# KINEMATICAL ANALYSIS OF THE PREPARATORY AND TAKEOFF MOTION IN THE LONG JUMP

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## INTRODUCTION

Approach velocity is one of the most important factors in the long jump. However, it is difficult for a jumper to prepare for the takeoff with a minimum loss of approach velocity. The purposes of this study were to investigate motion variability of the preparatory and takeoff motions for skilled long jumpers and to compare their motions between different approach velocity groups.

## METHODS

The last two steps of the approach and takeoff motions of thirty-three skilled male long jumpers (height, 1.79 ± 0.06 m; body mass, 69.9 ± 6.9 kg; and effective jump distance, 7.78 ± 0.31 m) were videotaped with two high-speed VTR cameras (250 Hz) during official competitions. Two-dimensional coordinates were used to calculate linear and angular kinematics of joints and segments and the location of the center of gravity (CG). The VTR images were collected by the Scientific Committee of Japan Association of Athletics Federations.

The preparatory and takeoff motions were divided into three support and two flight phases. Coordinate data were normalized by the body height and the duration of each phase and averaged [1]. Since the takeoff time was set at 100%, the support and flight time of the last two and last steps were 76, 91, 111 and 62%. Coefficients of variation (CV) of the angles of the shank, thigh and torso were determined by the following equation.

$$CV = \frac{SD}{|Mean + 360|} \times 100$$

Subjects were divided into two groups by the horizontal CG velocity at the touchdown of the takeoff phase, i.e. fast group (FG: n=14; height, 1.82 ± 0.07 m; body mass, 71.7 ± 9.1 kg; effective jump distance, 8.01 ± 0.30 m) and slow group (SG: n=19; height, 1.78 ± 0.05 m; body mass, 68.47 ± 4.7 kg; effective jump distance, 7.61 ± 0.19 m). Student's t-test was used to test significant differences between FG and SG for the angles of the shank, thigh and torso. The significance level was set at $p<0.05$.

## RESULTS AND DISCUSSION

The horizontal CG velocity at the touchdown of the FG, 10.38 ± 0.15 m/s, was significantly larger than that of the SG, 9.91 ± 0.12 m/s ($p<0.001$). The FG kept significantly larger horizontal CG velocity than the SG at all instants of all phases ($p<0.01$).

Figure 1 shows changes in coefficients of variation of the shank, thigh and torso angles during the preparatory and takeoff phases. The takeoff leg was identical to the support leg during the second last step. The CV of the segment angles of the leg during the support phase was small. In the flight phase, the CV of segment angles of the swing leg increased during forward swing and decreased during backward swing before the touchdown. These results indicated that all the subjects moved the support leg in a consistent manner during the support phase but they swung the free leg in more various manner.

Figure 2 shows changes in the torso angle of the FG and SG during the preparatory and takeoff phases. The significant differences were found between the FG and SG only in the torso angle around the touchdown of the last support, which indicated that the FG inclined the torso more forward than the SG. Although the horizontal CG velocity of the FG was larger than that of the SG, there was no significant difference in the decrease of the horizontal CG velocity during the support phase of the last step. These results indicated that a jumper with the torso tilted forward slightly before the touchdown of the last step may minimize the loss of the horizontal CG velocity during the preparatory phase.

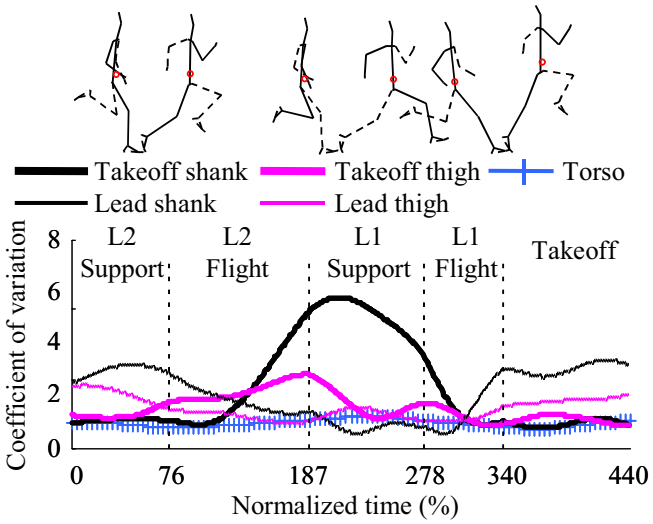


**Figure 1** averaged changes in coefficients of variation of the shank, thigh and torso angles from the last two step (L2 and L1) to the toeoff. Stick pictures showed the averaged preparatory and takeoff motions of all the subjects

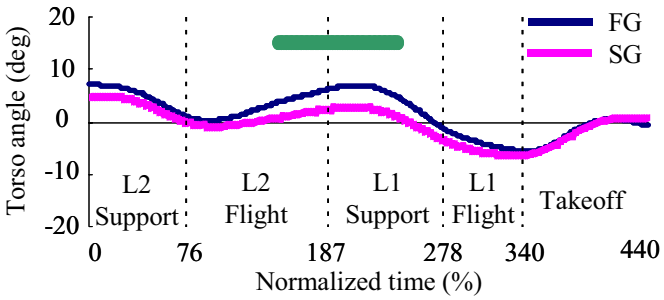


**Figure 2** averaged changes in the torso angles of the FG and SG from the last two step (L2 and L1) to the takeoff. Positive value indicated that torso tilted forward. Horizontal bar above the curves showed significant difference between FG and SG ($p<0.05$)