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TARGET VALUE FOR THE MAXIMUM RUN-UP SPEED OF THE LONG JUMP BASED ON THE PERFORMANCE LEVEL

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This study sought to obtain target values for the maximum run-up speed of the long jump based on performance level and to propose a method to easily estimate the maximum run-up speed. Run-up speeds of 429 male and 536 female long jumps were collected by a laser beam apparatus at 50 or 100 Hz. Subjects were divided into record-based groups for each 20 cm of the jumping distance, and the data were averaged in each group. Main results were as follows: 1) Average of maximum speed in higher performance groups was larger than that for lower groups: 2) A significantly negative correlation was observed between the interval time of the last 20 m before the takeoff and the maximum speed, and the obtained good fit regression line between them (R^2=0.968) will enable to estimate and evaluate jumpers' maximum run-up speed

KEYWORDS: long jump, run-up speed, performance level, estimation of the peak speed.

INTRODUCTION: In the long jump, the most important factor that determines jumping distance is the combination of the horizontal velocity developed in the run-up and the vertical velocity obtained during the take-off. In particular, since approach speed is significantly related to the official jumping distance compared with the vertical speed (Hay, 1986), jumpers have to enhance abilities to obtain higher approach speed as well as to evaluate their running speed to improve their performance. However, in daily training for long jumping, jumpers and coaches have been ambiguously evaluating the approach speed without crucial check points because there have been few attempts so far to analyze approach speed considering jumpers' performance levels.
Therefore, this study sought to obtain target values for the maximum run-up speed of the long jump based on performance level and to propose a method to easily estimate the maximum speed during the approach in daily training scenes.

METHODS: Subjects were 429 male and 536 female long jumpers who participated in athletic competitions held in Japan from in 2001 to 2009, including the IAAF World Championships in Athletics in Osaka 2007. Changes in displacement of jumpers during the run-up were recorded from their front side at 50 or 100 Hz with an apparatus using a laser beam (LAVEG Sport, JENOPTIK, Germany) placed at the top of the stadium.
Run-up speed was calculated by differentiating the displacement of the body by the sampling time and then smoothing the results with a Butterworth low-pass digital filter at a cut-off frequency of 0.5 Hz. The point at which a jumper reached the maximum run-up speed and the maximum speed at that point were extracted from the time series of the displacement and speed data. Analyzed jumping distances ranged from 6.79 to 8.57 m for men and from 5.30 to 7.03 m for women. Both male and female subjects were divided into seven groups for each 20 cm of the jumping distance, and run-up speed data were averaged for each group.
The equation to estimate the maximum run-up speed was derived in four steps. First, a point nearest to 20 m before the takeoff was derived from the displacement data measured by the LAVEG. Second, an interval average speed was calculated by dividing the distance between the extracted point and the takeoff board by the time to run that interval. Third, the interval time for the last 20 m was calculated using the derived interval average speed. Finally, a regression line was obtained from the relationship between the interval time for the last 20 m and the real maximum run-up speed.

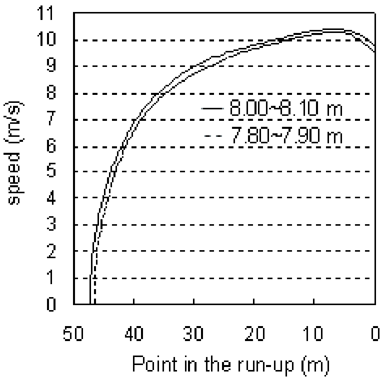

Figure 1: Average patterns of the run-up speed in two representative groups of jumping distance from 8.00 to 8.10 and from 7.80 to 7.90 m. Point of 0 m represent the point at the takeoff board.

RESULTS AND DISCUSSION: Figure 1 plots averaged patterns of the run-up speed in two representative groups of jumping distance (from 8.00 to 8.10 m and from 7.80 to 7.90 m). In all groups, jumpers accelerated sharply from the start of the run-up to about 30 m before the takeoff; after that, the speed increased almost constantly in the middle stage. Finally, the speed reached the maximum just before the takeoff. As illustrated in Figure 1, there were no remarkable differences in patterns of the speed change during the approach in all groups, but the maximum speed before the takeoff tended to differ in each group. Figure 2 plots changes in the average maximum run-up speed for each performance level. The mark "o" in each group indicates the maximum and minimum run-up speed.

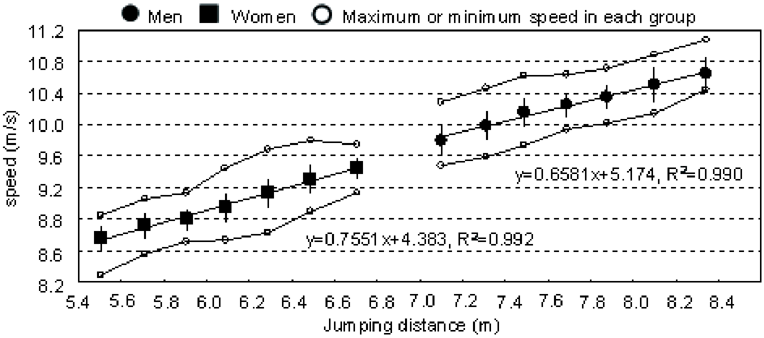

Figure 2: Changes in average of the maximum run-up speed for each performance level.

In addition to the traditional correlation analysis such as in the previous studies (Hay, 1986), we investigated the relationships between the speed and jumping distance by dividing jumpers into record-based groups. This investigation indicated that the higher performance groups certainly achieved higher average maximum speeds than the lower performance groups. More importantly, the maximum and minimum speeds within each group also tended to increase as the jumpers' performance increased. These results confirmed that the ability to develop a high sprinting speed in the run to the board could be an important factor for improving performance. Additionally, the results of Figure 1 could be used to evaluate the relationships between the speed and jumping distance. For example, all of 93 jumpers who were over 7.80 m achieved more than 10.0 m/s of the maximum run-up speed. Therefore, it is considered that jumpers who have less than 10.0 m/s of the maximum run-up speed would less likely to jump over 7.80 m. These indicated that run-up speed between the maximum and minimum values in each group could be the necessary speed to achieve each group's record, and we imply that the average values of maximum speed in each group should be the target value of the maximum run-up speed corresponding to jumpers' desired records, which means the necessary maximum speed during the run-up to break long jumpers' desired distances.

Figure 3 depicts the point at which the run-up speed reached the maximum for each performance level. There were no significant relationships between such points and jumping distances, and those points tended to appear at about 5 to 7 m before the takeoff. Koyama *et al*. (2010) reported that the sum of the stride lengths during the last three steps before the takeoff for male long jumpers was slightly shorter than 7 m. Therefore, our results indicated that the jumpers tended to increase their running speed up to the about second-last stride before the takeoff, similar to the results of the previous report of Hay (1993). In the last phase of the approach, jumpers visually control their stride pattern to guide themselves onto the board for the takeoff and decease the height of their centre of gravity for the transition from sprinting to jumping (Hay, 1994), and these preparations for the takeoff would slightly decrease the run-up speed. These facts and the lack of a significant relationship between the point at which the peak speed was reached and jumping distance suggested that the point of peak speed should be a parameter discussed with each jumper to improve his performance.

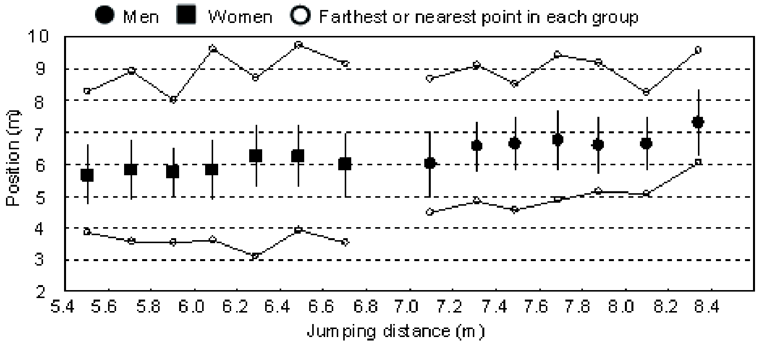

Figure 3: Point at which run-up speed reached the maximum for each performance level.

Figure 4 presents the relationship between interval time of 20 m before the takeoff and the maximum run-up speed. A significantly negative correlation was observed between that interval time and the peak run-up speed ($r=-0.984$, $p<0.001$, $y=-4.7936x+19.821$, $R^2=0.9676$, Equation 1). This significantly negative correlation indicated that a shorter interval time for 20 m before the takeoff is related to a greater peak run-up speed. Furthermore, a large coefficient of determination for the regression line relating the interval time and the peak speed suggested that the maximum run-up speed could be estimated by using the interval time of 20 m before the takeoff, as presented in Table 1, which lists the relationships between the interval time of 20 m before the takeoff and the maximum speed estimated by Equation 1. In daily long jump training, the interval time for 20 m before the takeoff can easily be measured by using a wireless timing system instead of the expensive apparatus with the laser beam. Therefore, this study suggested that jumpers and coaches could effectively train by combining the estimated maximum speed in Table 1 and the target maximum speed corresponding to the long jumping distance in Figure 2. However, we recognized limitations in this study. The analyzed records in Figure 4 ranged from 6.79 to 8.57 m of jumping distance. Therefore, the maximum run-up speed of jumpers outside these ranges might be estimate by extrapolation that uses the Equation 1, but the validity of the estimated speed is uncertain. Therefore, future study could expand the range of object records to apply to more wide-ranging jumpers.

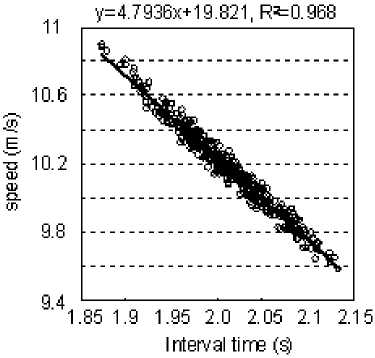

Figure 4: Relationship between interval time of 20 m before the takeoff and the maximum run-up speed.

Table 1
Examples of relationship between interval time of 20 m before the takeoff and estimated maximum speed (* interval time ranking from 1.91 s to 2.20 s)

Interval time (s)	2.20	2.19	2.18	2.17	2.16	2.15	2.14	2.13	2.12	2.11
Estimated maximum speed (m/s)	9.35	9.39	9.43	9.47	9.51	9.55	9.60	9.64	9.68	9.72
Interval time (s)	2.10	2.09	2.08	2.07	2.06	2.05	2.04	2.03	2.02	2.01
Estimated peak speed (m/s)	9.77	9.81	9.86	9.90	9.95	9.99	10.04	10.09	10.13	10.18
Interval time (s)	2.00	1.99	1.98	1.97	1.96	1.95	1.94	1.93	1.92	1.91
Estimated peak speed (m/s)	10.23	10.28	10.33	10.38	10.43	10.48	10.53	10.58	10.63	10.68

CONCLUSION: This study sought to quantify target maximum run-up speeds for the long jump based on performance level and to propose a method to easily estimate the maximum speed during the approach in daily training. The important results of this study are as follows; 1. Averages of the maximum run-up speeds for each 20 cm of jumping distance, ranging from 5.40 m to 8.40m, were obtained. These could be target speeds for jumpers' desired records; 2. A regression line to estimate the maximum run-up speed from the interval time for 20 m before the takeoff was obtained, and this will enable coaches to effectively evaluate jumpers' speed in daily training.

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