Investigation on the development of batting imagery in youth baseball players

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Received: December 25, 2018 / Accepted: July 26, 2019

Abstract The purpose of this study was to clarify the development pattern of batting imagery in youth baseball players. One hundred thirty-eight young baseball players (6–14 years old) were divided into 4 age groups. Tee and toss batting with a stationary tee stand and toss machine were used in the batting trials. In addition, the participants did an imagery task of hitting the optimal point of a ball where they wanted to impact it. To clarify the difference between the image trial and actual batting (tee and toss), the absolute error distance (AED) was calculated by subtracting the impact distance of the image trial from that of the actual batting. Two-way analysis of variance (4 age groups $\times$ tee and toss images) revealed that the AED was significantly lower in the 11- to 12-year-old players than in the 6- to 8-year-old players ($p < 0.001$). The relationships between the tee and toss images showed a significant correlation in all 4 groups (6–8 years old: $r = 0.445$, 9–10 years old: $r = 0.495$, 11–12 years old: $r = 0.589$, and 13–14 years old: $r = 0.804$; all groups: $p < 0.001$) and that tee and toss batting imagery appears unchanged as age increases. However, batting imagery seems to develop around 11–12 years old, and at the age group of 13–14 years old players are able to impact the same position on the bat regardless of the batting trials.

Keywords : youth baseball player, development, batting, imagery

Introduction

In baseball, batters try to hit the ball thrown by the pitcher, adjusting their swing timing to hit the ball accurately in a short period of time¹⁾. In addition, the baseball batters have to hit a small ball of approximately 6.6 cm in diameter (using the same ball as adult players from 9 years old, but softer ball until 8 years old) with a bat of less than 6.7 cm in width in Little League baseball. Using a tool separate from one's own body is difficult for athletes. Therefore, baseball batting is considered one of the most difficult skills to perform among sports²⁾.

Human movement is mainly controlled and mutually activated by visual, audial, and proprioceptive stimuli. However, these sensory functions are not completely developed in early childhood, and sensory improvement and integration are said to occur with growth. Nardini³⁾ reported that sensory integration begins at 7 to 8 years old, but visual modality is superior to proprioceptive modality in stimulating movement at that age. In addition, Petrini⁴⁾ said that visual and proprioceptive functions were almost equal at 10 to 11 years old. Furthermore, Guilbert⁵⁾ investigated the development of visual, audial, and proprioceptive functions in walking for 5-, 7-, and 9-year-

old children, and reported integration of these functions as age increased. In this way, these sensory functions change with growth. Since previous research studies have focused on the imagery of movement of the walking task, this study investigates the imagery of sports movement, which has yet to be clarified in youth.

Richard⁶⁾ classified some movements such as visual motor imagery (VMI) as external factors mediated by visual contribution and kinesthesia motor imagery (KMI) mediated by internal factors. The VMI shows the importance of visual elements, such as those in baseball batting and tennis when hitting a moving ball; and KMI is a recording of other types of competitions such as gymnastics and land-based sports. Baseball batting is classified as VMI because there is the external intervention of judging a moving ball. In addition, “tee batting” is used to hit a stopped ball and “toss batting” is used to hit a flying ball that is thrown softly in baseball practice. Thus, in youth, batting imagery can be clear, that is, matching one's own imagery of the target that the athlete wants to hit and the actual VMI movement.

The purpose of this study was to clarify the development patterns of batting imagery in youth baseball players. By clarifying such development patterns, it might contribute to providing knowledge about the age period when it would be easier to acquire batting skills.

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Materials and Methods

Subjects. One hundred thirty-eight young baseball players (6–14 years old) who have practiced baseball batting participated in this study (baseball playing history: 4.33 ± 1.95 years, 92 right- and 46 left-handed batters). The subjects were divided into 4 age groups as follows: 6 to 8 years old ($n = 17$), 9 to 10 years old ($n = 43$), 11 to 12 years old ($n = 45$), and 13 to 14 years old ($n = 33$). In this experiment, none of the subjects had any pain or injury. All subjects and their guardians received a detailed explanation of the experimental procedures and risks of the research before recordings were taken. Written informed consent was obtained from all subjects and their guardians, who assented to the study. The study was approved by the ethics committee of the Faculty of Sport Sciences, Waseda University (2018-208).

Batting experiment. The batting trial was tee batting using a stationary tee stand with adjustable height and toss batting with an automatic toss machine (FTM-240, Field Force Company). First, participants were asked to adjust the height of the tee stand at which it was easiest for them to hit the ball. Then, the stationary tee stand was set at the

home base of a baseball diamond and the toss machine location, where the ball could pass the same position as the height of the tee stand, was determined. At this time, the toss machine was set where the ball would be launched from 45° ahead and on the opposite side of the batter's box. In the batting trial, I asked the participants to select the bat that would be used. In addition, two high-speed cameras (EX-100PRO, Casio Company; 240fps) were installed to capture images of the back and side of the batters (Fig. 1) and synchronized with LED timing lights (PH-106, DKH Company).

In the experimental procedure, participants performed the batting image task before tee and toss batting as an actual trial. The batting image task was an indicator that the participants hit the optimal point where they wanted to impact the ball and was conducted by matching the bat to the ball on the stationary tee stand (in the same way as in the tee batting setup). They conducted it twice in order of tee batting and then toss batting as an actual batting trial. In addition, when there was a swing, but clear miss, it was redone. Also, subjects performed practice trials prior to actual measurements.

Data analysis. Several points of the bat head, bat end,

Table 1. Participants' information

Groups (number)	6-8 years (17)	9-10 years (43)	11-12 years (45)	13-14 years (33)	all (138)
chronological age (years)	7.7 ± 0.8	9.3 ± 0.6	11.4 ± 0.8	14.7 ± 0.6	11.2 ± 1.9
height (cm)	128.5 ± 5.5	139.1 ± 6.2	146.6 ± 9.4	162.4 ± 7.1	145.9 ± 12.9
weight	29.1 ± 6.9	33.9 ± 7.1	40.5 ± 8.4	45.8 ± 8.7	39.4 ± 10.4
baseball experience (years)	2.2 ± 1.2	3.3 ± 1.7	4.8 ± 1.3	5.8 ± 1.6	4.5 ± 2.0

Fig. 1 Batting experiment environment (In the case of the right batter)

and impact point which was projected on the long axis consisting of the bat head and end were digitized, and the movements were analyzed using a motion analysis system, Frame-Diaz V (DKH, Japan). The three-dimensional coordinates were obtained using the direct linear transformation (DLT) method. The right-hand orthogonal reference frame was defined as the X -, Y -, and Z -axes with the origin at the end of the home plate (Fig. 2). The Y -axis was directed from the home plate to the pitcher's plate, and the Z -axis indicated a vertical direction. The X -axis was defined as the cross product of the Y - and Z -axes. For calibration, poles with four markers (0, 0.5, 1.0, and 1.5 m from the bottom) were vertically set at four different locations on the home plate (The standard error was $x = 0.52$, $y = 0.84$, $z = 0.70$ cm). A recording of the calibration points with the two high-speed cameras was conducted from the start to the end of batting. The calculation section of the data was the moment of the impact in each trial. Then, impact distance, the distance between the bat top (x_1, y_1, z_1) and the impact point (x_2, y_2, z_2) was calculated using the pythagorean proposition (impact distance = $\sqrt{[x_2 - x_1]^2 + [y_2 - y_1]^2 + [z_2 - z_1]^2}$). To clarify the difference between the image trial and the actual batting (tee and toss), the absolute error distance (AED) was

calculated by subtracting the impact distance of the image trial from that of the actual batting. Thus, the smaller the AED, the better the sense of batting. In addition, this study adopted the average value as a representative value.

Statistical analysis. Two-way analysis of variance (ANOVA) of the AEDs of the tee and toss images was conducted for the 4 age groups (post hoc; Tukey). Then, the Pearson product-moment correlation between the tee and toss image distances was calculated. The alpha level for significance was set at $p < 0.05$.

Results

The impact distance in each of the 3 trials (tee, toss batting, and image task) and the AEDs of the tee and toss images in the 4 age groups are listed in Table 2. Fig. 3 shows the differences in tee and toss images among the 4 age groups. In the two-way ANOVA, no significant interaction was observed and a significant main effect was observed only in the age groups. In addition, the multiple comparison test revealed that AED was significantly lower in the 11- to 12-year-old age group than in the 6- to 8-year-old age group ($p < 0.001$). The tee and toss images

Fig. 2 Analysis (bat head and impact point) and calibration (0 m) based on home plate

Table 2. Impact distance and AED in 4 age groups

Groups	6-8 years	9-10 years	11-12 years	13-14 years	all
Impact distance					
tee	0.132 $\pm$ 0.058	0.101 $\pm$ 0.035	0.125 $\pm$ 0.065	0.111 $\pm$ 0.023	0.117 $\pm$ 0.068
toss	0.157 $\pm$ 0.071	0.125 $\pm$ 0.038	0.139 $\pm$ 0.072	0.122 $\pm$ 0.026	0.136 $\pm$ 0.059
image	0.135 $\pm$ 0.034	0.116 $\pm$ 0.025	0.127 $\pm$ 0.066	0.131 $\pm$ 0.030	0.127 $\pm$ 0.060
AED					
tee-image	0.047 $\pm$ 0.022	0.034 $\pm$ 0.021	0.014 $\pm$ 0.011	0.035 $\pm$ 0.028	0.033 $\pm$ 0.026
toss-image	0.049 $\pm$ 0.047	0.039 $\pm$ 0.024	0.016 $\pm$ 0.012	0.037 $\pm$ 0.024	0.035 $\pm$ 0.029

(m)

Fig. 3 AED in tee and toss batting in comparison with the image trial

Fig. 4 Correlation between the AEDs of the tee and toss images in the 4 age groups

showed a significant correlation in all 4 groups (6–8 years old: $r = 0.445$, 9–10 years old: $r = 0.495$, 11–12 years old: $r = 0.589$, and 13–14 years old: $r = 0.804$, all groups: $p < 0.001$) (Fig. 4).

Discussion

Compared to the 6- to 8-year-old age group, the AED in the 11- to 12-year-old age group was significantly decreased in tee and toss. Although no significant difference was found between the AED of the 9- to 10-year-old group and that of the 6- to 8-year-old age group, the result suggests that the batting imagery would improve at the age of 6 to 12 years. Guilbert⁴⁾ investigated the timing of the integrity of sensation of walking for 5-, 7-, and 9-year-olds and found that the integrity of the sensation improved as age increased. Batting was expected to be more difficult than the walking trial at the point of intervention of external factors such as visual stimuli. On the basis of this fact, the age at which the decrease in AED in batting was observed was higher than the age indicated in a previous study. However, the 13- to 14-year-old age group showed a higher AED than the 11- to 12-year-old age group, although the difference was not significant. This factor may reflect the characteristics of the growth age. The 13- to 14-year age group matched this age with the peak height velocity (PHV). Suwa⁷⁾ reported that Japanese male had a PHV at an average of 13.05 ± 0.94 years and that development of body composition would also increase at this time. Although it is thought to be a factor that this result was caused by a temporary discrepancy at PHV age between the development of the musculoskeletal system such as the bones on the long axis of the upper limbs and the motor imagery, such relationships have not been studied yet. Accordingly, it is considered to be more difficult to contact using a tool different from each part of the body than a simple physical exercise, so further basic research should be conducted based on this result.

To clarify the relationship of error distance between tee and toss images, which showed a different level of visual influence such as KMI and VMI, the Pearson product-moment correlation between the tee and toss image distances is shown in Fig. 4. All age groups showed a significant correlation between the error distances of the tee and toss images, which indicates that a relationship exists between the error distances of the tee image to that of the toss image. As the correlations of the tee and toss images reached close to $r = 1$, the subjects could impact the ball with a similar batting imagery in both trials. A high correlation ($r > 0.7$) was found between the 13- to 14-year-old age group ($r = 0.804$). High correlations ($0.4 < r < 0.7$) were also found among the 6- to 8-, 9- to 10-, and 11- to 12-year-old age groups ($r = 0.445$, 0.495 , and 0.589). In other words, the correlation of the 13- to 14-year-old age groups was the closest to $r = 1$ in the 4 age groups, which suggests that the degree of error between tee and toss is

low. Therefore, we could infer that the tee and toss impact positions would reach the same level as age increases. From the aforementioned, the batting imagery could be considered to be acquired at an older age (13–14 years old), not at the age (7–9 years old) when integration of sensation in walking motion is attained because of the specialized competitive movements.

Finally, the image trial was conducted to compare the actual trial as a subjective indicator of the batter in this study. In a previous study about the impact of batting, the “sweet spot” that was the maximum coefficient of restitution area was used as an objective indicator of impact position. In general, the sweet spot was placed on 15–20% of the bat length from the bat top⁸⁾. In this research, when calculating the error distance by absolute value in the same way between the impact distance of image trial and the sweet spot which was defined as 17.5% of the bat from the bat top according to age group, there were no significant difference between age group (6–8 years old: 0.024 ± 0.027 m, 9–10 years old: 0.028 ± 0.021 m, 11–12 years old: 0.021 ± 0.018 m, and 13–14 years old: 0.029 ± 0.015 m, $ES = 0.003$, $p = 0.354$). Namely, it could be inferred that the image trial was not much different from the objective indicator of impact depending on the age group.

Limitation

Since the standing position and the height of the tee stand were different depending on the individual, there was a possibility that there may be variability in the actual strike zone.

Conclusion

Batting imagery appeared to develop at 11–12 years old in the youth baseball players in this study. In addition, tee and toss batting imagery were the same as age increased.

Conflict of Interests

Authors have no conflict of interests.

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