RESEARCH ON GENDER DIFFERENCES OF PREPARATIVE MOTION FOR TAKEOFF IN THE LONG JUMP

Yuya Murakami[1], Keizo Takahashi[2]

[1]Graduate School of Sport Study, Biwako Seikei Sport College, Shiga, Japan
[2]Department of Athletics, Biwako Seikei Sport College, Shiga, Japan

The purposes of this study were to compare the preparative motion between female and male long-jumpers whose records were approximately the same, and to obtain the characteristics of motion of female long-jumpers. The motion was the female athletes have a larger extension angles and angular velocities of the hip and knee joint in the preparative phase than the male athletes. This motion influences on a CG drop which is the most important role for the preparation for takeoff. Upper body motion of female athletes indicated a large tilting range of motion at the time of each foot touching down. In addition, these two motions led the deceleration of the approach velocity. Therefore, it is thought that to improve these two motions resulting in better results.

KEY WORDS: Leg motion, Upper body angle, Three-dimensional motion analysis

INTRODUCTION: Japanese female long jump records are lagging behind in world records. Therefore, it is urgent to raise the level of competitiveness of female's long jump. The long jump is an exercise divided into four phases of; approach, take off, the air and the landing (Hay, 1986). Although horizontal and vertical velocity has a strong correlation with the distance of long jump, the approach is very important to maximize speed. Hay et al. (1993) reported that the maximum speed of the approach appears before two or three steps from takeoff. Koyama et al. (2007) reported the characteristics of preparative motion of elite long-jumpers; smaller swing back angular velocity of thigh of the supporting leg, larger swing back angular velocity of shank of support leg, more front of the thigh of swing leg, and landing the foot below the body at the last step of the approach. In addition, elite female long-jumpers showed similar motion to male long-jumpers during the preparative phase (Muraki et al., 2003). Many studies focusing on elite female and male long-jumper's technique have been reported, althrough there were few studies that focused on non-elite long-jumper's technique. Panoutsakopoulos and Kollias (2007) showed that all the participants utilize the “longer penultimate-shorter last stride” ratio previously described for top-level performers, and their takeoff velocities and takeoff angle were lower than high-level performers. Moreover, there were no studies that compared the technique done by female and male long-jumpers whose records were approximately the same. Therefore, the purpose of this study were to compare the preparative motion between females and males whose records were approximately the same, and to obtain the characteristics of motion of female long-jumpers.

METHODS: Fourteen long-jumpers (seven females and seven males) were captured in competitions as subjects. The female subjects were seven university students and the male subjects included four high school students and three university students. The subjects had an average result of 6.02±0.10m and 6.01±0.34m, respectively. Two high-speed digital cameras (CASIO EXILIM EX-F1, JAPAN; 300fps) were positioned on the stadium stand with a tripod, and captured preparative motion for takeoff. Twenty-five points were digitized manually with Frame DIAS IV (DKH Co., Inc.) in every video field. Using the DLT method three-dimensional coordinate data was analyzed. The Butterworth digital filter was used to smooth the raw data using Winter's method (Winter, 1990), employing cutoff frequencies between 3.0 and 9.0 Hz depending on the marker that was being smoothed. The preparation was defined as the motion carried out from 6m to 1m in front of the takeoff board, and was divided into five phases by six events; (1) the third-last step touchdown (3L-TD, 0%), (2) the third-last step takeoff (3L-TO, 20%), (3) the second-last step touchdown (2L-TD, 40%), (4) the second-last step takeoff (2L-TO, 60%), (5) the last step touchdown (L-TD, 80%), and (6) the last step takeoff (L-TO, 100%). Approach velocity, stride-length, stride-frequency, hip, knee, ankle angle, angular velocity, and upper body angle were calculated and normalized by the time of each phase and averaged. The Student’s T-test was used to test differences between

female and male long-jumpers, with the significance level set at 0.05.

RESULT: As for the official record of the long jump, the female athletes recorded 5.77±0.10m and the male athletes recorded 5.84±0.21m. The achievement rate for each personal record was 95.8% for the female athletes, and 97.2% for the male athletes. Fig.1 shows the mean approach velocity of the analysis phase and the mean pitch. No significant differences were observed in the mean record, mean velocity and mean pitch. But the approach velocity of this study was the average velocity from the third-last step section to the last step section. Therefore, this study could not clearly measure the maximum velocity in the approach. Fig.2 shows the stride length of each step. A significant difference was observed in the third-last stride ($p<0.05$). The male's stride-length was short at the last step, but the female's stride-length was long near the takeoff. Fig.3 shows an angle and angular velocity of the hip joint (takeoff support-leg), and Fig.4 shows an angle and angular velocity of the knee joint (takeoff support-leg). The point when a significant difference between both groups occurred is indicated by the straight line at the top of these figures. The hip joint angle of females were larger than that of males at fifty percent - fifty-five percent. So the angular velocity of females were larger than that of males at fifty-five percent - seventy-five percent. Similarly, the knee angle and the knee angular velocity were large for females. Therefore the female athletes' leg motion pushed the ground backward at sixty percent. In addition the leg position was more backward than males. Fig.5 shows an upper body angle and there was no significant difference between two groups.

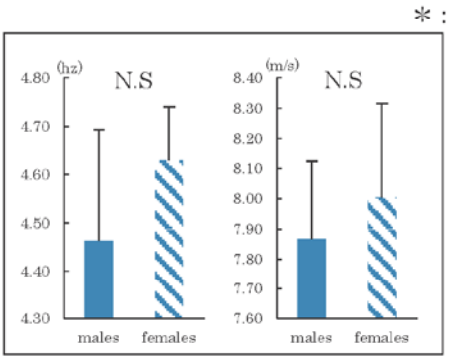

Fig.1 Stride-Frequency and velocity

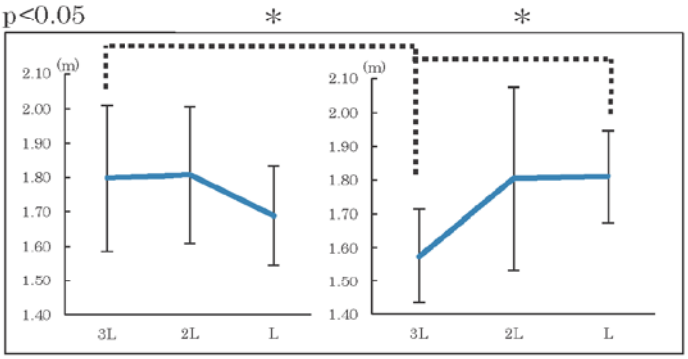

Fig.2 Stride-Length (Left: males, Right: females)

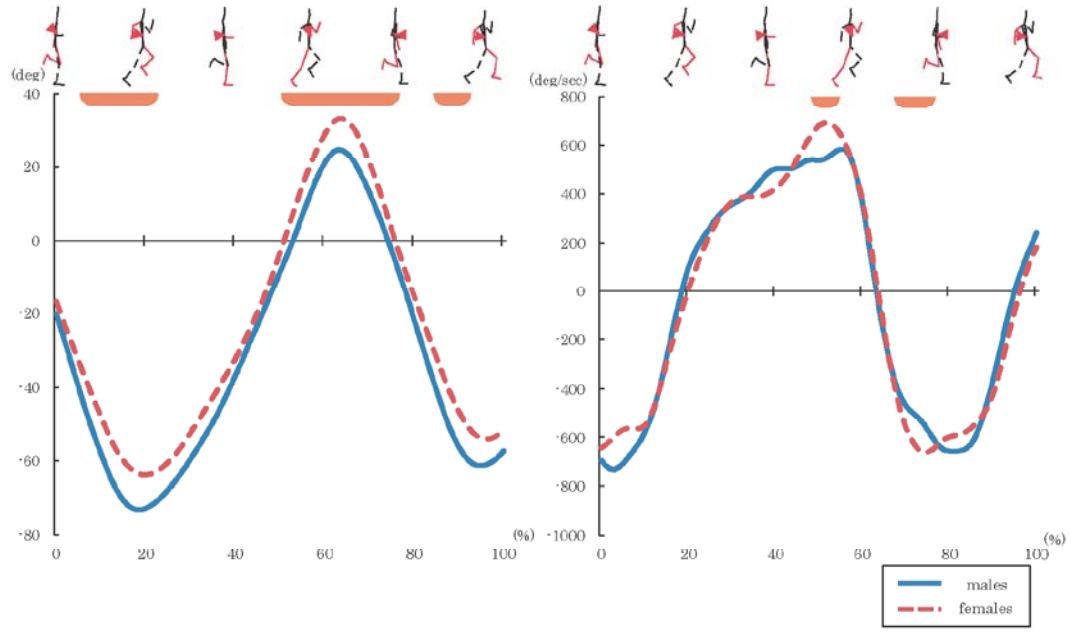

Fig.3 Hip joint angle and angular velocity for males and females (takeoff support-leg)

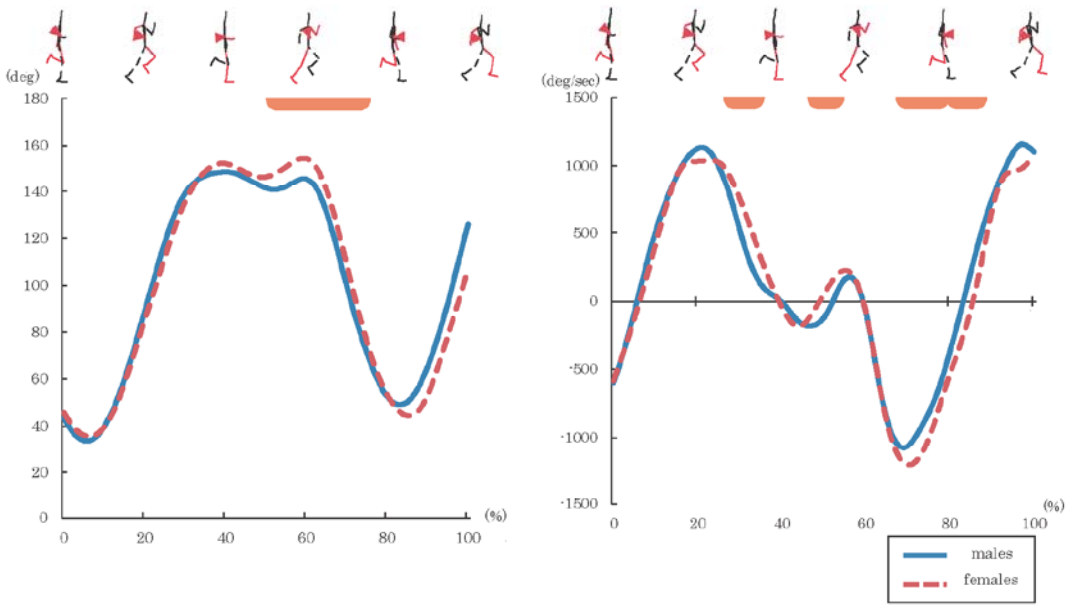

Fig.4 Knee joint angle and angular velocity for males and females (takeoff support-leg)

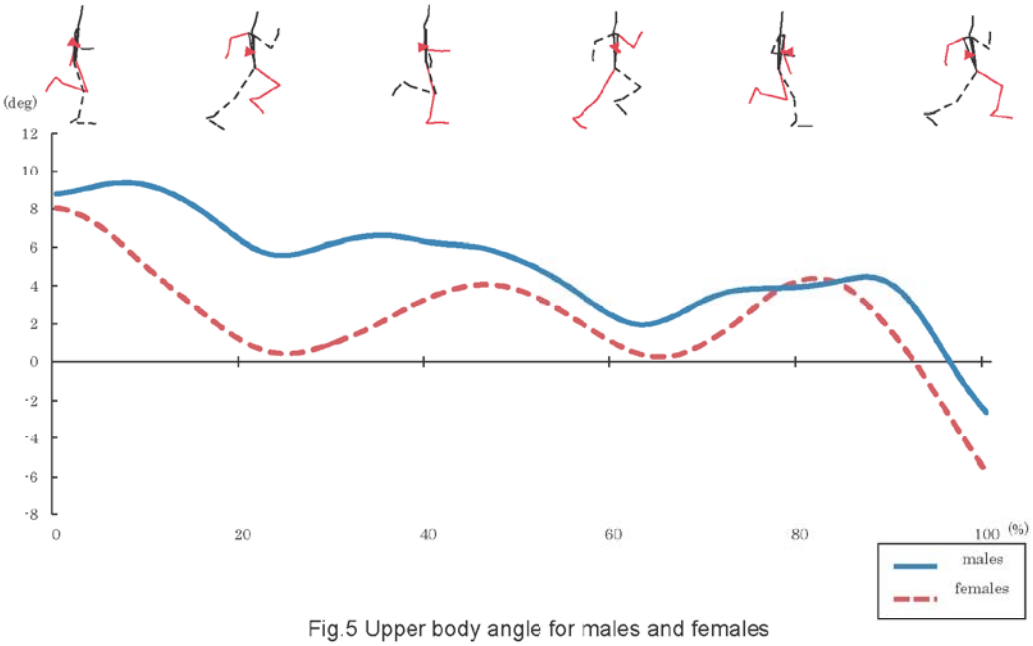

Fig.5 Upper body angle for males and females

DISCUSSION: In this study, no significant differences were observed in the mean record, mean velocity and mean pitch. Therefore, it could be said that to compare these subjects was reasonable to obtain the female motion characteristics. Stride-length, extension angle and angular velocity of hip and knee at touchdown showed significant differences between the two groups (Fig.2, 3, and 4). Panoutsakopoulos and Kollias (2007) reported that a pattern of "long - short" is used for the stride from the second-last stride to the last stride. Nilxdorf et al. (1983) reported that it is important to drop and keep the height of CG lower after touchdown at the second-last stride. In this study, female long-jumpers showed the larger extension angle of hip and knee joint at the preparative phase (Fig.3, 4). Therefore, it would be better for female long-jumpers not to over-extend their hip and knee joint in this phase. In addition, Ito et al.

(1998) reported that there is a negative correlation between the support extension angular displacement and the running velocity. Therefore the female athlete's leg motion of this study might lead to an approach deceleration.
Fig.5 shows an upper body angle, and there was no significant difference between the two groups. Change of this angle was less than 10 degrees, but female athletes were consistently backward tilting until the last-stride touchdown. This shows that female athletes had a large tilting range of motion at the time of each touching down. Ae et al. (1999) reported that the deceleration of the approach velocity is due to the upper body tilting backwards early. It can be inferred that the female athletes of this study showed that deceleration of the approach velocity was greater. It is thought that it may lead to improvement of long jump records by improving these motions.

CONCLUSION: As a result of this study, the female athletes can infer leg motion of the preparative phase for takeoff and the motion of the upper body compared to the male athletes when deceleration of the approach velocity has a greater motion. In addition, it became clear that a greater variable motion obstructs motion to drop the CG. It can be said that from these results further official record improvement of the female athletes could be expected by improving leg motion and upper body operation of this phase.

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