FEATURES OF TAKEOFF PHASE IN LONG JUMPS WITH VARIOUS RUN-UP LENGTHS

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The aim of the present study was to compare the kinematic characteristics of jumper's movements in long jumps with short, middle and extended run-ups. For this purpose three male and four female jumpers performed two three strides, eight strides and twelve strides run-up long jumps. All trials were captured on high-speed video. The results of the 2D analysis indicated that ground contact time and takeoff angle were significantly larger when the run-up was short. Also, the distance from the center of gravity to the heel in the horizontal plane and the knee angle at touchdown, as well as the maximum knee flexion of the takeoff leg during takeoff, were significantly smaller when the run-up was short. The heights of the center of gravity at touchdown and takeoff were constant in long jumps with various run-up lengths.

KEYWORDS: center of gravity, ground contact time, takeoff velocity, takeoff angle.

INTRODUCTION: Many coaches and scientists recommend long jumps from incomplete run-ups as exercises to improve the takeoff technique (Carr, 1999; Swope, 2008 and others). Using short run-ups in training allows jumpers to perform more jumps within one session and to focus their attention on the takeoff phase. At the same time, the majority of researchers investigated full run-up long jump technique (Conceicao et al., 1996; Koyama et al., 2008 and others). These investigations provide the information on run-up and takeoff velocity, the angle of the athlete's center of gravity (CG), and joints angles; help to evaluate the importance of these characteristics for achieving the best results in long jumps with full run-ups. Yet, it is possible to assume that takeoff techniques in long jumps from various run-up lengths might have significant differences. However, the character of athlete's movements in long jumps from incomplete run-ups has not been sufficiently studied so far. So, the aim of this study was to compare the kinematic characteristics of three-stride, eight-stride and twelve-stride long jumps.

METHOD: Three male (height 1.89 ± 0.02 m, body mass 83.7 ± 3.5 kg, age 20.5 ± 0.7 years, personal best 7.08 ± 0.17 m) and four female (height 1.73 ± 0.08 m, body mass 60.0 ± 5.9 kg, age 21.0 ± 2.8 years, personal best 5,66 ± 0,15 m) long jumpers took part in the investigation. After standard warming-up, each of the jumpers performed two trials of three-stride, eight-stride, and twelve-stride run-up jumping. All jumps were performed at maximum physical effort. The kinematic characteristics of the best attempts (jump length measured from the toe of the takeoff foot) in every style of jumping were taken into consideration.
Videotaping was done with high speed digital camera Casio EX-ZR700 operating at 240 Hz; SkillSpector (Version 1.3.2) software was used for 2D video analysis. "Full Body" model with 20 points was used for measuring the kinematic characteristics of movements. The recording was done in the sagittal plane. The optical axis of the camera was aligned with the takeoff line. The following measurements were taken: center of gravity (CG) height at touchdown and at takeoff; takeoff velocity; horizontal and vertical takeoff velocities; takeoff angle; knee angle at touchdown and knee flexion during support phase (knee angle at touchdown minus minimal knee angle during support phase); CG to heel distance at touchdown; ground contact time (GCT) (Figure 1).
Data smoothing was done with the help of quintic spline filter. One-way analysis of variance (ANOVA) was used to evaluate the significance of differences between kinematic data of long jumps from various lengths run-up.

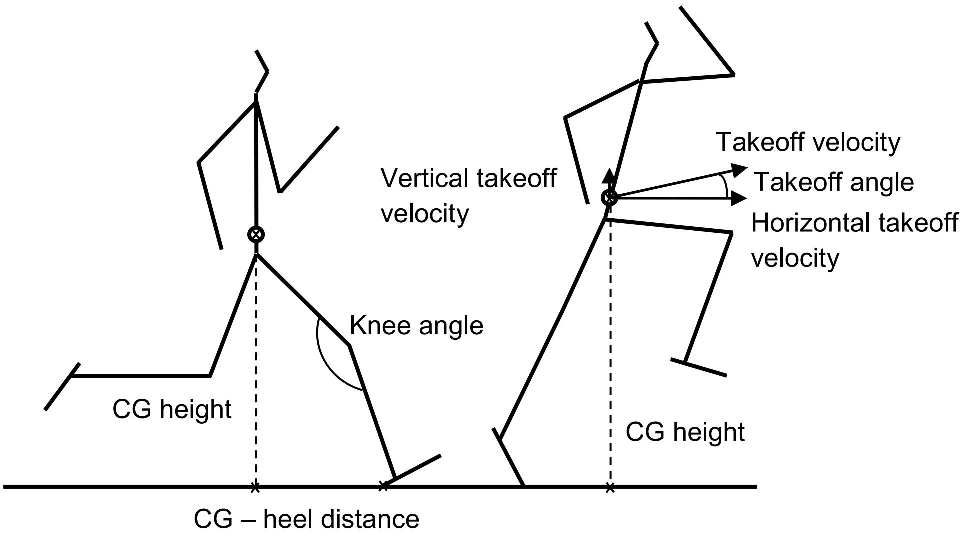

Figure 1: Variables defined in the research.

RESULTS: According to the analysis of the data from Table 1, takeoff velocity (p < 0.001) and its horizontal component (p < 0.001) significantly decreased in long jump from short and middle run-ups, but vertical takeoff velocity didn't change in various types of long jump (p > 0.05). The significant decrease in the takeoff velocity in long jumps from short and middle run-ups proved to be the reason for considerable changes in takeoff techniques. Takeoff angle significantly increased (p < 0.01) from twelve-stride to three-stride run-up jumps. Also, ground contact time significantly increased in long jumps with short and middle run-ups (p < 0.001). CG to heel distance (p < 0.01) at touchdown, knee angle at touchdown (p < 0.001), and knee flexion during takeoff (p < 0.05) were significantly smaller in long jumps with shorter run-ups. CG height at touchdown and takeoff had only insignificant differences between long jumps with various run-up lengths (p > 0.05).

Table 1
Kinematic data (Mean ± S.D.) of long jumps from three, eight and twelve running strides.

Kinematics data	3 strides	8 strides	12 strides	F (p value)
Long jump distance (m)	4.11 ± 0.58	5.25 ± 0.78	5.57 ± 0.71	8.51 (< 0.01)
Takeoff velocity (m/s)	5.40 ± 0.81	6.81 ± 0.63	7.35 ± 0.91	11.33 (< 0.001)
Horizontal velocity (m/s)	4.83 ± 0.84	6.21 ± 0.73	6.96 ± 0.84	12.59 (< 0.001)
Vertical velocity (m/s)	2.37 ± 0.35	2.74 ± 0.50	2.26 ± 0.85	1.22 (> 0.05)
CG – heel distance (m)	0.335 ± 0.045	0.427 ± 0.050	0.414 ± 0.054	7.09 (< 0.01)
Touchdown CG height (m)	0.916 ± 0.063	0.935 ± 0.071	0.945 ± 0.080	0.30 (> 0.05)
Takeoff CG height (m)	1.196 ± 0.082	1.193 ± 0.079	1.177 ± 0.090	0.09 (> 0.05)
Knee angle (°)	150.9 ± 5.5	162.8 ± 2.7	164.8 ± 3.5	23.97 (< 0.001)
Knee flexion (°)	19.3 ± 5.3	30.1 ± 7.4	30.7 ± 7.7	5.96 (< 0.05)
GCT (s)	0.187 ± 0.018	0.155 ± 0.007	0.145 ± 0.008	22.38 (< 0.001)
Takeoff angle (°)	26.7 ± 3.8	23.1 ± 2.6	19.7 ± 3.7	7.36 (< 0.01)

DISCUSSION: Long jump technique includes the approach run, the last two strides, takeoff, action in the air, and landing. During the last two strides, the structure of the movement changes and the jumper prepares for takeoff. Finding the optimal length for the approach run is the important task for athletes of different levels (Kilani and Al-Rofu, 2005; Jacoby, 2009). However, incomplete run-ups are often used in long jump training (Carr, 1999; Jacoby, 2009 and other). It gives the possibility to increase the number of jumps in one drill for takeoff technique improving. Incomplete run-up naturally leads to the decrease of horizontal velocity of CG and increase of the optimal takeoff angle (when the horizontal range is maximum),

according to mechanical and biomechanical laws (Hay, 1993). Thus, Linthorne et al. (2002) showed that long jumpers have larger takeoff angle when takeoff velocity is smaller.
The present study has shown that in long jumps from incomplete run-ups not only do takeoff velocity and takeoff angle change, but so do many other characteristics of the takeoff technique. In a long jump from a three-stride run-up, the jumper puts their foot closer to the projection of the CG on the horizontal plane to create a larger takeoff angle, while their knee angle is smaller than in long jumps from eight- and twelve-stride run-ups (Figure 2).

Figure 2: Jumper's position at touchdown in three-stride (left) and twelve-stride (right) run-up long jumps.

The significantly specific position of jumper's body segments at takeoff in long jumps from short run-ups can be caused by the need to accelerate in the horizontal plane as well; while in full-length run-up jumps, the acceleration is smaller during the last strides (Jacoby, 2009). There are fewer kinematic differences between the long jumps from eight strides and twelve strides run-up; however, differences of ground contact time and takeoff angle are rather great.
The results of the present study are indirectly confirmed by the data of Aoyama et al. (1996) who established that in the horizontal direction the proportion of the contribution of all body segments was the same in slow, medium and fast jumps, while in the vertical direction, when the approach velocity increased, the takeoff motion changed from "depending-on-the-takeoff-leg" type to "using-other-body-segments" type.
Significant differences in takeoff technique for eight-stride and, especially, three-stride long jumps, revealed by the present study, limit the use of these exercises for training athletes at pre-competition stages. On the other hand, long jumps with short run-ups can be considered as exercises to increase the takeoff angle of those athletes who still do not have the optimal one.

CONCLUSION: The results of the study give the reasons to claim that the techniques of long jumps with short, middle and extended run-ups have significant differences. The decrease of horizontal velocity in long jumps with short run-ups causes the increase of the takeoff angle. To create a larger takeoff angle, jumpers have to significantly change their takeoff techniques. These features of the long jump technique should be taken into account when training long jumpers.

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