# THE RELATIONSHIP BETWEEN VISUAL SKILLS AND BASEBALL ABILITY IN ADOLESCENT ATHLETES A PILOT STUDY

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## Abstract

*Out-of-office sports vision screenings require instruments, that are easy to transport and set up, and elicit pertinent information. The primary purpose of this pilot study was to determine if certain instruments, some of which have not reportedly been used in sports vision, are appropriate for an adolescent age group. Secondarily, we sought go determine the feasibility of the research design used in the present study.*

*A sports vision screening was administered to eight male adolescent baseball players before their baseball season. It utilized the Keystone Telebinocular, Wayne Saccadic Fixator with Balance Board, Acuvision and Visagraph II. The subjects' baseball statistics after the conclusion of their baseball season were compared to the vision screening data. Correlations and percentages of variance were calculated between the instruments and aspects of baseball performance; however, because of the small number of subjects, statistical significance could not be obtained. The resulting trends are reported.*

*We concluded that the instrumentation and research design employed in this pilot study could be used in future investigations with a sufficient number of subjects to determine the statistical significance of the resulting data.*



## Key Words

*Acuvision, adolescents, baseball performance, Keystone Telebinocular, rapid automized naming (RAN), speed of stereopsis, sports vision, Visagraph II, Wayne Saccadic Fixator with Balance Board*


## Literature Review of Adolescent Athletes And Vision

Ridini compared junior high school male athletes and non-athletes and found that the former had significantly better depth perception, reaction time and peripheral vision, significant at the .01 level.[1] Loran and Griffiths found a significant correlation (p=.01) between the coaches' ranking of their under 14-year-old soccer players and overall visual skills.[2] Vogel and Hale found that their subjects between the ages of 8 and 13, who had participated in organized athletics, scored significantly better (p=.0001) on an eye-hand coordination program of the Wayne Saccadic Fixator than children who did not participate in sports.[3] Raviv and Nabel found that their sample of adolescent athletes was significantly better than their sample of adolescent non-athletes at a figure ground task.[4] Falkowitz and Mendel reported their 11 to 13 year old Little Leaguers, who had better tracking and convergence skills than a comparable sample, were more likely to have higher batting averages; however, a statistical analysis was not reported.[5] Trachtman examined ocular motility in 36 Little League boys, ages 10 to 12 years old.[6] He found a coefficient of correlation of +0.40 between two pursuit directions (up/down and side to side) and batting averages at greater than 0.05 level of significance.

The purposes of the present study were to determine the suitability of certain optometric office testing equipment in an out-of-office sports vision screening, and the relationship between the vision tests and the adolescent athletes' baseball performance.

## METHODS

### Subjects

Eight male baseball players between the ages of 12 years 8 months and 13 years 4 months (mean age = 13 years, 1 month) participated in a sports vision screening on January 15, 2005 at the DiamondZone Baseball Academy in Kingston, NY. The subjects played for a team affiliated with the DiamondZone Baseball Academy. The team had a total of 16 players who participated in 20 games from July 19, 2005 through October 2, 2005. The other eight players were not on the premises on the day of the vision screening. Parental consent forms were completed prior to the screening.

### Instruments

The following instruments were utilized in the sports vision screening:

**The Keystone Telebinocular**[a] is a stereoscopic instrument in which targets are presented to each eye, and the patient describes what he sees. Four of the Keystone Visual Skills cards were used. See Procedures.

**The Acuvision 1000** (Figure 1) was produced and distributed by International AcuVision Systems, Inc. in Carlsbad California during the 1990s. It is no longer manufactured , but many units are still in use. It is an electronic pressure-sensitive board, measuring 32" x 48," that evaluates eye hand coordination. Up to 120 lights can be randomly illuminated, one at a time. The subject presses the light before it turns off and the next light turns on. The speed can be varied from a setting of zero (the light stays on indefinitely until it is pressed) to a setting of 13 (the light is on for 0.36 seconds). At the completion

of the Acuvision test, the board displays the number of lights pressed while still on ("on time responses"), and the total time required to complete the test. We used a full field of 120 lights with a setting of 4; the author's previous clinical experience indicated that speed 3 produced highly similar scores with adolescent patients.

**The Wayne Saccadic Fixator**[b] with its balance board evaluates eye body coordination. The subject stood on the balance board, the bottom of which has four pressure sensitive switches, one located in the middle of each side. The subject was instructed to lean his body in a specific direction according to the location of the illuminated light bulb on the Fixator. See Procedures. Results were automatically recorded. The 30 second program (#27) was used in this screening. See Figure 2.

**The Visagraph II**[c] connects a computer to goggles that transmit infrared light and detects the reflection at the limbus. The computer analyzes the data and displays the measurements of various oculomotor skills. See Procedures. We used the Visagraph Numbers Test that required the silent reading of 62 single digit numbers that were horizontally arranged in nine rows.

## Procedures

**Keystone Ophthalmic Telebinocular**

1. Keystone Visual Skills Test #2 (Card DB 8C Vertical Fusion Far Point) – The left eye was presented with a horizontal yellow line and the right eye with a column of numbers; zero corresponded to the ortho posture and numbers 1, 2 and 3 extending above and below the zero indicated various degrees of vertical misalignment. The athlete reported the number that was bisected by the yellow line and this number was recorded on the data sheet.
2. Keystone Visual Skills Test #5 (Card DB 3O Usable Vision Right Eye Far Point) – Both eyes were presented with a series of 10 squares that are numbered. The squares are of decreasing size and each has five white diamonds that are placed top, bottom, left, right and middle. One diamond in each square had a black dot, which was viewed only by the right eye. The athlete identified the location of the dot in each square, and the last correct response was recorded.
3. Keystone Visual Skills Test #6 (Card DB 2D Usable Vision Left Eye Far Point) – This card is similar to the previous test; but the dots were viewed by only the left eye.
4. Keystone Visual Skills Test #7 (Card DB 6D Stereopsis Far Point) – There were 12 rows of pictures, 5 pictures in each row. There was a disparity in one picture of each row and the disparity decreased from row 1 to row 12. One eye was occluded while the examiner explained, "The top row has a star, a square, a cross, a heart and a circle. In a few seconds one of those pictures will pop out closer to you than the rest. I want you to name the pictures that are closer to you from the top row to the bottom row as quickly as you can. Ready, set, go." The occlusion was removed and a Radio Shack LCD Quartz stopwatch was started. The timing was stopped as soon as the athlete verbalized the 3-D picture in row 12. The score was zero if all pictures were not correctly identified. For those subjects who correctly identified all of the pictures, the reciprocal of the time was calculated, so that faster times received higher values and slower times received lower values.

*Figure 1. Subject performing the Acuvision 1000*

**Visagraph II**

The Visagraph numbers test[7] was photocopied and placed on a slant board at 16 inches from the athlete. The goggles were placed on the athlete's head and the pupillary distance was properly adjusted. The instructions were: "I want you to look at each number and read it to yourself as quickly as you can, as if you were reading a book. Tell me when you are finished. Look at the circle at the top of the page until I say to start." Measurements included:

*Figure 2. Subject on the Wayne Saccadic Fixator with balance board.*

1. Fixations – the number of times that the athlete fixated the numbers.
2. Regressions – the number of times that the athletes' eyes moved from right to left by an amount smaller than the length of the row of numbers.
3. Cross Correlation – a correlation of the equivalence of the horizontal movements of the two eyes. This is a measure of binocularity according to the Taylor Associates User's Guide for the Visagraph II.[7]
4. Visagraph Speed – the numbers per minute that were read.

**Acuvision 1000**

The height of the Acuvision was adjusted so that the center light was approximately at eye level. The instructions were, "One light at a time will appear on the board. You must press the light using one or two fingers of either hand as quickly as you can. We will start with a practice that does not count." The practice run lasted 10 seconds. The following scores were recorded:

1. Acuvison score – the number of "on time" responses of the 120 lights
2. Acuvision time – the time required to complete the test. The Acuvision score was divided by the Acuvision time. This allowed us to differentiate those athletes with high scores and fast times from those with high scores and slower times.

**Wayne Saccadic Fixator with Balance Board**

The instructions were, "Get your balance on the balance board. When the top button lights up, you will turn it off by leaning forward. When the bottom button lights up, you will turn it off by leaning back. You will lean left for the left light and you will lean right for the right light. We will start with a practice that does not count." The practice run lasted 10 seconds. Only correct movements were automatically recorded. The score was noted after the 30-second program #27 was completed.

These instruments were chosen for ease of transport and assembly, and their appropriateness in testing visual skills that have been determined to be important to sports performance. The American Optometric Association Sports Vision Guidebook lists the following visual skills important for baseball:[8] Visual acuity (static and dynamic), peripheral vision, depth perception, eye motility, eye/hand/body/foot coordination, visualization, speed of recognition time, speed of focusing, glare recovery speed, ability to see in dim illumination, ability to withstand eye fatigue without decreased performance, color perception, eye dominance, fixation ability, visual memory, central/peripheral awareness and spatial localization. Time and equipment constraints limited the screening in this study to static visual acuity (Keystone Tests #5 and #6), binocularity & depth perception (Keystone Tests #2 and #7), eye motility (Visagraph), eye/hand coordination (Acuvision) and eye/body coordination (Wayne Balance Board).

## Baseball Data

The team's statistician provided data for the subjects' baseball performance during the subsequent season. The team statistician was unaware until after the baseball season that his data would be used in a research project.

The following hitting and pitching statistics were utilized in order to account for the different number of innings or at bats each subject played.

1. RBI / AB – runs batted in divided by the number of times at bat.
2. ERR / IP – the number of errors divided by the number of innings played.
3. SO / AB – the number of strike outs divided by the number of at bats.
4. Batting average – the number of hits divided by the number of at bats after subtracting the number of times the hitter was struck by a pitch, the number of sacrifice flies, and the number of times he walked to first base.
5. SO / IP – the number of strike outs divided by the number of innings pitched.
6. WALK / IP – the number of walks divided by the number of innings pitched.
7. ERA – earned run average = (earned runs / innings pitched) X number of innings in the game.

**Table 1. Batting Statistics**

| PLAYER | AT BAT | RBI | ERRORS | INN. PLAYED | STRIKE OUT | BATTING AV. |
|---|---|---|---|---|---|---|
| C | 46 | 3 | 2 | 92 | 13 | 0.111 |
| F | 47 | 6 | 3 | 93 | 2 | 0.235 |
| GRE | 59 | 7 | 2 | 95 | 5 | 0.186 |
| GRI | 78 | 14 | 10 | 108 | 15 | 0.322 |
| J | 72 | 7 | 11 | 126 | 7 | 0.204 |
| P | 33 | 7 | 3 | 61 | 1 | 0.322 |
| T | 56 | 1 | 7 | 81 | 8 | 0.163 |
| W | 80 | 11 | 14 | 126 | 17 | 0.277 |

**Table 2. Pitching Statistics**

| PLAYER | STRIKE OUTS | WALKS | INNINGS PITCHED | ERA |
|---|---|---|---|---|
| C | 7 | 13 | 17.66 | 4.36 |
| F | 15 | 9 | 23.3 | 2.7 |
| GRE | 2 | 4 | 5.66 | 4.94 |
| GRI | 12 | 22 | 16 | 4.81 |
| J | 12 | 23 | 24 | 7.29 |
| P | 24 | 24 | 25 | 6.72 |
| W | 10 | 31 | 19 | 12.53 |

**Table 3. Baseball statistics performance where variance was at least 40%**

| Baseball Statistic | Test | % Variance |
|---|---|---|
| RBI / AB | Visagraph Regressions | 47.6 |
| SO / AB | Usable vision right eye | 47.9 |
| SO / AB | Reciprocal of stereopsis speed | 78.7 |
| SO / AB | Visagraph cross correlation | 69.1 |
| SO / AB | Visagraph speed | 65.9 |
| SO / AB | Acuvision score | 42.6 |
| SO / AB | Acuvision score / time | 49.0 |

## RESULTS

The raw baseball performance data are found in Tables 1 and 2.

We analyzed the data by determining the correlations, squaring that number, and then multiplying it by 100 to obtain the percent of the variance. This statistic is a measure of the degree to which variations in the dependent variable (aspects of baseball performance) can be accounted for by the independent variable (the various instruments used).[9] The small number of subjects did not allow for a determination of statistical significance. However, if we arbitrarily set percent of variance equal to or greater than 40%, the following trends are noteworthy:

a. RBI/AB and Visagraph regressions
b. SO/AB and Keystone Skills usable vision (right eye), reciprocal of depth perception speed, visagraph cross correlation, visagraph speed, acuvision score and acuvision score / time.

See Table 3. A full listing showing correlations and variances for each test and each area of baseball performance is contained in the Appendix.

## DISCUSSION

Our results in this pilot study indicate that the following visual factors were noteworthy in predicting the number of strike outs/at bats (SO/AB): speed of stereopsis (reciprocal of Keystone Visual Skills Test 7); level of binocular coordination (Visagraph Cross Correlation), accurate and fast eye hand coordination (Acuvision Score and Acuvision Score/Time). The speed of saccades (Visagraph Speed) is also included in the category. Visagraph Regressions accounted for almost 48% variance in the runs batted in/at bats category. These factors are included or implied in the visual factors recommended by the American Optometric Association as being important in baseball.[8] The usable vision right eye (Keystone Visual Skills Test #5) accounted for almost 48% of the variance in strike outs/at bats; however, it is difficult to account for this relationship. Further investigation is needed to test this relationship.

The speed of stereopsis accounted for the highest degree of variance in the SO/AB category. As it was measured in the present study, both the level of binocularity and rapid automized naming (RAN) are involved. RAN is the speed with which an individual serially and accurately names a sequence of letters, numbers, objects or colors. Slow RAN may be due to inefficient vision or language, a faulty connection between vision and language or a general timing deficit.[10] In order to test the speed of stereopsis as was done in the present study, it might be advisable to first test RAN to either implicate or eliminate it as a factor in the speed of stereopsis. Otherwise, an athlete with excellent stereopsis, but with a general timing deficit would not score well on a test of speed of stereopsis; he probably would not be a good baseball hitter either. An athlete with slow RAN solely due to a language deficit could score poorly on a test of stereopsis speed despite excellent stereopsis.

Coffey and Reichow determined that speed of stereopsis was significantly better ($p<.05$) in athletes under consideration by the U.S. Olympic Committee for Dynamic Sports, compared to age-matched non-athletes. [11] They used the Pacific Sports Visual Performance Profile protocol which called for the use of the AO Vectographic Projector Slide at 20 feet.[12] However the ease of transport and space requirement of the Telebinocular as opposed to the AO device makes the former the instrument of choice to measure speed of stereopsis in a non-office based sports vision screening. As in the present study, it can also be used for other screening tests, and it is self-illuminated so that the environmental lighting is not a factor in the result.

When performing a vision screening outside of the office several factors must be considered. The examiner must decide which visual skills are most important to the sport and which visual skills are most easily tested outside of the office. The equipment, that is transported to the screening site, should produce meaningful results and be easily moved and set up. The testing should not require an inordinate amount of time to complete so as to allow a large number of subjects to participate within the time frame. The examiner should be aware that extraneous noise or distractions or lighting levels may influence the results. [13]

Our screening protocol allowed approximately six athletes to be screened each hour by one examiner. One athlete looked in the Telebinocular and then he used the Visagraph while another athlete used the Acuvision and then the Wayne Balance Board. Then they switched places. The equipment that was used in this screening was relatively easy to move from the office and to set up at the site.

## CONCLUSION

The Keystone Telebinocular, the Acuvision 1000, the Wayne Saccadic Fixator with the balance board and the Visagraph II were easily transported from the office to the screening site and they were well tolerated by the athletes who found the screening to be enjoyable. There were indications that all instruments except the Wayne Saccadic Fixator / Balance Board may be influential in baseball batting. Due to the small number of subjects in the study we can not rule out the usefulness of the Wayne Saccadic Fixator with Balance Board for eye body coordination. Keystone Visual Skills Card #DB-6D (stereopsis) appeared to be an excellent substitute for the AO Vectographic Slide to measure speed of stereopsis. The examiner must use caution when finding an athlete with a poor score of stereopsis speed because it could be due to slow RAN from a language deficit. More research is needed with a larger number of subjects to determine if the relationships between baseball skills in the pediatric and adolescent population and their visual skills are truly significant.


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## Appendix
## Statistical analysis of visual and baseball skills

| | | RBI/AB | ERR/IP | SO/AB | BAT AV | SO/IP | WALK/IP | ERA |
|---|---|---|---|---|---|---|---|---|
| KS2 | Pearson Correlation | -.347 | -.549 | .569 | -.613 | -.367 | -.394 | -.379 |
| | % Variance Explained | 12.0 | 30.1 | 32.3 | 37.6 | 13.5 | 15.5 | 14.4 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| KS5 | Pearson Correlation | .584 | .204 | -.692 | .611 | .250 | .131 | .264 |
| | % Variance Explained | 34.1 | 4.2 | 47.9 | 37.3 | 6.3 | 1.7 | 7.0 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| KS6 | Pearson Correlation | -.165 | -.081 | -.490 | -.114 | .380 | -.389 | -.358 |
| | % Variance Explained | 2.7 | 0.7 | 24.0 | 1.3 | 1.4 | 15.1 | 12.8 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| KS7 (recip) | Pearson Correlation | .084 | -.238 | -.887 | .142 | .384 | -.611 | -.535 |
| | % Variance Explained | 0.7 | 5.7 | 78.7 | 2.0 | 14.7 | 37.3 | 28.6 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| VISA FIX | Pearson Correlation | -.219 | .346 | .392 | .038 | .048 | .243 | .195 |
| | % Variance Explained | 4.8 | 12.0 | 15.3 | 0.1 | 0.2 | 5.9 | 3.8 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| VISA REG | Pearson Correlation | -.690 | .352 | .166 | -.369 | -.585 | .628 | .699 |
| | % Variance Explained | 47.6 | 12.4 | 2.8 | 13.6 | 34.2 | 39.4 | 48.9 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| VISA CC | Pearson Correlation | .475 | .318 | -.831 | .627 | .538 | .088 | .187 |
| | % Variance Explained | 22.6 | 10.1 | 69.1 | 39.3 | 28.9 | 0.8 | 3.4 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| VISA SPEED | Pearson Correlation | .068 | -.044 | -.812 | .129 | .125 | -.396 | -.311 |
| | % Variance Explained | 0.5 | 0.2 | 65.9 | 1.7 | 1.6 | 15.7 | 9.7 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| AV SCORE | Pearson Correlation | .265 | -.084 | -.653 | .390 | .385 | -.263 | -.441 |
| | % Variance Explained | 7.0 | 0.7 | 42.6 | 15.2 | 14.8 | 6.9 | 19.4 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| AV TIME | Pearson Correlation | -.402 | .457 | .709 | -.253 | -.155 | .459 | .533 |
| | % Variance Explained | 16.2 | 20.9 | .049 | 6.4 | 2.4 | 21.1 | 28.4 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| SCORE/ TIME | Pearson Correlation | .343 | -.344 | -.700 | .296 | .225 | -.403 | -.522 |
| | % Variance Explained | 11.8 | 11.8 | 49.0 | 8.8 | 5.1 | 16.2 | 27.2 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| WAYNE BAL | Pearson Correlation | .279 | -.007 | -.223 | .259 | -.148 | -.136 | -.264 |
| | % Variance Explained | 7.8 | 0 | 5.0 | 6.7 | 2.2 | 1.8 | 7.0 |
| | N | 8 | 8 | 8 | 8 | 7 | 7 | 7 |

*KS=Keystone Visual Skills Card: 2=Vertical Fusion, 5=Usable Vision, O.D., 6=Usable Vision, O.S., 7=Reciprocal of Speed of Stereopsis*
*Visa=Visagraph II: Fix=Fixations, Reg=Regressions, CC=Cross Correlation*
*AV=Acuvision; Wayne=Wayne Saccadic Fixator with Balance Board*