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Sally Jackula  
Pacific University

Joy Johnson  
Pacific University

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Abstract
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Methods: A sports vision testing battery was designed according to perceived importance to visual task demands in football, as suggested in the literature. The three most important areas for football were identified as visual acuity, depth perception, and reaction time. These were all included in the screening along with current refractive status, visual alignment, eye-hand coordination, accommodative-vergence facility and speed and span of recognition. Freshman and sophomore high school players and junior and senior college football players were included in the study. The football positions considered to have similar visual skills were included in the study, they were receivers, running backs, defensive backs and linebackers. These are the positions requiring optimum visual performance for play.

Results: The data was analyzed using a two-tailed t-test and it was found that there were no statistically significant differences between the two groups of athletes in any of the areas tested in the screening battery, all p-values were 2:0.005.

Conclusions: The results of this study indicated that there are no significant differences between the high school and college athletes. On the visual performance tests that we used to evaluate the athletes, there was no significant improvement in any of the visual skills with age and experience. Freshman and sophomore age football players have developed the skills analyzed in this study to the level that would allow them to compete at an advanced college level. Other factors, such as superior size, strength, stamina, and experience, may be more critical for achievement at higher levels in football.

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Committee Chair
Graham Erickson

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COMPARISON OF VISUAL SKILLS BETWEEN HIGH SCHOOL AND COLLEGE ATHLETES

By

SALLY JACKULA

AND

JOY JOHNSON

A thesis submitted to the faculty of the College of Optometry
Pacific University
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Advisor:
Graham Erickson O.D., F.A.A.O., F.C.O.V.D.
Comparison of Visual Skills Between High School and College Athletes

Authors: Sally Jackula, Optometry Student

Joy Johnson, Optometry Student

Advisor: Graham Erickson, O.D., F.A.A.O., F.C.O.V.D.
BIOGRAPHY

**Sally Jackula** graduated from Saint Cloud State University in 1998 with a B.A. in Biomedical science. She married Clint Tesmer in August of 1999 and they had their first child, Kalina Iris, on October 12, 2001. She will receive her O.D. degree from Pacific University College of Optometry in May of 2002. She and her family will return to Minnesota where she plans on practicing with her dad in Saint Cloud.

**Joy Johnson** received her Bachelor of Visual Science from Pacific University in 2000. She received her Doctorate of Optometry in 2002 from Pacific University.
ABSTRACT

Background: In the field of sports vision research there is a need for more information about the relationship between performance and visual abilities. A visual performance testing battery was designed to compare the skills positions in ninth and tenth grade high school athletes to junior and senior Division I college athletes.

Methods: A sports vision testing battery was designed according to perceived importance to visual task demands in football, as suggested in the literature. The three most important areas for football were identified as visual acuity, depth perception, and reaction time. These were all included in the screening along with current refractive status, visual alignment, eye-hand coordination, accommodative-vergence facility and speed and span of recognition. Freshman and sophomore high school players and junior and senior college football players were included in the study. The football positions considered to have similar visual skills were included in the study, they were receivers, running backs, defensive backs and linebackers. These are the positions requiring optimum visual performance for play.

Results: The data was analyzed using a two-tailed t-test and it was found that there were no statistically significant differences between the two groups of athletes in any of the areas tested in the screening battery, all p-values were ≥0.005.

Conclusions: The results of this study indicated that there are no significant differences between the high school and college athletes. On the visual performance tests that we used to evaluate the athletes, there was no significant improvement in any of the visual skills with age and experience. Freshman and sophomore age football players have developed the skills analyzed in this study to the level that would allow them to compete at an advanced college level. Other factors, such as superior size, strength, stamina, and experience, may be more critical for achievement at higher levels in football.
ACKNOWLEDGEMENTS

The authors would like to thank Dr. Graham Erickson for all of his help and guidance throughout this project.
The authors would also like to thank Dr. Karl Citek for his expertise in statistical analysis.
INTRODUCTION

In the field of sports vision research there is a need for more information about the relationship between performance and visual abilities. We were unable to find any documented visual performance evaluation data specific to football players. It has been demonstrated in the literature that some performance-related visual abilities can be linked to higher functional levels but this has not been proven true for sports performance as of yet.

It has been proven in the literature that the visual skills of athletes are better than those of nonathletes and that better athletes have better visual skills than poorer athletes. The following skills have been proven to be superior in athletes in general as compared to nonathletes, larger extents of visual fields, field of reaction, and field of motion perception, lower amounts of heterophoria at far and near, more consistent simultaneous vision, more accurate depth perception, better dynamic visual acuity, closer near point of convergence, and better motilities, including pursuits and saccades. No visual skills, including those listed above, have been proven to be superior when comparing high level to lower level football players, which is what our study was designed to do.

One method to determine valuable visual performance characteristics for a given sport or position is to compare the visual abilities of inexperienced and experienced athletes. A sport like football has athletes performing in a variety of positions. There appear to be different visual task demands for different positions. There are, however, some visual skills that are necessary for all positions. Visual acuity, peripheral vision, eye motility and visualization have been proposed as necessary for all football positions. Another method that has been used to determine meaningful visual skills for athletes is to test a wide range of skills and determine meaningful skills based on the data collected. This method was used to assess volleyball players in a study published on high school athletes, but hasn’t been used to assess football players in any published studies.

Due to the lack of current research specific to visual skills in football, we chose a general approach to gather data specific to the sport. We wanted to focus on research that would be beneficial to both sports optometry and athletics. By doing so, we could provide football coaches with information that could theoretically enhance their players’ abilities at higher levels of organized football by enhancing those visual skills important to peak performance. It would benefit sports optometry by creating a focus for enhancement training specific to football. With these two goals in mind it was anticipated that there would be a statistically significant difference between high school and college athletes in any or all of the areas included in our testing battery.
METHODS

A sports vision testing battery was constructed according to importance, as suggested in the literature. The three most important areas at high levels of organized football are visual acuity, depth perception, and reaction time. These were all included in the screening along with current refractive status, visual alignment, eye-hand coordination, accommodative-vergence facility and speed and span of recognition.

Freshman and sophomore high school players and junior and senior college football players were included in the study. The football positions that have similar visual skills were included in the study, they were receivers, running backs, defensive backs and linebackers. These are the positions requiring optimum visual performance for play. Those that were excluded were quarterbacks, defensive and offensive lineman, kickers, and punters. There were fourteen players assessed from high school and thirteen from an NCAA Division I college. The player or his parent/guardian, prior to inclusion in the screening signed an informed consent. Each players' performance was recorded on the ‘Football Skills Evaluation Form’. See Figure 1.

Case History
Procedure: An athlete specific case history was performed on each player prior to the screening. See Figure 2.

Static Visual Acuity at Distance
This refers to the clarity of eyesight as tested with a standard Bailey-Lovie test chart.
Instrumentation: A Bailey-Lovie chart and an occluder.
Procedure: Visual acuities were measured through habitual vision correction worn during competition for right eye, left eye and both eyes together at 8 feet using standard clinical procedure.
Illumination: Standard room illumination

Duane Cover Test at Distance and Near
The Duane cover test is a procedure to objectively measure the presence of a heterophoria or heterotropia in a quick and efficient manner.
Instrumentation: A Bailey-Lovie chart, occluder, and prism bars
Procedure: A unilateral cover test was performed at 8 feet and 16 inches using an acuity line letter size larger than the threshold acuity for each athlete. This was followed by an alternating cover test using the line larger than threshold at distance and near. An alternating cover test was then performed in up-right gaze, up-gaze, up-left gaze, left gaze and right gaze. Each of these results were measured and recorded in prism diopters using a prism bar.
Illumination: Standard room illumination

Autorefraction
The autorefractor measures the amount and type of the athletes' refractive condition, weather it myopia, hyperopia, or astigmatism. All measurements were taken using a
handheld autorefractor. For athletes currently wearing eyeglasses or contact lenses, the adequacy of the current prescription is evaluated.

**Instrumentation:** A Nikon Retinomax handheld autorefractor was used.  
**Procedure:** The refractive status of the right eye and left eye of each athlete was assessed using the standard instructions for the autorefractor.

**Illumination:** Standard room illumination

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**Eye-Hand Reaction/Response Speed**

Measures of visual reaction and response times consisted of an accurate hand movement in response to a visual stimulus in the center of the visual field. The reaction time is the time it takes to mentally determine the presence of visual information and to make a motor response. Response time is the total time required to process the information and complete the motor response.

**Instrumentation:** A Reaction Plus timer was used.  
**Procedure:** Each athlete was given five trials on the Reaction Plus timer while they were seated comfortably and using their dominant hand to respond with. An average of these five trials was recorded in milliseconds.

**Illumination:** Standard room illumination

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**Eye-Hand Coordination**

A measure of speed and accuracy of visually guided hand movements in all areas of the visual field. The score reflects overall efficiency of visual motor reaction time or eye-hand coordination.

**Instrumentation:** Wayne Saccadic Fixator

**Procedure:** Each athlete was given one trial using program number three on the Wayne Saccadic Fixator. Lights flash in a random sequence at a self-paced and steady rate for a total of sixty seconds. If a light isn't depressed in a certain amount of time, the machine moves on to the next light and they don't get a score for that light. Their score was then recorded as the total number of lights depressed in the sixty second time frame.

**Illumination:** Standard room illumination

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**Accommodative/Vergence Facility**

Tests the athletes' ability to quickly and efficiently change accommodation and vergence from a distance chart to a near chart at two separate acuity levels, first at 20/80 and then at 20/25.

**Instrumentation:** The Haynes Distance Rock Test was used.

**Procedure:** The standard Haynes Distance Rock testing protocol was followed. The athlete held the near chart at 40 centimeters, and the distance chart was placed at 6 meters. The athlete called out the letters on the 20/80 lines alternating between the near and distant charts for thirty seconds, then repeated the procedure with the 20/25 line for thirty seconds. The number of cycles completed was recorded, with one cycle being accurate calling of a near and far letter.

**Illumination:** Standard room illumination
Threshold and Speed of Stereopsis at Distance
A measure of the ability to quickly and accurately judge depth perception in the distance. These measurements were taken in primary field of gaze.
Instrumentation: A Mentor Binocular Visual Acuity Tester (BVAT) and liquid crystal goggles were used.
Procedure: The BVAT stereopsis program number six was used with it set at 20 feet to find each athlete's threshold of stereopsis. This number was recorded in seconds of arc. Each player's speed of stereopsis was then tested for sixty seconds using one stereopsis level larger than his threshold. The number of correct responses in sixty seconds was recorded.
Illumination: Standard room illumination

Tachistoscope
A measure of quickness and accuracy of processing of visual information presented in the center of the visual field.
Instrumentation: A portable tachistoscope was used
Procedure: Each athlete was given two demonstration slides before the testing began. They were then presented ten slides with five to six digits on each slide. The timer was set at 1/100 of a second for the entire slide presentation. The number of slides correctly identified was recorded.
Illumination: Dim room illumination
RESULTS
The data was analyzed using a two-tailed t-test and it was found that there were no statistically significant differences between the two groups of athletes in any of the areas tested in the screening battery, all p-values were >0.050. See Table 3. The p-values are as follows: static visual acuity at distance, p=0.076; cover test at distance, p=0.938; cover test at near, p=0.217; cover test in diagnostic action fields, p=0.774; autorefraction, p=0.055; eye-hand reaction speed, p=0.079; eye-hand response speed, p=0.268; eye-hand coordination, p=0.413; Haynes Distance Rock large letters, p=0.442; Haynes Distance Rock small letters, p=0.294; threshold of stereopsis at distance, p=0.113; speed of stereopsis at distance, p=0.093; and tachistoscope, p=1.000.

Sixteen NCAA Division I football players were included in the measurement of visual acuity. As a group the poorest visual acuity (VA) measured (in the better eye) was 20/20 and the best was 20/10. The average for this group was 10/14.1. In comparison the fourteen high school players screened had a range of 20/34 to 20/12.5 with an average of 20/18.1. Statistical analysis revealed a non-significant relationship at a level of p=0.076.

There were also sixteen NCAA players included in the cover test measurements (at distance and near. In the distance (CT Dx) their heterophorias ranged from 2Δ exophoria to 2Δ prism diopters esophoria, and their average was 0.56Δ of exophoria. The fourteen high school players tested had heterophorias ranging from 5Δ exo to 1Δ esophoria. The p-values showed a non-significant relationship with p equaling 0.938. At near (CT Nr) the range for the college athletes was 8Δ exophoria to orthophoria and an average of 2.75Δ exophoria. The range for the high school athletes was 16Δ exophoria to 2Δ esophoria with their average being 4.92Δ exophoria. This was also an insignificant relationship with a p-value of 0.217.

There were sixteen and twelve participants in the diagnostic action field (CT DAF) testing in the college and high school groups respectively. The college players had phorias that ranged from 2Δ exophoria to 1Δ esophoria and their average was 0.63Δ exophoria. The high school players’ range was the same but there was an average of 0.5Δ exophoria. This yielded a non-significant p-value of 0.774.

The results from autorefraction (OD AR) of the sixteen college players’ right eyes’ ranged from 0.75 diopters (D) of hyperopia to 0.50D of myopia with a mean of 0.02D of hyperopia. This was compared with eleven of the high school players’ right eyes’ autorefractions which ranged from 0.25D of hyperopia to 2.25D of myopia with their average being 0.48D of myopia. This gave us a non-significant value of p=0.055.

Fifteen of the sixteen college football players’ scores were included in the eye-hand reaction response screening. Their reaction times (Hand Rxn) ranged from 206 milliseconds (ms) to 280 ms with an average of 235 ms. Their response times (Hand Rsp) ranged from 330 ms to 452 ms with an average of 394 ms. The fourteen high school players by comparison had a reaction time range from 228 ms to 306 ms and a response time ranging from 358 ms to 460 ms. Their averages were 258 ms and 411 ms
respectively. Both the reaction and response times statistical analysis p-values were non-significant at $p=0.079$ and $p=0.268$ respectively.

There were sixteen college players' scores and fourteen high school players' scores included in the eye-hand coordination section of the screening (WSF). The college players' scores ranged from 49 to 103 with an average of 74.6, these were compared with the high school players' range of 61 to 93 with their average being 78.5. These scores resulted in a non-significant p-value of 0.413.

Accommodative and vergence facility was analyzed next with fifteen college players and fourteen high school players included in the final results. The college players' range with the 20/80 demand letters was 7 cycles per minute (cpm) to 2 cpm with an average of 15.3 cpm. The high school players' range was 3 cpm to 19 cpm and their average was 13.9 cpm. The college players' range with the 20/25 letters was 5 cpm to 13 cpm with an average of 10.1 cpm, by contrast, the high school players' range was 0 cpm to 14 cpm and their average was 8.5 cpm. Neither the 20/80 demand cycle nor the 20/25 demand cycle yielded a significant results with their p-values being 0.442 and 0.294 respectively.

Threshold and speed of stereopsis was then tested using the BVAT. The fifteen college players' threshold of stereopsis (BVAT Thresh) ranged from 240 arcseconds to 30 arcseconds with an average of 126 arcseconds. The fourteen high school player's scores also ranged from 30 to 240 arcseconds with their average being 68.5 arcseconds. The relationship between these two groups was not significant with a p-value of 0.113. The fifteen college players speed of stereopsis (BVAT Speed) results ranged from 0 correct responses to 25 correct responses with an average of 12.9 responses correct. The ten high school players' results ranged from 8 to 33 correct responses with their average being 18.9 responses correct. The p-value for this relationship was not significant at $p=0.093$.

The last area evaluated was speed and span of recognition using the tachistoscope (Tach) with fourteen players' scores from both the college and high school groups being included. The college players range was 0 to 12 correct responses. Their average was 4.9 correct responses. The college players' range was 0 to 10 correct responses, and their average was also 4.9 responses correct. This relationship was also insignificant with a p-value of 1.000.
DISCUSSION

The results of this study indicated that there are no significant differences between the high school and college athletes. On the visual performance tests that we used to evaluate the athletes, there was no significant improvement in any of the visual skills with age and experience. Freshman and sophomore age football players have developed the visual skills analyzed in this study to the level that would allow them to compete at an advanced college level. Other factors, such as strength, superior size, stamina and experience, may be more critical for achievement at higher levels of football.

There are a number of variables that must be considered that they may have influenced the validity of our screening results. They are, the test population, methodology, and the test administrators. These could provide useful pointers that can be integrated for future research in this area.

The first variable to consider is that of the number of athletes involved in the study. The population number wasn't large enough to be significant, due to the difficulty in obtaining coach and athlete participation at both levels tested. A minimum number of thirty athletes in each group was desired because it may have reduced erratic results and given a better sample of our chosen population. The data gathered is still useful for the participating coaches in evaluating their own team as well as being useful for a starting point for future research in this area. In order to gain a larger population size for future study the investigators may want to pursue college and high school sports teams that have a vision care provider on staff or already participate in sports vision screenings. These teams may be more willing to participate in these research screenings.

The athletes' personal history must also be considered, this includes previous football experience, as well as positions played, off-season visual demands, and any past visual training. Some of these factors may even be considered for exclusion from future studies.

The off-season demands include other sports the athlete is or has been involved with. For example, if an athlete is a pro volleyball player in the off-season they may have better eye-hand coordination due to the quick movements necessary for that sport. Another example would be of an off-season soccer goalie. This position would give the football player an advantage when it comes to eye-hand coordination and eye-hand reaction/response time due to the quick eye/body movements required of this soccer position.

Any enhancement therapy or visual training undergone by the athlete in the past may have enhanced their results in that area they had training in and that could skew our results in one direction, no longer giving us an average of our selected population.

Another variable that needs to be considered is that there were different test administrators for each of the two screenings conducted, which may have introduced some inter-examiner variability into the results. In order to keep control of this we trained the administrators prior to each screening. In order to control it even better for
future studies a specific protocol for each administrator to follow could be developed that includes a written instructional set for each screening station. In addition to this, the same administrators should be used for each screenings if at all possible.

The last variable to consider is the testing environment. The screenings were conducted on site and specific sizes and types of rooms were sought out to control the environment as much as possible. The lighting, noise level, and glare factors weren't the same at each testing site for every screening station. For future studies the best way to control these factors would be to bring the athletes to one central testing center where all these variables can be manipulated and kept constant.
### Football Skills Evaluation Form

**Name:**

**Position:**

**Age:**

**Correction worn during play:**

**Visual Acuity (Distance)**

- **Habitual (when playing):**
  - OD 20/20
  - OS 20/20
  - OU 20/20

**Autorefractor**

- **OD:**
- **OS:**

**Visual Alignment**

- **Cover Test**
  - **Dx**
  - **Nr**
  - **UCT**
  - **ACT**

**Diagnostic Action Fields**

**Eye-Hand Reaction/Response Speed:**

- **Reaction:**
  - Mean: ______ msec
- **Response:**
  - Mean: ______ msec

**Eye-Hand Coordination:** (Wayne Saccadic Fixator #3)

- Total # in 30 seconds: ______________

**Accommodative/Vergence Facility:**

- **Haynes Distance Rock:**
  - 20/80 ______ cycles/30 sec
  - 20/50 ______ cycles/30 sec

**Stereopsis:** (B-VAT #6)

- **Threshold:** ______ seconds of arc
- **Speed:** ______/_______ total # correctly identified/total # shown in 60 seconds
  
  (athlete must have obtained at least 30 seconds or arc on threshold)
## Tachistoscope

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<th>Slide</th>
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<td></td>
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Figure 2

Case History

1. Do you have any concerns about your vision?

2. Do you have any momentary blur?

3. Do you have any inconsistent performance during play?

4. Do you experience a decrease in performance when stressed?

5. Do you experience a decrease in awareness of your peripheral vision?

6. Do you experience and visual headaches? If yes, when? Where are they located? How often?

7. Do you currently wear a correction? If yes, while you are playing?

If the athlete is a contact lens wearer:

8. What type of contact lenses do you wear?

9. Do you wear them while playing?

10. Describe how you wear your lenses and how you care for them including how and when you clean them.
### Table 1
Division I College Players Results

<table>
<thead>
<tr>
<th>Player</th>
<th>VA1</th>
<th>CT Dx2</th>
<th>CT Near2</th>
<th>CT DAF2</th>
<th>OD AR3</th>
<th>Hand Rxn4</th>
<th>Hand Rsp4</th>
<th>WSF5</th>
<th>HDR 20/806</th>
<th>HDR 20/256</th>
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1 Recorded in Snellen denominator
2 Esophoric values are positive; exophoric values are negative; 0 is orthophoric
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9 Number of slides correct
10 Standard deviation
Table 2
High School Players Results

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### Table 3
#### Statistical Analysis

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