Paper

Training Effects of Visual Function on College Baseball Players

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The purpose of this research study was to determine whether or not visual function of baseball players would be improved by specific training. A total Forty-four male baseball players (age: 20.7±1.4, athletic career: 11.0±2.5 years) voluntarily participated in this study. The sample subjects were divided into three groups : Experimental group I, Experimental group II, and Control group. Sample subjects in the experimental group I were assigned to be trained with using the Speesion (computer software program for improving and measuring visual function), while the subjects of the experimental group II practiced watching high speed pitched baseballs and identifying the color of stickers on a ball. All the subjects underwent a usual baseball practice six days a week. Both experimental groups conducted a training session three times a week for eight straight weeks on top of the usual practice. The following items were measured by ordinary device for all sample subjects, static visual acuity (SVA), dynamic visual acuity (DVA), and Kinetic Visual Acuity (KVA). In addition, the following items were examined by the Speesion, DVA, eye movement, visual field, and moment perception. The measurements were conducted three times: at the prior to, after the 4th weeks, and at the end of the training sessions. No significant change in DVA and KVA was found in either experimental group when the ordinary testing devices were employed. However, by using the Speesion tests, significant improvements in some visual functions were found in both experimental groups. Therefore, the training methods utilized in this project improved the visual functions of the college male baseball players.

Key words : visual functions, sports vision, baseball player, training effects, SPEESION

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1. Introduction

Humans receive information from the external environment through several sensory organs. Vision plays the most important role among them. Visual function which enables the brain to receive information more quickly and precisely is necessary for sport performances, where appropriate motion is required to respond to the change of surrounding conditions. The study of visual function which is indispensable for sport activity started in 1978 in the U.S. Subsequently, a study group was born in Japan in 1988 and has been studying "Visual" science as the third sport science following "Physical" and "Mental" sciences.[15] Several research results[4) 10) 17)] have already been published to report that the visual function of sport athletes is better than non-athletic people, and that high level athletes have better visual function than lower level athletes.

Studies related to visual function are conducted in terms of various sport events. Players in track and field events and kendo (the Japanese art of fencing) have become subjects of study among individual sports. In particular, players of sports involving balls, such as volleyball, basketball, table tennis and soccer, have been studied frequently.[9) 16) 25)] Above all, research on the visual function of baseball players[8) 20) 21) 24) 26)] is conducted most frequently. It is reported that the players competing at the Olympic Games and professional baseball players have superior visual function. Ishigaki [24)] suggests that baseball demands the highest visual function among all sport performances because players are required to hit a ball pitched faster than 140km/h (88 m/h) accurately as the characteristic feature of this sport.

Furthermore, various visual training methods to enhance sport performances have been discussed and are attracting attention in recent years. Shibata, et al,[23)] examine the effect of one training method which uses a metronome. In their study, subjects are asked to read letters on an eye-tracking target attached to a metronome which swings at five different frequencies. They report that improvement in Dynamic Visual Acuity (DVA hereafter) was observed after performing this training fifteen minutes a day, five days a week during four weeks. Brown[2)] and Barmack [3)] indicate that saccadic eye movements would be an important factor affecting DVA. Referring to this, Shibata, et al,[23)] report that saccadic eye movements can be assumed to have contributed mainly in making out what was written on a target during the training, which improved DVA noticeably.

An eye fitness program using a videotape named "Eyerobics" was developed in North America, and research studies concerning the effect of this program have been reported. Revien[22)] reports that depth perception, visual field, moment perception and tracking ability can be improved by performing the program of "Eyerobics" three times a week during four weeks in total. Moreover, Meleod, et al,[18) 19)] report that similar training performed three times a week during four weeks in total enhanced static balancing capacity and eye-hand coordination movements. On the contrary, there is a report[1)] stating that no effects from training with "Eyerobics" were observed. Thus a consensus has not been reached yet on this matter. Currently in Japan, SPEESION, a training software program which runs on a PC, has been released for training to improve visual function. Although SPEESION attracted attention when used at the training camp of a Japanese professional baseball team, sufficient studies on the effect of this training software have not been conducted yet.

Meanwhile, since visual function is just one of many factors constructing an athlete's performance, some researchers have a view that visual training should be performed combined with daily skill practice rather than aiming for visual function improvement solely[6)]. There are a few studies reporting the effect of visual training from this perspective. Maeda, et al,[12) 14)] studied visual training in baseball, reporting that Kinetic Visual Acuity (KVA hereafter) showed a tendency to improve, though not significantly, by performing training in which participants watched baseballs pitched at speeds slightly faster than those pitched by a pitcher in usual games. However, Ishigaki [6)] suggests that study reports on visual training combining motor skill practices are not enough at present, and that the training method concerning intensity, frequency and period has not yet been established.

As stated above, the importance of visual function in sport activity has come into focus recently and studies on the effect of visual training are progressing. Nevertheless, sufficient examination has not been achieved. There are not enough studies on the subject, and reports are not consistent concerning the training effect. While various visual training methods have been empirically developed and have begun to be introduced in sport instruction, it seems highly useful to prove their effect by experiments.

Given the actual status, this study conducts visual training, with university baseball players as subjects. In this study, one group of subjects performed visual training using recently developed computer training software called SPEESION, by Asics, and the other group performed visual training combined with baseball skill practice. The purpose of this study is to examine the presence or absence of the effect of visual training by reviewing each measured value of visual function.

2. Methodology

2.1. Subjects

The subjects of this study were 44 male baseball players (fielders) belonging to Toto Daigaku League's third division. Their average age was 20.7 (± 1.4) years and their average athletic career was 11.0 (± 2.5) years.

Subjects were divided into three groups: the Experimental Group I—16; the Experimental Group II—18; and the Control Group—10, so that the average Static Visual Acuity (hereafter SVA), which was measured in a pilot study, would be equal, and regular players and quasi-regular players would be allocated in equal proportion in each group. Subjects in Groups I and II were asked to perform visual training. Each group carried out usual batting practice about six days a week. In addition to batting practice, Groups I and II conducted visual training. The purpose and content of the experiment were explained to all the participants and each of them gave consent to cooperate in the study by a written document.

2.2. Method and appliance to measure visual function

When measuring visual function, participants who need to correct poor vision were allowed to wear glasses or contact lenses as in their usual performances. All measurements were conducted for both eyes.

SVA was measured using a Kinetic Vision Tester AS-4D (Kowa Co.) in SVA mode in a room kept in a certain degree of illumination intensity.

DVA was measured using a HI-D (Kowa Co.). When measuring DVA, an individual is required to discern where the break in a Landolt Ring is located, while the ring moves horizontally from left to right or from right to left in a hemicycle screen. The rotational velocity of the Landolt Ring gradually decreases from a maximum 49.5 rpm. A subject is asked to push a switch at the moment of discerning the break in the Landolt Ring, and to answer the location of that break before the ring is shown at the center of screen. The rotational velocity at switching is recorded as DVA when the answer is correct. The moving direction of the target is differentiated between two ways: the same direction as in training (from left to right for right-handed batters, and from right to left for left-handed) and the reverse direction (DVA reverse direction, hereafter) and changes in random order during measurement.

KVA is measured using the same tester as for SVA, in KVA mode. In KVA mode, the Landolt Ring is set to come straight from 50 m distance to 2 m in front of a subject at the speed of 30 km/h while widening its size. A subject is asked to push a switch at the moment when discerning the break in the ring. The Landolt Ring stops at the moment the switch is pushed and light turns off at the same time. Landolt Ring at 30 m distance corresponds to twenty-twenty vision and eyesight value is calculated from the distance at which a subject discerns the break. Not only the absolute value of KVA but the rate of KVA against SVA is also analyzed.

Both DVA and KVA were measured five times and average values were adopted as measured values.

SPEESION is a computer software program and the distance from a computer display to a subject's face is determined by the size of display in order to prevent differences in measuring conditions. Thus, a stand for setting the jaw is placed at a predetermined distance to fix the head when measuring.

SPEESION can measure DVA, eye movements, visual field and moment perception. Measured values are shown on a zero-to-ten scale. When measuring DVA, a subject is asked to identify figures moving from left to right and from right to left. The ability is evaluated by the moving velocity of a target. A figure changes twice while moving and a subject has to answer a total of three figures correctly. When measuring eye movements, a symbol moves randomly in the screen and changes one to three times on the way. The subject has to keep tracking a quickly moving symbol only with eyes, and answer the position correctly when a different symbol appears. The ability of eye movements is also evaluated by the moving velocity of a target. In terms of visual field, a figure at the center of screen and eight lines aligned with identical symbols around the figure are shown for a moment. Two of the eight lines contain one different symbol each. A subject has to find two different symbols in the lines while identifying a figure at the center. As difficulty level increases, two different symbols will appear at the outer part from the center of the screen and become difficult to identify. When moment perception is measured, three differently arranged 3 by 3 grids setting two kinds of symbols in an array are shown in sequence. A subject is asked to

Figure 1 Ball with color stickers

instantaneously memorize the array of symbols shown at the second time. As difficulty level increases, the time showing an array of symbols will be shorter, which makes it more difficult to answer correctly.

2.3. Method of visual training

The Experimental Group I performed visual training using computer software, and the Experimental Group II performed visual training combined with baseball skill practice. Both groups trained three times a week during eight successive weeks.

2.3.1. Visual training using SPEESION

The Experimental Group I performed computer software training using SPEESION. The content of training is similar to each measurement conducted with SPEESION. For instance, DVA training was performed repeatedly until a subject could identify targets (figures) correctly at a certain moving velocity based on the evaluation phase of the first measurement. The training focused on DVA, eye movements, visual field, and moment perception, and took about 30 minutes in total. In addition to this, SPEESION measurement was performed every week in order to reflect the result in the basic evaluation phases of training. Since a ball moves from left to right before a right-handed batter while batting, the ball was set to move from left to right for a right-handed batter and from right to left for a left-handed batter in the DVA training.

2.3.2. Visual training combined with baseball skill practice

The Experimental Group II performed two kinds of visual training combined with baseball skill practice. One kind of training was to watch a ball pitched slightly faster than in usual games, based on the study of Maeda, et al.[14] The number of pitches to watch was determined to be 20, calculated as the average number of pitches for a batter to watch in a game referring to a scorebook. A pitching machine was used for throwing balls and the velocity was set at around 140 km/h (88 m/h).

An additional form of training is to identify the color of stickers on a pitched ball, which is conducted applying a test form to score the percentage of times identified correctly (Table. 1). Six unicolor stickers are put on a ball separately, up and down, left and right, back and front. The colors of the stickers are red, blue, black, yellow and green. A total of twenty balls, four balls for each color, are pitched randomly. The size of each sticker is 16 mm in diameter. In the pilot test, various sizes of stickers were used for determining the

Table 1 Measured results of Control Group

		before training		4 weeks later		after training	
		average value	standard deviation	average value	standard deviation	average value	standard deviation
Vision Tester	SVA	1.12	0.33	1.17	0.36	1.25	0.3
	DVA (training direction)	45.59	1.85	45.66	1.09	45.64	1.34
	DVA (reverse direction)	44.53	1.9	44.39	3.42	45.06	2.36
	KVA	0.7	0.31	0.74	0.25	0.73	0.27
	KVA(ratio to SVA:%)	61.47	21.07	63.58	9.66	56.45	11.23
SPEESION evaluation phase	DVA (training direction)	3.6	2	3.3	0.5	4	1.7
	DVA (reverse direction)	3.8	1.3	2.7	0.5	3.4	1.3
	eye movements	3.4	0.7	4.2	1.2	4.4	1.3
	vision field	4.9	1.3	4.8	0.6	5.6	0.8
	moment perception	5.7	1.6	5.6	1.4	5.9	1.4
color sticker identifying test (rate of correct answer : %)		51.1	24.2			49.4	20.7

The unit of DVA value measured using Vision Tester is rpm. Measured values of SPEESION show evaluation phase.

Table 2 Measured results for Experimental Group I (training using SPEESION)

N:16

		before training		4 weeks later		after training	
		average value	standard deviation	average value	standard deviation	average value	standard deviation
Vision Tester	SVA	1.24	0.24	1.3	0.2	1.29	0.17
	DVA (training direction)	45.4	2.59	45.77	2.07	46.17	2.36
	DVA (reverse direction)	44.45	3.13	45.55	1.99	46.13 *	1.37
	KVA	0.77	0.23	0.78	0.17	0.84	0.21
	KVA(ratio to SVA:%)	62.4	15.97	60.53	12.56	65.58	15.86
SPEESION evaluation phase	DVA (training direction)	3.3	1.2	6.9 **	2.4	8.0 **	2.2
	DVA (reverse direction)	3.1	0.8	4.3	1.6	5.4 **	2.5
	eye movements	4.1	1	6.1 **	1.2	6.3 **	1.5
	visual field	4.8	1.1	7.1 **	1.3	7.7 **	1.5
	moment perception	4.5	1.4	6.4 **	1.5	7.3 **	1.8

The unit of DVA value measured using Vision Tester is rpm.
Measured values of SPEESION show evaluation phase.

* $p < 0.5$ compared to the value measured before training
** $p < 0.01$

proper size. Since the percentage of correct answers was about 50 on average when using 16 mm stickers, this size was adopted for the experiments. Pitching was performed by a pitching machine at around 125 km/h (80 m/h), which is almost the same as in daily batting practice. Subjects were asked to identify the color of the stickers after each pitch, and the percentage of correct answers was scored. In order to be accustomed to the ball speed, subjects were allowed to watch ten balls pitched at around 125 km/h before the 20-pitch experiment.

This training took 15 minutes for a single time. The two training methods were performed in random order. Subjects were asked to step to the same side of the plate as in a game, that is, right-hand batters to the right side and left-hand batters to the left side.

2.4. Visual function measurement protocol

Subjects were allowed to be well accustomed to the visual function measuring procedure in the pilot test. After advanced measurement was performed, visual training commenced for eight weeks. Measurement was also performed four weeks into the training, and again at the end of eight weeks of training.

2.5. Statistical analysis

Average values and standard deviation of each group were calculated in terms of each measuring item of visual function and the percentage of correct answers for the color sticker identifying test. In order to compare average values of each group before training, four weeks later and again after training, Dunnett's Multiple Comparison was used. The statistically significant level was set at below 5 %.

3. Results

Table 1 shows the results of measurement conducted for the Control Group, before the training, four weeks later, and again after training. When measured values of the Control Group before training, four weeks later and after training were compared, significant differences were not observed in any measured item.

3.1. Change of measured values in visual training using SPEESION

Table 2 shows the result of measurements conducted for the Experimental Group I, before training, four weeks later and at the end of training. When comparing measured values of the Experimental Group I, the measured values of DVA (reverse direction) using Vision Tester showed significantly higher values ($p < 0.05$) at the end of training compared to those before training, while a significant difference was not observed between those values before training and four weeks later. No significant difference was observed among measured values in terms of DVA (training direction), KVA, or the rate of KVA to SVA. All items measured

Table 3 Measured results of Experimental Group II (training combined with baseball skill practice)

N:18

		before training		4 weeks later		after training	
		average value	standard deviation	average value	standard deviation	average value	standard deviation
Vision Tester	SVA	1.27	0.28	1.27	0.33	1.27	0.26
	DVA (training direction)	46.05	1.22	45.69	1.88	46.28	1.38
	DVA (reverse direction)	45.72	1.07	45.79	1.42	46.13	0.96
	KVA	0.75	0.32	0.76	0.31	0.75	0.31
	KVA(ratio to SVA:%)	57.44	18.87	58.05	17.28	56.94	17.55
SPEESION evaluation phase	DVA (training direction)	3.1	0.7	3.9	1.3	4.1 *	2
	DVA (reverse direction)	3.2	0.8	3.8	1.5	4.6 *	2
	eye movements	3.7	1.2	4.5	1.3	5.2 **	1.2
	visual field	5.1	0.9	5.1	0.8	5.4	1.3
	moment perception	4.3	1.7	4.3	1.7	5.1	1.5
color sticker identifying test (rate of correct answer:%)		50.6	14.4	63.6 **	13.5	65.0 **	9.3

The unit of DVA value measured using Vision Tester is rpm.
Measured values of SPEESION show evaluation phase.

* $p < 0.5$ compared to the value measured before training
** $p < 0.01$

using SPEESION four weeks later and at the end of training showed significantly higher values ($p < 0.01$) compared to those measured before training. In fact, the color sticker identifying test was also conducted on the Experimental Group I. This report omits the result because an effective number of data could not be obtained.

3.2. Change of measured values in visual training combined with baseball skill practice

Table 3 shows measured results of the Experimental Group II before training, four weeks later and after training.

When comparing measured values of the Experimental Group II before training, four weeks later and after training, none of the items measured using Vision Tester showed any significant difference among measured values before training, four weeks later and at the end of training. DVA (training direction / reverse direction) and eye movements measured using SPEESION showed higher values ($p < 0.05$) at the end of training compared to those before training, while no significant difference was observed among any values measured before training and four weeks later. In terms of visual field and moment perception, however, no significant difference was observed among measured values.

When comparing the percentage of correct answers in the color sticker identifying test before training, four weeks later and at the end of training, significantly higher values ($p < 0.01$) were observed four weeks later and after training compared to those before training.

4. Some considerations

4.1. The effect of visual training using SPEESION

This study examined the effect of the computer software program SPEESION, developed for visual training in Japan. Improvement in DVA (training direction) and KVA was not observed when measured using Vision Tester. Since SPEESION includes a function of DVA training, it was expected that DVA values would improve when measured using Vision Tester. However, although the result showed only a tendency to improve, a statistically significant improvement could not be observed. The evaluation value of DVA measured by Vision Tester is the rotation frequency at the moment when a subject can discern a break in a Landolt Ring, while the rotation frequency decreases gradually from 49.5 rpm at its highest level. The average value of the Experimental Group I is 45.4 rpm before training and close to the highest number of rotation frequency. It suggests that subjects could discern a break when the Landolt Ring passes before their eyes just a few times. Therefore, measured values probably could not reflect improvement by training in this measuring method. Shibata, et al,[23] who analyzed the effect of DVA training using a metronome, set the moving velocity of a target at five levels based on the measured values at the beginning, and measured 16 times at each level. They examined the effect of training through assessing DVA from the rate of correct answers. This indicates that a more detailed analysis of DVA is necessary as well as popularly applied measuring methods in order to examine the effect of DVA training.

Since KVA is a measuring method specific to Japan, the effect of training using a video program such as "Eyerobics" has not been examined yet. In this study, it is suggested that the effect on KVA cannot be achieved from training using SPEESION on a computer screen.

In contrast, measured values of DVA (reverse direction) by Vision Tester improved significantly. One of the factors affecting this improvement which occurred when a ball was pitched in the direction not trained by SPEESION is considered to be the fact that the measured values of DVA (reverse direction) were lower than those of the training direction before training. The lower values might be the cause of the significant improvement of measured values.

Concerning the measured items using SPEESION, all the evaluation phases of DVA (training direction / reverse direction), eye movements, vision field and moment perception improved significantly ($p < 0.01$), and the effect of training was observed. The improvement of DVA ability is reported in several advanced studies[5) 11)] which perform an analogous training to some measuring methods using the same measuring machine. In this study, the training was also analogous to the measuring methods, and it is supposed that this is the reason similar improvement has been achieved. Therefore, this result suggests that training using SPEESION improves the evaluation phase of DVA, eye movements, vision field and moment perception. As a future issue, it is necessary to examine whether training using SPEESION would affect the performance of university baseball players.

Ishigaki[7)] reports that visual function improves through training using SPEESION once or twice a week. The report indicates that the training of DVA ability to discern a target moving in a certain direction would not influence the ability in a different direction. Contrary to this, DVA to discern a target moving in the direction reverse to daily training improved significantly when measured using both SPEESION and Vision Tester in this study. Moreover, the subjects of this study (N : 44) showed strong connectivity in their measured values of DVA in the training direction and those in the reverse direction using Vision Tester before training, the correlation coefficient standing at 0.695 ($p < 0.01$). This fact suggests that subjects who have better DVA in the training direction also have better ability of DVA in the reverse direction. Since the training was performed three times a week in this study, a greater amount of training than expected in the advanced research might have some influence on the result. It can be assumed that the DVA training to discern a target moving in a certain direction would have an effect on the ability in the different direction when the target moves horizontally. However, in order to conclude clearly, it is necessary to study the mechanism of DVA and the relationship between the ability to discern a target moving vertically and one moving horizontally.

4.2. The effect of visual training combined with baseball skill practice

Maeda, et al,[14)] report that KVA tends to improve, though not to a statistically significant degree, after conducting training to watch balls pitched at higher speeds than those pitched in regular games, 30 balls at a time 5 days a week during a total of 10 weeks. The number of balls to watch in a week during the training of this study is the same as that of the study conducted by Maeda, et al, even though the frequency is different, 5 times a week there and 3 times a week here. In addition, this study includes test form training which scores the rate of correct answers given by subjects in identifying the color of stickers on a pitched ball. This kind of training requires participants to concentrate harder on the ball than usual training. The rate of correct answers in this identifying test improved significantly ($p < 0.01$) after training compared to the rate before training, and the effect of training was observed. In contrast, KVA and DVA did not improve significantly. The subjects of this study have comparatively longer careers in baseball. Their average athletic career is 11 years, and their ability to identify a moving target has been trained well through daily practice. It is assumed that the training in this study did not have a marked effect on their well trained ability to improve KVA and DVA. Maeda, et al, also report in other research[13)] that after batting practice with balls pitched faster than usual, 30 balls at a time five times a week during one year, industrial baseball team members showed significant improvement in KVA in 25 weeks. This indicates that the shortage of training period could be one of the reasons why the effect was not achieved in this study.

However, the evaluation phases of DVA (training direction / reverse direction) and eye movements improved significantly among measured items using SPEESION. It is assumed that the training in this study to eye-track a ball pitched faster or one marked with colored stickers consciously and correctly improved DVA and eye movements. Even though the method differed in training and in measurement, measured values improved significantly. This result indicates that the training to discern a ball moving at high velocities or to identify the color of stickers on a ball can improve the visual function of university baseball players.

In addition, because the effect of training could not be observed on vision field and moment perception, it is supposed that baseball batting needs the ability in DVA and eye movements much more than the ability in vision field and moment perception, in order to ensure the eye-tracking of a pitched ball.

5. Conclusion

Although DVA and KVA did not improve significantly when measured using Vision Tester, which was conducted as an indicator of the training effect for the Experimental Groups I and II, measured values using SPEESION showed significant improvement. Therefore, it is indicated that visual training using SPEESION, or visual training combined with regular baseball skill practice would improve the visual function of university baseball players.

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