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BIOMECHANICAL CHARACTERISTICS OF MOVEMENT PHASES OF SNATCH STYLE IN PERFORMACE WEIGHTLIFTING

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Abstract

The purpose of this paper is to highlight the kinematic and dynamic characteristics of movement phases of snatch style in performance weightlifting.

Methods and procedures. This scientific approach has led to a study conducted during the European Junior Weightlifting Championships, Bucharest, 2011, with a group of 7 athletes, finalists of 56 kg class. The methodology of research focused on video recording, conversion of video capture into AVI format and the video biomechanical analysis of weightlifters' performances by means of a specialized program named Physical ToolKit.

Results. Each execution has shown the trajectories of the main joints involved in movement, highlighting the kinematic and dynamic characteristics of snatch style phases. The comparative analysis of the biomechanical indicators of movement phases in terms of beginning, extension, scoop, dip-under, catch and squat emphasize the duration of phases, the execution speed and the force to overcome the resistance of the barbell.

Conclusions. The study results revealed the kinematic and dynamic characteristics of movement phases of the snatch style, especially the snatch, phases that had an influence on the performances achieved in competition.

Key words: biomechanics**,** weightlifting, performance, snatch style, technique.

Introduction

The increase of performances in weightlifting, a phenomenon that we are continuously witnessing, is based on the improvement of technique and training methods. The modernization of training and competition materials and equipment (stage, platform, podium, barbells, arbitration and display equipment, computerized programs for conducting competitions) imposed the emancipation and selection of lifting styles, of arbitration rules and resulted in increased performance and spectacular events (***, 2009).

Athletes' training is carried out in an oriented, planned, systematic and long-term way, aiming to achieve performance. The changes during workouts cover both the component *performance*, as a result, and the structural component. The transformation in terms of performance refers to the mainly quantitative improvement of athlete's performance individual potential, which occurs usually in competition (Ulăreanu, 2012).

Sports training contents includes those structure elements based on the methodological laws and rules that help to achieve sports performance, physical exercises structured and diversified according to various specific rules (biomechanical, pedagogical, psychological, etc.) that represent the key elements of modern sports training contents (Simion, Mihăilă, Stănculescu, 2011, p.123).

In recent decades, the kinesiology discipline imposed conceptually as a scientific discipline that studies tha body activity in all its complexity, in many fundamental ways: philosophical, psychological, pedagogical, biophysical (physiological, biomechanical), hygienic (Hoffman & Harris (2000), quoted by Epuran,

The electronic development provided largely the objectification of sports training and competitions. Watching repeatedly, dozens of times, a freeze-frame of a loop-film or showing the images at normal speed can largely contribute to understanding some parts of the global execution of a technical procedure. Obviously, the specific character of each sports event

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or branch is given by the structure of technical elements, number, complexity, spectacular aspect, originality, frequency and efficiency in competition. The following biomechanical methods of research can be identified in the training field (Nicu, 1993):

a) *cinematographic method* – it is based on recording athlete's motor actions by means of high-speed filming equipment.

b) *method of stereography* – it makes possible the recording of sports technique using two infrared capture video cameras. The measurements are performed completely automatically; this method is extremely accurate and laborious (measurements can be bi- and tri-dimensional).

c) *method of dynamography* – it allows the registration of the changes in force intensity by means of tension control device (tenso-platform), of a tracking device (tensotractor) and of some telemetric sensors especially adapted to athlete's equipment.

d) *method of static-kinesimetry* (stabilometry) - it helps to determine the ability of maintaining the balance under various conditions (after effort, at a change of temperature, after vibrations, etc.).

e) *method of accelography* – it ensures the recording of intensity modifications of the accelerations of the real points of athlete's loco-motor system.

f) *method of electromyography* – it is based on the recording of the bio-currents in the muscles that are performing a mechanical work.

g) *method of goniography* – by means of special sensors attached to body joint projection, it allows the recording of the variations of the angle between two points of athlete's body during his movements.

The review of specialized literature has allowed establishing that this part of sports practice and theory has been the subject of special attention from the experts of this field. The objectives established, the structure and contents of mezzo-cycles indicate the place of each one in various stages of preparation (Bojko,1987; Verhoshanskij, 1985; Marchenko, Rogozjan, 1995; Matveev, 1991).

Learning the techniques used in various sport branches is generally characterized by the laws and phases of motor skills and actions, of course, with some differentiating, specific notes, determined by the particularities of sport branches. (Dragnea, 1996). The relations between technical elements and technical procedures are not present in all branches of sport, some of them having technical procedures only (weightlifting) (Dragnea, Mate-Teodorescu, 2002).

One of the major problems in performance weightlifting refers to the gradual training of the athletes for the execution of competition exercises in snatch and clean & jerk styles with a certain weight of the barbell, when athlete's body condition must be maximal. The factor that ensures the optimal conditions for the solution of these problems is the reasonable sports technique (without violating the competition rules), by which the athlete uses efficiently his physical, functional and psychological traits possibilities for lifting a barbell of maximal weight (Dvorkin, 2005).

The purpose of this paper is to highlight the kinematic and dynamic characteristics of movement phases of snatch style in performance weightlifting.

Methods

Hypothesis of the paper. We consider that the biomechanical video analysis will reveal the kinematic and dynamic characteristics of movement phases in snatch style, especially the flipping phase. Â

This scientific approach has led to a study conducted in the European Weightlifting Championship for juniors, Bucharest, 2011, on a group of 7 athletes, finalists of 56 kg class. We used the following research methods during the study: method of bibliographic study, observation method, video computerized method, method of experimental study and method of graphical representation. The methodology of research focused on video recording, transformation of video capture in AVI format (Pinnacle studio 9) and biomechanical video analysis of weightlifters' executions by means of a specialized program named Physical ToolKit, where every successful movement has been divided in 24 sequences every 4 frames (for example: 0.767 sec. x 4 frames = 3.068 sec).

Results

The findings of the study have been automatically processed by the biomechanical analysis program called Physical ToolKit. In order to highlight the kinematic and dynamic features of the athletes-subjects of the study in snatch style, we shall introduce the first three athletes honored in the European Championship for juniors, Bucharest, 2011.

Table no. 1. Results of biomechanical indicators in snatch style, 118kg weight, 56kg class, (CFI)

Time,	Movement	Position (m)		Velocity (m/s)			Force (N)		
sec	phases	X	Y	V_x	V_y	V	F_x	F_y	F
0.000	SP	-0.017	0.166						
0.033		-0.0552	0.188	0.00	1.004	1.004			
0.067		-0.017	0.232	-0.335	1.841	1.871	-354.606	1770	1810
0.1	Straightening	-0.028	0.309	-0.418	3.095	3.124	212.763	1770	1790
0.133		-0.044	0.436	-0.084	3.932	3.124	851.053	1770	1970
0.167	Flipping	-0.033	0.569	0.586	5.187	5.22	709.21	1280	1460

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0.2		-0.0552	0.779	0.753	5.438	5.49	-567.367	-1700	1790
0.233		0.017	0.928	-0.084	3.179	3.18	-1210	-3970	4150
0.267		-0.011	0.988	-0.669	0.753	1.007	-780.132	-3260	3350
0.3		-0.028	0.977	-1.004	-0.669	1.207	-212.763	-1350	1360
0.333		-0.077	0.944	-0.92	-0.837	1.244	496.447	709.209	865.7
0.367	Getting	-0.088	0.922	-0.418	0.167	0.451	567.369	1700	1790
0.4	under	-0.105	0.955	-0.251	1.171	1.198	283.685	1350	1380
0.433	barbell	-0.105	0.999	-0.084	1.757	1.759	70.922	709.21	712.747
0.467		-0.11	1.071	-0.167	2.008	2.015	70.921	354.606	361.628
0.5		-0.116	1.132	0.00	2.175	2.175	212.762	921.973	946.204
0.533		-0.11	1.215	0.084	3.095	3.097	-70.921	638.29	642.217
0.567		-0.11	1.132	-0.084	2.928	2.929	-283.684	-1840	1870
0.6		-0.116	1.408	-0.251	0.92	0.954	-212.765	-2840	2840
0.633		-0.127	1.397	-0.335	-0.418	0.536	70.921	-1210	1210
0.667	Catch	-0.138	1.38	-0.167	-0.502	0.529	283.685	212.763	354.606
0.7		-0.138	1.364	0.00	-0.167	0.167	-70.921	496.447	501.487
0.733		-0.138	1.369						
0.767		-0.155	1.369						

Note: *Phases of movement:* **SP** –Start position [0.00 sec.], Getting under the barbell [0.233-0.4]; Lifting and catching the barbell [0.433-0.767].

Table no. 1, figures 1 and 2 shows the biomechanical indicators in the snatch style performed by the Romanian athlete whose name is CFI, with competition weight of 55.95kg, at the performance of 118kg. There are highlighted: duration of movement divided into 5 phases of the movement, bar trajectory (X, Y); velocity and force of barbell lifting (X, Y, R- resultant of these ones).

In table no. 1, figures 1 and 2, there are shown the biomechanical indicators in snatch style achieved by the Romanian athlete CFI, with competition weight of 55.95kg, at the performance of 118kg. We can see: duration of movement divided into 5 phases of the movement, bar trajectory (X, Y); velocity and force of barbell lifting (X, Y, R- resultant of these ones).

a) **b)** **c)**

Figure no. 1. Start position (a), getting under barbells (b) barbell catching in snatch style (c) athlete - CFI

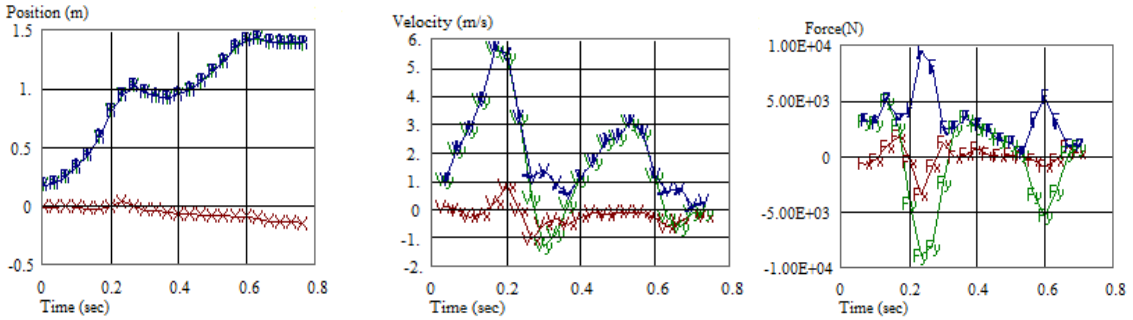

Figure no. 2. Trajectory of barbell, velocity and force of barbell lifting in snatch style (CFI)

Table no. 2. Results of biomechanical indicators in snatch style, weight 117kg, class 56kg, (CS)

Time, sec	Movement phases	Position (m)		Velocity (m/s)			Force (N)		
		X	Y	V_x	V_y	V	F_x	F_y	F
0.000	SP	-0.0055	0.183						
0.033		-0.0055	0.189	0.00	0.454	0.454			
0.067		-0.011	0.189	-0.076	0.757	0.76	-192.322	897.501	917.876
0.1	Straightening	-0.022	0.272	-0.227	1.513	1.53	-192.322	1150	1170
0.133		-0.044	0.367	-0.303	2.119	2.14	64.106	512.858	516.849

0.167	Flipping	-0.056	0.444	-0.151	2.119	2.124	-192.322	1600	1610
0.2		-0.067	0.566	-0.53	4.01	4.045	-512.857	2370	2430
0.233		-0.061	0.761	-0.757	4.918	4.976	-192.322	-897.502	917.877
0.267		-0.067	0.883	-0.757	2.951	3.046	-320.537	-4170	4180
0.3		-0.094	0.944	-1.135	0.00	1.135	-384.644	-4100	4120
0.333		-0.155	0.894	-1.211	-1.892	2.246	384.645	-1150	1220
0.367	Getting	-0.183	0.816	-0.681	-1.362	1.523	769.287	1540	1720
0.4	under	-0.205	0.789	-0.303	-0.076	0.312	256.428	1540	1560
0.433	barbell	-0.217	0.772	-0.378	0.454	0.591	128.215	384.645	405.451
0.467		-0.233	0.8	-0.151	0.378	0.407	320.536	448.752	551.472
0.5		-0.244	0.827	0.00	0.984	0.984	64.106	897.501	899.787
0.533		-0.244	0.877	-0.076	1.438	1.44	-192.322	448.75	488.226
0.567		-0.261	0.922	-0.227	1.513	1.53	-128.214	256.428	286.696
0.6		-0.261	0.977	-0.227	1.74	1.755	128.215	64.108	143.349
0.633		-0.272	1.038	-0.076	1.589	1.591	128.214	-448.749	466.706
0.667	Catch	-0.289	1.1	-0.076	1.211	1.213	64.107	-448.753	453.309
0.7		-0.294	1.155	0.00	1.059	1.059	192.322	-128.217	231.144
0.733		-0.289	1.194	0.151	1.059	1.07			
0.767		-0.255	1.211						

Note: PS –Start position [0.00 sec.], Straightening [0.033-0.133sec.]; Flipping [0.167-0.2]; Getting under barbell [0.233-0.367]; Barbell lifting and catching [0.4-0.767]

Table no. 2, figures no. 3 and 4 highlight the biomechanical indicators in snatch style executed by the Bulgarian athlete CS, with competition weight of 55.92kg, at the performance of 117kg. We notice: movement duration divided into 5 phases of the movement, barbell trajectory (X, Y); velocity and force of barbell lifting (X, Y, R- their resultant).

Figure no. 3. Getting under barbell and catching barbell (CS)

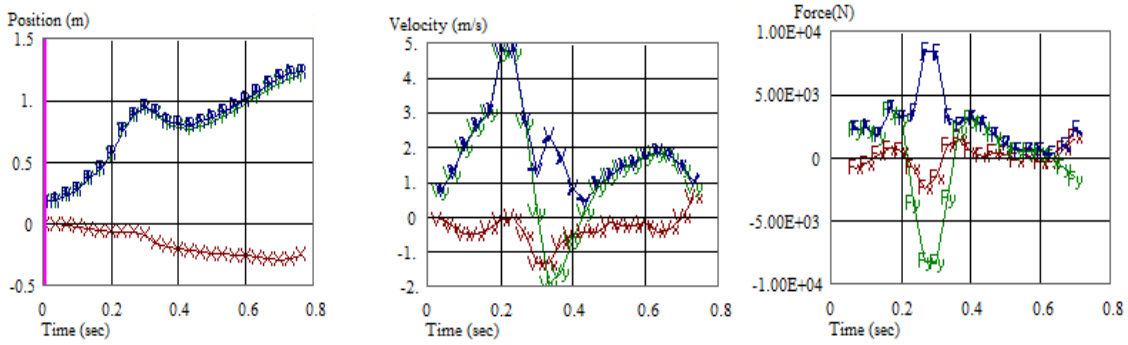

Figure no. 4. Trajectory of barbell, velocity and force of barbell lifting in snatch style (CS)

Table no. 3. Results of biomechanical indicators in snatch style, weight 109kg, class 56kg, (BGJ)

Time, sec	Movement phases	Position (m)		Velocity (m/s)			Force (N)		
		X	Y	V_x	V_y	V	F_x	F_y	F
0.000	SP	-0.019	0.193						
0.033		-0.019	0.193	0.00	0.489	0.489			
0.067		-0.019	0.226	0.00	1.172	1.172	-248.603	1330	1350
0.1	Straightening	-0.019	0.271	-0.293	2.052	2.073	-580.076	1330	1450
0.133		-0.039	0.361	-0.684	2.736	2.82	82.867	828.682	832.815
0.167	Flipping	-0.064	0.451	-0.195	3.029	3.035	1080	1080	1520
0.2		-0.052	0.561	0.586	4.006	4.048	911.549	1820	2040
0.233		-0.026	0.716	0.879	5.178	5.252	165.738	911.55	926.495
0.267		0.0065	0.903	0.782	5.08	5.14	-828.681	-3070	3180

0.3		0.026	1.051	-0.098	1.563	1.566	-1240	-5720	5850
0.333		0.00	1.006	-0.684	-1.661	1.796	-165.736	-2490	2490
0.367	Getting	-0.019	0.941	-0.293	-1.368	1.399	911.551	1080	1410
0.4	under	-0.019	0.916	0.391	-0.391	0.553	580.078	1160	1300
0.433	barbell	0.0065	0.916	0.391	0.00	0.391	-165.736	1080	1090
0.467		0.0065	0.916	0.195	0.879	0.901	-82.868	1570	1580
0.5		0.019	0.974	0.293	1.856	1.879	-248.605	911.549	944.842
0.533		0.026	0.974	-0.098	1.954	1.956	-414.341	-248.603	483.2
0.567		0.013	1.038	-0.195	1.563	1.575	82.868	-165.735	185.298
0.6		0.013	1.103	0.00	1.759	1.759	165.736	414.34	446.258
0.633		0.013	1.141	0.00	2.052	2.052	-82.868	82.867	117.192
0.667	Catch	0.013	1.219	-0.98	1.856	1.859	-82.868	-414.34	422.545
0.7		0.013	1.277	-0.098	1.563	1.556	-165.736	-828.679	845.091
0.733		0.0065	1.341	-0.293	0.879	0.927			
0.767		-0.013	1.399						

Note: SP – Start position [0.00 sec.], Straightening [0.033-0.133sec.]; Flipping [0.167-0.2]; Getting under barbell [0.233-0.4]; Barbell lifting and catching [0.433-0.767]

Table no. 3, figures no. 5 and 6 shows the biomechanical indicators in snatch style, performed by the Spanish athlete BGJ, with competition weight 56kg, performance of 109kg. There are highlighted: movement duration divided into 5 phases of the movement, barbell trajectory (X, Y); velocity and force of barbell lifting (X, Y, R- their resultant).

Figure no. 5. Start position, getting under barbell and catch in snatch style (BGJ)

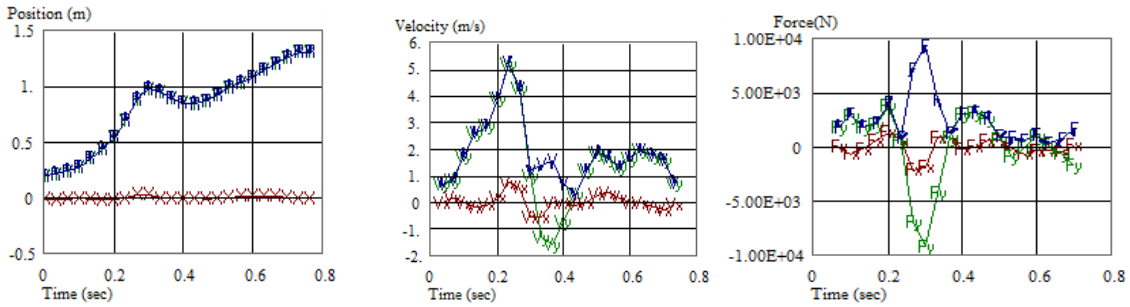

Figure no. 6. Trajectory of barbell, velocity and force of barbell lifting in snatch style

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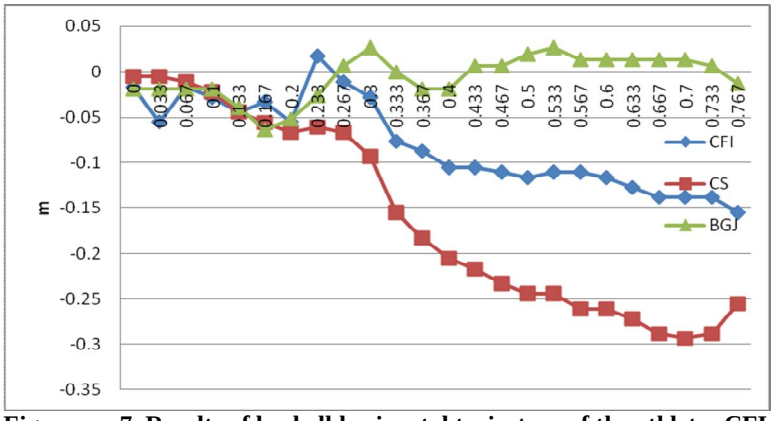

Figure no. 7. Results of barbell horizontal trajectory of the athletes CFI, CS and BGJ

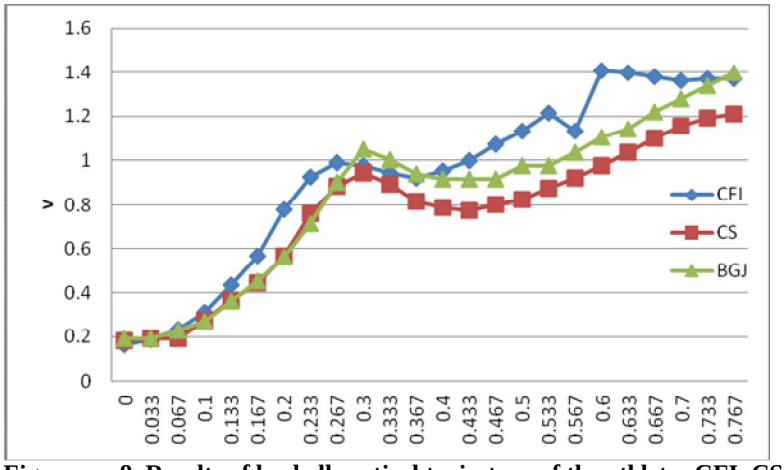

Figure no. 8. Results of barbell vertical trajectory of the athletes CFI, CS and BGJ

Figure no. 7 shows the trajectories of barbell lifting by the first three weightlifters (**CFI, CS și BGJ)**, in terms of horizontal movement, while figure no. 8 highlights the vertical movement.

Table no. 4. Results achieved in the European Championship for juniors, Bucharest 10.09.2011, snatch style, 56 kg class, men

No.	Full name /	Nationality	Event weight	Attempts (kg) 1	2	3	Result, (kg)
1	CFI	ROU	55.95	118	121	~~126~~	121
2	CS	BLG	55.92	113	~~117~~	117	117
3	BGJ	ESP	56.00	103	108	109	109
4	MS	BUL	55.98	105	~~108~~	108	108
5	SG	HUN	55.94	100	105	~~108~~	105
6	MA	BUL	55.75	100	104	~~106~~	104
7	MS	ARM	55.60	95	~~100~~	100	100

Table no. 4 presents the results achieved in the European Championship for juniors, Bucharest, 2011 in snatch style, 56kg class - men, showing the nationality, weight in event, resultants of each attempt and final result.

Discussions

The medal awards in weight-lifting contests depend on how much total weight is lifted with two lifting styles. Movement ofthe barbell is determined by the forces applied by the weight lifter. The relationships between displacement and time, or velocity and time, are often used at a practical level as the most important indices for as.sessing lifting technique (Baumann, Gross. Quade. Galbierz. & Schwirtz. 1988).

In this study, barbell trajectories, except for one subject, did not cross the vertical reference line

projected upward from the start position. Rather, the barbell was pulled toward the lifter during the snatch movement, especially from the first pull to transition

phase. This technique used during the first pull and transititm phase most likely requires the body to be inclined away from vertical, and the resulting barbell trajectory follows the inclination ofthe body (Isaka, T., Okada, J., Funato, K., 1996).

A number of 7 finalist weightlifters, 56kg class, participants in the European Championship for juniors, Bucharest 2011, were the subjects of this research. The study exemplified the characteristics of movement phases of the top ranked athletes.

In terms of results of the biomechanical indicators in snatch style, we notice the movement duration, analyzed every 4 frames, equal to 0.767 sec, while with normal speed – 3.068 sec;

The phases of the movement are analyzed by highlighting barbell horizontal and vertical travel (X, Y), where the start position (SP) was taken at the end of the execution (0.0- 0.033 sec); straightening at (0.1- 0.133 sec); flipping at (0.167- 0.333 sec.); getting under the barbell at (0.367- 0.633 sec); lifting at (0.433 – 0.633 sec.) and barbell catch at (0.7 – 0.767 sec.)

As for the kinematic features of barbell travel velocity in flipping phase at sec.0.2, we notice that the athlete CFI has a velocity of 5.438 m/s, the athlete CS has a velocity of 4.045 m/s and BGJ has a velocity of 4.006 m/s.

Regarding the lifting force of the barbell, we notice that the highest value is achieved by the athlete CFI, namely 4150 N in flipping phase; the athlete CS has 4180 N in the end of flipping phase and the athlete BGJ has 5850 N in the end of flipping phase.

The comparative analysis of the biomechanical characteristics of snatch style phases points out that the highest values are recorded in the end of "flipping" phase, fact that confirms the importance of this phase for lifting the weight as efficiently as possible.

The results achieved in competition in snatch style emphasize that the Romanian CFI lifted 121kg and was ranked the first, followed by the Bulgarian CS with a weight of 117 kg while the third place was taken by the Spanish BGJ who lifted a weight of 109kg.

Conclusions

The biomechanical video analysis of snatch style reveals the kinematic and dynamic characteristics of each phase of the performed style.

The results of the biomechanical indicators of the individual values highlight significant differences of barbell trajectories in snatch style, consistent with the body mass and the lifted weight and also with the personal technique of each athlete.

The performance of the biomechanical video analysis showed the kinematic and dynamic features of movement phases in snatch style, especially the flipping phase, which influenced the performances achieved in competition.

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