BIOMECHANICAL CHARACTERISTICS OF MOVEMENT PHASES OF SNATCH STYLE IN PERFORMACE WEIGHTLIFTING

ULĂREANU MARIUS VIOREL1, POTOP VLADIMIR1, TIMNEA OLIVIA CARMEN1

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 the 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 stereophotography** – 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 acceloography** – 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 object 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; Verhoshanski, 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)

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>Movement phases</th>
<th>Position (m)</th>
<th>Velocity (m/s)</th>
<th>Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>Vx</td>
<td>Vy</td>
</tr>
<tr>
<td>0.000</td>
<td>SP</td>
<td>-0.017</td>
<td>0.166</td>
<td></td>
</tr>
<tr>
<td>0.033</td>
<td>-0.0552</td>
<td>0.188</td>
<td>0.00</td>
<td>1.004</td>
</tr>
<tr>
<td>0.067</td>
<td>-0.017</td>
<td>0.232</td>
<td>-0.335</td>
<td>1.841</td>
</tr>
<tr>
<td>0.1</td>
<td>Straightening</td>
<td>-0.028</td>
<td>0.309</td>
<td>-0.418</td>
</tr>
<tr>
<td>0.133</td>
<td>Flipping</td>
<td>-0.044</td>
<td>0.436</td>
<td>-0.084</td>
</tr>
<tr>
<td>0.167</td>
<td></td>
<td>-0.033</td>
<td>0.569</td>
<td>0.586</td>
</tr>
</tbody>
</table>
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].

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).

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>Movement phases</th>
<th>Position (m)</th>
<th>Velocity (m/s)</th>
<th>Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>Y</td>
<td>Vx</td>
</tr>
<tr>
<td>0.000</td>
<td>SP</td>
<td>-0.0055</td>
<td>0.183</td>
<td>0.00</td>
</tr>
<tr>
<td>0.033</td>
<td></td>
<td>-0.0055</td>
<td>0.189</td>
<td>-0.076</td>
</tr>
<tr>
<td>0.067</td>
<td>Straightening</td>
<td>-0.011</td>
<td>0.189</td>
<td>-0.227</td>
</tr>
<tr>
<td>0.133</td>
<td>Straightening</td>
<td>-0.044</td>
<td>0.367</td>
<td>-0.303</td>
</tr>
</tbody>
</table>

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)
0.167 Flipping -0.056 0.444 -0.151 2.119 2.124 -192.322 1600 1610
0.2 -0.067 0.566 -0.03 4.017 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 barbell -0.205 0.789 -0.303 -0.076 0.312 256.428 1540 1560
0.433 -0.217 0.772 -0.378 0.454 0.591 128.215 384.645 406.141
0.467 -0.233 0.8 -0.15 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 0.00 0.105 0.105 192.322 -128.217 231.144
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 [0.033-0.133 sec.]; 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 55.92 kg, at the performance of 117 kg. 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 109 kg, class 56 kg, (BGJ)

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>Movement phases</th>
<th>Position (m) X</th>
<th>Y</th>
<th>Velocity (m/s) V_x</th>
<th>V_y</th>
<th>F_x</th>
<th>F_y</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>SP</td>
<td>-0.019</td>
<td>0.193</td>
<td>0.00</td>
<td>0.489</td>
<td>0.489</td>
<td>-248.603</td>
<td>1330</td>
</tr>
<tr>
<td>0.033</td>
<td></td>
<td>-0.019</td>
<td>0.193</td>
<td>0.00</td>
<td>1.172</td>
<td>1.172</td>
<td>-580.076</td>
<td>1330</td>
</tr>
<tr>
<td>0.100</td>
<td>Straightening</td>
<td>-0.019</td>
<td>0.271</td>
<td>-0.293</td>
<td>2.052</td>
<td>2.073</td>
<td>-828.673</td>
<td>1330</td>
</tr>
<tr>
<td>0.133</td>
<td></td>
<td>-0.039</td>
<td>0.361</td>
<td>-0.684</td>
<td>2.736</td>
<td>2.82</td>
<td>828.682</td>
<td>828.682</td>
</tr>
<tr>
<td>0.167</td>
<td>Flipping</td>
<td>-0.064</td>
<td>0.451</td>
<td>-0.195</td>
<td>3.029</td>
<td>3.035</td>
<td>1080</td>
<td>1080</td>
</tr>
<tr>
<td>0.233</td>
<td></td>
<td>-0.052</td>
<td>0.561</td>
<td>0.586</td>
<td>4.006</td>
<td>4.048</td>
<td>911.549</td>
<td>1820</td>
</tr>
<tr>
<td>0.267</td>
<td></td>
<td>0.0065</td>
<td>0.903</td>
<td>0.782</td>
<td>5.08</td>
<td>5.14</td>
<td>-828.681</td>
<td>-3070</td>
</tr>
</tbody>
</table>

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Note: SP – Start position [0.00 sec.], Straightening [0.033-0.133 sec.]; 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
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

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

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

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 of the 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 assessing 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 transition phase most likely requires the body to be inclined away from vertical, and the resulting barbell trajectory follows the inclination of the 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 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 BGI 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.

References


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