KINEMATICAL PARAMETERS CONTRIBUTION TO THE FLIGHT HEIGHT USING ONE-FOOT OR TWO-FOOT TAKE-OFF

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The purpose of this study was to investigate which of the kinematics parameters most contribute to vertical flight heights. Eight subjects were filmed using Sony digital camera with 25 images from the sagittal plane during execution of the following vertical jump conditions: free two-foot take-off, free one-foot take-off, fixed arm two-foot take-off, and fixed arm one-foot take-off. Arm swing contribution, leg swing contribution, height of centre of gravity at take-off (HCGTO), vertical velocity at take-off, arm's angular momentum, work, and power were analyzed in each condition using stick figures according to Clauser, McConville, and Young (1969). Correlation and regression analysis indicated that HCGTO contributed the most to the flight heights in all conditions.

KEY WORDS: one-two-foot, vertical jump, kinematics.

INTRODUCTION: In vertical jumps, two components contribute to the power output: the amount of optimum impulse generated at take off and type of muscle contraction with related mass. So it is assumed that having more leg muscle mass would be associated with a better utilization of elastic component in the muscle and achievement of a higher jump height (Kilani et al., 1989). Thus, a two-foot take off should produce a higher vertical jump than a one-foot take off since the jumper carries the same body weight. Vint and Hinrichs (1996) quantified the differences between one- and two-foot vertical jumping performances and they reported greater flight heights during two-foot jumps, as expected, but the magnitude of this difference was only about 9 cm. One-foot jumps might benefit from an increased take off height which is largely attributable to the elevation of the free swinging leg. Factors associated with the development of muscular tension, such as vertical velocity at touchdown during eccentric contraction, height of center of gravity at take-off and horizontal approach velocity may account for the small differences in flight height between one-foot and two-foot jumping performances. The purpose of this current research was to test differences in heights of a vertical jumping performance using one-foot or two-foot take-off and to investigate which of the kinematics parameters are most contributing percent wise to vertical flight heights.

METHOD: Eight subjects with a mean height of 176.62 cm and a mean weight of 67.62 kg were intentionally selected from the physical education students at Sultan Qaboos University in Muscat, Oman (table 1). They were filmed using Sony digital camera (DCR-SX41/R/Max Shutter Speed 1/4000 sec) with 25 images from the sagittal plane during the executions of the following vertical jump conditions free two-foot take-off (FTFT), free one-foot take-off (FOFT), fixed arm two-foot take-off (FATFT), and fixed arm one-foot take-off (FAOFT).

Table 1 Subjects heights and weights

Parameters	Means	SD
Height cm	176.62	8.10
Weight kg	67.62	8.35

Before data collection, each subject signed a consent form and visited the lab once, several days before the measurement and was instructed how to perform each of the jumps. The starting position for the FTFT and FOFT jumps was standing upright with the arms down at the side. For the FATFT and FAOFT jumps, the subjects stood upright with their hands on their hips. The subjects performed each jump maximally 3 times and were given enough rest so that they didn't feel any fatigue from the previous jump conditions. No instructions were given with regard to the amount of knee bend a subject should have. Variables were analyzed manually from the flat Sony TV screen for the following independent variables in each condition using stick figures as noted by Clauser, McConville, and Young (1969): 1) Arm swing contribution (ASC) which is measured as a percent from the maximum height achieved without constraint relative to each condition; 2) leg swing contribution (LSC) which is measured as a percent from the maximum height achieved without constraint relative to each condition; 3) height of centre of gravity at take-off which is the distance measured from the instance of take off to the ground (HCGTO); 4) vertical velocity at take-off (VVTO) which is measured as the displacement between 2 images over time at the instance of take off; 5) arm's angular momentum (AAM) which is measured as the arm mass times the angular velocity of the shoulder flexion to the take off; 6) knee extension phase (KEP) which is the distance measured from the moment of maximum knee flexion to maximum knee extension prior the instance of take off; 7) work (W) which is calculated as body weight times the vertical distance measured from knee extension until the maximum height of CG; and 8) power (P) which is measured by the work out put over time. The dependent variable was the maximum flight height jump achieved in each condition and was measured as the distance between highest points reached of the CG to the ground. Correlations, comparisons, and regression analyses were conducted using SPSS software package version 15.

RESULTS: The means and standard deviations for the independent and dependent variables are presented in Table 2. The power and work output for FTFT and FOFT are also in Table 2. Arms and legs contributions to FTFT and FOFT jumps are displayed in Table 3.

Table 2. Means & standard deviations for FTFT and FOFT

Parameters	Maximum flight height(m)	HCGTO (m)	KEP (m)	VVTO (m/s)	AAM (Kg.Rad/S)	Work (kg.m)	Power (kg.m/s)
Mean	1.61	1.06	0.39	2.06	7.75	127.24	1485.1
Standard deviation	0.10	0.05	0.06	0.94	2.36	30.58	346.8

Table 3. The contribution in percentages for the arms and legs in jump conditions.

Jump conditions	Free jumps		Fixed Arm Jumps		Difference mean	Arm's Contribution %	Leg's Contribution %
	Mean	SD	Mean	SD			
Two-foot	1.16	0.68	1.11	0.068	0.05	4.31%	95.69%
One-foot	1.14	0.50	1.12	0.057	0.02	1.75%	98.25%

Table 4. The percentages of the parameters contributed the most to the flight height in the 3 conditions FOFT, FTFT, and FAOFT as it was derived from the linear regression equations

Jump positions	FOFT	FTFT	FAOFT	
Parameters	KEP (m)	HCG before takeoff	Vertical Distance during preparatory phase (M)	Work
Standard deviation	0.04	0.05	0.042	23.26
Constant	1.701	0.294	1.50	
Correlation Coefficient	2.132	0.284	2.522	0.0020
(F) value	**29.82	*50.245	**49.18	
Significance Level	0.002	0.000	0.001	
% Partial Contribution	٪ 83.2	٪89.3	٪75.6	٪75.6
% Cumulative Contribution	٪ 83.2	٪89.3	٪19.5	٪95.1

* F value in (P ≤0.05) = 5.79

** F value in (P ≤0.01) = 13.27

Table 4 illustrates the percentages parameters that contributed the most to the flight height in the 3 conditions FOFT, RTFT and FAOFT.

DISCUSSION: Results derived from the statistical manipulation showed that arms contributed greater flight heights in FTFT than FOFT. This result agrees with that of Holvoet, Lacouture, and Duboy (1999) where arm's swing contributed about 20% at vertical jump.The swinging free leg contributed in one-foot take-off for the height by increasing the CG elevation at take off. Consequently, it increased the momentum of the body in the vertical direction. Researchers referred this to the extreme dynamic range of swinging free leg which was achieved in FOFT and this case explains the results found by Caroline & Wooden I (2000). HCGTO contributed the most to the flight heights in all conditions. (F) Value for both parameters HCGTO & VVTO was significant at the level of (P ≤ 0.01). As it is shown in table 3, the small differences in the flight height between one-foot and two-foot jumping performances may be due to the swinging leg that affect CG elevation at take off with increased vertical velocity which counteracts the two-foot muscle force production against the same body weight carried (Vint & Hinrichs, 1996).

CONCLUSION: The powerful swings of arms, the high strength of hip joint with short downward motion (KEP) of CG are much more helpful to improve the flight jump height. It is recommended that training programs take into account the kinematics that contributes to the vertical jumps. In addition, it is helpful to practice with both feet and single foot jumping drills without the aid of swinging neither legs nor arms if muscular strength is needed. If power on the other hand is needed, swinging arms and free leg are crucial to maximize performances.

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