RELATIONSHIP OF BASE-RUNNING PERFORMANCE WITH RUNNING DIRECTION AND ITS CHANGE

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The purpose of this study was to clarify whether the running direction and its change affect the base-running performance. Thirty-five male baseball players performed 54.86 m (180 ft.) straight-line sprinting and distance-matched base-running, during which two dimensional positions of players were recorded with ZXY Sports Tracking System. The results of this study revealed that the total base-running performance was probably affected by the running performance of the later running phase. In addition, smaller direction change before the first base and larger direction change after the first base maybe responsible for better performance in the entire base-running through better performance in the later section. These results would be useful for players and coaches who attempt to improve base-running performance.

KEY WORDS: baseball, proportion of time, changing direction, sprinting.

INTRODUCTION: Base-running performance is one of the most important factors for scoring in a baseball game. The performance of base-running through two or three bases (e.g. hitting a double or triple) is determined not only by pure straight-line sprinting capability but also by technique and strategy when changing direction, as is the case with running performance with changes in direction, which is influenced by straight running speed, leg muscle qualities, and direction change technique and strategy (Young et al., 2002). The ratio of base-running time in relation to the distance-matched straight-line sprinting time may be useful to quantify one's skill and strategy in base running. Miyaguchi et al. (2011) reported that baseball players showed a smaller impaired time ratio (the ratio of base-running time with distance matched straight-line sprinting time) compared with track and field athletes, and indicated that baseball players might suppress the increase in time during base-running by having better direction change technique and strategy. Therefore, it is possible that the technique and strategy of changing direction has some effect on the impaired time ratio. Revealing the technique and strategy of changing direction to reduce impaired time ratio will contribute to improve base-running performance. Therefore, the purpose of this study was to clarify whether running direction and its change affect the base-running performance.

METHODS: Thirty-five male baseball players (age, 22.0 ± 2.9 years; stature, 173.4 ± 6.2 cm; mass, 73.0 ± 12.0 kg) participated in this study. All of the participants provided written informed consent before participating in the experiment. After warming up, the participants performed 54.86 m (180 ft.) straight-line sprinting and distance-matched base-running with two bases on artificial turf field in an indoor experimental site for two times (in total 4 sprints). Participant's two dimensional positions (parallel with the ground) during both sprint conditions were recorded with a ZXY Sports Tracking System, operating at 20Hz (ChyronHego, New York, USA). A tracking sensor was attached to the participant's waist using a belt. Eight stationary radio receivers were mounted under the roof of the indoor experimental site. In order to distinguish small difference in time and position, positional data for each trial was interpolated with a spline function from 20 Hz to 100 Hz. For both running conditions, the entire run was divided into four sections of equal distance (Fig 1). The running times and the actual running distance were calculated by positional data for the entire and respective sections in both conditions. Moreover, the impaired time ratio and the direction change angle were also computed. This study defined the direction change angle as the angle between the horizontal velocity vectors from the sensor at the current frame and at the previous frame (positive values indicate left from the perspective of the runner). A t-test was used to reveal the difference in running time between base-running and straight-line sprinting. Relationships between variables were determined with the Pearson's product-moment correlation coefficient. Statistical significance was set at $p < 0.05$.

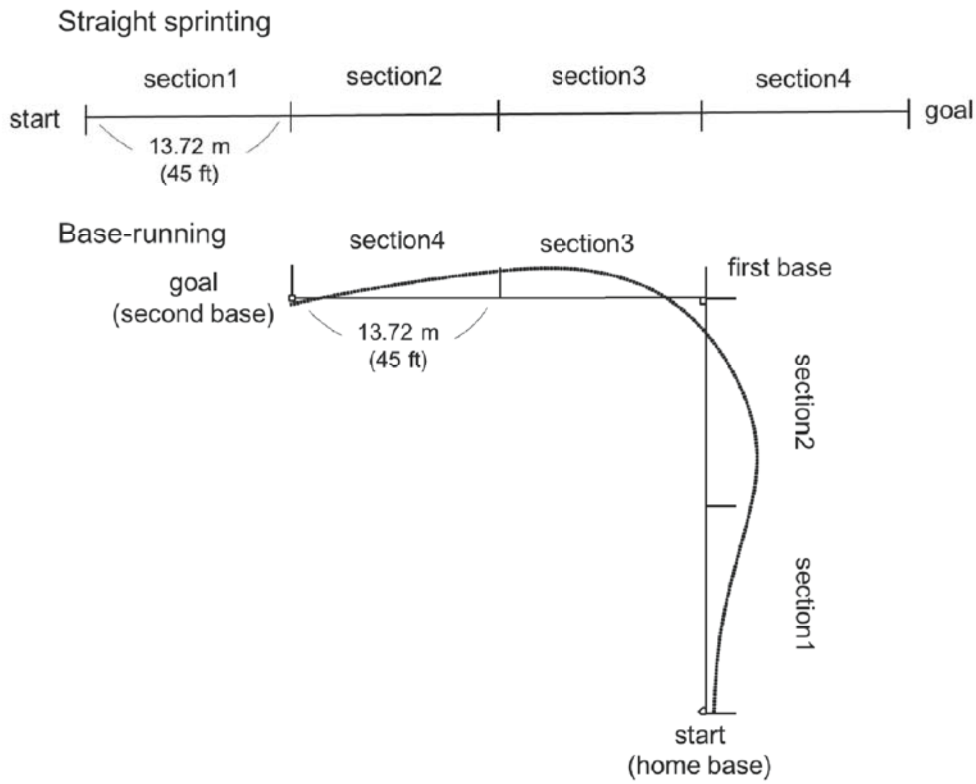

Figure 1: Experimental set-up of straight-line sprinting and distance-matched base-running. Curved line in the base-running shows a trajectory of a typical runner.

RESULTS: Table 1 shows the running times for the entire and respective sections in both conditions and the impaired time ratio, as well as the actual running distance and ratio of the actual running distance to the course distance (distance ratio) and the direction change angles for the entire and respective sections in base-running. For all participants, the total and all sections' running times of base-running were significantly longer than straight-line sprinting. The impaired time ratio for the section 2 and 3 were greater than that for the section 1 and 4. Table 2 shows the correlation coefficients between the total impaired time ratio on the one hand and the impaired time ratio in each section, the distance ratio and positive and negative direction change angles on the other hand. There was significant positive relationship between the total impaired time ratio and impaired time ratios in the section 3 and 4 ($r = 0.62$ and 0.38). The total impaired time ratio was significantly correlated with total negative direction change angle and negative direction change angle in the section 1 ($r = -0.38$ and -0.37). Table 3 shows the correlation coefficients for the impaired time ratio in the section 3 versus the distance ratio and positive and negative direction change angles. There was significant positive relationship of the impaired time ratio in the section 3 with distance ratio and positive direction change angle in the section 2 ($r = 0.34$ and 0.47). The impaired time ratio in the section 3 was significantly negatively correlated with positive direction change angle in the section 3 (r = −0.39).

Table 1
Mean and standard deviations of running variables

	Total	Section 1	Section 2	Section 3	Section 4
Base-Running Time (sec)	7.8 ± 0.3	2.3 ± 0.1	2.1 ± 0.1	1.6 ± 0.1	1.8 ± 0.1
Straight-Line Sprinting Time (sec)	7.2 ± 0.3	2.1 ± 0.08	1.7 ± 0.1	1.1 ± 0.1	1.7 ± 1.1
Impaired Time Ratio (%)	107.3 ± 1.5	103.4 ± 3.4	126.7 ± 6.6	141.9 ± 15.3	104.5 ± 5.4
T-Score	28.2**	6**	24.3**	23.0**	4.8**
Base-Running Distance (m)	55.2 ± 0.4	13.5 ± 0.1	15.2 ± 0.5	11.1 ± 0.6	13.4 ± 0.2
Distance Ratio (%)	100.7 ± 0.7	102.78 ± 1.0	115.4 ± 4.1	84.6 ± 0.6	101.6 ± 1.1
Total Direction Change Angle (deg)	101.1 + 6.6	−8.2 + 6.7	69.3 + 7.7	37.6 + 6.7	7.5 + 5.1
Positive Direction Change Angle (deg)	119.4 ± 5.1	5.1±3.7	69.4 ± 7.9	37.6 ± 6.8	7.9 ± 5.6
Negative Direction Change Angle (deg)	−13.8 ± 4.5	−13.4 ± 4.3	−0.1 ± 0.1	-	−0.4 ± 1.0

Table 2
Correlations coefficient between the total impaired time ratio and distance ratio and positive and negative direction change angles

	Total	Section 1	Section 2	Section 3	Section 4
Impaired Time Ratio	-	0.30	0.31	0.62**	0.38*
Distance Ratio	0.26	0.25	0.13	0.00	−0.03
Positive Direction Change Angle	0.13	−0.17	0.25	−0.10	0.00
Negative Direction Change Angle	−0.38*	−0.37*	−0.03	-	0.12

* : p < 0.05. ** : p < 0.01

Table 3
Correlations coefficient between impaired time ratio in the section 3 and distance ratio and positive and negative direction change angles

	Section 1	Section 2	Section 3	Section 4
Distance Ratio	0.33	0.34*	−0.28	−0.27
Positive Direction Change Angle	−0.09	0.47*	−0.39*	−0.18
Negative Direction Change Angle	0.33	−0.06	-	0.09

* : p < 0.05.

DISCUSSION: This study aimed to clarify the influence of direction change angle on base-running performance. We showed here that the impaired time ratio after the first base was related to the total impaired time ratio, and the smaller positive direction change angle in the section 2 and the larger positive direction change angle in the section 3 were important to reduce the impaired time ratio in the section 3.

In line with a previous study (Miyaguchi et al., 2011), the base-running time was longer than distance matched straight-line sprinting time (table 1). The total impaired time ratio was correlated the negative direction change angle (opposite to the second base) during the section 1 and in total. The negative direction change angle during the section 1 accounted 97% of total negative direction change angle, and thus sprinting linearly during the section 1 with initial sprinting direction being negative is probably important for better base-running performance. Moreover, this strategy would also induce a smaller positive direction change angle in the section 2 which is beneficial to increase running speed in the section 2.

There were significant positive relationships between the total impaired time ratio and impaired time ratios in the section 3 and 4 (table 2). The impaired time ratio in the section 3 was highly correlated with the total impaired time ratio, and the running speed during the section 4 would strongly be affected by the running speed in the section 3. These results indicate that the running performance in the section 3 is most critical for the total running performance during base-running. Impaired time ratio in the section 3 was positively correlated with the direction change angle in the section 2 and was negatively correlated with that in the section 3. The results demonstrate that suppressing direction change in the section 2 seems to be important to the better base-running performance through better performance in the section 3. During the section 2 (the distance ranging approximately 14 to 28 m from the start), the running speed approaches its maximum. When the athlete changes his running direction greatly in the section 2, the increase in running speed may be suppressed greatly, and this suppression of increase in running speed in the section 2 would bring lower running speed in the section 3.

CONCLUSION: This study demonstrated the relationship of base-running performance with running direction and its change. This study had two major findings. First, the total base-running performance was probably affected by the running performance of the later section (e.g. first to second base in the case of hitting a double). Secondly, smaller direction change before the first base may be responsible for better performance in the later section. These results could be useful for players and coaches attempting to improve base-running performance.

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