Capabilities of using bar elastic properties in the training of weightlifters

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Summary

Article aims to evaluate athletes' ability to catch the swinging bar, resulting from the performance of clean and jerk weightlifting. A device with an intelligent sensor, based on the method of wireless tensometry, was used to register the swinging. To identify key moments of the phases of movements, correlation of parameters of bar swinging with moves exercise, was carried out. As a result of the research, indices, characterizing the dynamics of apparatus swingings, were obtained and the evaluation of athlete's use of bar elastic properties was given. On the basis of the experiment, it had been shown that the model stereotype of movements was better to form under the condition of optimum use of bar elastic properties, when in trainings and competitions the equipment of identical manufacturing firms is used. Comparing the Eleikobar and ZKC bar, it was found that the Eleikobar in the load testing had a higher amplitude of swingings; that is a strong argument in favour of its use in the training process. Eleikobar has less swinging load on ligaments and joints, preventing possible injuries of athletes. The presence of intelligent sensor in the device provides biological feedback, while the athlete, in the controlled phase of movements, has the ability to track the bar swinging and combine maximum effort with optimal resonance of the bar.

Keywords: weightlifting, clean and jerk, bar elastic properties, intelligent sensor, evaluation algorithm.

Introduction

Rapid growth of records, significant intensification of training and competitive loads, as well as tough competition of powerfully equal opponents are typical for modern sport. To achieve high sport results, you need decades of intense training. In weightlifting, the result depends not only on the scores of athletes, but also on the technique of performing the exercise, which involves Provence's high-level control and structure-engine action (Storey, Smith, 2012; Akkus, 2012; Musser et al., 2014; Kipp, Harris, 2015).

The growth of athletic performance in weightlifting is achieved by increasing training loads. Nevertheless, further increasing of their volumes cannot be perpetual since the increasing relevance has the problem of finding new ways to improve the efficiency of the process of training (Gourgoulis et al., 2009; Ho et al., 2014; Petrizzo et al., 2016).

As considered, the most difficult elements of athletes' movements in weightlifting, in terms of cooperation, are the clean and jerk lifts. The reason for this is its performance that takes place before the background of the processes of fatigue after the snatch and is characterized by a large lifting weight as well as maximum tension during the lift (Gourgoulis et al., 2009; Ikeda et al., 2012; Harbili, 2012; Harbili, Alptekin, 2014; Жуков, 2009). As a result, there are frequent lift-offs at competitions during the performance of clean and jerk power (Жуков, 2009; Gourgoulis et al., 2009; Ikeda et al., 2012; Harbili, 2012; Harbili, Alptekin, 2014;). Aiming to improve the efficiency of the technique of performing a competitive clean and jerk move, great importance lies in the ability of an athlete to catch the weight bar swinging (Chiu et al., 2008; Chiu, 2010; Мамий, Поляков, 2014). The forces, arising on the bar at the time of the apparatus swingings, are determined by bar elastic properties. In particular, performing power jerk due to bar elastic properties and the barbell weight under the influence of external force are at its own swinging. An experienced athlete, who applies appropriate efforts, causes these fluctuations and, in the process of performing the ascent, uses them to achieve the best result (Lanka et al., 2017). In this regard, it has become necessary to develop a system that would allow determining the time of occurrence of swingings, their amplitude, and direction.

The received results can be used to improve the technical training of weightlifters in execution
of clean and jerk moves on the basis of the use of the barbell inertial forces, coinciding in time and direction with the force, applied by the athlete, to the apparatus in the phases of jerk and clean power.

**Goal of the research** is to improve the technical readiness of weightlifters in the clean and jerk move based on the use of bar elastic properties.

**Object of the research:** the training process of weightlifters.

**Subject of the research:** technical preparedness of weightlifters during clean and jerk lifting.

**Material and methods**

The following methods were employed for the study: analysis of scientific and methodological literature, the method of strain measurement, high-speed video, calculation and graphical methods of data analysis.

The study involved an athlete of age 22 with experience in performances at the World and European Championships.

The ability of the athlete to catch the bar swinging, resulting from the performance of the clean and jerk weightlifting, was evaluated. A special device with a built-in intelligent sensor, based on the method of wireless strain measurement, was developed for swingings registration. The connection diagram and the main elements for data logging are shown in Figure 1. Synchronous time video recording was carried out by digital video camera Panasonic HC-V770 with a frame rate of 60 Hz. This synchronization is necessary for the selection of the corresponding phases in the barbell swinging registration files.

![Fig. 1. The connection of diagram and key elements of the device for bar elastic properties evaluation](image)

1 – personal computer; 2 – Bluetooth signal transmission; 3 – Bluetooth module transmission; 4 – intelligent transmitter; 5 – bar

Determination of bar elastic properties was carried out using specially designed device that was fixed at one end of the bar. The weight of the device was 120.0 gr.

Algorithm of bar elastic properties evaluation consisted of three main blocks (Fig. 2).
In block 1, the following actions were consistently carried out:
- fixing the module of signal transmission and power supply of the intelligent sensor on the bar;
- connection via USB between a signal receiver and a personal computer;
- configure the connection between the PC and the sensor;
- running the software and creating a stable data connection;
- entering personal data of an athlete and the working weight of the barbell;
- calibration of the system (during changing the bar);
- connection and setting of the multimedia projector to display information about the bar swinging.

In block 2, the actions, related to the order of the exercise performance and data registration, were performed:
- the athlete held the starting position, the assistant-coach synchronously turned the device and the video camera on;
- when performing the exercise, the athlete was tracked through a multimedia projector on the wall with the image of the forces acting on the bar. The success of the attempts with the stated weight was due to the contact forces, applied by the athlete, to the bar resonance;
- completing a weightlifting exercise or an attempt, the assistant coach stopped recording on the device and the video camera with the preservation of information.

The same sequence of actions can be used without biofeedback, when the task is to assess the level of technical readiness of the athlete.

In block 3, the actions, related to the processing of test results and analysis of the data, were carried out:
- transferring the digital array of the space-time parameters, reflected by interaction of an athlete with a bar from the software of the device to the Excel table;
- processing the data, eliminating additive error values, and calculating the required values;
- construction of graphs, reflecting the bar swingings, during performance of exercises, with a given weight;
- data correlation of the bar swingings with video fragments of phases of the athlete’s movements (displayed by putting markers on the graph).

In the experiment, the athlete alternately performed four attempts of lifting a barbell with a weight of 170 kg from racks. In the dynamics of exercises on the wall, a graph of the bar swingings was displayed using a multimedia projector. The athlete had to start the jerk phase when the curve on the graph reached its lowest point (it was an indicator of the maximum bending of the bar in the direction of the squat). A fragment of the exercise with the use of a device for assessing the bar elastic properties using biological feedback is shown in Figure 3.

![Fig. 3. Fragment of the exercise using neuro-feedback Processing of the data was carried out using Microsoft office Excel](image)

Results and discussion

Obtained data gave a characteristic to the apparatus swinging when performing clean and jerk lifts. Dynamics graph of the bar swinging, during the performance of the first attempt, is represented in Figure 4.

![Fig. 4. Dynamics graph of the bar swinging during the performance of the exercise with 170 kg weight (1st attempt)](image)
In the analysis of the graph of the first attempt, it can be concluded that the athlete started the phase of jerk, when inertial forces of bar swingings already coincided with the direction of the force, applied by the athlete, as evidenced by the marker on the graph, located on the upward line. This performance can be considered satisfactory, but the athlete started the phase of jerk with delay.

Dynamics graph of the bar swinging, during the performance on the second attempt, is represented in Figure 5.

Performing the second attempt, the athlete started the jerk phase prematurely, as evidenced by the marker on the downward line of the graph. However, this performance can be considered satisfactory, as it did not lead to the attenuation of the bar swingings (it would be expressed in the graph as a plateau).

Dynamics graph of the bar swinging, during the performance on the third attempt, is represented in Figure 6.
Performing the third attempt, the athlete was in resonance with the bar swinging as evidenced by the marker at the beginning of jerk, falling on the peak. The force, applied by the athlete, exactly coincided with the inertial forces of bar swingings. Such performance can be considered as the model. Dynamics graph of the bar swingings, during the performance the fourth attempt, is represented in the Figure 7.

**Fig. 6.** Dynamics graph of bar swinging during the performance of the exercise with 170 kg weight (3rd attempt)

**Fig. 7.** Dynamics graph of bar swinging during the performance of the exercise with 170 kg weight (4th attempt)
Performing the fourth attempt, there is a premature start of the jerk phase as evidenced by the plateau in the graph after the vertical line that is a marker of the beginning of the jerk. Besides that, the beginning of the jerk came at the time of bar swinging motion, opposite in its direction to the force, applied by the athlete to the apparatus, which made it difficult to perform the exercise. This performance cannot be considered as satisfactory.

This study allows to conclude that the athlete has a significant potential in improving the utilization of bar elastic properties to facilitate the exercise through the use of barbell inertial forces coinciding in time and direction with the force, applied to the apparatus, in the phase of jerk. However, to learn how to optimally use bar elastic properties, as well as to take into account the elastic and power capabilities of the muscles and the entire musculoskeletal system of a weightlifter a long training is needed. Although, an important condition should be realized: the elasticity of the training bar should be the same as that of the competition (Chiu et al., 2008; Chiu, 2010; Мамий, Поляков, 2014). Currently, the weightlifting competition of the continental and planetary scale is carried out using sports equipment company Eleiko.

In this regard, we have compared the vultures of Eleiko and ZKC that were used in the training process of weightlifters. Vultures have a good elasticity effect and are made of special spring steel. The Eleikobar withstands the maximum load up to 1500 kg, the ZKC bar carries a load up to 1000 kg. Using the developed devices parameters of incurvation and swinging amplitude of the bar with 25 kg weight plates were measured. Following tests were carried out:

1. Static test with the bar on the racks (weight of 70 kg bar). During carrying out the test, the weight plates of equal weight were installed on the bar. The test was carried out on racks. With the help of the device, the bar incurvation, caused by this load, was fixed.

2. Bar dynamic test performing barbell clean and jerk lift from the starting position “power clean” (from the racks). The athlete took the bar (weight 70 kg) from racks and did the jerk lift from the chest to outstretched arms. During the movement, data of the bar swinging amplitude were recorded.

3. Bar dynamic test performing barbell clean and jerk lift from the starting position “power clean” (from the racks) with a shifted position of the weight plates (weight of the barbell: 70 kg and 120 kg). The athlete took the bar from the racks and performed jerk lift from the chest to the outstretched arms. To increase the moment of force, weight plates were shifted closer to the ends of the bar at a fixed distance by means of locks. During the process of the jerk lift, the sensor recorded the data of the bar swinging amplitude.

Data, obtained in the process of carrying out the tests, are represented in Table 1.

Table 1: Data of comparing bars according to their elastic properties

<table>
<thead>
<tr>
<th>Test title and content</th>
<th>Apparatus weight, kg</th>
<th>Measured parameter</th>
<th>Comparable bars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>Eleiko ZKC</td>
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<td>relative units</td>
<td>relative units</td>
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</tbody>
</table>

Test № 1. Static test with the bar on the racks

| Test № 2. Bar dynamic test performing barbell clean and jerk lift from the starting position “power clean” (from the racks) | 70 | incurvature magnitude | 5041 | 17641 |
| Test № 3. Bar dynamic test performing barbell clean and jerk lift from the starting position “power clean” (from the racks) with a shifted position of the weight plates | 70 | swinging amplitude | 67024 | 177358 |
| 120 | swinging amplitude | 103618 | 292251 |

According to the obtained data, the difference in the amplitude of the bar swingings is more than doubled and the readings increase in proportion to the increase in the total weight of the apparatus. It is natural for the results of dynamic test with shifted position of the weight plates. According to the measured parameters, the Eleiko bar differs significantly from the ZKC analogue, which is a strong argument in favour of its use in training. With a lower swinging amplitude, the Eleiko...
bar has less stress on the ligament apparatus and joints, which prevents injury to the joints and their premature wear. Taking into account that the athlete performs about 70–100 lifts per training, of which 10–20% with weights, 80% or more of the limit, the use of the ZKC bars in the preparation can lead to changes in the technique of movements and the formation of an incorrect motor skill. This change may have a negative impact on the preparation of the athlete and, as a result, cause failure of attempts at a competition.

Conclusion
The constant search for ways to optimize the training process, in order to achieve the highest sports results, requires the use of modern mobile tools in the evaluation and improvement of technical training of athletes in weightlifting. The device approved by us allows to determine the dynamics of the bar swinging and to evaluate the effectiveness of bar elastic properties by the athlete on the key phases of the clean and jerk lift. The use of biofeedback in training allows the athlete, using bar elastic properties in real time with high accuracy, determining the most favourable moments for the development of maximum effort in the controlled phases of movement in combination with the bars optimal resonance. In addition, the developed device can be used in the comparison of bar elastic properties of different manufacturers in order to select the most similar properties to those used in competitions.

REFERENCES
ŠTANGOS PLIENINIO VIRBALO TAMPRUMO SAVYBIŲ PANAUDOJIMAS RENGIANT SUNKIAATLEČIUS

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SANTRAUKA

Darbo tikslas – įvertinti sportininkų gebėjimą panaudoti štangos plieninio virbalio vibravimą sunkiaatlečiams atliekant klasikinį štangos stūmimo veiksmą. Vibravimų registracijai buvo panaudota įranga su išmaniuoju davikliu, kuris veikia belaidės tenzometrijos būdu. Pagrindinių judesio fazių nustatymas vyko lyginant štangos plieninio virbalio vibravimą su pratimo atlikimo vaizdo įrašo fragmentais. Tyrimo metu buvo gauti duomenys, apibūdinantys įrankio vibravimo dinamiką ir įvertintos kitos štangos plieninio virbalio tamprumo pritaikymo galimybės atliekant štangos stūmimo veiksmą.

Eksperimento būdu nustatyta, kad modelinį judesių stereotipą geriausia yra formuoti optimaliai išnaudojant štangos plieninio virbalio vibravimo savybes, kai treniruotėse ir varžybose naudojamas vienos firmos gamintojų inventorius. Lyginant firmų „Eleiko“ ir ZKC virbalus, nustatyta, kad „Eleiko“ virbalas, testuojant jį su svoriu, turi didesnę svyravimo amplitudę ir tai yra svarbus argumentas jį naudoti treniruočių procese. „Eleiko“ virbalas sukelia mažesnį svorio poveikį sąnariams ir raiščiams, labiau sumažina sportininkų traumų pavojų. Išmanusis daviklis įrankyje suteikia biologinį grįžtamąjį ryšį, dėl kurio sportininkas vaizdo monitoriuje matydamas atskiras judesio fazes turi galimybę sekti įrankio judėjimą ir suderinti maksimalias savo pastangas su optimaliu štangos virbalio rezonansu.

Raktažodžiai: sunkioji atletika, štangos stūmimas, štangos virbalio tamprumas, išmanusis daviklis, vertinimo algoritmas.