Optimal Distance of The Long Jump Approach Run Calculated Using Quadratic Regression Equation Approximation in Female College Students Attending A Physical Education Class

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ABSTRACT

OBJECTIVES This study aimed to examine whether the calculation-based distance (CBD) of approach run, which was obtained using quadratic regression equation approximation, was optimal for jump distance in running long jump in female college students attending a physical education activity class.

METHODS Forty-seven healthy female college students (17.2 ± 0.4 years) were included in the study. The CBDs were calculated by themselves using a graphing calculator as their learning activity. CBDs were based on four jump distances and approach-run distances (including self-selected distance [SSD]).

RESULTS There was no significant difference between maximal SSD (JD_{SSD}) and maximal CBD (JD_{CBD}). There was no significant difference between SSD and CBD. Moreover, on average, there was no significant difference between JD_{SSD} and JD_{CBD} . From the viewpoint of individual differences of delta in $JDCBD - JDSSD$, the association with the speed-effectiveness index (SEI), as one of the jump skill metric, was investigated. The correlation coefficient between SEI and delta in $JD_{CBD} - JD_{SSD}$ was not significant.

CONCLUSION In this study, female college students would determine SSD as much as theoretical optimal approach-run distance (CBD) derived by their own quadratic regression model in spite of their jump skill.

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Introduction

Running long jump is one of the jumping events that comprise approach-run, take-off, posture in the air, and landing. Jumpers should effectively utilize approach-run speed for longer jump performance, with the horizontal speed in approach-run as one of the crucial factors [1-5]. Determining the approach-run distance to acquire horizontal speed is an important factor in running long jump.

Generally, determining the approach-run distance depends

on the jumpers. However, there is no general guideline in determining the optimal distance of an approach run for long jump in female college students attending physical education (PE) activity class. Studies have reported the relationship between maximal speed in approach-run measured using high-end devices, such as high-speed cameras and motion analysis systems, and jump distance or take-off speed [6-8]. However, these devices have extremely complicated settings and are expensive. Moreover, students cannot obtain instant feedback in measurements accurately. Additionally, the guideline of estimating optimal distance by students themselves can be a good resource to improve students'

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motivations and their learning improvement.

Because the sprint speed decreases after the point of peak speed [9], to maximize the horizontal speed at take-off, a precise adjustment of approach-run distance is required. Matsui and Azuma [10] provided the guideline of determining the optimal approach-run distance derived from quadratic regression equation approximation between approach-run and jump distance in male college students. In contrast, there is an 18% apparent difference in the World Records of running long jump between male and female athletes (World Record, 8.95 m vs. 7.52 m [11]). A similar sex difference is also found in the Japan National Records (8.25 m vs. 6.86 m [15]). Nevertheless, the guideline in determining the optimal approach-run distance as mentioned above has not focused on female college students.

In this study, we aimed to examine whether the calculation-based distance (CBD) of an approach run for long jump, which was obtained using quadratic regression equation approximation using a commercial calculator by students as participants, was optimal for jump distance in female college students attending a PE activity class.

Methods

Participants

We enrolled 47 healthy female college students (age, 17.2 ± 0.4 years; height, 159.2 ± 5.9 cm; weight, 52.7 ± 6.3 kg) as participants. No participant had a case history or disorder that affected the trial of running long jump. This study was conducted as part of a PE activity class, and students were regarded as participants. A written informed consent was obtained from all participants after an adequate explanation of the purpose, procedure, and publication of the study. This study was approved by the Research Ethics Committee of the National Institute of Technology (KOSEN), Fukui College (Permission number: 29-1, 30-1).

Procedure

Under guided instruction, participants performed approach-run, take-off, posture in the air, and landing before the trial. Then, they were instructed to perform the standing long jump into a sandpit and take-off with a spring board

during the initial trials. Based on the guidance that running speed is greatly important in long jump, the measurement of time for a 50-m sprint, which has been widely adopted as one of the physical fitness tests for running speed in Japan, was conducted in each participant during the same session (Day 1).

Participants performed the same activities on Day 1, and trials and jump distances on Days 2 and 3 were measured. Participants were instructed to jump as much as they could at different approach-run distances (5, 10, and 15 m). After the trial, maximal jump distances were measured at each approach-run distance. Then, the participants decided a self-selected distance (SSD) to achieve longer jump distances, and maximal jump distances at SSD (JD_{SSD}) were measured after the trial (Day 4). Therefore, four data sets (jump distances at different approach-runs: 5 m, 10 m, 15 m, and SSD) were performed and measured on Day 4. Furthermore, the students estimated their CBD using a quadratic regression equation described as

$$Y = aX^2 + bX + c,$$

where X is the approach-run distance and Y is the jump distance [10]. Initially, the coefficients $a < 0$, b , and c were determined using the measured approach-run distances and the corresponding jump distances for each student using a commercial graphing calculator (Texas Instruments, TI-Nspire CX). Then, the approach-run distance (X_{maxY}), which maximizes the jump distance, was regarded as their CBD. Furthermore, CBD derived by the participants using X_{maxY} was the expected estimated maximal jump distance. At the end of Day 4, jump distances that participants obtained with CBD (JD_{CBD}) were measured. This gradual order in 5 m, 10 m, 15 m, and SSD was consistent for all participants because of safety practice.

It was insufficient to fit a quadratic regression model using only four data sets. However, four approach-run distances, which were 5 m, 10 m, 15 m, and a SSD, were provided to the participants for the safety trial. These trials (four different approach-run distances) were completed by all participants. Therefore, we considered that the calculation of a quadratic model using four data sets would provide an educational

opportunity to determine participants' optimal approach-run distance.

Analysis

The data of 12 participants were excluded from the analysis because their convex is not above. The peak of quadratic regression curve (Y value) was regarded as the theoretical maximal jump distance. Therefore, the Y-coordinate of the curve peak (CP) was expressed as JD_{CP} . First, the comparison between SSD and CBD was conducted. Then, the comparison among JD_{SSD} , JD_{CBD} , and JD_{CP} was performed. Additionally, the differences (delta) in $JD_{CBD} - JD_{SSD}$ were calculated to determine the correlation with the speed-effectiveness index (SEI). Azuma and Matsui [12, 14] provided the SEI as the metric of utilizing sprint speed for jump distance, as defined in the following equation:

$$SEI = \frac{\text{Actual jump distance (m)}}{\text{Estimated jump distance (m)}}$$

The actual jump distance indicates the measured jump distance (JD_{SSD} or JD_{CBD} , whichever was longer). The estimated jump distance is calculated by substituting the participant's time for 50-m sprint into a linear regression equation between time for a 50-m sprint and jump distance (longer of either JD_{SSD} or JD_{CBD}), which was similar to that reported by Kubota [13]. In this study, the SEI was derived from all participants ($n = 47$).

Statistics

The mean SSD and CBD were compared using paired t-test. One-way ANOVA (repeated measures) was used for the comparison among JD_{SSD} , JD_{CBD} , and JD_{CP} . If the F-value was significant, Holm method was adapted as the post hoc test. Pearson's correlation coefficient and simple linear regression analyses were employed to determine the relationship between time for a 50-m sprint and jump distance and that between SEI and delta in $JD_{CBD} - JD_{SSD}$, respectively. A P-value < 0.05 indicated statistical significance.

Results

There was no significant difference between SSD and CBD (Figure 2). Moreover, one-way ANOVA revealed that there was a significant difference among jump distances ($F = 8.25$,

Figure 1. Graphing calculator with the display of a quadratic regression equation

Figure 2. Means and SDs of self-selected distance (SSD) and calculation-based approach-run distances (CBD)

Figure 3. Means and SDs of jump distance of SSD (JD_{SSD}), CBD (JD_{CBD}), and curve peak (JD_{CP})

$P < 0.05$). Furthermore, JD_{CP} was greater than both JD_{SSD} and JD_{CBD} . There was no significant difference between JD_{SSD} and JD_{CBD} (Figure 3).

Figure 4. Relationship between jump distance (y) and 50-m run time (x)

Figure 5. Relationship between the difference in $JD_{CBD} - JD_{SSD}$ (y) and SEI (x)

The relationship between time for a 50-m sprint and jump distance was negatively significant (Figure 4, $P < 0.05$). Additionally, Figure 5 shows the relationship between the difference in $JD_{CBD} - JD_{SSD}$ and SEI. The SEI varied from 0.72 to 1.23. There was no significant difference between SEI and delta in $JD_{CBD} - JD_{SSD}$.

Discussion

This study examined whether the CBD of approach-run, which was obtained using quadratic regression equation approximation, was optimal for jump distance in running long jump in female college students attending a PE activity class.

The SSD was not longer than the CBD, and there was no significant difference between JD_{SSD} and JD_{CBD} . Hence, CBD

did not seem to lead to the theoretical maximal jump distances (JD_{CP}) in female college students. Bridgett and Linthorne [8] reported that the individual relationship between approach-run speed and jump distance was not linear, but jump distance barely increased at maximal sprint speed. Thus, SSD and CBD were regarded to be both close to the maximal sprint speeds of individuals. For this reason, it was speculated that no significant difference would be found between them.

In male college students, Matsui and Azuma [10] reported that the difference between JD_{SSD} and JD_{CBD} was also not significant, but a significant negative relationship between SEI and the delta in $JD_{CBD} - JD_{SSD}$ was observed same not as female college students in this study. Thus, male college students whose sprint speeds were ineffectively used for their jump distances (SEI was below 1) were regarded to be poor at determining the self-selected approach-run distance. Moreover, their JD_{CBD} were greater than their JD_{SSD} . Furthermore, the range of delta of $JD_{CBD} - JD_{SSD}$ in female college students (-0.49 to 0.43) was smaller than that in male college students (-0.89 to 1.23 , according to Matsui and Azuma [10]). Hence, the variability of jump skills of female college students was considered smaller than that of male college students.

When students determine their own approach-run distances, individual sprint speed or take-off skill will be considered. According to the sprint speed-curve reported by Volkov and Lapin in 1979 [9], it was assumed that increasing approach-run distance will increase the approach-run speed. If CBDs are assumed to be adequate to achieve participants' maximal jumping distances, it is regarded that participants determine accurate approach-run distance for their best performance. When the convex of the regression equation was above, the peak (maximal Y) was the same as or more than the JD_{SSD} . Therefore, the difference between SSD and CBD determines the difference between JD_{CP} and JD_{SSD} . In contrast, JD_{CP} was greater than JD_{CBD} . Because CBD was not freely selected by participants, it might be difficult for participants to perform maximal jump. For this reason, they could not achieve JD_{CP} .

Meanwhile, Azuma and Matsui [12] reported that time for a 50-m sprint accounted for 29% of the variance of jump

distances in male college students. In female college students, Azuma and Matsui [14] indicated that time for a 50-m sprint accounted for 50% of the variance of jump distances in female college students (larger contribution of sprint ability to the jump distance than that in male college students). If an unaccountable proportion except for sprint ability is assumed to be a jump skill, this enables the strong correlation between the SEI and delta in $JD_{CBD} - JD_{SSD}$. The SEI was defined as the ratio between the actual jump distance and estimated jump distance derived by substituting the subject's time for a 50-m sprint into a linear regression equation correlating time for a 50-m sprint with an actual jump distance. Thus, the effect of the jump skill may be lesser in female students than in male students.

The findings of this study suggested that female college students would determine SSD as much as theoretical optimal approach-run distance (CBD) derived by their own quadratic regression model regardless of their jump skill. Lastly, in PE activity class, the practice of calculating the optimal approach-run distance using a graphing calculator is expected to help students develop their scientific learning through PE activities. Furthermore, while expecting to enhance students' motivation toward physical activities, the identification of the relationship between the derived data and students' introspection is considered a future agenda.

As a limitation of this study, it was difficult for students including novice to repeatedly perform the maximal jump distance measurements in several days of long jump classes. Additionally, using only four data sets might lead to inaccurate regression approximation because 12 participants did not obtain CBDs.

Conclusion

This study revealed that, in female college students attending PE activity class, the approach-run distance (CBD) in a running long jump estimated using quadratic regression approximation was not different from the SSD and their individual delta in $JD_{CBD} - JD_{SSD}$ was not significantly correlated with the SEI. Therefore, regardless of their jump skill, female college students would determine self-selected approach-run

distance as much as theoretical optimal approach-run distance derived by their own quadratic regression model.

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Conflicts of Interest

The authors declare no conflict of interest.

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