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ORIGINAL RESEARCH

ELEMENTS OF KINEMATICS SPECIFIC TO THE JUMP OF THE MALE TRIPLE JUMP EVENT

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Abstract: The quality of results obtained in competitions is based on the use of the most efficient technologies and conducting systems in the sportive training process, all embedded in operational strategies to enable the efficient filtering of the information exchange between coaches and athletes in order to ensure all the resources needed for an optimal monitoring and conveyance training process.

The purpose of this study was to examine the kinematic point of view the main technical aspects of specific proof of triple last step - the long jump. Research was conducted on athletes who specialize in this sample, and components of the National Olympic Lot Romanian Athletics Federation.

Using kinematic analysis software movement - Dartfish © I obtained a series of kinematic parameters (time, position, angles) discussed specific issues in research, processing and interpretation leading to the general conclusion according to which: kinematic analysis of the key features approach specific technical triple last step of the sample by use of IT leads to useful information specific to this test in monitoring technique

Key words: kinematics, jump, triple salt.

Introduction

The quality of the results obtained in competition sports has as a sustain element an interdisciplinary nd complete process through which every aspect of sportive training should be addressed at a higher level by implementing the most effective ways and means whose effects should determine the real expression of athletes' motor capacity at the right time.

According to Abernethy, B. (2008), reall knowledge of the aspects of the human movement is fundamental in terms of a variety of fields, which interact in order to provide the necessary support to achieve certain general and particular objectives: physical exercise and sport science, physical education, medicine, psychotherapy, occupational therapy, nursing, etc. After Gagea, (2010), „the advanced sciences are based on the most recent huge increasing of technology and on interdisciplinary commencement of great interest topics, as top sport is considering. The main problem in top sport seems to be the obtaining high sport's performance in as short as possible time, having great efficiency and minimum risks".

Foreign literature (Stergiou, 2008; Hamill, Haddad, McDdermott, 2000; Heiderscheit, BC, 2000) introduces methods for assessing the variability of human movement, applied theories of dynamical systems specific to motion analysis, advanced methods for data analysis specific to human movement. The methods used to obtain such information must satisfy the scientific requirements in terms of confidence and accuracy of the methodology for their application according to the aimed purposes and features of the athletes. (Schwameder, 2008).

Real-time motion analysis, on kinematic characteristics is an essential tool in monitoring sportive technique and involves the existence of an operational system through which the data that are acquired by using software technology, can be processed, interpreted and exploited for accurate description and awareness of the technical issues. (Payton, Bartlett, 2008)

Using information provided by specific kinematics parameters for the efficiency of the training process on the technical component is a prerequisite in promoting quality and efficiency in sportive training. (Mihailescu, Mihai Mihailescu, 2010)

Research hypothesis

1. I believe that by identifying kinematics specific elements, the features of the jump from the male triple jump event, I will perform a kinematic analysis of the key technical parameters of this athletic event.

2. I believe that, by analyzing the specific kinematic parameters of the jump from the male triple jump event, there can be to obtained information that can be used in objective monitoring and management of the training process in this event.

Research aim

The goal of this research is to analyze, from the kinematic point of view, the main technical issues of the jump characteristic of the male triple jump event.

Material and methods

Human resources contained in this research were the National and Olympic Team of the Romanian Athletics Federation, specialized in the triple jump event.

The research methods used in order to achieve this scientific approach were: documentation method, case study method, kinematic analysis method, statistic - math method (using the following statistical indicators: the arithmetic mean ($\overline{X}$) standard deviation (σ), coefficient of variability (Cv. %)), graphical method, table method.

The identification of the specific elements in the jump kinematics from the triple jump event and their analysis was performed using imaging and kinematic analysis of movement software - Dartfish © - the kinematic parameters being the following: *time*, general *location* of the center of body mass (BMC), the *angles* formed in hip-femoral and knee joints realized with the hit and swing lower limb, contact, hit and take-off angles. It should be noted that images that were at the basis of the kinematic analysis were purchased by three video cameras, all with the same resolution, and accuracy for each camera was 0.0083 m / pixel.

The kinematic data obtained from the measurements made during the last step of the triple jump event - the jump, referred to the technical issues coverage realized from the moment of contact with the ground in order to execute the hit until the landing preparation.

Results and interpretation

Following imaging and analysis of kinematics parameters previously mentioned we obtained statistically and graphically data presented in the following tables and graphs:

Table 1. Jump time (milliseconds)

Athletes	Analyzed phases during the jump	
	Hit	Flight
M.O.	160	540
A.A.	160	560
D.A.	160	560
Statistical indicators		
$\overline{X}$	160	553,33
σ	± 0	± 9,43
Cv. %	0	1,70

Table 1 shows that the *hit phase* recorded by all athletes during the jump has the same value, respectively 160 milliseconds, and the *flight* has the same values to two athletes included in the experiment, respectively 540 ms with 560 ms, with an average of 553.33 ms, standard deviation of ± 9.43 ms and a value of 1.70% for the coefficient of variability.

Data presented in Table 2 and illustrated in:

- Chart *1a* shows that the peak recorded value of BMC trajectory is 1.56 m, the difference between its position in the contact moment (1.06 m) and the peak flight is 0.50 m, with an average value of 1.08 m during the ground contact, and 1.44 m during the flight, standard deviation of 0.10 ± m, respectively ± 0.11 m and a value of the coefficient of variation of 8.84%, respectively 7.41 %;

- *Chart 1b* demonstrates that the recorded maximum height of BMC trajectory is 1.53 m, the difference between its position in the contact moment (1.10 m) and peak flight is 0.43 m, with a averaged value of 1.15 m during contact with the ground and 1.37 m during flight, standard deviation of ± 0.9 m, respectively ± 0.16 m and a value of the coefficient of variation of 7.73%, respectively 11. 41%;

Table 2. The position of the body mass center during the jump (m)

Athletes	Statistical indicators	Analyzed phases	
		Contact	**Hit - flyght**
M.O.	$\overline{X}$	1,08	1,44
	σ	± 0,10	± 0,11
	Cv.%	8,84	7,41
A.A.	$\overline{X}$	1,15	1,37
	σ	± 0,09	± 0,16
	Cv.%	7,73	11,41
D.A.	$\overline{X}$	1,02	1,41
	σ	± 0,08	± 0,10
	Cv.%	7,59	7,17

- *Chart 1 c* reveals that the recorded peak trajectory value of the BMC is 1.51 m, the difference between its position in the contact time (1.01 m) and the peak flight is 0.50 m with an average value of 1.02 m during contact during the ground contact and 1.41 m during the flight, ± standard deviation of 0.8 m, respectively ± 0.10 m and a value of the coefficient of variation of 7.59% and 7.17 %.

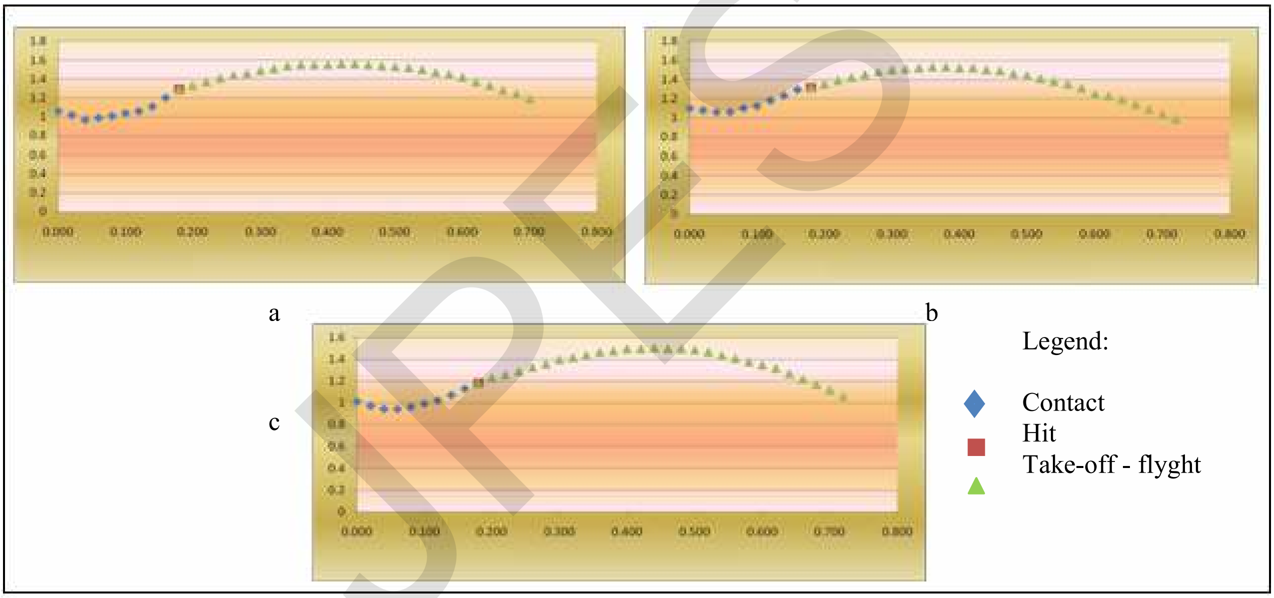

Chart 1. The trajectory of the B.M.C. during the jump: a – O. M.; b – A.A.; c – D.A.

Table 3 and Chart 2 shows that during the jump, after take-off, O.M. achieves the smallest value of knee joint angle (38.10^0) while the opposite is situated D.A. with a value of 116^0. The average value is placed on an upward trend from $104,23^0$ in the case of O.M. and stopping at $127,01^0$ in the case of D.A., with an intermediate value of 124.90^0 for A.A. Standard deviation have values falling between $\pm 46.40^0$ (O.M.) and $\pm 19.76^0$ (D.A.) and the coefficient of variation indicates values between 44. 51% (O.M.) and 15.56% (D.A.).

Table 3. The values of the statistical indicators concerning the knee joint angle (degree) – hit lower limb

Statistical indicators	Athletes		
	M.O.	**A.A.**	**D.A.**
$\overline{X}$	104,23	124,90	127,01
σ	± 46,40	± 35,71	± 19,76
Cv.%	44,51	28,59	15,56

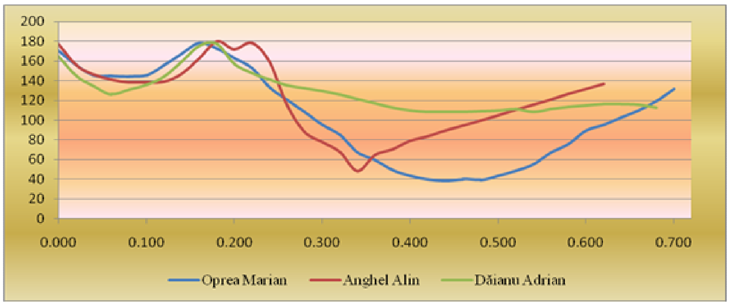

Chart 2. The dynamic of the knee joint angle value **- hit lower limb**

Table 4. The values of the statistical indicators concerning the hip-femoral joint angle (degree) – hit lower limb

Statistical indicators	Athletes		
	M.O.	**A.A.**	**D.A.**
$\overline{X}$	140,29	135,11	165,43
σ	± 40,40	± 47,32	± 13,02
Cv.%	28,80	35,02	7,87

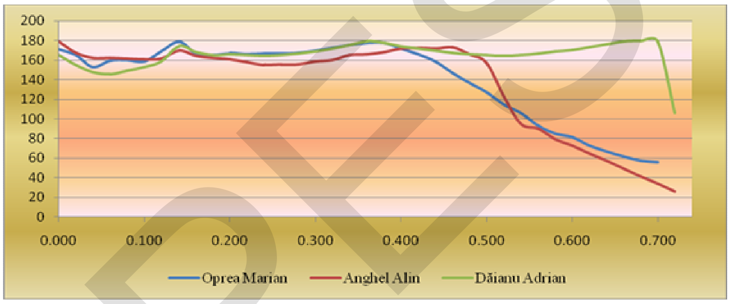

Chart 3. The dynamic of the hip-femoral joint angle value **– hit lower limb**

Table 4 and Chart 3 shows the mean of the angle formed in the hip-femoral joint of the hit lower limb, value that is between $135{,}11^0$ (in case of A.A.) and 165.43^0 (in case of D.A.). The standard deviation has values ranging from $\pm 13{,}02^0$ (in case of D.A.) tot $\pm$ 47.32^0 (in case of A.A.), respectively $\pm$ 40.40^0 (for O.M.). Variability coefficient has values between 7.87% (in case of D.A.) and 35.02% (in case of A.A.), with a percentage of 28.80% for O.M.

Table 5. The values of the statistical indicators concerning the knee joint angle (degree) – swing lower limb

Statistical indicators	Athletes		
	M.O.	**A.A.**	**D.A.**
$\overline{X}$	98,83	90,54	104,54
σ	± 9,45	± 16,85	± 22,66
Cv.%	9,56	18,61	21,67

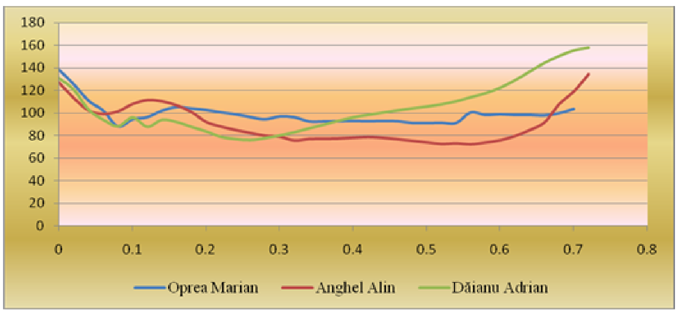

Chart 4. The dynamic of the knee joint angle value **- swing lower limb**

The data presented in table 5 and illustrated in chart 4 indicate that the values of angles made by O.M. and A.A. have a similar dynamic angle, after take-off, in terms of changes in value, with values between 92.3^0 and 134.5^0 (A.A.), respectively 102.6^0 and 103^0. (O.M.). The values achieved by D.A. have a greater value variation being placed between 87.6^0 and 157.9^0. In terms of specific mean values of this kinematic indicator, their dynamics are between $90{,}54^0$ (in case of A.A.) and $104{,}54^0$ (in case of D.A.) with an intermediate result of 98.83^0 for O.M. Regarding the standard deviation and coefficient of variability, they show the lowest values for O.M. (± 9.45^0, respectively 9.56%) and highest in case of D.A. (± 22.66^0, respectively 21.67%).

Table 6. The values of the statistical indicators concerning the hip-femoral joint angle (degree) – swing lower limb

Statistical indicators	Athletes		
	M.O.	**A.A.**	**D.A.**
$\overline{X}$	104,81	125,46	121,61
σ	± 26,48	± 18,20	± 19,02
Cv.%	25,27	14,50	15,64

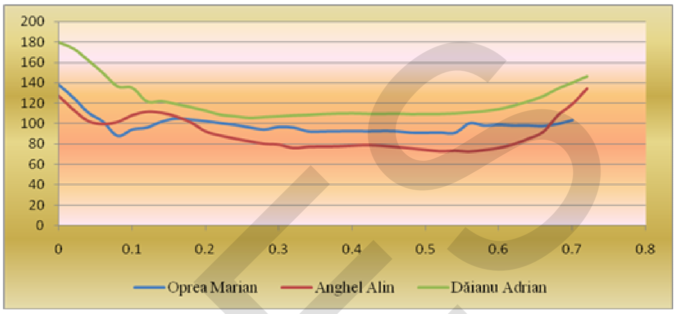

***Chart 5. The dynamic of the hip-femoral joint angle value* – swing lower limb**

Table 6 and Chart 5 indicate that O.M. records the lowest values of the hip-femoral joint angle in the downward phase of flight (53.2^0), with an average of 104.81^0, standard deviation of ± 26.48^0 and coefficient of variability with value of 25.27%. Lowest results of two other athletes have values of 88.2^0 (A.A.) and 146.5^0 (D.A.), the average being 125 $.46^0$ (A.A.) and 121.61^0 (D.A.). Regarding the standard deviation and coefficient of variability, their values are the ± 18. 20^0 (A.A.), ±19. 02^0, (D.A.) and 14.50% (D.A.), respectively 15.64% (A.A.).

Table 7. The value of the contact, hit and take-off angles

Athletes	Contact angle	Hit angle	Take-off angle
	S.L.	S.L.	S.L.
O.M. Marian	74.8	73.8	18.5
A.A. Alin	73	69.5	19.9
Dăianu Adrian	68.6	78.3	20.9

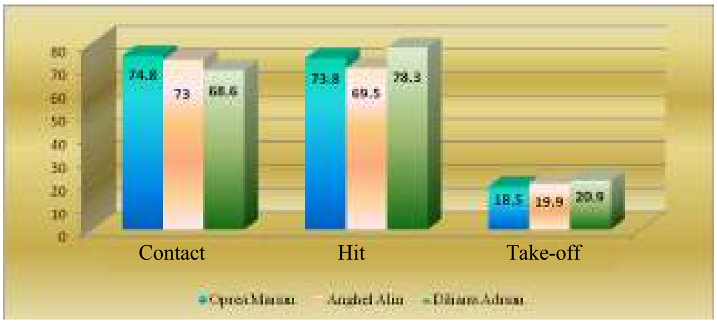

Chart 6. The dynamic of the contact, hit and take-off angles value

The data presented in Table 7 and illustrated in Chart 6 show that contact angle values vary between 68.6^0 (D.A.) and 74.8^0 (O.M.), with an intermediate value obtained by A.A. (73^0). In the hit angle, things are changing in that the lesser angle is recorded by A.A. (69.5^0) followed by O.M. (73.8^0), respectively D.A. (78.3^0). The angle of take-off is between 18.5^0 (O.M.) and 20.9^0 (D.A.), noting that between these two lies the decrease in A.A. case (19.9^0).

Conclusions

The results obtained by kinematic analysis using movement kinematic analysis software - Dartfish© and based on video images recorded with three filming cameras, were analyzed providing objective information on key technical issues that can be monitored during the jump from the men's triple jump event.

The execution time of the jump provides real and accurate information on the duration of this step, helping the coach in monitoring the time of the structural elements of the event, knowing that as the time needed to perform basic mechanism elements (especially the three beats) is bigger the losses of horizontal velocity are greater, which leads to poor performance results.

Determining the characteristic angles of this type of jump (contact, hit and take-off angle, the angle formed in hip-femoral and knee joints, at hit and swing lower limb level) allows the highlight of some information which, through their values, constitutes elements of assessing the technical behavior of the lower limbs, helping to monitor the specific technique of each step, and also the event overall.

Using movement kinematic analysis software - Dartfish© may be useful for determining the trajectory and iconographic representation of the general body mass center or different joints of the body and could obtain data showing the direction and their fluctuations encountered in basic elements of the base mechanism.

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