SOME QUESTIONS OF BIOMECHANICAL CHARACTER IN WEIGHTLIFTING

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Professional paper

Abstract
Biomechanics, as a subscience of biophysics is successfully applied for analysis and control of technique of olympic weightlifters. The paper deals with some important questions of biomechanical character in olympic lifting. Special attention is paid to the following topics: efficient and optimum technique, ideal trajectory in snatch and clean, analysis of the barbell+lifter common system, change of category of the lifters from point of view of biomechanics. The paper deals with a new proposition, concerning the analysis and improvement of the technique in olympic weightlifting, based on the complex system. To the new statement the optimum technique means: not the barbell, but the center of the gravity of the common (barbell+lifter) system should be lifted vertically. This statement is valid in case of snatch and also in case of clean and jerk.
Keywords: *center of gravity, clean+jerk, snatch, strength, technique, trajectory*

INTRODUCT ION

To the opinion of Geoff Fleming(www.chidlovski.net): „ In lifting you must be superior in strength, speed, flexibility and coordination, plus have a lot of courage. Most sports require only one or two of these things." I have a similar opinion. Today there are different lifting branches (e.g. stone lifting, power lifting), and one of these sports, one of the iron games is the weightlifting. Modern weightlifting (olympic lifting) is not only an individual sport branch - evaluating on the competition the performance of the competitors in snatch and clean+jerk – but this is a basic sport, the adequate background for many other sport branches, fitness for almost all other sports(Ajan, Baroga, 1988). Trying to give an appropriate definition of modern olympic lifting Ishould agree perfectly with opinion of an excellent, 75 kg category former lifter, today a wellknown specialist in weightlifting, vice-president of the International Weightlifting Federation, chairman of the Coaching and Research Committee of IWF, Dragomir Cioroslan(1996): „Olympic weightlifting is a sport of outstanding neuromuscular coordination, fine kinestetic perception, agility and ability to perform accelerated and explosive movements in a specific line of technique with maximum accuracy."

I would like to stress the following words of the definition: „specific line of technique". In the paper I am going to deal with this topic, focusing of course only on the execution of lifts in weightlifting (both on the training and competition). With other words: how to perform a lift in snatch or clean and jerk, correctly to the principles of biomechanics?

We all know, that there are many factors, influencing the performance level of the lifters, e.g. the physical, biological and mental parameters of the competitors, the volume and intensity of the training, the conventional nourishment and the application of food supplements, medical care, the level of coaching etc. Of course if we speak about performance of really top lifters we should not forget to mention the application of scientific knowledge, which is becoming increasingly important in order to maximaze the performances as a result to increase the chances to win medals at the major international competitions, World Championships and even Olympic Games.
One of the possibilities of application of modern scientific knowledge in olympic weightlifting sport is to use the achievements of up-to-date biomechanics. This can be carried out e.g. in the following directions:

- to study the dynamics of the movements (bar, body, parts of human body)
- to determine the velocity and acceleration in linear motion and in angular motion
- to analyze the lifting technique for classical lifts (snatch and clean+jerk)
- to determine the efficiency of the different lifts
- to study the kinematic movement of the barbell+human body common system
- to determine the strength and power parameters of the lifters

Of course to carry out such types of measurements we need sophisticated monitoring and measuring systems, modern

equipments to analyze the lifting and the technique of he lifters in training and in competition, as well. So the biomechanical experts, researchers should employ computers, video equipments, specialized sensors and many other powerful tools. In well developed countries – paying special attention to application of the newest results of scientific research – there are in use some special possibilities of biomechanical character, e.g. measurement of 3D external and internal kinematic parameters (barbell trajectories, barbell velocity and acceleration, horizontal and vertical displacement, angular velocities and accelerations in the hip, knee and ankle joints etc.). And many other tools, e.g. application of other measuring systems, like force plates, mounted into the platform, containing sensors to record the ground reaction forces and some other high performance techniques, based on the registration of ultrasound, magnetic resonance (MR), computer tomography(CT) signals Medvedjev (1979), Szabo (1982,1986), Baumann (1985), Lukashev, Sivokhin (1989), Hiskia (1993, 1997, 2002), Jones (1995),(Cioroslan (1997), Barton (1997), Garhammer (1998), Okada et al. (1998), Kingma et al.(2001), Tschamer, Sust (2001),Tihanyi (2002), Poletaev (2007), Jones et al.(2009).

The application of biomechanical knowledge for measurements, investigation, evaluation and analysis in weightlifting is a huge field, and let me emphasize that analysis of the technique is not possible without taking into account the biomechanical principles. Also in the journal MILO – journal for serious strength athletes - there was a considerable amount of interesting and useful scientific articles – e.g. Hirtz (1996), Askem (1999), Schmitz (2007) – covering e.g. the technique improvement field, based on the biomechanical type evaluation.

In this paper I do not want to carry out a general biomechanical analysis of olympic lifting. I have a new proposition to analysis of the lifting movements, suggesting for biomechanical analysis the way of the common center of gravity of the barbell+body system! This is an absolutely new idea, no other similar statements in the scientific literature of weightlifting. I try to focus only on the following special topics:

- mechanics and biomechanics of lifting – from point of view of economy
- common center of gravity of the barbell+body system
- appropriate technique, efficient technique, development of technique and strength
- optimum trajectory, ideal lifting technique, technique improvement
- change of category of lifters from point of view of biomechanics

MECHANICS AND BIOMECHANICS OF LIFTING – FROM POINT OF VIEW OF ECONOMY

What is biomechanics? Biomechanics is the study of structure and function of biological systems, by means of the methods of mechanics. Mechanics is the branch of physics,
two sub-fields of the study:

1. sports biomechanics, which is a sub-discipline of exercise science, that provides insight into human movements, associated with sports and physical exercises
2. the sciences that deal with biomechanics allow to describe of why and how the human body moves the way it does, and why certain individuals perform at varying levels of success in sports

Mechanics is a part of physics, and biomechanics is a part of mechanics. But biomechanics belongs also to biological sciences, so biomechanics (as a part of biophysics) is a bridge between mechanics and biology. The task of the lifter – of course accordingly to the valid technical rules – is to lift the barbell (bar with the discs) to the necessary height. This height depends from the anthropometrical parameters, weight category of the lifter. The efficiency of the lift can be characterized by the the skill of the lifters. The skill of technique is a function
of flexibility, the level of development of muscles, neuro-muscular coordination etc.

From mechanical point of view it seems to be the optimum the vertical trajectory of the lift, because the lift should be performed in a gravitation space, and the vertical trajectory is the shortest way. It is known that the labour (energy) required to perform the lift is proportional to the product of multiplication of force (weight) and way (trajectory). With simple formulas:

$L = F \times s$ and $F = m \times a$ where:

L – labour (energy)
F – force (strength)
s – way (trajectory)
m – mass (bodymass or weight of the barbell or the mass of the common system)
a – accelaration (dv/dt, where v is the velocity and t is the time)

May I add, that knowing the I momentum (impuls) which is calculated as mass x velocity,

we can determine the force, as well. To the formula:

$F = dI/dt = d(m \times v)/dt = m \times dv/dt$

But from point of view of mechanics we have to take into account the question of turning moments, as well – turning moment is the measure of force multiplied with lever - which is necessary to minimize. Easy to understand the difference if we compare the work, carried out by the lifter with e.g. 40 kg load on the bar, having 2 different positions. The first one: the bar is on the chest, so the centre of gravity of the body and the centre of gravity of the barbell is appr. on the same vertical line. The second one: the bar is holded by the lifter on straight arms, in horizontal position, and there is no coincidence regarding the center of gravity of the lifter and the center of gravity of the barbell, because the 2 centers are far away. In this case the lifter has to use some parts of his/her strength ability to compensate the turning moment of the barbell.

Of course weightlifting is not a pure mechanics, but biomechanics, so it is a science applied for movements in biological systems. The lifter practically never lifts the weight perfectly vertical, and this is correct. Why? Because the lifter lifts not only the barbell but also his/her own bodyweight. Therefore analysing the technique we should take into account not only the movement of the barbell (trajectory) and the movement of the centre of gravity of the body, but analysing the common (body+barbell) system and the movement of the common center of gravity (Szabo, 2007, 2009)(Zsuga, 2011). From economical point of view – effective and efficient technique – the common center of gravity should be lifted vertically, to minimize the energy use for performing the lift. Of course this movement needs a little longer trajectory (optimum trajectory) than the vertical one, but we can avoid the negative impact of turning moment on the performance of the lifters.

COMMON CENTER OF GRAVITY

The center of gravity of a body is the point at which the mass of this body can be considered to act. It can almost be thought of as a balance point. Due to the force of gravity its line of action is always vertically down. For a barbell, which is of regular and rigid dimension, the center of gravity is fixed and does not change with increasing weight, as the barbell is loaded. It is always located at the center of the bar. But the center of gravity of the human body however, depends very much on the position of the body of the lifter and can change dramatically. For example standing upright the center of gravity is located just above the waist, but with raised arms (finishing position of the lifts) the center of gravity is much higher. Or there is a huge difference between the centers of gravity of the lifter in sitting or standing position with the barbell on the chest.

Once an athlete lifts a barbell from the platform, this common unit (athlete and barbell) can be considered as one system, having a common center of gravity. The location of the common center of gravity will shift toward the heavier unit (athlete or barbell), so as the barbell becomes heavier, the combined center of gravity will shift toward the barbell. This fact has an enormous bearing on preserving the balance and stability of the lifter. Maintaining stability and balance while lifting big weights is of paramount importance, not only from safety perspective but also for the efficient application of maximum force on the bar by the lifter. To maintain balance, the line of action of the common center of gravity must pass through the base. Once the barbell leaves the platform, the base is provided by the feet of the lifter. Thus the line of action of the common center of gravity must be maintained through it, or balance will be lost.

APPROPRIATE TECHNIQUE, EFFICIENT TECHNIQUE, DEVELOPMENT OF TECHNIQUE AND STRENGTH

To my mind it is not correct if the coaches differentiate sharply between strength development and technique development (improvement) training sytems using classical competition lifts. The reason is quite simple: with low intensity weights it is not possible to develop the technique, because e.g. in case of exercise with 50 % intensity weight the trajectory of the lift is perfectly different from the ones, what the lifters use in case of submaximum or even maximum weights. On the other hand: if the weight exceeds the minimum requirement (70-75 %) for improvement of the technique, this interval is typical for the dynamic (explosive) strength development, and even in case of higher reps it is convenient for maximum strength development, as well. So, if you really improve the technique on the training with optimum intensity classical lifts, in the same time it is good also for strength development. This statement is valid of course only for classical lifts, because e.g. with back squat (independently from the intensity) we can not develop the technique, this is a typical exercise for strength development.

Speaking about the evaluation of the weightlifting technique, power is also very important, and relation of that with biomechanical character should be mentioned by all means. Power is the ability or capacity to act or perform effectively. Power in weightlifting is a specific capacity, faculty or aptitude of the athletes. Power can be accepted as strength or force exerted or capable to exercise control. Power is the combination of speed and strength, characterising the dynamic abilities of the lifters.

Based on the principles of biomechanics it is evident, that each weight (different intensity!) needs a different technique, if we would like to perform an optimum lift from biomechanical point of view. The good, appropriate technique means in the same time an effective and economic technique – demanding only minimum energy - and the correct evaluation of the trajectory with the given weight can be performed only based on this fact. And one another, not negligable fact is the following: using good technique the probability of injuries is much less than in case of not adequate technique. So, the coach should teach for the lifters good technique not only to be able to lift bigger weights, but to be an injury-free athlete, as well.

Evaluating the technical skill of Pyrros Dimas, one of the greatest weightlifters of all times, Jim Schmitz(2007) had the following opinion: It is better to be fast and strong than to just have good technique. May I add to this opinion that an excellent lifter – Dimas is a 3-times olympic gold medalist – has to have of course high level speedy and strength parameters, but also a very effective, for him appropriate, precisely individual technique, based on biophysical principles and his own anthropmetrical peculiarities. Good technique is a reserve for performance improvement, and with improvement of the performance we need a step-by step technique modification, as well.

OPTIMUM TRAJECTORY, IDEAL LIFTING TECHNIQUE, TECHNIQUE IMPROVEMENT

There are general rules, but the real and actual technique applied by the different lifters (different performance-level and skill) is not the same. The exercise carried out by the weightlifter is in that case close to the optimum, if during the lift the movement of the common center of gravity is vertical and the energy requirement for compensation of the negative impact of the turning moments is on the minimum. Based on these general principles the different loads (different intensities, different weights) need different trajectories, if we speak about ideal ones. But the ideal technique is never absolute, it is always individual! Why? Because of the anthropometrical differencies among different individuals. At the competitions – expecting the maximum results from the lifters – the competitors have to perform lifts with maximum or almost maximum weights, and successful lifts are possible only using optimum or close to the optimum techniques. The maximum or close to the maximum weights need therefore a similar (rather stabile) lifting trajectory, therefore the ideal weight for technique improvement on the trainings is appr. 80-85 %. This intensity is enough high for optimization of the trajectory (biomechanical point of view) and it is still not a too high psychical load on the athlete, because of the high intensity of the lifted weights. And the risk of injury is also less with these weights than in case of over 90 % intensity attempts. Because the load and the duration of the attempt is not the same in case of snatch and clean+jerk, to my mind the optimum intensity for technique improvement should be in the range 75-80 % for clean+jerk, and 80-85 % for snatch. The reason is that the recovery after snatch is faster, so the intensity of the training weight can be slightly higher.

The ideal technique is always individual. Let me mention the opinion of an indian thinker, Swami Vivikananda: „Your way is the most appropriate one for yourself, but it is not applicable for other people. Always use your own way, and do not copy the others"

I think this opinion is valid also in case of technique of olympic lifters. This is a relevant advice also for the athletes, because the good balanced technique should be always individual, based on the own anthropometrical parameters.

CHANGE OF CATEGORY OF LIFTERS FROM POINT OF VIEW OF BIOMECHANICS

Based on the statement for the common center of gravity, it is not too difficult to understand that the ideal technique of the lifters depends not only from the intensity, but somewhat also the bodymass of the lifter (the category) has an impact on it. Its a quite typical case today, that the adult lifter in age 22 years competes e.g. in the 77 kg category, a few years later – because he has a higher training weight – he is a competitor of the 85 kg category , and finishing his lifting career he participates in the competitions for the 94 kg lifters. The very famous hungarian weightlifter (my P.E. teacher in gymnasium), world champion and silver medalist of Olympic Games, Geza Toth (1932-2011) was a 75 kg lifter till 1958, till 1964 a

82.5 kg lifter and from 1965 till the end of his lifting career (1970) he competed in the 90 kg category. So changing the bodyweight, changing the category, it changes the common center of gravity, as well, even in case of the same weight of the barbell. So we need a slightly modified technique in comparison with the previously used one, because of the fact, that during the lifting – as I proved - not the barbell, but the the common center of the gravity should be lifted vertically. And with change of the own bodymass of the lifter it changes also the center of the body+barbell common system.

It seems to be necessary to mention that the question of technique-modification as a function of category-changes is more difficult, and the determination of the optiumum category for the lifter is sometimes not an easy task. There are other and not only biomechanical (and anthropometrical and physiological) parameters, what we have to take into consideration. I do not want to go into details about these factors, but let me mention the most important ones: change of body-composition (muscle-ratio, fat-ratio, bone-ratio) change of level of development of different muscle groups, change in the flexibility and in the joint mobility, change of the ratio of agonistic and antagonistic muscles, change of the loadability, change of expectations and change of rivals. Because of long years training (adaptation process) significant changes can be determined also in the physique (stature) of the lifters, the somatotype modification is evident, the mesomorf component (measured e.g. by Heath-Carter method) increases, the ectomorf one decreases.

PRACTICAL ASPECTS

Every individual human being has to have his/her own lifting technique, which can be rather different from the technique applied by other people with other body parameters. Of course if somebody would like to carry out an attempt with optimum technique, this should be based on correct biomechanical principles. To my proposition it means, not the barbell, but the center of the gravity of the common (barbell+lifter) system should be lifted vertically during the attempt. This is the requirement from point of view of efficiency, economy, safety and stability. This statement is valid in case of snatch and also in case of clean+jerk.

Why to pay attention to develop this type of technique? The reason is quite clear also for the practical coaches: if the common center of gravity will be lifted vertically we can minimize the energy requirement for the lift and minimize also the negativ effect of turning moments on the performance of the lifter. So he/she will produce a better result. Plus another advantage: having an optimum technique from biomechanial point of view the risk of injury is also much less. This fact is because of the good balanced lift, minimizing the unnecessary load on the joints of the body of lifters.

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NEKA PITANJA BIOMEHANIČKIH ODLIKA DIZANJA TEGOVA

Stručni rad

Sažetak

Biomehanika, kao substratna nauka biofizike, uspješno se primjenjuje za analizu i kontrolu tehnike olimpijskog dizanja tegova. Rad se bavi nekim važnim pitanjima biomehaničkim odlikama olimpijskog dizanja. Posebna pažnja je posvećena slijedećim temama: efikasna i optimalna tehnika, idealna putanja u izbačaju i trzaju, analiza zajedničkog sistema dizač – šipka, promjena kategorije dizača sa biomehaničkog gledišta. Također, rad se bavi novim propozicijama, analizom i poboljšanjem tehnike olimpijskog dizanja, a zasnovanom na složenom sistemu. Prema novim izjavama optimalna tehnika podrazumjeva: ne šipku, nego zajednički centar gravitacije (dizač-šipka) koji bi se trebao vertikalno podizati. Ova izjava je validna u slučaju i trzaja i izbačaja.

Ključne riječi: *centar gravitacije, nabačaj, trzaj, snaga, tehnika trajektorija*

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Biomechanical engineers can often communicate with people in other countries. Being able to speak another language can be a valuable asset. Look for ways to work on your problem solving abilities. Problem solving is a key attribute of biomechanical engineers. You can hone your problem solving abilities in a variety of classes, clubs, and athletic teams while still in high school. Advertisement.Â Go to career fairs at your college. Some career fairs may focus on engineering, so you can start talking to some companies youâ€™d be interested in working for. Make contacts early so you can talk to them later about potential jobs. Take the Fundamentals of Engineering examination.Â 200 characters left. Include your email address to get a message when this question is answered. Submit. Biomechanical Engineer Interview Questions. 12 Questions and Answers Written by Professional Interviewers. Question 1 of 12. Why do you want a career as a biomechanical engineer? Next Question. Get More Interview Practice.Â Our careers, companies, industries, and schools may have duplicate interview questions and answers found elsewhere on our website. Specifically, our companies and our graduate school interviews. For these two, we use the industry in which we believe the company most well-represents and the graduate programs, as the basis for the interview questions and answers that generate for each company or school.