Paper

Effect of bunt training employing monocular vision on kinetic and dynamic visual acuity and bunt performance in collegiate baseball players

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The purpose of this study was to examine the effect of bunt training employing monocular vision on kinetic and dynamic visual acuity and bunt performance in collegiate baseball players. Thirty-four collegiate male baseball players participated in this study as subjects. Subjects were divided into two groups: Pitcher group (n: 7) and Training group (n: 27). The training group performed special bunt training employing monocular vision three times per week for seven weeks. Subjects bunted balls at 120 kilometers per hour employing monocular vision. Static, Kinetic, and Dynamic visual acuity and bunt performance were measured at pre- and post training. In the Training group Kinetic visual acuity and bunt performance were increased significantly ($p<0.05$). However, there was no significant difference of Dynamic visual acuity between pre- and post training in the Training group. It was suggested that the training methods utilized in this study improved the Kinetic visual acuity in collegiate baseball players. Moreover there is a possibility that this training improves bunt performance.

Key words :Visual training, Visual function, Bunt test

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1. Introduction

In our daily lives, the majority of the external information we receive is obtained visually. In the realm of sports, as well, visual information plays an important role. Visual abilities such as static, kinetic and dynamic visual acuities, eye movement and depth perception are considered essential in obtaining information accurately and quickly (Christenson & Winkelstein, 1998; Stein et al., 1982). The visual abilities that play an important role in sports are referred to as “sports vision.” A number of studies have shown that the sports vision in individuals who engage in sports activities is superior to that of individuals who do not engage in sports activities, and that high-level athletes are superior to low-level athletes (Christensen & Winkelstein, 1998; Ishigaki & Miyako, 1993; Kioumourtzoglou et al., 1998; Melcher & Lund, 1992; and Rouse et al., 1988). Visual ability is thought to be closely related to sports performance, particularly in ball games in which players and/or balls remain in constant motivation. Because baseball players need to learn to hit any ball pitched into the strike zone, including curve and 140-km-per-hour fastballs, many studies have examined the kinetic and dynamic visual acuity of baseball players (Bahli & LaRitz, 1984; Murata & Sugiashi, 2000; and Winograd, 1942).

In recent years, a number of visual training methods for the improvement of kinetic and dynamic visual acuity and eye movement have been researched for the purpose of upgrading sports performance (Kohmura & Yoshigi, 2004a; Kohmura & Yoshigi, 2004b; Maeda & Tsuruhara, 1998; Maeda et al., 1999; Mcleod, 1991; and Mcleod & Hansen, 1989). Long & Rourke (1989) and Long & Riggs (1991) have reported that dynamic visual acuity (DVA) can be improved through training with the use of measuring equipment. Maeda & Tsuruhara (1998) and Maeda et al. (1999) have reported that kinetic visual acuity (KVA) and bunt performance can be improved by training in following super-fastballs with the eyes and in hitting super-fastballs. Meanwhile, some researchers have expressed the opinion that such improvement in visual ability (e.g. DVA and KVA) is a result of test familiarity. Given such contention, the contribution of visual training to improvement in visual ability remains controversial (Abernethy & Wood, 2001; Hitzeman & Beckerman, 1993; and Stine et al., 1982).

Some sports instructors are beginning to use their own individually developed training methods, while other instructors are making use of company-developed training programs and equipment. In recent years, there have been many top athletes who have undergone such visual training. Meir (2005) has reported on a certain professional rugby team in England which practices skill drills employing monocular vision by placing a patch over one eye of each team member. Though based primarily on the results of subjective reports rather than on objective experiment, the study carried out by Meir suggests that this training method can contribute to a reduction in misplay and an increase in field of view.

Because there is little experimental research on training that employs monocular vision, the physiological effect of such training has not yet been clarified. Compared to binocular vision, however, monocular vision is thought to significantly reduce visual abilities such as static visual acuity (SVA) and contrast sensitivity (Uozato, 2006). Moreover, there are substantial differences between binocular and monocular vision in depth cue for visual object and in field of vision (Hirai, 2004). It is reasonable, therefore, to speculate that the information one obtains by monocular vision would be inferior to that obtained by binocular vision both in terms of quantity and quality. If the effect of the training, training that places a burden on vision by requiring that the training be performed under conditions that reduce visibility, is clarified through experiments, such information might be utilized to propose new training methods to PE teachers and coaches. Such training methods employing monocular vision might positively affect KVA, DVA, and the performance of baseball players who are thought to require enhanced visual abilities.

Considering its specificity and resulting controllability of conditions, bunt training was chosen as the training employing monocular vision for this study. The aims of this study were to research the effects of training on the KVA, DVA, and bunt performance of university baseball players and to publish data obtained through the bunt training employing monocular vision and bunt performance tests.

2. Procedures

2.1. Subjects

The subjects of this study were 34 male baseball players belonging to the Third Division of the Tohto University Baseball League. The average age of the subjects was 20.2±1.6 years, and the average length of participation in baseball was 10.5±2.6 years. Of the 34 subjects, 7 pitchers were placed into a Pitcher Group and 27 fielders were placed into a Training Group. Both groups performed regular skill practice. In addition to this, the Training Group underwent bunt training employing monocular vision. Though pitchers do not usually perform batting practice, the Pitcher Group was required to engage in batting practice just as the Training Group did during the experiment period. None of the subjects performed bunt practice other than the bunt training designed for this study. The bunt training employing monocular vision was conducted 3 times per week for 7 consecutive weeks. Visual ability and bunt performance tests were conducted before and after the 7-week bunt training. The Pitcher Group underwent measurement twice at approximately the same times that the Training Group did. Though some failed to undergo all of the 21 training sessions, the subjects as a whole participated in an average of 19.4±1.7 training sessions. In order to familiarize subjects with the methods and measurement procedures, a preliminary measurement was conducted before the experiment was begun.

Written informed consent was obtained from all study subjects after a detailed explanation of the aim of this study and the experiment procedures was provided. This study was conducted with the approval of the Ethics Committee of the School of Health and Science, Juntendo University.

2.2. Visual ability measurement methods and equipments

At the measurement of visual abilities, subjects with corrected vision were allowed to wear glasses or contact lenses which they usually wore while participating in baseball games. Measurement was conducted on both eyes, right eye, and left eye in random order.

SVA was measured by Kinetic Vision Tester AS-4D (Kowa Co.) in a room which was maintained at a certain degree of illumination intensity. KVA was measured by the same tester, AS-4D, after being changed to the KVA-measurement mode setting. In this mode, the Landolt ring was set to approach straight on from 50-meters distant to 2 meters ahead of the subject at a speed of 30km/h while increasing its size. The subjects were directed to flip the switch at the moment the break in the ring was discerned. On flipping the switch, the ring would stop and the light would be turned out simultaneously. The ability to discern the Landolt ring gap correctly from 30 meters away corresponds to the possession of a visual acuity of 20/20. The visual acuity value of the subjects was calculated based on the distance at which the ring gap was correctly discerned. The geometric average value of KVA was calculated from the results of measurements that were conducted a total 5 times. Measured values of SVA and KVA were obtained by decupling and then logarithmically converting the absolute values of SVA and KVA.

DVA was measured by Kowa HI-10. The subjects were required to discern the gap of Landolt ring, which moved from left to right or from right to left on semicircular screen. The rotating velocity of the Landolt ring was set initially at 49.5 rpm (maximum) and reduced gradually thereafter. The subjects were directed to flick the switch at the moment when the ring gap was discerned and to identify the position of the gap verbally before the Landolt ring appeared at the center of the screen. The rotating velocity at the moment when the subjects correctly flicked the switch was recorded as the DVA value. The eye-tracking target was set to move from left to right for a right-handed batter, and to move in the opposite direction for a left-handed batter. Previous studies (Kohmura & Yoshigi, 2004a; and Kohmura & Yoshigi, 2004b) have reported that the measured DVA values of university baseball players tend to be distributed around the maximum value when the size of eye-tracking target used corresponded to a visual acuity of 20/800. Considering this, this study adopted a smaller eye-tracking target whose size corresponded to a visual acuity 20/200. DVA was measured a total of 5 times and the average value was utilized as the measured value.

2.3. Bunt training employing monocular vision

Bunt training employing monocular vision was conducted with the use of an eye-mask and a pitching machine with its speed set to 120 km/h. The subjects were required to perform bunt training utilizing the right eye and with the left eye 10 times each, performed in random order. The pitching machine was positioned at a distance of 18.44 meters from the home base. The subjects were directed to use a bat around which 3 rubber plates, which measured 10 cm across, were wrapped at 3-cm intervals. Every time any of the three 3 rubber plates was struck with a baseball, a mark was left on it, enabling the subject to know the exact spot at which the ball hit the bat. The subjects were required to bunt a ball by hitting it with a rubber plate specified from among the 3 plates wrapped around the bat, and to hit the ball into the fair zone. The rubber plate used to hit the ball was randomly specified just prior to the pitch. Each time a pitch was made and a bunt was attempted, the subjects were required to check where on the bat the ball hit, if it did indeed hit. Bunting was recorded as successful if the ball was hit into the fair zone by a bunt with the use of a bat at the designated position. Figure 1 shows the bat that was used during the training in this study. In the training, the subjects who

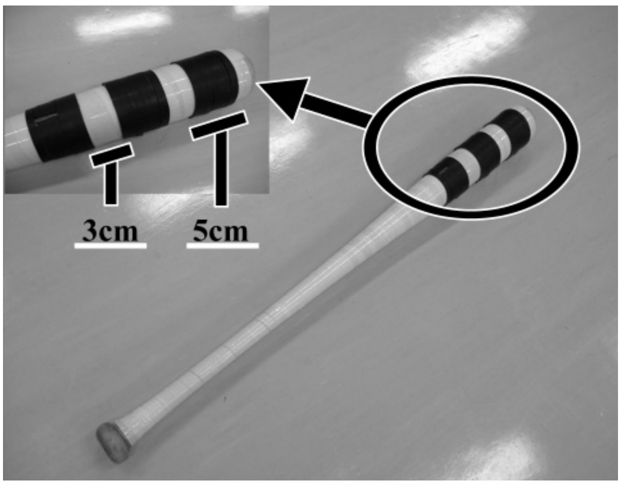

Figure 1. Training bat

were right-handed hitters swung from the right and the subjects who were left-handed hitters swung from the left, just as they would usually have done when participating in actual baseball games.

2.4. Bunt performance test

Using a pitching machine with the speed set to 120 km/h, bunt performance tests employing binocular vision were conducted. The pitching machine was placed at a distance of 18.44 meters from the home base. The success zone for bunting is as shown in Figure 2. Based on the location at which the bunted ball stopped rolling, the subject was awarded points for the bunt performance. The total number of points received for bunting 20 pitches was recorded as the performance score. From the catcher-side corner of the home base, a line was extended towards each of the pitcher-side corners of the home base. The angular difference between each of these lines and the line between home base and first base or the line between home base and third base was approximately 22.5 degrees. Three points were awarded when the ball stopped within the 2-meter long zone which was located halfway between the drawn-in fielders and the home base (the zone located 5-7 meters away from home base), and 2 points were given when the ball stopped within either of the 2-meter long zones located in front of and behind the middle zone (3-5 meters and 7-9 meters away from home base, respectively). If the ball stopped after rolling more than 9 meters distant from home base and within the angle of 22.5 degrees, 1 point was awarded. If the ball stopped with neither of the above-mentioned zones, no point was given. If the ball was hit higher than the height of the subject (a fly ball), the point to be given was also 0.

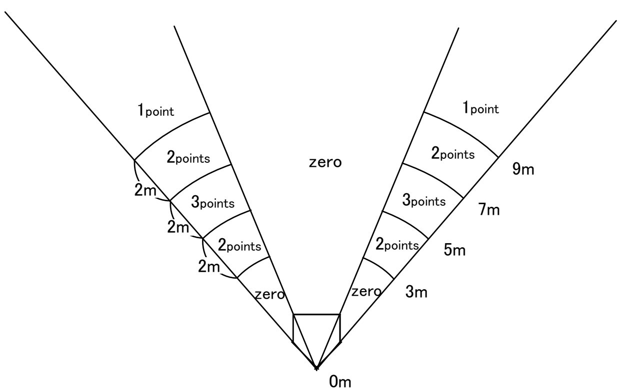

Figure 2. Bunt performance test

Prior to the performance of the test, each of the subjects was asked to indicate in which direction the bunt would be hit, to the first-base side or to the third-base side. If the ball stopped within the point-qualifying zone but on the side which was not indicated by the subject prior to the test, no point was given.

2.5. Analyses and statistical processing

Regarding the reproducibility of bunt performance test, Pearson's correlation coefficient between the measured values before and after the training was calculated.

In terms of the measured values of the visual ability of the both groups, two-way analysis of variance was performed using two factors; that is, before and after the training and employing both binocular and monocular (right/ left) vision. Regarding the bunt performance test results, two-way analysis of variance was conducted with one factor; that is, before and after the training and between the groups. Scheffe's post-hoc test was used for the hypostasis test.

The quantity of successful bunts in the training was analyzed by the following method: Due to the fact that the subjects included both right-handed and left-handed hitters, the subject classification for this analysis was based not on right eye or left eye, but on the eye which was closer to the meeting point for bunting (i.e. right eye for the right-handed hitter, and left eye for the left-handed hitter) and the eye which was further from the meeting point (i.e. left eye for the right-handed hitter, and right-eye for the left-handed hitter), which are hereinafter referred to as "near" and "far," respectively. The average value and standard deviation of the quantity of successful bunts (for the near eye, the far eye, and the total) during the first 5 sessions of the training, which were considered to have been least affected by the training, were calculated and compared. The difference between the average numbers of successful bunts with the near eye and the far eye was verified through paired t-test. The coefficient of correlation between these values and the bunt performance test results were also calculated. The level of statistical significance was determined to be lower than 5%.

3. Results

The coefficient of correlation of the results of the bunt performance tests before and after the training was 0.69.

The measurement results of the respective visual abilities are shown in Table 1. In the comparison of the measured values of the Training Group before and after the training, the major effect of the factor, before and after the training, proved to be significant (KVA, F: 11.88, partial η^2: 0.31, $p<0.05$). The results of the bunt performance tests were as follows: The Pitcher Group: 1st test: 6.29±2.69, 2nd test: 7.14±3.02. The Training Group: before the training: 9.22±2.23, after the training: 11.74±3.52 (See Figure 3). The results of the two-way analysis of variance showed that the major effect of the factor of the groups was significant (F: 10.73, partial η^2:0.25, $p<0.05$). In the hypostasis test, the measured value of the Training Group after the training was significantly higher than the measured value before the training ($p<0.05$).

Figure 4 shows the change in quantity of successful bunts (near, far, and total) for the subjects who participated in all 21 sessions of the training. The average numbers of successful bunts during the first 5 sessions of the training were 4.0±1.1 for the near eye and 2.9±1.2 for the far eye. There was a significant difference between the near eye and the far eye (t: 6.08, d: 0.94, $p<0.05$). The coefficients of correlation of the average number of successful bunts for the first 5 sessions of the training and the bunt performance test results were: the near eye: 0.597 ($p<0.05$); the far eye: 0.645 ($p<0.05$); and total: 0.679 ($p<0.05$).

4. Speculation

This study aimed to research the effect of bunt training employing monocular vision on the visual abilities and bunt performance of university baseball players. As a result of the bunt training employing monocular vision, KVA increased significantly. Maeda & Tsuruhara (1998) have reported that the KVA of junior and senior high school baseball players significantly increased as a result of a 10-week hitting practice regimen (5 times/week) with a ball that was pitched faster by several percent than in usual games and that the KVA of adult baseball players, which was originally as high as 1.0 or more, did not increase significantly as a result of the same type of hitting practice regimen. Kohmura & Yoshigi (2004a) have reported that the KVA of university baseball players did not increase as a result of training to identify the colors of stickers placed

Table 1. Measured results of visual function

			Static Visual Acuity			Kinetic Visual Acuity			Dynamic Visual Acuity †		
			both eyes	right eye	left eye	both eyes	right eye	left eye	both eyes	right eye	left eye
Pitcher group n:7	1st	M	1.06	1.01	0.99	0.75	0.63	0.65	30.62	23.64	21.51
		SD	0.11	0.10	0.15	0.12	0.20	0.22	6.87	8.79	3.77
	2nd	M	1.08	1.03	0.99	0.82	0.70	0.65	32.37	24.06	23.46
		SD	0.08	0.11	0.11	0.10	0.17	0.22	7.30	8.29	7.11
Training group n:27	pre-training	M	1.08	1.00	0.99	0.78	0.68	0.64	32.22	26.07	25.94
		SD	0.09	0.12	0.12	0.23	0.24	0.29	8.59	9.42	8.24
	post-training	M	1.09	1.02	1.01	0.88 *	0.77 *	0.73 *	34.29	28.89	26.83
		SD	0.11	0.13	0.14	0.20	0.20	0.22	7.93	9.36	9.03

* p<0.05 compared with pre-training † In measurement of Dynamic visual acuity for Pitcher group, the number of subjects is 6., unit: rpm

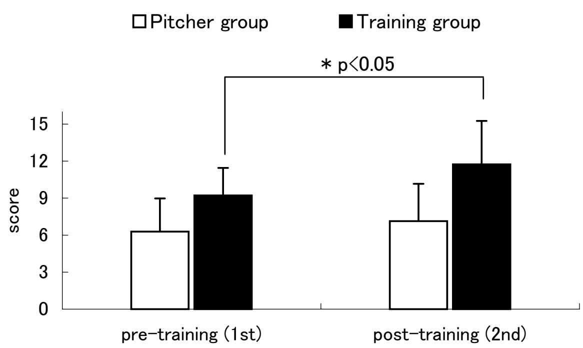

Figure 3. Changes in bunt performance test score

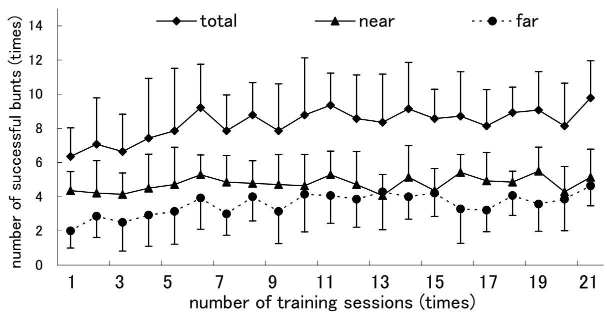

Figure 4. Changes in the number of successful bunts (n:14)

on the baseball or as a result of training to follow fastballs with their eyes. It is noteworthy that the subjects of this study showed a significant increase in KVA as a result of the training which was performed less frequently and for a shorter period than the above-mentioned training that was conducted for the studies conducted by Maeda and others. Considering that the average value of the KVA of the subjects of this study was originally 0.7, however, it can be speculated that the lowness of the initial value of KVA served as a major factor in the increase of KVA. In the previous study, junior and senior high school students, who were in their growing period, showed a significant increase in KVA, whose average value was originally as low as that of the subjects who participated in this study. Depending on the initial KVA value, it would seem to be possible to improve the KVA of university students as well. Visual abilities decrease when an individual is employing monocular vision. With one eye covered, the subjects of this study reported feeling that the ball was less visible than usual while performing the bunt training. Considering this, monocular vision might have served as a stimulating factor in the training. Meanwhile, the results of this study indicate nothing about psychological effect of monocular vision and the physiologic mechanism of improving visual ability. These issues will have to be researched in future studies.

It is also worth consideration that the results of this study could be affected by differences not only in the original visual abilities of the subjects but also by differences in training method. The bunt training employing monocular vision required the subjects to position their faces in front of the ball to be pitched in order to perform an accurate bunt. This situation was different from that of the training employed in the study condicted by Kohmura & Yoshigi (2004b), which required the subjects to stay in the hitting position and to follow the pitched ball with their eyes until the ball passed the home base. The situation in which a ball came directly toward the subject was similar to the method utilized for the measurement of KVA. This training method may have served as a factor for the improvement of KVA in this study. It may also be because of this method that DVA did not increase significantly in this study.

The bunt performance test that was used in this study was a completely original test developed by the researchers involved. Further investigation of its reliability and reproducibility will be required in future studies. Though being inevitably affected by the training effect, the bunt performance test is thought to have reproducibility to an extent because of the fact that the coefficient of correlation of the results of the tests before and after the training equaled 0.69. The subjects who scored high in the bunt performance test tended also to exhibit a high quantity of successful bunts during the training.

The results of the bunt performance test of the Training Group showed a significant improvement after the training. The bunt performance test required the subjects to have advanced skills with which they attempted to bunt the ball accurately to reduce its impetus and to roll it into the point-earning zone. It can be speculated that the effect of the training of this study, in which the subjects were required to bunt with reduced vision, was positively reflected in the results of the bunt performance test. The number of successful bunts increased, though gradually, as participation in training increased. Because the Pitcher Group was exempted from bunting skill practice, however, it is not clear whether the training employed in this study and an increase in KVA directly contributed to the improvement of bunt performance. Strictly speaking, this study should have had another subject group performing training employing binocular vision. Nevertheless, it can at least be speculated that training employing monocular vision exerts no bad effect on baseball players and that it does not prevent players from improving their baseball performance. Because pitchers basically do not have a turn at bat in university baseball, their skills in bunting varied in this study. Pitcher trainability could also be affected by measured values before the training. The results of this study, therefore, need to be examined with a certain caution.

Bunt training employing monocular vision requires participants to perform in a state in which they have difficulty in seeing a ball as well as their surroundings. It is important for instructors to be aware of the potential danger of such training. Such training with the use of a baseball can be even more dangerous than training with the use of a rugby ball, as was shown by Meir (2005). It is necessary to consider the potential problems involved in covering one eye, especially for children who are under 8 years of age, when visual sense is highly susceptible to stimuli (Namida & Yamamoto, 1999; Miyake, 2003; Wiesel & Hubel, 1963). Considering that the effect of covering an eye for a certain period of time has not yet been clarified, it will be necessary for baseball instructors to be cautious about adopting this training employing monocular vision. In this study, the training was performed safely in part due to the fact that the subjects were university baseball players with highly-developed skills in bunting. Meanwhile, the training used in this study has the following advantages: 1) It can easily create a situation in which a player has difficulty in seeing the ball as if he were watching a super-fastball at a speed of 140-150km/h, which would otherwise be available only through the use of an expensive, high-performance pitching machine. 2) A pitching machine is freer from control errors when its speed is set as slow as 120 km/h.

The number of successful bunts was also analyzed. It seems that success in bunting depended on which of the subject's eyes was covered, the eye near to the meeting point or the eye far from it. As a result of correlation analysis, it became clear that the subjects who obtained high bunt performance scores tended to have a high quantity of successful bunts during the training without regard to which eye was covered.

Another analysis was made on team batting averages and the number of sacrifice bunts recorded during the Fall-Season League Games, which started in the final week of this training program, and those recorded during the Spring-Season League Games, which were held before the initiation of this training program. The success rates of bunting for the first pitch were 68.0% for the Spring-Season and 85.2% for the Fall-Season. While such official game records are not a simple reflection of the effect of the training, we present this analysis result here for the sake of reference.

5. Conclusion

Based on the results of this study, it is suggested that bunt training employing monocular vision can improve the KVA of university baseball players. It is also suggested that the training can serve as a method to improve bunt performance.

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