The Ground Reaction Force of Standing Triple Long Jump

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Abstract: The purpose of this study was to investigate the characteristics of ground reaction force (GRF) for standing triple long jump with the quantitative analysis of force platform in biomechanics, and also to compare the differences of GRF and impulse among jump movements and standing long jump. Thirteen high school athletes participated for this study. Six Kistler force platforms (9260AA6, 1000 Hz) were used to record the GRF data during the participant performed the movements of standing long jump and standing triple long jump. The results showed that the every jump distance of standing triple long jump was only the 0.92-0.95 times as the maximal standing long jump. The performance of the 3rd jump was less consistent, because of the continuous jump movement of task constraint and the larger impact force (4.49 ± 1.53 BW) during landing.

1 OBJECTIVES

During walking or jogging, the person will perform the movements in the appropriate or optimal stride length to adapt the requirements of task or/and environment. The characteristic of maximum movement following a maximum movement is an issue of this study. The movement pattern of walking or running shows that the main extensors of lower extremity will be lengthened to decrease the downward trend during the initial stage of landing, and the main extensors will shorten immediately to accelerate the body upward to takeoff.

The standing triple long jump is one of event of entrance examination of sport related department in Taiwan. Unlike the submaximal movement of supporting training, such as double-leg hop progression, alternate leg bound, etc., the standing triple long jump is asked to reach the maximal displacement in two continuous horizontal jumps following standing long jump. But will the continuous long jumps following utmost standing long jump be affected by the larger impact force or the instable movement? The purpose of this study is therefore to investigate the characteristics of ground reaction force (GRF) for standing triple long jump through the quantitative analysis of force platform, and to compare the differences of GRF and impulse among jump movements and standing long jump.

2 METHODS

Thirteen male high school athletes (17.3 ± 0.7 years, 1.71 ± 0.06 cm, 67.7 ± 11.5 kg, mean ± SD) participated in this study. They were training regularly without history of lower extremity injuries. The testing procedures were explained to each participant. All participants signed an informed consent form approved by the Ethical Advisory Committee of Tsaotun Psychiatric Center, Ministry of Health and Welfare of Taiwan (IRB No: 104022) before the start of testing.

Participants were instructed to perform standing long jump and standing triple long jump. Two successful trials were recorded at each movement. GRFs were acquired at 1000 Hz using six Kistler force platfroms (9260AA6) with 64 channels data acquisition system (5695B) for every jump. The detail of the set-up of force platforms are shown as figure 1.

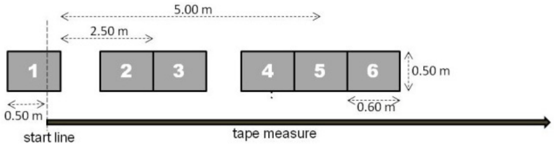

Figure 1: Schematic drawings of the set-up of six force platforms.

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Table 1: Means, standard deviation, and analysis of variance (ANOVA) results for effects of standing triple long jump and standing long jump (SLJ) on kinematical and GRF variables.

Variable	1st	2nd	3rd	SLJ	F(3, 36)	η^2	Tukey's test
Distance (m)	2.61 (0.22)	2.62 (0.29)	2.71 (0.28)	2.85 (0.30)	3.26*	.214	SLJ > 1st, 2nd
Takeoff V_x (m/s)	3.28 (0.13)	3.54 (0.31)	3.81 (0.20)	3.36 (0.17)	23.52*	.662	3rd > 2nd > 1st, SLJ
Takeoff V_y (m/s)	1.75 (0.19)	2.18 (0.27)	2.04 (0.32)	1.83 (0.28)	10.25*	.461	2nd > 1st, SLJ; 3rd > 1st
Angle of takeoff (deg)	28.08 (3.08)	31.68 (3.76)	28.01 (3.84)	28.53 (3.62)	5.08*	.298	2nd > 1st, 3rd, SLJ
Peak active GRF_x (N)	778.7 (140.3)	611.6 (130.5)	615.9 (91.7)	789.3 (146.7)	48.46*	.802	1st, SLJ > 2nd, 3rd
Peak active GRF_y (N)	1431.7 (301.2)	2159.3 (391.2)	2137.7 (556.1)	1427.5 (311.5)	49.41*	.805	2nd, 3rd > 1st, SLJ

*p < .05. Note: x - horizontal, y – vertical

The first and the second landing positions of standing triple long jump were estimated by the center of pressure of force platforms. The total distance of standing triple long jump was decided by the center of pressure of force platform 1 plus the distance from tape measure. The distance of standing long jump was quantified from the distance of the center of pressure of force platform 1 and the center of pressure of force platform 2-3. The vertical and horizontal center of mass velocities were estimated using the impulse method.

Repeated measures one way ANOVA with Tukey's post-hoc test were applied to examine the differences in the kinetics and kinematics data between jumps and landings ($\alpha = .05$).

3 RESULTS

The analysis of reliability across trials showed the distances of the first jump, the second jump, the third jump, and the standing long jump were ICC = .766, .628, .373, and .876, respectively. The ICCs across trials of peak active vertical GRFs for each jump were .889-.991, but the ICCs of peak active horizontal GRFs for the first jump, the second jump, the third jump, and the standing long jump were .970, .884, .726, and .991, respectively.

There were significant differences in the jump distances, $F(3, 36) = 3.26$, $p = .032$, $\eta^2 = .214$. The Tukey's post-hoc test showed the SLJ was longer than the first and second jump of standing triple long jump (table 1). The results of takeoff velocity showed that the angle of takeoff at the second jump was the greatest, $F(3, 36) = 5.08$, $p = .005$, $\eta^2 = .298$. The statistical results of biomechanical parameters are showed as Table 1.

4 DISCUSSION

The analysis of reliability showed the distances of two jump trials of SLJ and the first jump of standing triple long jump were consistency highly. But the jump distance of consistencies were reduced during the second and the third jumps of standing triple long jump. It indicated that the standing triple long jump is asked the utmost jumping movement following two feet landing. The performer had to adapt the landing impact following the process of quite long flight, and it increased the variability of movement to perform the takeoff movement continually.

The distance of each jump of standing triple long jump was 92-95% of the maximal SLJ. Although the statistical analysis showed that the first and second jumps were less than SLJ, and the distances of three jumps were no differences. These indicated that the most performers did not jump longer than the maximal SLJ during every jump of standing triple long jump. The initial impact peak in vertical GRFs were 3.47 BW and 4.49 BW at the second (the first landing) and third (the second landing) jumps, respectively. Such higher load of impact force could inhibit the mechanism of pre-stretch for leg extensors; as a result, it explained the cause that the consistency was decreased during the second and third jump of standing triple long jump.

In conclusion, the results showed that the every jump distance of standing triple long jump was only the 0.92-0.95 times as the maximal standing long jump. The performance of the third jump was less consistent, because the continuous jump movement of task constraint and the larger impact force during landing.

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