BIOMECHANICAL STUDY TO ASSESS THE VARIATIONS BETWEEN MALE AND FEMALE IN LONG JUMP

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Original scientific paper

Abstract
The purpose of this study is assessment the variations between male and female in long jump and determine the causes that led to the differences between male and female in long jump for improve the performance. Ten long jump players are high level athletes participated in this study (Five male and five female). They were the elite athletes in Egypt. The long jumps were performed on a two-dimensional analysis, marker position data were obtained by a high-speed camera (JVC GR – DVL 9800) at a frequency of 240 Hz, video point v 2.5 2D motion analysis for Biomechanical parameters, and statistically T-test for independent samples and Change Ratio were used to compare results for male and female. The results of biomechanical parameters between male and female ranged between (0.89% - 34.57%) in favor of male or female, male surpassed in velocity of free leg swing during takeoff phase, Selected a biomechanical parameters group influential in the long jump performance (pre- last stride resultant velocity, last stride resultant velocity, horizontal velocity at touch down, resultant velocity at touch down, resultant velocity of the free leg at touch down, horizontal velocity at takeoff, resultant velocity at takeoff, resultant velocity of the free leg at takeoff, total takeoff time, linear momentum at touch down, kinetic energy at touch down, linear momentum at takeoff, and kinetic energy at takeoff), and confirmed by the strong correlation between these parameters and long jump distance.

Key words: *Kinematic, Kinetic, Motion analysis, Track & Field.*

INTRODUCTION

The long jump is one of field competitions which is characterized by speed and strength, it's a singular movement has one objective and a clear end, and it contain a repetitive motion represented in the approaching phase, and the movement is the only one in the actual jump process and therefore the long jump competition is divided into: preparation phase (approaching), basic phase, and include takeoff and flight, it's the main part which leads to the target of the movement, and end Phase (landing).

The long jumping performance is determined primarily by the athlete's ability to attain a fast horizontal velocity at the end of the approach run (Lees et al., 1993). So the last two strides of the approach are crucial. More than 67% of the total adjustment to correct for prior errors in striding is made during the last two strides of the approach (Hay, 1988). Furthermore, elite long jumpers adjust their body position in order to prepare for take-off during the pre-last stride by increasing their stride length and thus lowering their BCM (body's center of mass) height (Hay and Nohara, 1990).

Therefore the approach velocity and the take-off technique are the most important for the long jump length (Luhtanen and Komi, 1979; Chow and Hay, 2005; Bridgett L. A. and Linthorne, 2006; Muraki et al., 2008). The takeoff phase is critical to the success of the entire performance. The total distance jumped can be divided into three sub distances: the takeoff distance, the flight distance and the landing distance (Hay and Reid, 1982). Each of these distances as well as the total distance jumped is greatly affected by the takeoff parameters. The takeoff distance is determined by the athlete's physique and body configuration at the instant of takeoff.

And observing the results of the female contestants found very big difference with the results of the male contestants, so the researcher did a pilot study to determine the differences between the results of male and female in the last four years (2010 - 2011 - 2012 - 2013) for the championships of the Republic of the long jump (local championship), and the World Championships, the results of the pilot study showed the big difference between male and female in the championship of the Republic. It was found that the difference between male and female in the world championships ranged between 17.32% to 20.81% over the last four years, while in the Republic Championships difference ranged between 25.2% to 46.61%, while the difference between male contestants in the Republic and the world championships ranged between 13.77% to 17.97%, while the female difference ranged between 22.25% to 39.15%, indicating a large gap in performance results between male and female in the Republic Championship more than between male and female in the world championships and also confirmed that the big difference between the results of female in local championships and results female in the world Championships, prompting the researcher to conduct this study to assess the variations between male and female in long jump and determine the causes that led to the big difference in the results between male and female in local championships for the treatment of these reasons, and improve the level of performance to the long jump contestants in the Arab Republic of Egypt.

METHODS

Participants

Ten long jump players are high level athletes participated in this study, five male (mass 70.60±13.30 kg, length 181.60±7.54 cm, and long jump distance 6.97±0.37), and five female (mass 58±2.74 kg, length 169.60±4.04 cm, and long jump distance 4.92±0.48. They were the elite athletes in Egypt, and participated in all competitions.

Procedures

The long jumps were performed on a two-dimensional analysis, marker position data were obtained by a high-speed camera (JVC GR – DVL 9800) at a frequency of 240 Hz, video point v 2.5 2D motion analysis for Biomechanical parameters.

Statistical analysis

For the statistical analysis of the data the IBM SPSS Statistics 21 was used. Descriptive statistics, Kolmogorov-Smirnov and Shapiro-Wilk tests were used to check data normality, and results showed that all parameters had a normal distribution. After that, T-test for independent samples and Change Ratio were used to compare results for male and female and the Pearson correlation to evaluate the relationships.

Table 1. Descriptive values (mean ± SD), and Variations (Change Ratio %), (t-test) between male and female in long jump Performance.

parameters	Units	Male		Female		Change ratio	t	Significance
		Mean	S.D	Mean	S.D	%		
2LS	**(m)**	2.15	0.35	1.96	0.24	9.69	1.03	*NS*
1LS	**(m)**	2.00	0.26	1.87	0.09	6.95	1.09	*NS*
$X_{TO}D$	**(m)**	0.99	0.08	0.98	0.04	1.02	0.36	*NS*
$H_{COM}TD$	**(m)**	0.86	0.10	0.90	0.08	-4.44	-0.72	*NS*
$H_{COM}TO$	**(m)**	1.11	0.09	1.12	0.10	-0.89	-0.03	*NS*
YD	**(m)**	0.25	0.05	0.21	0.04	19.05	1.45	*NS*
$2LSV_R$	**(m/s)**	9.84	0.96	8.05	0.56	22.24	3.60	0.01
$1LSV_R$	**(m/s)**	9.91	0.34	7.71	0.82	28.53	5.52	0.00
V_XTD	**(m/s)**	9.67	0.30	7.77	0.74	24.45	5.35	0.00
V_YTD	**(m/s)**	0.53	0.40	0.81	0.50	-34.57	-0.95	*NS*
V_RTD	**(m/s)**	9.69	0.31	7.82	0.73	23.91	5.31	0.00
Free leg	**(m/s)**	12.52	1.13	9.70	1.46	29.07	3.42	0.01
V_XTO	**(m/s)**	8.34	0.45	6.95	0.65	20.00	3.91	0.00
V_YTO	**(m/s)**	3.44	0.43	2.77	0.59	24.19	2.07	*NS*
V_RTO	**(m/s)**	9.03	0.32	7.49	0.77	20.56	4.16	0.00
Free leg	**(m/s)**	10.64	0.91	8.98	0.95	18.49	2.81	0.02
TTO	**(s)**	0.12	0.01	0.15	0.00	-20.00	-6.13	0.00
Θ_{FLIGHT}	**(º)**	23.00	2.92	21.30	3.27	7.98	0.87	*NS*
L_RTD	**(kg.m/s**	687.59	148.27	454.34	55.19	51.34	3.30	0.01
KETD	**(J)**	3350.74	814.76	1792.05	396.95	86.98	3.85	0.00
L_RTO	**(kg.m/s**	640.28	136.08	435.15	59.47	47.14	3.09	0.01
KETO	**(J)**	2905.83	689.41	1646.14	406.26	76.52	3.52	0.00

Legends*: 2LS - pre- last stride length; 1LS - last stride length; $X_{TO}D$ - horizontal takeoff distance; $H_{COM}TD$ - body center of mass height at touch down; $H_{COM}TO$ - body center of mass height at takeoff; YD - vertical displacement; $2LSV_R$ - pre-last stride resultant velocity; $1LSV_R$ - last stride resultant velocity; V_XTD - horizontal velocity at touch down; V_YTD - vertical velocity at touch down; V_RTD - resultant velocity at touch down; Free leg V_RTD - resultant velocity of the free leg at touch down; V_XTO - horizontal velocity at takeoff; V_YTO - vertical velocity at takeoff; V_RTO - resultant velocity at takeoff; Free leg V_RTO - resultant velocity of the free leg at takeoff; TTO - total takeoff time; Θ_{FLIGHT} - flight angle; L_RTD- linear momentum at touch down; KETD- kinetic energy at touch down; L_RTO - linear momentum at takeoff; KETO - kinetic energy at takeoff ; NS; Non-significant.*

RESULTS

In the biomechanical analysis of long jump performance for male and female, it was found that there are differences between the results of biomechanical parameters between male and female ranged between (0.89% - 34.57%) in favor of male or female and it was such parameters, differences among them is not significant (2LS-1LS-X_{TO}D-H_{COM}TD-H_{COM}TO-YD-V_YTD-V_YTO-Θ_{FLIGHT}), while the results showed significant differences in the parameters (2LSV_R-1LSV_R-V_XTD-V_RTD-Free leg V_RTD-V_XTO-Free leg V_RTO-V_RTO-TTO), and all the differences were in favor of male, and change ratio ranged between (18.49% -29.07%). The results in table 1 shows the descriptive values of Biomechanical parameters and variations between male and female in long jump.

DISCUSSION

The purpose of this study is assessment the variations between male and female in long jump, by observing the values of parameters with the significant of female, found that the average of resultant velocity is lowest in the velocity of the last stride, which means a decrease in the rate of velocity by 0.34 m / s , which is inconsistent with supposed to be achieved at the end of approaching, it is different from what came a study (Muller and Hommel, 1997), for the elite of the contestants and also what came to study (Panoutsakopoulos and Kollias, 2007) to the level of at least the elite , where rate increases the velocity of the pre-last stride to the last stride by 0.18 m / s , while the values of the significant parameters of male found that the average of resultant velocity is highest in the velocity of the last stride than the pre- last stride , and the change rate 28.53 % in favor of male (Hussain et al., 2011b), which is the largest in the velocity of the pre-last stride , which means an increase in velocity by 0.07 m / s and is consistent with (Muller and Hommel, 1997), And it means the importance of parameters of velocity for the last strides of approaching, and confirms this the strong correlation between them and the long jump distance at 0.01, which means that improving the velocity of approaching so contestant to reach the maximum velocity in the last two strides will contribute to the improvement of distance achievement for the female.

Table 1 shows that the significance between male and female in horizontal velocity at touch down, and the change ratio 24.45 % in favor of male (Panoutsakopouloset al., 2010; Haridi et al., 2012; Matić et al., 2012). And so on resultant velocity at touch down, and the change ratio 23.91 % in favor male. As well as the change ratio of horizontal velocity was 20% in favor of male, and the change ratio of resultant velocity at takeoff was 20.56 % in favor of male. And is what shows benefit male of velocities during the approaching (2LSV_R & 1LSV_R) to achieve a higher velocity during the takeoff (V_XTD- V_RTD & V_RTO ، V_XTO), which is confirmed by the correlation between the parameters of velocity (2LSV_R & V_XTD: 0. 797**, 2LSV_R & V_XTO: 0. 758*, 1LSV_R & V_XTD: 0.896**, 1LSV_R & V_XTO: 0. 751*, 2LSV_R & V_RTD: 0. 800**, 2LSV_R & V_RTO: 0. 764*, 1LSV_R & V_RTD: 0. 891**, and 1LSV_R & V_RTO: 0. 819**), (Hussain et al., 2011a; Haridi et al., 2012; Matić et al., 2012).

And the reason of loss in velocity on the takeoff board is that the changes in body position during preparation phase for takeoff, the center of body mass landing to achieve vertical linear acceleration at knee flexion of takeoff leg, lead to a reduction in velocity to achieve appropriate of vertical velocity for optimum takeoff angle.

Male used the free leg during the takeoff phase better than female, perhaps due to the strength of the muscles of legs in male than female, Which is confirmed by correlation between long jump distance & Free leg V_RTD: 0.822**, and long jump distance & Free leg V_RTO: 0.762*, which helped them to swing by full strength that lead to a high velocity of free leg. And male took advantage of the takeoff angle than female because the increase of horizontal velocity at takeoff, and breaking directly the contact of ground compared by female velocity (Panoutsakopoulos and Kollias, 2007; Muller and Hommel, 1997).

The average takeoff time for male and female reflects the extent of the ability possessed by male in the process of rapid strong extension in takeoff leg muscles during takeoff, where (Hay et al., 1986) explained that the best time to takeoff is ranged between 0.11 sec to 0.13 sec, and confirms that the negative correlation between long jump distance & TTO: -.882**, and probably due to the low velocity of a free leg and the velocity of the body's center of mass compared to male.

The results show superiority male in the parameters of the momentum at touch down and also the moment of takeoff and due to male superiority in velocity during those moments, which led to a quantity of movement better than females, and also of male superiority in the kinetic energy and in accordance with the principle of the work and energy, the occurrence of kinetic energy is the result of the work done. Therefore considered the momentum and kinetic energy parameters influential in the long jump performance, and confirms that the positive correlations between long jump distance & LRTD, KETD, LRTO, and KETO.

CONCLUSION

Decreasing average velocity of the pre-last stride to the last stride for female is the opposite of what should be, which requires treatment the loss of velocity by improved horizontal velocity and vertical velocity during breaking contact of ground and working to improve the velocity during approaching phase. Male surpassed in the velocity free leg swing during takeoff phase (TD, TO) and is what must be improved when the female. Select a biomechanical parameters group influential in the long jump performance ($2LSV_R$-$1LSV_R$- V_XTD- V_RTD- Free leg V_RTD- V_XTO- Free leg V_RTO -V_RTO- TTO, L_RTD, KETD, L_RTO, and KETO), and confirmed by the strong correlation between these parameters and long jump distance.

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Received: 27. May 2014

Accepted: 18. June 2014