11TH INTERNATIONAL CONFERENCE
BIOMDLORE 2016
OCTOBER 20–22, 2016, DRUSKININKAI, LITHUANIA
BIOMDLORE.VGTU.LT

eISSN 2345-0630
ISBN 978-609-457-959-2
eISBN 978-609-457-958-5
DOI: 10.3846/biomdlore.2016.22

# The influence of barbell's weight, lifting technique and skills on weightlifter's blood pressure and heart rate

**Mečislovas Mariūnas[1], Julius Griškevičius[2], Gintaras Jonaitis[3]**
[1, 2, 3] Vilnius Gediminas Technical University, Lithuania
**E-mails:** [1] *mecislovas.mariunas@vgtu.lt (corresponding author)*, [2] *julius.griskevicius@vgtu.lt*,
[3] *gintaras.jonaitis@vgtu.lt*

*(Received 1 July 2016; accepted 15 July 2016)*

**Abstract.** Article presents hodographs of the arterial blood pressure relation to heart-rate enabling to evaluate organism sensitivity of trained weightlifter to the magnitude of lifted weight, lifting technique and weight repeatability. Variation regularities of the latter relation have been explained and approximate criterions of relative stability and skill level were formulated. Analysing variations of the relation of the arterial blood pressure to the heart-rate and barbell's lifting accelerations and velocities the weaknesses of trained weightlifters have been explained. It has shown that in most cases the blood pressure of the weightlifter can increase 8–13% after the barbell drop.

**Keywords:** blood pressure, heart rate, snatch, clean and jerk, lifting accelerations and velocities, organism reaction to weight, indexes of relative stability and technique, hodograph.

## Introduction

The reaction of weightlifter's organism to the lifted weight and lifting technique can be evaluated analysing the variations of the arterial blood pressure and the heart-rate. Regularities of variations can give insight on weightlifter's skill level. High competition results can be achieved having mastered optimal trajectories of barbell's lifting, i.e. its kinematics. Barbell's lifting kinematics during snatch and clean and jerk has been fairly explored in various scientific works [2, 3, 4, 5, 6, 7]. For example, in the article [5] authors have analysed the parameters of elite athletes' lifting trajectories during 2010 weightlifting championship. They've determined relation of the final result to common barbell's trajectories of the women weightlifters. Despite many research works on kinematics of the barbell only few pay attention to variations of arterial blood pressure and heart-rate after the barbell drop, however presented results are only descriptive [1, 3, 8, 10]. In these work regularities of arterial blood pressure and heart-rate variations are not explored. Some authors attempted to analyse the regularities of time variations of arterial blood pressure and heart rate in response to constant load [9]. A lack of works studies reaction of the organism to load and lifting manner.

The goal of present research is to investigate relationship between the arterial blood pressure of the weightlifter and heart rate after dropping the barbell, understand the variation tendencies of latter parameters and to formulate criterions of organism's sensitivity reaction to lifted weight and technique. By analysing barbell's lifting accelerations and velocities to investigate weaknesses of the athlete and approximately evaluate his prospective abilities in chosen sport.

## Methods

Research was carried out in the weightlifting gym of the Vilnius University "Health and sport centre" under the guidance of the coach Rimantas Cijūnėlis. Total six athletes were recruited for the study and were divided in two groups: three beginners and three advanced weightlifters. The barbell's weight was varying from 60 to 80 kg. Inertial sensors with ±1.5g – 6g Three Axis low-g micromachined accelerometer were fixed on the hand and forearms of the weightlifters and one on the barbell. Weightlifters were instructed to perform snatch and clean and jerk lifting techniques. The heart rate and arterial blood pressure was measured using Siemens and Space Lab Medical monitoring and data processing system before (at 0 sec) and after each attempt after 60, 180, 300, 480 and 540 seconds. All data was registered and stored on the PC.

**Results**

The arterial blood pressure and heart rate graphs alone are not informative enough. Combining them in a hodograph $p(t) = f[h(t)]$ it is possible to note two important phenomena. First, variation of the area of the hodograph with respect to the lifted weight (Fig. 1). Secondly, location of latter hodographs on the plane, i.e. what area on the plane they are covering after repeated lifting of the barbell (Fig. 2).

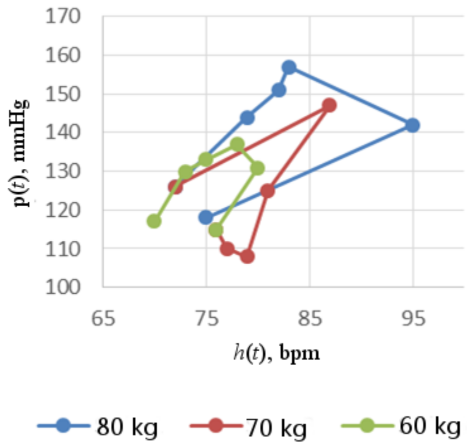


**Fig. 1.** Hodographs of the beginner athlete

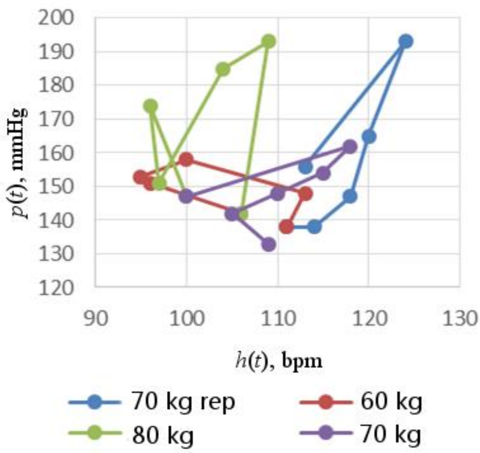


**Fig. 2.** Hodographs of the advanced athlete (rep means the load was lifted repeatedly)

Fig. 1 and 2 shows that hodographs are located unevenly on the plane. In Fig. 1, the area of the largest weight's hodograph approximately overlaps areas of hodographs corresponding to lower weights. In Fig. 2, hodographs of barbells' during the lifting of different weights and repeatedly 70 kg weight are distributed in bigger area and hodograph of the largest weight does not cover hodographs of lower weights. Therefore, analysing distribution area of the hodographs on the plane of the repeats it is possible to evaluate reaction of the athlete organism to repeated lifts. Magnitude of the distribution of the hodograph on the plane $[p(t); h(t)]$ during lifting barbell of different weight can be described by the ratio:

$$S_d = \frac{Q}{q_{\max}}, \text{ where } Q = \sum_{i=1}^{m} \int_{p(t)_{iap}}^{p(t)_{ivir}} f\left[h(t)_i\right] d(t)_i + Q_t, \tag{1}$$

where $Q$ – total area of the hodograph; $Q_t$ – empty area between the hodographs; $q_{max}$ – area of the largest hodograph; $m$ – number of hodographs; $h(t)_i$ – heart rate time dependence; $i$ – index indicating which hodograph is being analysed; $p(t)_{\text{iap}}$ and $p(t)_{\text{ivir}}$ – integration limits.

The higher the value of $S_d$ criterion, the higher the distribution of the hodograph's on the plane. Suggested criterion is summary: it is accounting the sensitivity of the organism to the increased load of the barbell, lifting technique and repeatability of the lifting and normal reaction of the organism to the increased load. The value of this criterion would always be $1 \leq S_d < \infty$. When

$S_d \approx 1$, the area of the hodograph of the largest lifted weight covers all other hodographs corresponding repeated lifts with lower weights and it would indicate stable organism reaction to the magnitude of lifted weight.

The natural reaction of the organism to the increased weight and lifting technique can be evaluated with following criterion:

$$S_{st} = \frac{\max\limits_{i}\left\{\int\limits_{p(t)_{iap}}^{p(t)_{ivir}} f\left[h(t)_i\right] d(t)_i\right\}}{\min\limits_{i}\left\{\int\limits_{p(t)_{iap}}^{p(t)_{ivir}} f\left[h(t)_i\right] d(t)_i\right\}}. \tag{2}$$

The value of this criterion is $1 \leq S_{st} << \infty$. When the value of the latter criterion is very large, it is indicating that the skills of the athlete needs to be improved.

**Discussion**

Presented hodographs in the Fig. 1 and Fig. 2 represent possible distribution of the hodographs on $p(t)$ and $h(t)$ plane (Fig. 1) and constant reaction of the advanced athlete to the lifted weight (Fig. 2). Carried out calculations on the presented above hodographs are showing that the criterion value of the advanced athlete is $S_d \approx 3.1$, while for the beginner it is $S_d \approx 1.24$. It shows that the organism of the advanced athlete reacts very sensitively to the repeated lifts and lifting weight magnitude. When comparing values of second criterion $S_{st} \approx 4.0$ and $S_{st} \approx 2.0$ for beginner and advanced athlete respectively, they're differ almost two times. The beginner athlete needs to improve his skills, while the reaction of his organism is more stable to the repeated lifts. The coach should evaluate the features of the athletes.

The criterions are integral and they do not identify particular weaknesses of the athletes. For example, the $S_d \approx 4.0$ for beginner athlete could mean that his lifting technique is low, but does not clearly shows what is wrong. Further analysis of the weightlifter's biomechanics parameters might provide related to the technique additional and missing information. Inertial measurements of athlete's hands accelerations during the lifting revealed that there is uneven distribution of the strength between the arms in beginner athlete. The advanced athlete is showing more even distribution of the arm velocities during snatch than it is for the beginner athlete. Therefore, additional analysis of accelerations and/or velocities can contribute to better evaluation of athlete's weaknesses and coach, combining values of $S_d$ and $S_{st}$ criterions, could develop more personalized training methodology and to help increase athlete skills.

**Conclusions**

Results of experimental research and their analysis allowed making following conclusions:

1. Based on explained regularities of arterial blood pressure relation to heart rate it is possible to evaluate sensitivity of the weightlifter's organism to the magnitude of the weight, lifting technique and repeated lifting.
2. Formulated integral criterions for the evaluation of sensitivity of the athlete organism and his skills. However, criterions need to be used in combination with additional information about the biomechanics of the athlete performance.
3. There is now unambiguous relationship between heart rate and arterial blood pressure. It has been shown that in most cases the blood-pressure of the weightlifter can increase 8–13% after the barbell drop.

## References


[1] Mostofsky, E., *et al.* 2011. Physical activity and outset of acute ischemic stroke, *American Journal of Epidemiology* 173(3): 330–336. http://dx.doi.org/10.1093/aje/kwq369

[2] Moon, Y.-J. 2005. Determination of performance determinant factors in snatch weightlifting, *Korean Journal of Sport Biomechanics* 15(2): 21–29. http://dx.doi.org/10.5103/KJSB.2005.15.2.021

[3] Vladimir, P.; Violer, U. M.; Carmen, T. O. 2014. Spatial–temporal aspects of the influence of the ability to concentrate on the execution of snatch style in performance weightlifting, in *Procedia – Social and Behavioral Sciences* 117: 210–215. http://dx.doi.org/10.1016/j.sbspro.2014.02.203

[4] Nejadian, S. L.; Rostami, M.; Naghash, A. 2010. Cost evaluation of different snatch trajectories by using dynamic programing method, in *Procedia Engineering* 2(2): 2563–2567. http://dx.doi.org/10.1016/j.proeng.2010.04.032

[5] Akkus, H. 2012. Kinematic analysis of the snatch lift elite female weightlifter's during the 2010 World Weightlifting Championship, *Journal of Strength and Conditioning Research* 26(4): 897–905. http://dx.doi.org/10.1519/JSC.0b013e31822e5945

[6] Gourgoulis, V., et al. 2009. Unsuccessful vs. successful performance in snatch lifts: a kinematic approach, *Journal of strength and conditioning research* 23(2): 486–494. http://dx.doi.org/10.1519/JSC.0b013e318196b843

[7] Isaka, T.; Okada, J.; Funato, K. 1996. Kinematic analysis of the barbell during the snatch movement of elite Asian weightlifters, *Journal of Applied Biomechanics* 12(4): 508–518. http://dx.doi.org/10.1123/jab.12.4.508

[8] Martinelli, F. S., *et al.* 2005. Heart rate variability in athletes and nonathletes at rest and during head-up tilt, *Brazilian Journal of Medical and Biological Research* 38(4): 639–647. http://dx.doi.org/10.1590/S0100-879X2005000400019

[9] Mariūnas, M.; Kuzborska, Z. 2011. Influence of load magnitude and duration on the relationship between human blood pressure and flow rate, *Acta of Bioengineering and Biomechanics* 13(2): 67–72.

[10] Poderys, J., *et al.* 2005. Mobilization of cardiovascular function during the constant-load and all-out exercise tests, *Medicina* 41(12): 1048–1053.