# TRAINING

## BENCH PRESS TECHNIQUE

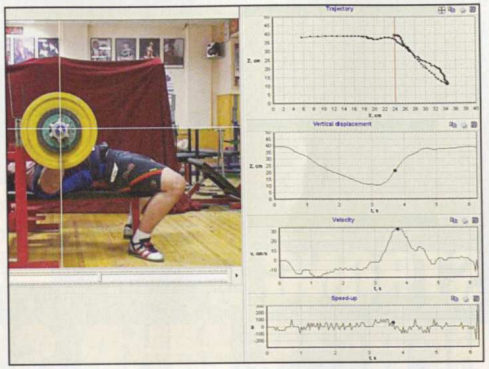
### Results of the Biomechanical Analysis of the BP Technique

*as told to Powerlifting USA by Boris Sheiko, Vladimir Fetisov, and Boris Lukyanov*

For the achievement of the top results in sport, the efficient technique is necessary—the most rational and efficient way of the competition exercises execution. On the all sporting way from a beginner to the world-class athlete, a sportsman must constantly work upon the improvement of his technical skill.

Technical preparation of athletes is impossible without the analysis of the performance of the sport's exercises. The biomechanical analysis is the most objective and substantial. The question about its efficiency has particularly come up at the present stage of the sport development: the exercises technique getting more and more complicated, high requirements to the technical skill, the enormous incandescence of the sport fighting compels to mobilize the available reserves of the training information.

The exact quantitative biomechanical analysis of the exercise execution presents itself a powerful instrument of research in the sport field. This form of the analysis is necessary for revealing and setting the standards of competition exercises execution, for decision on a matter of the building of the motion, for determination of the biomechanical regularities of moving functions. This kind of analysis allows us to understand the reasons and essence of technical mistakes of making physical exercises—first of all the athletic ones, to find the way to remove such mistakes, to select the variant of the efficient individual interpretation of the exercise technology and at the same time to save wholeness of the rational base of the technique. The biomechanical analysis presents the unit, which is called to link the biomechanics organically with sport training.




***Picture 1.*** *Typical graphs of the trajectory of the center of the barbell's butt and of the time-bases of its vertical displacement, velocity and speed-up (on the graphs the black point designates the position of the current observable shot) (photos & graphs courtesy Sheiko)*

In modern sport the approach to the estimation of the sport exercise technique, either as many factors of the organism of the athlete, remains basically empirical. Very often the working of the researcher on analysis of facts about moving functions and their comparison carries the stale nature, particularly if serial experiment is conducted with many tested persons. Meantime with the information technologies development it became possible to automate the researcher's work, save him from the need to process manually the immense amounts of data. In particular, the tempestuous development of the video and computer technologies of the video files processing makes much more expedient the using of these achievements in the analysis of the sport moving functions.

In such sports as powerlifting at present time there is the deficiency in information about the biomechanical parameters of the competition exercises execution technique. During the studying of the scientifically-methodical literature the authors did not discover any works with detailed description of the rational technology of exercises execution in powerlifting, of the possible changes of this technology depending on different factors (such as athlete's antropometric parameters, the level of physical preparedness and athletic skill, the presence of the special equipping and others). Thereby, the undertaking of the studies in specified directions is very actual. All this can give more valuable information to the coaches and sportsmen in the field of skill revealing and rational management of the training process.

The goal of our research is a study of the sport exercises technique in powerlifting with attraction of modern technical facilities. The detailed knowledge of the features of the motion will considerably help to elaborate the recommendations for the technique improvement methods of powerlifters of the different sport qualification. The given article describes some results of our work on studying of one of the three sport exercises—bench press.

The priority problems of this study were: 1) the statistical observations of the bench press execution technique by the athletes with different techniques and qualification in competition conditions; 2) the categorization of the received kinematic features; 3) the comparison of the received features with success of the current attempts and the athlete's achievements in longer retrospective review.

In our study we have used the kinematical analysis elements of the human physical actions, in which the following motion features are usually studied as trajectories, displacement, velocities and speed-up time-bases. At this stage of the studies, for the bench press technique analysis in powerlifting we used the motion trajectory of the centre of the barbell's butt, as well as the time-bases of changes of the vertical coordinate of this point.

Basically all barbell's points move relatively to the athlete in planes, which are parallel to his sagittal plane. So in order to make an analysis of the motion of any point of the biokinematical system "athlete-barbell" it is particularly important to know two strands of its motion: vertical and horizontal, whose the integral factor is the motion trajectory of some point of the barbell. The trajectory of the barbell's center of gravity is one of the most important features of quality of the competition exercises technique in powerlifting, giving corresponding idea of vertical and horizontal spatial displacements of the whole system. Under certain admissions it is possible to think that the trajectory of the centre of the barbell's butt (CBB) repeats the trajectory of the barbell's center of gravity (BCG).

The study was conducted on the base of the School of the highest sportsmanship of the Republic of Bashkortostan (city of Ufa). The bench press execution by the athletes of different level was analyzed (Candidate master -30 persons, Master of sports of Russia – 70 persons, World-class athletes – 20 persons). The observations were conducted at the period of 2006-2007 during the competitions of regional and all-Russian levels: the Cup of the Republic of Bashkortostan (2006), the bench press championship of the Republic of Bashkortostan (2006), the Ural and Volga regions' championship (2007), the championship of the Republic of Bashkortostan (2007), the Russian junior championship (2007), the Cup of Russia (2007). During the studies in the purpose of video filming we have used the digital Sony HDR-HC3E video camera with shooting speed of 25 frames per second. For the video clip's digital conversion we have used the base plate of the frame capture and software package Pinnacle Studio 10.0; the frame format - .avi, 720x576 pixels. For the video segments' computer analysis the authors have elaborated the software product Motion Trace/Powerlifting.

The authors have analyzed more than 250 exercise execution attempts by the athletes of different level and different weight categories with the analysis of the above-mentioned kinematical features of the CBB's motion.

The bench press technique analysis was conducted on the base of the bench press phase structure [5, 6] (Table 1).

**Table 1: Phases of the Bench Press Execution**

| Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Phase 6 | Phase 7 |
|---|---|---|---|---|---|---|
| The prior start position | Start position (fixing the weight on the straight hands) | Descent the weight to the chest after the referee's command <start> | The pause fixing with the weight on the chest | The bench pressing after the referee's command to press | Fixing the apparatus in the final position | Putting the weight to the support after the referee's command <to the supports> |

According to the technical competition rules, the 1st and the 7th phases are executed by the athletes by the means of assistants [7], that's why the bench press technique analysis directly from the 3rd to 5th phases provokes the most interest.

#### Phase 3. Descent the weight to the chest

After the acoustical signal "start", which is given by the main referee, an athlete lowers the barbell on his chest (the chest, according to the present rules, ends beside the base of the breastbone) [7]. The time of the barbell's descent on the chest depends on athlete's anthropometric particularities of the (the lengths of hands), the width of the grip, the height of the "bridge", the lowering velocity and the barbell's weight, as well as it depends on the bench press shirt quality. After more than 250 graphs of the barbell's vertical moving in the descent phase were being analyzed, it was revealed that the duration of the descent phases varied from 0.6 up to 3.0 seconds that at the average has formed 1.28 seconds.

#### Phase 4. The pause fixing with the weight on the chest

After the barbell's descent on the chest, the athlete must keep it in still position on the chest [7]. The barbell's still position on the chest means the stop. At the analysis of the vertical displacements graphs it was revealed that the athletes' pauses are different, not only in its duration, but also in its execution. Along with athletes, who begin the barbell's press execution from the same point, where they have lowered it (for example see picture 7 and picture 8), we can meet the considerable amount of sportsmen, whose barbell is displaced during the pause on the chest. The barbell can be displaced onward (from the head) or back (for example see picture11).

The minimum fixed pause duration made 0.3 seconds, the maximum pause duration was equal to 1.5 seconds. The average pause was 0.70 seconds.

#### Phase 5. Bench press

After the command "press" of the main referee the athlete must press the barbell upwards on straight hands without the surplus (too strong) uneven unbending of the hands [7].

All paths of the bench press execution can be conditionally divided upon their form into several groups, differing by the typical elements. The each of the pictures 2-11 presents one typical example of the each trajectory group that we have noted.

For all trajectories presented in the given work, the athlete's head must be situated on the left. The criterias of the clusterization on groups are: presence or absence of the intersection with the vertical, getting through the trajectory's beginning (which is shown by means of the vertical line on graphs); presence or absence of the loop; presence of the trajectory's vertical area, presence or absence of the lower flat area (the offset of the bar onward or back before the beginning of the ascent of the barbell from the chest).

We shall consider the typical trajectories groups and their elements that we have detected:

1. The trajectory of the type 1 (picture 2). The trajectory of the phase of the ascent (strictly the press) practically repeats the trajectory of the phase of the barbell's descent. There is no any intersection with the initial vertical. The trajectory is often nearly straight. The distant point of the stop from the vertical tells that the athlete has lowered the barbell far on his belly that is forbidden by the competition rules.

2. The trajectory of the type 2 (picture 3). The trajectory of the phase of the ascent once crosses the initial vertical and vastly deviates from the trajectory of the phase of the barbell's descent aside the athlete's heads.

3. The trajectory of the type 3 (picture 4). The trajectories of the barbell's descent and ascent phases don't cross with each other and with the initial vertical; herewith they slightly disperse from each other. The entire trajectory is situated on the right from the initial vertical.

4. The trajectory of the type 4 (picture 5). The trajectory of the ascent phase is slightly displaced onward from the trajectory of the descent phase and returns nearly in the source point. There is no any intersection with the initial vertical.

5. The trajectories of the type 5 (picture 6) are characterized with the presence of the loop in the lower part of the trajectory, moreover the ascent phase beginning is displaced to the right (up to the athlete's legs) relatively to the descent phase end. The trajectory of the ascent phase can cross or can not cross the initial vertical.

6. The trajectories of the type 6 (picture 7) are also characterized with the presence of the loop, but it is higher than in the previous trajectory. The ascent phase beginning is displaced to the left (to the athlete's head) relatively to the descent phase end. The trajectory of the ascent phase doesn't cross the initial vertical.

7. The trajectories of the type 7 (picture 8). The ascent phase trajectory once or twice crosses the initial vertical. On the picture 8 we can see that after the barbell's stop the athlete has done the indention of the bar in the chest that is forbidden by the rules.

8. The trajectories of the type 8 (picture 9) are characterized with the presence of the typical "stumbling block" (hereinafter "dead point") on the area of the ascent phase. This area is the most uncomfortable for the manifestation of active muscular power of the athlete. This zone is one of the main factors, limiting the sport result. The correlative analysis has shown that the height and the time of the "dead point" manifestation is individual for each athlete. Their amounts depend on the qualification, gender, per-

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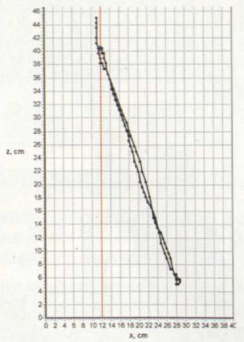
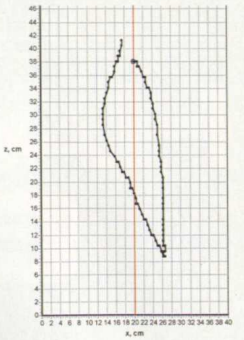
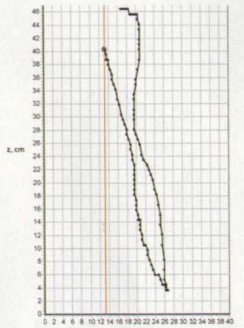


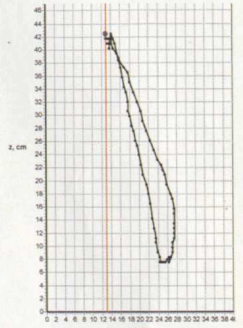
***Picture 2.*** *Trajectories of the 1st type*



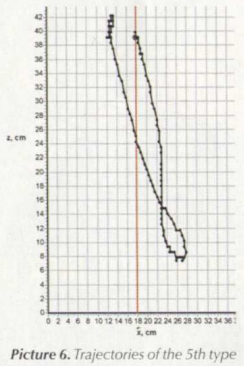
***Picture 3.*** *Trajectories of the 2nd type*



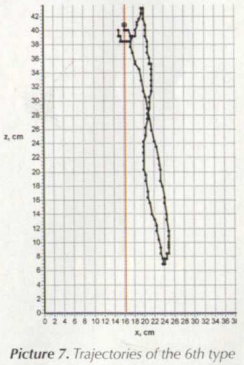
***Picture 4.*** *Trajectories of the 3rd type*



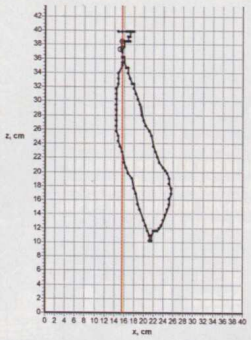
***Picture 5.*** *Trajectories of the 4th type*



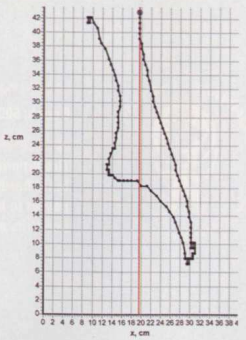
***Picture 6.*** *Trajectories of the 5th type*



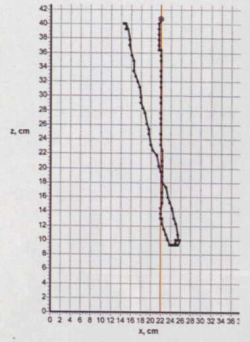
***Picture 7.*** *Trajectories of the 6th type*



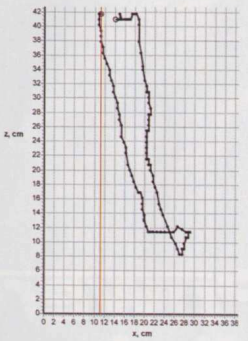
*Picture 8. Trajectories of the 7th type*



*Picture 9. Trajectories of the 8th type*



*Picture 10. Trajectories of the 9th type*



*Picture 11. Trajectories of the 10th type*

*(continued from page 13)*

centage of the apparatus weight and the individually-maximum result in the press. The trajectory of the ascent phase can cross or can not cross the initial vertical.

9. The trajectories of the type 9 (picture 10) are characterized with the nearly vertical descent of the barbell with a possible (single or double) intersection of the initial vertical. The ascent of the barbell is possible either on the trajectory with forming the loop, or on the trajectory, wholly lying to the left of the initial vertical.

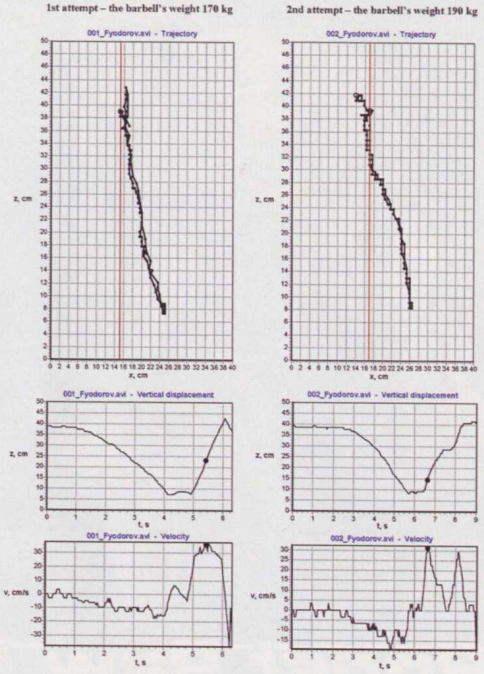
10. The trajectories of the type 10 (picture 11) are characterized with the presence of the offset of the bar to the left or to the right in the lower part of the trajectory.

The juxtaposition of the trajectories configuration with the average number of ascents successfully executed by the athletes of different qualifications has shown that the trajectories on the pictures 1–4 are characteristic most of all for the athletes who have got high and stable results in the competitions.

The duration of the phase of the press from the chest were also quantitatively evaluated. This phase has a wide scatter of values in time: from 0.5 seconds up to 5.0 seconds, at the average duration of 1.4 seconds.

We can notice an observable repeatability of elements which are typical for the concrete athlete, so it makes sense to carry out the technique analysis, the estimation of the athlete's current condition, the forecasting of the following results and the loads' correction, having a set of statistical matters on the given athlete. We were, in particular, gathering the information on trajectories and temporary unrolling of the CBB's vertical displacement, supplied by the materials about the weight of the athlete and of the apparatus, the attempt success and the factors, which can influence upon the result.

For example, on the pictures 11 and 12 we see the trajectories as well as the time sweep of the CBB's vertical displacement and the relative CBB's




*Picture 12. Trajectories and time sweeps of the CBB's vertical displacement for the two attempts of A.Fyodorov (Candidate Master, born in 1978, his own weight 100 kg, the Bashkiria's Cup 17.12.2006)*

motion velocity for the two different athletes. On the left of each of these illustrations there are the graphs for the attempt with weight, corresponding to 80–85% of the limit load, and on the right—for the attempt with weight, very close to the limit. Black points on the graphs mark the positions, corresponding to the spike of the barbell's ascent velocity. The graphs give the visual presentation about the technique particularities of each athlete.

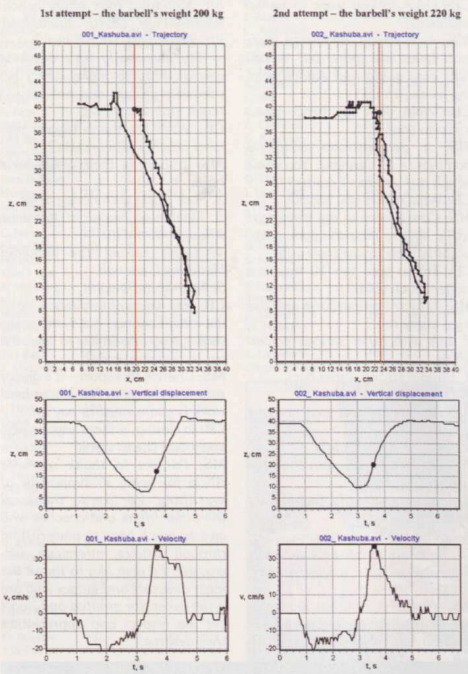
So, the athlete A. Fyodorov (picture 12) is typified by the fluent beginning of the descent phase (about 3 seconds), by the delay in lower position (about 0.6 seconds), and then by the uniform quick ascent (nearly 1 second). When the barbell's weight is close to the limit loads, the uniformity of the ascent is broken: on the time sweep we see the evident "dead point" between the 7th and the 8th seconds, and the ascent velocity graph becomes "double-humped". We can observe this fact beside the majority of athletes during the limit loadings. The corresponding areas can be also often seen on the trajectory graph (see the picture 8).

The technique of D. Kashuba (picture 13) is characterized by the considerably stable trajectory, by the minor deformation during the loads increasing, the uniform ascent and descent nearly equal in time and forming 1.5–2.0 seconds, a short (≈ 0.4 seconds) delay in lower position. The load increasing also causes a certain deceleration of the second half of the ascent phase and a narrowing of the positive surge on the velocity graph, but it is not very much expressed.

It makes sense to recommend the use of the quantitative information about the degree of the trajectory deformation during the barbell's weight increasing and about the deceleration in the medium of the ascent phase in order to make the operative estimation of the athlete's possibilities of the and to plan the trainings.

The time sweeps of the vertical displacement also allow to check the refereeing quality during the competitions, as they can clearly show good and bad barbell's ascent attempts of the athlete. As example, the picture 14a demonstrates the graph for the occasion, when the press delay during the ascent has the critical value, but the attempt is usually scored as the good






*Picture 13. Trajectories and time sweeps of the CBB's vertical displacement for the two attempts of D.Kashuba (Master of Sports, born in 1987, his own weight 135 kg, the Bashkiria's Cup 17.12.2006)*

one, because there is no practically the negative vertical displacement. On the picture 14b we see the area with the negative offset (the offset downwards on the 4th second), because of which the attempt is scored as bad one in spite of the fact that the athlete pressed the barbell by himself.

The analysis of the typical deceleration occasions during the ascent allows to make a conclusion that the attempt is usually scored as bad one, if the ascent velocity at the beginning of this phase doesn't exceed 10 cm/sec or the duration of the flat area in the medium of the phase exceeds 1 second, and the barbell's weight is close to the limit. The pictures 14c and 14d show the graphs for the occasions, when the barbell is already put on the stances by assistants.

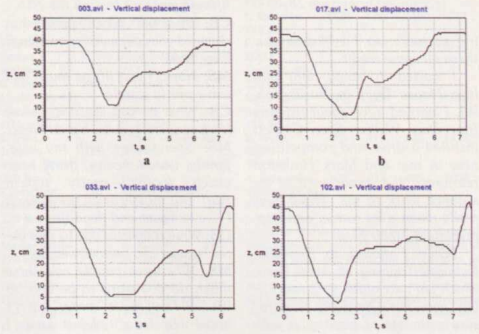
In the course of this research we have realized the biomechanical analysis of the execution of the bench press competition exercises that has allowed to reveal the factors, defining the differences in technique of these exercises, and to make objective estimations of them.

The high-class athletes with the fully formed technique are typified by their own stable and unique trajectory type, as well as by the type of the time sweeps of the vertical displacement and velocity.

The trajectory analysis allows to draw conclusions concerning the motion rationality and the presence of the evident mistakes while doing an exercise.

The revealed kinematical particularities of the exercises performing can be used in creating the models of the rational (master) powerlifting exercises techniques.

The obtained results of the studies allow to make a qualitative express-analysis of the motion during




*Picture 14. Time sweeps of the CBB's vertical displacement during the athletes' unsuccessful attempts of the apparatus ascent in the bench press*

the trainings or competitions, even without the accumulated video segments base on the concrete weightlifter.

Comparing the space-temporary and dynamic features of the motor actions of the athletes of different sport skill during performing the exercise, we can get a foretaste of mistakes of the athlete with the lower skill level and of the master technique parameters, required for the high results achievement.

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