Method of calculation of asymmetry of bar push from chest according to the results of high-speed 3d shooting

UDC 796.886

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Abstract

Objective of the study was to develop and test a methodology for analyzing the asymmetry of the push of the barbell from the chest.

Methods and structure of the study. High-speed 3D video filming was carried out with four cameras. The push-and-pull exercise was performed by the candidate master of sports S. Kh-vym, the weight of the barbell was 125 kg. Coach - Honored Coach of Russia S.A. Syrtsov. An analysis of the push of the barbell from the chest is presented. The method of performing a push of the barbell from the chest is "in scissors". Shooting was carried out synchronously at a speed of 250 fps.

Results and conclusions. The analysis of the video recording was carried out and the following indicators were calculated: the time dependence of the coordinates, velocities and accelerations of the ends of the bar during the push from the chest, the difference between the vertical and horizontal coordinates of the right and left ends of the bar, the vertical and horizontal components of the forces applied by the athlete to the right and left packages of pancakes. A comparative analysis of these indicators was carried out in two approaches. The moments of time are found at which the minimum and maximum differences of the vertical and horizontal coordinates of the neck ends are reached. Estimates of the asymmetry of the shock have been made. The proposed method can be recommended for use in the training process of athletes and the training of coaches and weightlifting specialists.

Keywords: *bar push from the chest, biomechanical characteristics, high-speed video filming, bar turns, asymmetry.*

Introduction. The relevance of this work is determined by the fact that this technique allows you to calculate the indicators necessary for the analysis of technique based on the results of high-speed shooting: vertical and horizontal movements, speeds and accelerations of the ends of the neck, vertical and horizontal forces applied by the athlete to the right and left packages of pancakes, etc., and allows performance-related visualization of the movement of the athlete and the barbell. The technique has no analogues in the world.

Objective of the study was to develop and test a methodology for analyzing the asymmetry of the push of the barbell from the chest.

Methods and structure of the study. To assess the asymmetry of the movement of the bar during the push of the bar from the chest, the necessary spatio-temporal, kinematic and dynamic indicators are calculated and the boundaries of the phases are determined. To calculate these indicators, a complex technique was used [2]. To register movements, high-speed 3D video recording was carried out with four cameras. Two cameras were located at the ends, one in front, one at an angle. The survey results in fig. 11-15. The presented arrangement of cameras allows shooting, according to which the necessary indicators can be calculated [1, 3].

Results of the study and their discussion. Let's analyze the asymmetry of the movement of the bar during the push from the chest. Graphs of vertical and horizontal displacements, speeds and accelerations of the left and right ends of the neck are shown in Figures 1-6. On all these graphs, the time is counted along the abscissa axis from the start of the

push. As can be seen from figures 1, 3, 5, the shapes of the curves of vertical displacements, velocities and accelerations are identical for the right and left ends. Differences in amplitude values are maximum for acceleration peaks – 18%. The differences in the curves of horizontal displacements of velocities and accelerations are more pronounced and reach 28% for acceleration peaks. There are differences in the forces acting on the right and left packets of pancakes. Thus, the maximum horizontal force at the left end is 290 N, and at the right end it is 200 N. The vertical forces are almost the same, the maximum difference at the peak of braking is 30 N. Using the obtained dependencies, it is possible to calculate the rotations of the barbell at any time and obtain the values kinematic and dynamic characteristics at that moment.

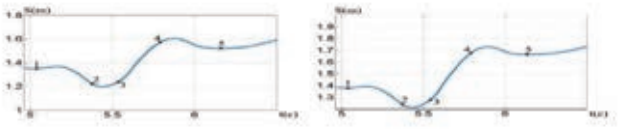

Figure 1. *Vertical movements of the left (left) and right (right) ends of the neck*

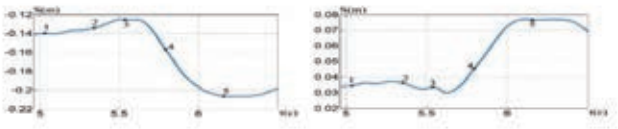

Figure 2. *Horizontal movements of the left (left) and right (right) ends of the neck*

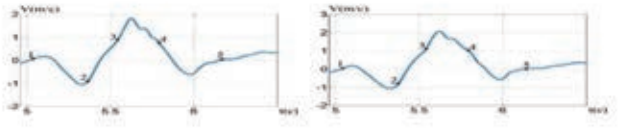

Figure 3. *Vertical speeds of the left (left) and right (right) ends of the neck*

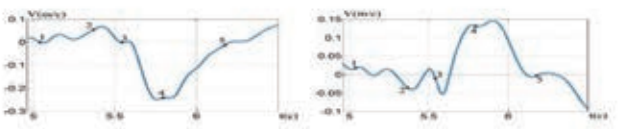

Figure 4. *Horizontal velocities of the left (left) and right (right) ends of the neck*

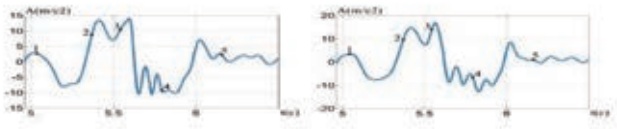

Figure 5. *Vertical accelerations of the left (left) and right (right) ends of the neck*

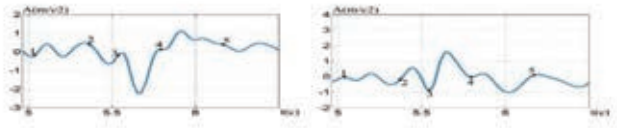

Figure 6. *Horizontal accelerations of the left (left) and right (right) ends of the neck*

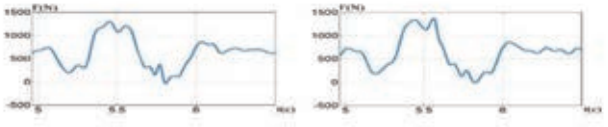

Figure 7. *Graph of the dependence of the vertical components of the forces applied to the packages*

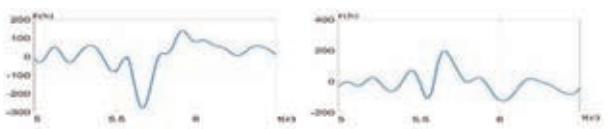

Figure 8. *Graph of the dependence of the horizontal components of the forces applied to the packages*

Positive values of the difference in vertical coordinates correspond to the rotation of the bar counterclockwise in the frontal plane (Figure 9). Negative values of the difference in horizontal coordinates correspond to the clockwise rotation of the neck (top view) (Figure 10).

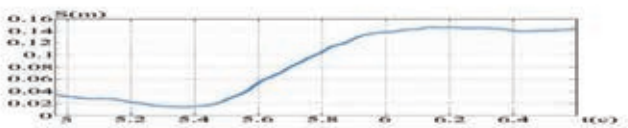

Figure 9. *Graph of the difference in the vertical coordinates of the ends of the neck*

The difference in vertical coordinates (Figure 9) at the beginning of the half-squat phase was 3 cm. On the graphs (Figures 1-6), the point of the beginning of the half-squat is marked with a marker “1”. The pos-

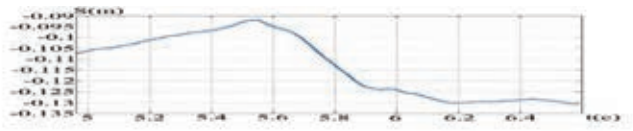

Figure 10. *Graph of the difference between the horizontal coordinates of the ends of the neck*

ture of the athlete at this moment is shown in Figure 11. Vertical and horizontal coordinates, speeds and accelerations of the ends of the neck at this point in time are shown in tables 1 and 2. During the half-squat, this value decreases to 1.4 cm, and then, up to fixation, increases and reaches a maximum value of 14.6 cm. The posture of the athlete at the moment of the minimum tilt is shown in Figure 12. On the graphs shown in (Figures 1-6), the point corresponding to the minimum value of the difference in coordinates is indicated by the marker "2". The inclination of the neck at the moment of fixing the barbell is clearly visible visually (see Figure 13). The moment of fixing the rod on the graphs shown in Figures 1-6 is indicated by the marker "5". The moment of change from a decrease in inclination to an increase occurs after the completion of acceleration down and with the onset of intensive braking.

Figure 11. *The posture of the athlete at the beginning of the semi-squat*

Consider the graphs shown in Figures 3 and 5. At the moment of the beginning of the increase in the inclination of the bar, the speeds of the ends of the bar passed a local minimum and begin to grow. At this moment, the speeds of the left and right ends of the neck are -0.87 m/s, the accelerations are 8.83 m/s2 and 9.43 m/s2, respectively. The right end is braked more intensively, which leads to a counterclockwise turn. The rotation continues to increase monotonously until the bar is fixed. So, at the moment indicated on the graphs (Figures 1-6) by the marker "4", the turn value is 10 cm. The values of the coordinates, velocities and accelerations of the neck ends at this moment are given in tables 1 and 2.

Let's move on to the consideration of the difference in horizontal coordinates (Figure 10). At the beginning of the semi-squat (Figure 11), the difference in horizontal coordinates was -10.5 cm. In the process of performing the semi-squat, this turn decreased to -9.1 cm, and then began to increase and reached -13 cm upon fixation (Figure 13).

Figure 12. *Athlete's posture at the moment of barbell rotation in the vertical plane*

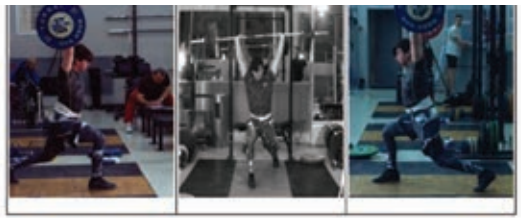

Figure 13. *The posture of the athlete at the moment of fixing the barbell*

Table 1. *Movement parameters at times 1-4 for the left end of the neck*

Coordinate value	1 (t=5,040)	2 (t=5,368)	3 (t=5,54)	4 (t=5,792)	5 (t=6,156)
Y	1,350	1,228	1,242	1,574	1,520
Y'	0,077	-0,878	0,863	0,757	0,020
Y''	2,612	8,834	5,540	-9,646	2,306
X	-0,140	-0,133	-0,125	-0,157	-0,206
X'	0,000	0,054	0,000	-0,241	-0,020
X''	-0,151	0,380	-0,140	0,136	0,410

Y – vertical coordinate, Y' – vertical speed, Y'' – vertical acceleration,
X – horizontal coordinate, X' – horizontal speed, X'' – horizontal acceleration.

Table 2. *Movement parameters at times 1-4 for the right end of the neck*

Coordinate value	1 (t=5,040)	2 (t=5,368)	3 (t=5,54)	4 (t=5,792)	5 (t=6,156)
Y	1,379	1,242	1,276	1,677	1,655
Y'	0,018	-0,870	1,083	1,025	0,020
Y''	3,461	9,427	13,390	-6,451	1,038
X	0,035	0,036	0,034	0,045	0,077
X'	0,018	-0,036	-0,011	0,132	0,006
X''	-0,019	-0,211	-0,864	-0,030	0,042

Y – vertical coordinate, Y' – vertical speed, Y'' – vertical acceleration,
X – horizontal coordinate, X' – horizontal speed, X' – horizontal acceleration.

The athlete's posture at the moment of reaching the minimum difference in coordinates is shown in Figure 14. On the graphs (Figures 1-6), the point corresponding to the minimum difference in horizontal coordinates is marked with a marker "3". Fluctuations in the difference of horizontal coordinates - less than 4 cm. The moment of change in the direction of the horizontal turn (Figure 14) is in the region of the final acceleration phase. At this moment, the values of vertical accelerations at the left and right ends of the neck are 10.45 m/s2 and 13.39 m/s2, respectively (see Figure 5), the horizontal velocity and acceleration are close to zero at both ends of the neck (see Figures 4, 6 and tables 1, 2). The horizontal turn continues in the unsupported phase (Figure 15).

Figure 14. *The posture of the athlete at the moment of changing the direction of the horizontal rotation of the bar of the bar*

Figure 15. *Athlete's posture corresponding to maximum flexion in the knee and hip joints in the unsupported phase*

The analysis of the second approach showed that the bar turns significantly decreased. The turn in the vertical plane increased monotonously until the bar was fixed and at the end it was 3 cm. The turn in the horizontal plane increased and at the end of the semi-squat it was 3.6 cm. Further, until fixation, it decreased to zero. You can consider the turns in the second approach as insignificant. They were no more than one degree.

Conclusions. An analysis of the two approaches showed that the asymmetry calculations are confirmed by motion visualization. In the second approach, the asymmetry of movement was much less, the angles of rotation were less than one degree. In the second approach, the grip changed, which may explain the decrease in bar rotation. The distances from the edge of the palms of the left and right hands to the bosses in the first approach are 33.5 cm and 34 cm, in the second - 34.3 cm and 33.1 cm, respectively. In the second approach, the grip shifted towards the right boss. To conduct a more accurate analysis, it is necessary to use a larger number of surveys.

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