633	3.84	0.64	141
VB5- dynamic eyes closed	2.67	1.04	631	2.09	0.75	141
VB6- eyes closed with image	NA	NA	NA	NA	NA	NA
VBtot- 1 thru 5	17.78	4.40	650	17.54	2.84	142

TABLE 18: Athlete vs. non-athlete descriptive data for eye hand/body coordination.

APPENDIX B- PACIFIC SPORTS VISUAL PERFORMANCE PROFILE

PSVPP

Pacific Sports Visual Performance Profile

REVISED TESTING PROTOCOLS

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The Pacific Sports Visual Performance Profile (PSVPP)

Revised Testing Protocols
Revision Number Five (3/87)

The following pages list specific testing protocols for several tests of visual performance related to athletic competition. Validity of tests and normative data is enhanced when protocols are strictly followed. The abbreviations used in the protocols are as follows:

- E: Evaluates. Definition of the primary ability evaluated by the test
- TD: Test distance
- IL: Illumination level
- P: Position of subject(s)
- CF: Critical factors to be observed in administering the test
- C: Criterion level required to differentiate A vs. B ability level (see evaluation recording form for definition of ability levels; see below for criterion level determination)
- IS: Instructional set. IS should be presented nearly verbatim to maintain consistent test standards.
- R: Recording; how to record data, what data should be recorded

Criterion Level Determination

Except where noted, these criterion levels were generated through analysis of data collected at the 1985 National Sports Festival and reflect the measured visual performance of that sample of elite athletes. These figures represent the mean (+/- 1 standard deviation). Depending on the visual demands of the individual athlete's particular sport and position, we feel the mean should represent the cutt-off criterion. Athletes whose scores fall more than one standard deviation below the mean may be limited by the ability being tested. Athletes whose scores fall between the mean and one standard deviation below the mean should be counseled and further evaluated to assess the quality of the tested ability.

I. VISUAL ACUITY

SNELLEN VISUAL ACUITY

E: Clarity of vision; visual discrimination ability
TD: 6m, 40cm
IL: Standard room (34-79 footcandles)
P: Sitting relaxed
CF: Testing sequence OD, OS, OU (6m); OU only (40 cm)
C: Crisp 20/20 OD, OS, OU @ 6m; crisp 20/20 OU @ 40cm
IS: "Please call the smallest row of letters that you can see. Guess on any of the letters which aren't completely clear to you."
R: Record BVA plus the number of letters called from next finer acuity line or minus the number of letters called incorrectly from the recorded line.

VISTECH CONTRAST SENSITIVITY

E: Visual contrast sensitivity; visual discrimination ability
TD: 10 feet
IL: Test is calibrated utilizing Vistech's photometric system
P: Standing relaxed
CF: Test only OU unless there is greater than one line difference in monocular Snellen VA's or if athlete is a CL wearer. For these S's test OD, OS, OU. Illumination level is critical.
C: All five rows correctly called to the stimulus number 6 $\pm$1. Criterion based upon data from 1985 and 1986 Olympic Festivals.
IS: "Each of the patches on the chart contain bars that vary in contrast. Each row contains a different size bar pattern. The patches on the far left of each row are high contrast sample patches which show the size bars you will be looking for to the right of that sample patch.
The four patches on the bottom of the chart show the three ways the bars may be oriented and a blank. The bars will be straight up and down, slanted slightly up to the right, or slanted slightly up to the left. Some patches are blank.
Your task is to read across each row, starting with Row A, Patch 1, and call out whether the patch is oriented to the left, right, straight up and down or blank. Some of the patches are very low in contrast and you may not see any bars in these patches. If this is the case, simply answer "blank." However, if you do see something in a patch but you are not sure of the orientation, you are allowed to guess."
R: Record the highest numbered grid orientation (patch) called correctly in each of the five rows of plates on the Vistech chart.

DYNAMIC VISUAL ACUITY (Kirschner Rotator)

E: Visual acuity for a moving target when S is stationary.
TD: 10 feet
IL: Dim room (6-7 footcandles at screen)
P: Standing relaxed
CF: Head must be held stationary. Test target is a 20/20 letter projected at 10 feet (20/40 VA demand). Speed on rotator should be gradually and steadily decreased at a rate of 4-5 rpm/sec from a starting speed of 100 rpm. Diameter of arc of letter rotation must be 55cm.
C: 48 ($\pm$ 10) rpm mean over 3 trials.

IS: Demonstrate slowing the target. "Watch the rotating letter on the screen and call it as soon as you can see it. I'll gradually slow its movement until you can identify it. Follow the letter with your eyes only; don't move your head." No practice trials.

R: Record the speed of rotation (to the nearest one rpm) at which the S can first correctly identify the rotating letter on each of three trials.

II. EYE MOVEMENT ABILITY

PROJECTED KING-DEVICK

E: Speed and quality of self-guided, target-directed saccadic-fixation ability with a distant visual stimulus.

TD: 10 feet

IL: Dim room (6-7 footcandles)

P: Standing relaxed

CF: Head must remain stationary. Separation of the projected stimulus letters on Test III (measured between the first and last letters in each row) should be 48 in.

C: Total time less than 41.6 (± 6.3) seconds, zero errors

IS: Intro test, show demonstration test form. "Without moving your head, I'd like you to call out the letters on the screen in order from left to right, just as if you were reading a book. Call the letters as quickly as you can without making an error."

R: Record time and errors on each of the three K-D subtests as well as total time and errors for the test.

ENTRANCE EYE MOVEMENTS

E: Subjective quality of smooth eye movements and near point of convergence with near-distance testing beads (3/16" diameter) used as visual stimulus.

TD: 40-50 cm (16-20 inches)

IL: Standard room (34-79 footcandles)

P: Standing relaxed

CF: Head must remain stationary. Beads should be moved at a rate of 6-8"/sec.

C: This test is subjective in nature and results will not be statistically analyzed. As such, make qualitative observations of smoothness, accuracy, and consistency of EM throughout all cardinal positions of gaze. Note any gross inefficiencies or limitations of performance.

IS: Smooth EM: "I'd like you to follow my bead with your eyes. Keep your head still and follow the bead moving only your eyes." NPC: "Watch my bead carefully as I move it toward your nose. Keep the bead clear, and tell me if you ever see what appears to be two beads. ...now tell me when the bead appears to be single again."

R: Record general quality of smooth EM and note any unusual NPC findings.

III. REFRACTIVE CONDITION

E: Presence and degree of refractive condition as measured by Canon Auto Refractor.

C: Based on habitual Rx for competition (overrefraction), or standard refraction if no Rx habitually utilized:

- Hyperopia: less than + .75
- Myopia: less than -.25
- Astigmatism: less than .50
- Anisometropia: less than .50 equiv sphere

IV. ACOMMODATION/VERGENCE

DISTANCE ACCOMMODATION ROCK

E: Accommodation/vergence facility in changing from a 40cm to a 6m to a 40cm (etc) visual target under two VA demand conditions, 20/25 and 20/80.

TD: Near chart at 40 cm, dx chart at 6m.

IL: Standard room (34-79 footcandles at both charts)

P: Standing relaxed

CF: Must keep both eyes open at all times. The near chart should be held just below eye level and on line with the distance chart.

C: At 20/80, 33.8 (± 7) cpm; at 20/25, 23.7 (± 6) cpm.

IS: Intro test and demonstrate. "I'd like you to look quickly back and forth between this close chart and the other chart in the distance. Call the first letter on the near chart, then quickly look to the far chart and call the first letter on it. Look back quickly and call the second letter on the near chart, then again look to the far chart, and so on. Go as quickly as you can, but be careful not to lose your place. Make the letters clear when you look at either chart. Call only the large letters first, then we'll start again and I'll have you call only the small letters.

R: Record the number of near-far cycles completed without error in 30 seconds at each of the two VA demand levels. One cycle consists of a shift from near to far, then back to near. You can easily determine the number of cycles completed by subtracting 1 from the total count of letters called on the near chart.

VERGENCE ROCK (Supplemental testing only; to be administered when subject doesn't meet criterion on distance accommodation rock)

E: Facility in changing vergence posture while maintaining accommodation posture for clarity of a 20/30 VA demand letter at a distance of 40-50cm.

TD: 40cm

IL: Standard room (34-79 footcandles) with supplemental glare-free 60-75 watt incandescent desk lamp.

P: Seated comfortably

CF: Test distance must remain constant throughout testing. S should be exposed to demo of prism effects to insure ability to fuse through the 8 BI/BO testing prisms. S should be emphatically directed to keep the print clear at all times.

C: 10 cpm

IS: Demo test - "Look through the prisms until the letters become clear and single, then call the first letter. Immediately flip the prisms to the other side and, again, make the letters clear and single, then call the next letter. Continue this sequence until I say stop; we'll go for one minute. Ready, begin."

R: Record number of vergence cycles completed in one minute. One cycle consists of fusing the BO prism, then fusing the BI, then regaining BO fusion. To determine the number of cycles completed, count the number of times the prism flipper was flipped and divide that number by two.

VERGENCE RANGE

E: Maximal vergence ranges in the BI, BO, BU, and BD directions. Vergence limits are defined as follows: Blur - the first instance of blur noticeable to the subject; Break - the point at which diplopia occurs; Recovery - the point at which single vision can be maintained following the break point (blur is permissable).

TD: 6 meters
IL: Standard room (34-79 footcandles)
P: Seated comfortably behind AO Ultramatic phoropter. Instrument height and PD adjusted to accurately center S's eyes in instrument apertures.
CF: Stimulus is a single 20/20 letter for all vergence tests. If S's BVA is less than 20/20, use a stimulus letter corresponding to S's 6m OU BVA. Measuring prisms should be adjusted at a rate of change of 3 prism diopters (total for both eyes) per second. Place measurement prism for vertical vergences before the S's left eye. Measurement sequence: BO, BI, BU, BD
C: BO: 13.6/6.2 ±5   BI: 7/3 ±3   BU and BD: Equal
These criteria based upon data from 341 athletes at the 1986 U.S. Olympic Festival in Houston, Texas.
IS: After seating S and inserting prisms: "How many letters do you see?" Proceed with evaluation if S reports one. If two stimuli are reported, insert appropriate compensating prism and proceed. "I'm going to slowly change the lenses that you're looking through. You may notice the letter begin to get slightly blurry or to go double. If you notice the letter getting a bit blurry, quickly say "BLUR"; if it goes double, quickly say "TWO"." Perform the blur and break tests, then: "OK, now tell me when the two letters move together into one again. Say "ONE" when the letters come back together." Repeat sequence for vertical ranges eliminating the instructional set for the Blur measurement.
R: Record the measurements for each condition, recording an X if a response for a particular measurement is not elicited. Record the presence or absence of suppression behavior.

V. DEPTH PERCEPTION/EYE TEAMING

AO VECTO

E: Sensitivity to binocular disparity-dependent depth information at a 6 meter (20 feet) testing Dx.
TD: 6 m
IL: Standard room (34-79 footcandles)
P: Standing comfortably in alignment with test stimuli. S wearing polaroid glasses positioned level with orientation of stimuli.
CF: No head movement may be allowed. Each of the four rows of stimuli should be presented individually and in order. Timing begins as soon as a stimulus line is presented.
C: Accurate depth judgement on each row of stimuli. No criterion for time.
IS: "I'm going to show you a row of five circles. One of the circles may appear to be closer to you than the others. Tell me as quickly as you can which circle appears to be closer as I show you each line. I'll take your first answer only."
R: Record whether correct (+) or incorrect (-) for each stimulus line and the elapsed time on each line between initial exposure of the stimulus and the S's response. Record to the nearest one-tenth second.

BROCK STRING

E: Vergence posture relative to a point in real space. The vergence data derived from Brock string testing is very similar to fixation disparity data.

TD: 10 feet

IL: Standard room (34-79 footcandles)

P: Standing relaxed. Evaluation may be performed in any of the nine cardinal gaze positions relative to the demands of the athlete's sport. To evaluate non-primary gaze positions, the S's head should be tipped forward or backward approximately 45° and/or turned leftward or rightward 50°.

CF: String should be held against bridge of nose with index finger. String must be taut at all times. Record data from S's response within first two seconds of viewing target bead. When testing left and right gaze insure that S's nose does not block view of string.

C: Brock string evaluation is performed primarily for qualitative and demonstrative purposes. As such the performance criterion consists of no presence of suppression in any tested gaze position.

IS: "Hold this string against the bridge of your nose and pull the string so it's tight. Look out directly at the bead [at 10 feet]. Do you see two strings? [YES] Where exactly do the strings cross? Do they cross in front of the bead or behind it?" Repeat sequence for other indicated positions of gaze.

R: For any response indicating vergence is postured <u>at</u> the target bead, record an <u>A</u> (at). Any response indicating vergence posture closer to the S than the bead should be assigned an F (front); any response indicating vergence posture behind the target bead should be assigned a <u>B</u> (behind).

COVER TEST

E: Presence and magnitude of phoric or tropic posture.

TD: 40cm, 6m

IL: Standard room (34-79 footcandles)

P: Standing relaxed

CF: Insure that S is attending to designated target, and that S is instructed to keep the target clear. Target at 6m: 20/40 VA demand letter. Target at 40cm: near-distance test bead (3/16" diam).

C: No tropia, estimated phoria between 8 EXO and 2 SO.

IS: "Look at the target and keep it clear."

R: Record whether phoric or tropic response, direction of phoria or tropia, and estimated magnitude of phoria or tropia.

VI. CENTRAL/PERIPHERAL VISUAL RECOGNITION

TACHISTOSCOPE

E: Quality of central visual information processing ability based upon tachistoscopic presentation of visual info and verbal response.

TD: 3m (10 ft)

IL: Dim room (6-7 footcandles)

P: Standing relaxed

CF: Exposure time for each stimulus is .10 sec. Stimuli consist of 12 sets of digits (4 sets each of 5, 6, and 7 digits arranged randomly). Digits are 20/100 VA demand with inter-digit spacing of approximately 5 mm. The instructional preset timing is critical.
Set of digits in order of presentation:

Slide #	Digits
Demonstration 1	531068
Demonstration 2	8524001
Slide 1	56203
Slide 2	113320
Slide 3	3368522
Slide 4	9863045
Slide 5	642079
Slide 6	57942
Slide 7	857201
Slide 8	98964
Slide 9	3154107
Slide 10	530298
Slide 11	4201567
Slide 12	42057

C: No criterion, normative data analysis

IS: "I'm going to show you some slides of printed numbers. Each slide will be presented very quickly and will have 5, 6, or 7 numbers on it. After I flash the slide, I want you to tell me the correct order of the numbers you saw. You'll receive credit for each number you get correct. I'll take your first answer only. Let me show you a couple of slides to demonstrate. We won't count these first two. I'll say ready, set, and then flash the slide one and a half seconds later. The slide will appear just above the spot on the screen." [Indicate target area and demo the first two slides. Say "Ready," then pause 1 1/2 sec, "set," pause 1 1/2 sec, then expose the slide.] "OK, here we go. Remember, your task is to call the numbers in their correct order." Go through the sequence of test slides with a 5-10 second pause after each slide presentation. Precede the exposure of each slide with the preset, "Ready, set," then expose the slide.

R: Record the number of digits called in correct order for each slide.

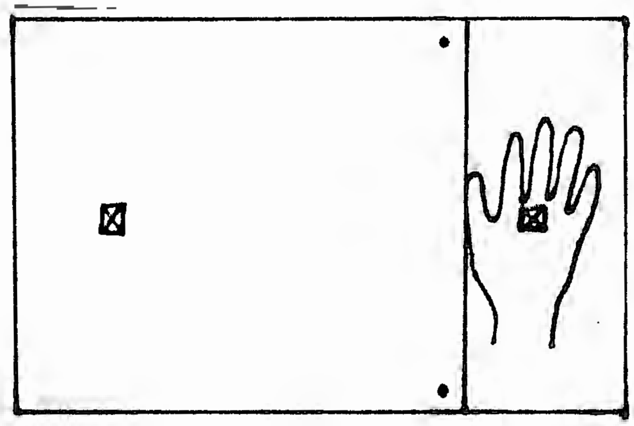
REACTION PLUS (Eye-Hand)

E: Visual motor reaction and response time to central visual stimuli based upon visually-guided eye-hand motor response (via hand button release and press of lit target button)

TD: Top of instrument 34" above floor

IL: Dim room (6-7 footcandles incident on instrument)

P: Standing relaxed with dominant hand depressing reaction button until ready light is lit. Dominant hand must be lined up tangent to boundary line with reaction button line under flat of hand at base of fingers. (See diagram below) Subject's head aligned vertically over target button.



CF: Body, head, hand alignment. Control panel and examiner behind and off to side of subject so panel is not visible to him/her.

C: Not slower than .23 (± .04) sec. Response not slower .396 (± .05) sec.

IS: "Which hand is your dominant hand?" Adjust instrument appropriately. "Place your right (or left depending on dominancy) hand on this button so that your hand lies up against the line without crossing it. The ready light will come on when you have placed your hand on the reaction button. Position yourself with your head directly over the response button. I will say Ready... and within one to five seconds the response button will light up. Move your hand over and depress the button as quickly as possible. The reaction button should lie under the base of your hand as I will demonstrate." Examiner will initiate stimulus between two and four seconds following "Ready" command. Athlete will be given two practice trials. Athlete will not be told his/her times during testing sequence.

R: Record both scores for each of five trials.

REACTION PLUS (Eye-foot)

E: Visual motor reaction and response time to central visual stimuli based upon visually-guided eye-foot motor response (via foot pedal release and press in response to a lit stimulus button).

TD: Reaction Plus standing on edge facing subject 34.5" from center of response button to floor. 8' lateral separation between Reaction Plus and front edge of standard, hard surface library chair. Foot-pedal system lies 14" in front of chair. Seat-top 18" above floor. Anchor chair and foot-pedal system to floor via tape.

IL: Dim room (6-7 footcandles incident on face of instrument).

P: Sitting relaxed with right foot depressing reaction foot-pedal until ready light is lit.

CF: Strict compliance with subject positioning and instructional set. Control panel and examiner behind and off to side of subject so panel is not visible to him/her.

C: Reaction not slower than .255 sec.; response not slower than .412 sec. (criteria derived from normal college-age population, not from 1985 NSF data).

IS: "Place your right foot on the right foot-pedal so that the green lights on the instrument light up. I will say "Ready" ... and within one to five seconds the button on the left side of the instrument will light up. Move your foot over and depress the left pedal as quickly as possible". Examiner will initiate stimulus between two and four seconds following "Ready" command. Athlete will be given two practice trials. Athlete will not be told his/her times during testing sequence.

R: Record both scores for each of five trials.

PATT (Wayne Peripheral Awareness Tester)

E: Visual motor response time (via lever press) to peripheral visual stimuli presented in eight distinct visual field locations.

TD: 20 inches

IL: Dim room (6-7 footcandles)

P: Standing relaxed with eyes level with center light on PAT. Alignment is especially critical with those athletes wearing eyeglasses which might restrict the visual field.

CF: PAT control settings: DISPLAY - TESTING: MODE SWITCH - 8 lights/touch; 60-SECOND TIMER - OFF. Instrument should be mounted against a neutral, light color background. It is critical that S fixate center light on PAT at start of testing and after response to each peripheral stimulus. S's are to be allowed one practice trial through the entire testing sequence prior to formal evaluation. Data will be recorded for two complete testing trials following the practice trial. To begin a test trial, depress the Start/Stop Reset Button until the green light is on. After 2-5 seconds the testing sequence will begin. Emphasize quick release of joystick when giving IS; response timing continues until joystick is released after response movement.

C: Mean for all responses not slower than .36 ($\pm$ .07) sec.

IS: "This instrument evaluates your peripheral vision. I'd like you to always look at the center light [demo]. When you see a light at the end of one of the arms, move the joystick quickly in any direction and release it <u>immediately</u>. One of the lights will turn on every 2-5 seconds. Use your peripheral vision; always look straight ahead at the center light. We'll go through the procedure once to let you get used to it, then we'll run it again twice and record your results."

R: Record, in order (beginning with 12:00 postion), the response times displayed by the PAT after each trial of eight test stimuli have been presented.

VII. EYE/BODY/HAND COORDINATION

WAYNE/EYESPAN

E: Visual motor response time to visual stimuli based upon a precise, visually-guided motor response (finger press of lighted target button). The Wayne Saccadic Fixator, when integrated with the Electronic Balance Board, tests visual motor response time to visual directional stimuli based upon a gross motor postural change in a direction related to the visual stimulus.

TD: Dependent upon athlete (see "P" below). Balance sequence at 8 feet.

IL: Critical at 6-7 footcandles incident upon instrument and equal across face of instrument. Use photometer.

P: Standing relaxed with center of instrument at eye level. Distance from instrument should be such that while standing relaxed with arms extended directly in front of subject the fingertips of both hands touch the face of the instrument.

CF: Check instrument calibration (eg., instrument actually running 62 sec.; not 1 minute as instrument indicates. Note this error, if present). Illumination level and test distance are critical. S's may either move their eyes to the stimuli, or may gaze to any other desired position at personal discretion. All trials in all testing modes are to be run for 30 seconds. The Wayne in mode II and Eyespan in mode B should be set for .75 second exposure of each stimulus.

C: Wayne mode I: 34.5 (± 5.34); Eyespan mode A: 40.6 (± 4.54); Wayne mode II: 25.9 (± 6.24); Eyespan mode B: 36 (± 6.56); Wayne balance mode: 32.2 (± 4.8).

IS: With the Wayne mode I or the Eyespan mode A, the S is to depress the lighted stimulus buttons as rapidly as possible. With the Wayne mode II or the Eyespan mode B, the S's task is the same, but if the stimulus button is not depressed within .75 second, the stimulus light will automatically shift to its next random location. With the Wayne in balance mode, four stimulus lights (3,6,9 and 12 o'clock) are utilized. The S must tip the balance board in the direction of the stimulus light (eg, forward for 12 o'clock, to the right for 3 o'clock) in order to score. As in mode I, the stimulus light will remain lit until the correct motor response is accomplished. For modes I and A: "When you see one of the lights turn on, press it quickly using the tips of your fingers. Another light will come on automatically and, again, turn it off as quickly as you can. Your task is to turn off as many lights as you can in 30 seconds." For modes II and B: "Now we'll do the same thing again, but this time in order to score you must press the lighted button before it goes out automatically." For balance mode: "This time you'll need to tip the balance board to turn off the light. Tip it forward to turn off the top light, tip to the right to turn off the right-hand light, to the left to turn off the lefthand light, and backward to turn off the bottom light."

R: Record the value displayed on the digital readout of each instrument at the conclusion of each testing mode.

VIII. VISION & BALANCE

E: Visual factors involved in maintaining gross motor balance under various conditions.

TD: 40cm for eye movement sequence, otherwise not applicable.

IL: Standard room (34-79 footcandles)

P: Standing on flat edge of standard 2x4 (1 5/8" x 3 5/8" wood block, 10 ft in length). S should place feet heel to toe, parallel to long dimension of balance board. Shoes should be removed and testing performed in barefeet or stocking feet at S's discretion.

CF: Carefully read scaling definitions prior to screening. Memorize criteria to avoid need for reference while screening. Testing beads for eye movements should be 3/16" diameter.

C: At least grade 3 on all phases of screening. Total 18.7 ($\pm$ 3.3)

Scoring Criteria: 1 2 3 4 5 minimal maximal <u>Performance Scale</u>

Scaling definitions:

1. Highly stressed. Tremendous wavering and struggling. Obvious difficulty staying on board. Unable to stay on any longer than 2-3 seconds during task.

2. Stressed, with considerable struggling and wavering present. Falls off board 2 or more times during task.

3. Significant wavering but able to recover. Falls off board no more than 1 time during task. Excessive wavering and struggling (to point where barely recovers) with no falls would be included in the category.
4. Slight noticeable lean with minimal wavering effects. No falls or near-falls. Maintains high level stability during majority of task.

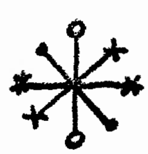
5. No wavering. Never falls off. Maintains high level stability throughout task.

IS: The vision and balance testing consists of five subtests each of which should be carefully scored in accordance with the criteria listed above. "Stand heel to toe and maintain balance while looking straight ahead with arms at your sides (demonstrate). You may use whichever foot you prefer in the forward position."

a. As soon as stability and comfort achieved, score for 10 sec.
b. "Now, close your eyes". Score for 10 sec beginning the moment athlete closes eyes.
c. "Open your eyes. I want you to follow this target (bead) with your eyes only. Do not use head movements." Use the following four eye movement probes:

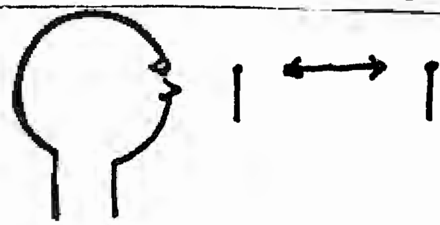
1. NPC
   2 slow NPC's to nose (B&R) over 15 seconds total
   1 slow NPC 6" to S's right (B&R) over 8 seconds
   1 slow NPC 6" to S's left (B&R) over 8 seconds

2. Rapid saccadics between opposite cardinal points at test dx of 40cm, beads separated by approximately 75cm

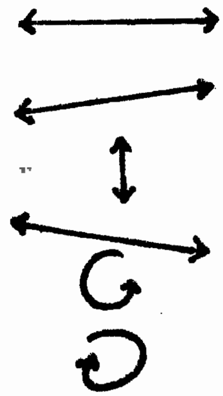


2 x each point

3. Rapid near-far saccadics 3 feet away to 6" away



4. Smooth eye movements, 40cm test target dx



Lateral pursuits — 2 x (2 round trips) (full range)

Oblique pursuits — 2 x

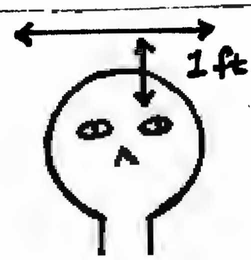
Vertical — 2 x at 2 sec/1 way

Oblique — 2 x

Rotation — 2 x full range at 4 sec/rotation

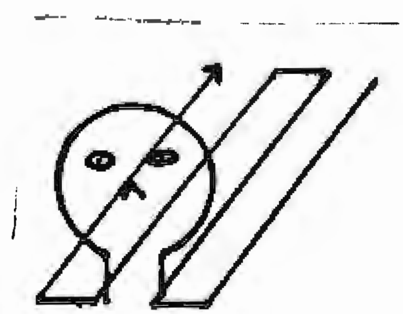
2 x (moderate speed)

Overhead laterals - over 1 ft above eyeline   2 round trips



Obliques with 3" shifts to right:

Obliques with 3" shifts to left



And vice versa to the left

d. Dynamic: Eyes open - "Walk forward to end of board and back heel to toe. Try to keep your eyes pointed straight ahead".
e. Dynamic: Eyes closed - same direction except Dr. will tell S when to stop, reverse and stop.

R: Record the performance scale rating on each subtest by circling the appropriate number.

APPENDIX C- RECORDING FORMS AND QUESTIONNAIRES

PACIFIC SPORTS VISUAL PERFORMANCE PROFILE Name ____________

Habitual Sports Rx: Y N Worn today Y N Age ____ Sport ____________

A B I. VISUAL ACUITY

◊ Static Distance: OD____ OS____OU_____ Near: OD_____OS_____OU_____

◊ Vistech Contrast Sensitivity Chart #_____ OD 1_____2_____3_____4_____5_____

OS 1_____2_____3_____4_____5_____

OU 1_____2_____3_____4_____5_____

◊ Dynamic Visual Acuity 20/20 @ 10 ft _____ _____ _____ RPM Dom Eye: OD OS

A B II. ◊ EYE MOVEMENT SKILLS (Observation) Saccadics ____________

◊ Pursuits (horiz) ____________ (vert) ____________ (diag) ____________

A B III. REFRACTIVE CONDITION OD ____________ OS ____________

Habitual Sports Rx? YES NO OD ____________ OS ____________

If YES, type and condition

A B IV. EYE HEALTH/CONTACT LENSES Comments

◊ Ophthalmoscopy

◊ Visual Fields

◊ Color Vision

◊ Anterior Seg / CL

Follow up: Tonom ___ Biomicros ___ Ret photo ___ Dilat ___ Glare rec ___

A B V. ACCOMMODATION / VERGENCE

◊ Distance Rock 20/80 _______30 sec 20/25 _________30 sec

◊ if B, Vergence Rock _____CPM (8BI /BO) Phoria ____/____

◊ Verg. Range BO ___/___ BI ___/___ BU (OS) ___/___ BD (OS) ___/___ Supp Y N

◊ Fixation Disparity Assoc phoria ____ so xo OD OS OU Stable? Y N Hyper? ________

3BI adpt? Y N Stable? Y N 3BO adpt? Y N Stable? Y N

A B VI. DEPTH PERCEPTION / EYE TEAMING

◊ AO Vecto (1) + - ____ sec (2) + - ____ sec (3) + - ____ sec (4) + - ____ sec

◊ Brock String Supp? Y N Position

◊ Cover Test 6m ____ eso exo ortho ph strab 40cm ______ eso exo ortho ph strab

A B VII. CENTRAL / PERIPHERAL VISUAL RECOGNITION & REACTION / RESPONSE TIME

◊ Tach _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____

◊ PATT _____, _____, _____, _____, _____, _____, _____, _____

_____, _____, _____, _____, _____, _____, _____, _____

◊ Reaction Plus (R Hand) / , / , / , / , / ____ / ____

◊ Reaction Plus (L Hand) / , / , / , / , / ____ / ____

◊ Reaction Plus (R Foot) / , / , / , / , / ____ / ____

◊ Reaction Plus (Diff Motion) / , / , / , / , / ____ / ____

◊ BASSIN

	1 mph	5 mph	10 mph	20 mph	30 mph
Obj	___/___/___	___/___/___	___/___/___	___/___/___	___/___/
Obj (EL)	___/___/___	___/___/___	___/___/___	___/___/___	___/___/
Subj (EOL)	___/___/___	___/___/___	___/___/___	___/___/___	___/___/

A B VIII. EYE/BODY/HAND COORDINATION

◊ Eyespan A _____ Eyespan B (.75 sec.) _____ Letters(30 sec)_____Buttons_____Both____

◊ Wayne w/balance _______

◊ Vision and Balance Static: Eyes Open 1 2 3 4 5 Stat: Eye Movements 1 2 3 4 5

Eyes Closed 1 2 3 4 5 Dynamic: Eyes Open 1 2 3 4 5

Closed w/ image 1 2 3 4 5 Eyes Closed 1 2 3 4 5

A B IX. IMAGERY / VISUALIZATION ABILITY Projective ______ Manipulative____(___/___/___)

- -

Key: A = Screening results adequate for competitive sport performance.

B = Results reveal a possible limitation to peak sport performance; follow-up care is indicated

1987 PSVPP Research Questionairre

Number ____
Name ______________________________Sex____________ Age ________
Address ______________________________ Phone __________________
Date Sept. __

Please fill out the following information. If you have any questions feel free to ask for assistance. Thank you very much for your time and cooperation.

YES NO 1. Have you ever had a complete visual examination by an eye care practioner?
   a. if yes, when was your first examination? ____________________
   b. if yes, When was your most recent examination?________________
   c. What is the name of your eye doctor and where does she/he practice?_____
   ____

YES NO 2. Do you wear glasses?
   a. If yes, how old are they? ________________
   Are they satisfactory at the present? YES NO
   When used? Near distance Far distance Both
   During sports? YES NO

YES NO 3. Do you presently wear contact lenses? If yes, what type? Soft Rigid GasPerm
   a. If yes, do you wear them during sport? YES NO
   b. Do you wear them all day? YES NO
   When did you last have them checked by your vision practitioner?
   ____
   List any problems with your present lenses. ____________________

YES NO 4. Have you ever been involved in a visual training program?
   Remedial or Enhancement
   a. If yes, when and for what reason(s)? __________________________
   b. If yes, do you feel it was successful? ______ Explain ______________
   ____

5. What sports do you participate in at this time?_____________________
   ____
   If you do actively participate in sports, circle the appropriate frequency.

Sport				
a.________________	<1X/week	1X/week	2X/week	3X/week or more
b.________________	<1X/week	1X/week	2X/week	3X/week or more
c.________________	<1X/week	1X/week	2X/week	3X/week or more

YES NO 6. Have you had any organized collegiate sports experience?
   Circle proper classification. ONLY INTRAMURAL
   VARSITY
   JUNIOR VARSITY
   Where? ____
   How long? (dates) ____
   What Sports ____
   Any additional information __________________________________

YES NO 7. Have you had any professional sports experience?
   IF yes, explain. ______________________________________

YES NO 8. Have you had any contact with optometric research before?
   If yes, explain. ____

YES NO 9. Do you ever see blur?
a. If yes , where? Near distance Far Distance How Often ________
b. When? ____________________________________

YES NO 10. Do you ever see double?
a. If yes , where? Near distance Far distance How Often _________
b. When?____

INFORMED CONSENT FORM

1. Institution
   A. Title of Project: Visual Evaluation of the Non-Athlete: Optometric Performance Profiling
   B. Principal Investigators: Bradley Coffey, O.D., Alan W. Reichow, O.D., David Malmanger, Kent Visher 357-6151 ext. 2280
   C. Location: Pacific University College of Optometry, Forest Grove, Oregon
   D. Date: September - December 1987

2. Description of Project
   This project is designed to establish non-athlete performance norms for the Pacific Sports Visual Performance Profile (PSVPP). The PSVPP is a defined battery of tests which evaluate visual performance in the following areas: visual acuity, eye movement ability, accommodation/vergence ability, depth perception/eye teaming, central/peripheral visual recognition, visual reaction and response time, eye/hand/body coordination and vision/balance.

3. Description of Risks
   No risks are associated with routine administration of the PSVPP.

4. Description of Benefits
   Our project will involve testing the non-athlete with the battery of tests that make up the PSVPP to establish a non-athlete data base from which comparisons may be made with previously established norms of performance for the elite athlete.

5. Compensation and Medical Care
   If you are injured in this experiment it is possible that you will nor receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the experiment. All reasonable care will be used to prevent injury however.

6. Offer to Answer Any Inquiries
   The experimenters will be happy to answer any questions that you may have at any time during the course of this study. If you are not satisfied with answers to your questions, please call Dr. James Peterson, 357-0442. During your participation in the project you are not a clinic patient for the purposes of research and all questions should be directed to he researchers and/or the faculty advisor who will be soley responsible for any treatment (except for an emergency).

7. Freedom to Withdraw
   You are free to withdraw your consent and to discontinue participation in this project or activity at any time without prejudice to you.

I have read and understand the above. I am 18 years of age or over (or this form is signed for me by my parent or guardian).

Printed name ______________________________ Age ___________

Signature ______________________________ Date ___________

Address ______________________________ Phone ___________

Name and address of a person not living with you who will always know your address:

____

____

APPENDIX D- INSTRUMENTATION REFERENCES

sources of equipment utilized in PSVPP test battery

Reaction Plus	VisionTronics P.O. Box 782 Forest Grove, Oregon 97116-0782
Eyespan	Monarch America Inc. 1610 6th Avenue West Seattle, Washington 98119 (800) 841-9019
Wayne Saccadic Fixator	Wayne Engineering 4120 Greenwood Skokie, Illinois 60076 (312) 676-2171
Wayne PATT	Wayne Engineering
Vistech Contrast Sensitivity	Vistech Consultants 1372 North Fairfield Road Dayton, Ohio 45432 (800) VIS-TECH
Kirschner Rotator	no longer available - similar device available from: Vision Dynamics % Dr. John Thomas 12556 West 38th Avenue Wheat Ridge, Colorado 80033
Canon Auto Refractor	
a clearinghouse for much of this equipment	Bernell Corporation 422 East Monroe Street South Bend, Indiana 46601 (219) 234-3200

A product of Fosston High School, Fosston, Minnesota, **David Malmanger** will graduate from Pacific University College of Optometry on May 22, 1988. His undergraduate degree, a Bachelor of University Studies degree, from North Dakota State University, Fargo, North Dakota, was awarded May 26, 1984. Future plans include optometric practice in rural Minnesota.

Kent Visher hails from the sleepy little rural town of Wadena, Minnesota. Undergraduate studies lead to a B.S. degree in physiological psychology at North Dakota State University. NDSU is located in the banking and medical hub of the midwestern plains, Fargo, North Dakota. After eight years of college living he will receive his O.D. on May 22, 1988 and enter the real world. Future plans hopefully include working in a practice setting that offers visual therapy and sports vision. Eventually Kent would like to enter private practice.