Dynamics of changes in the biomechanical characteristics of the snatch technique with increase in the weight of the projectile under competition conditions

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PhD, Associate Professor **L.A. Khasin**[1]
E.R. Gross[2, 3]
[1]Moscow State Academy of Physical Education, Malakhovka, Moscow Region
[2]Moscow State Academy of Physical Education, Malakhovka, Moscow Region
[3]The Federal Training Sports Center of the representative teams of Russia, Moscow

Corresponding author: eug.gross@yandex.ru

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Abstract
Objective of the study is to assessment and comparison of spatio-temporal and kinematic characteristics of the barbell jerk performed with various weights.
Methods and structure of the study. To achieve this goal, the approaches of 13 athletes of the Russian national team were analyzed in competition conditions using high-speed video filming as part of a survey of competitive activity by a comprehensive scientific group in weightlifting. The results obtained were assessed in order to detect reliably significant differences between the spatio-temporal and kinematic characteristics between the approaches.
Results and conclusions. The results obtained indicate that with an increase in the weight of the projectile, the speed characteristics of the snatch technique significantly decrease, which corresponds to Hill's law, and this, as a consequence, affects the decrease in the height of the approach of the bar at the end of the final acceleration, at the end of the unsupported phase and the maximum height of the approach of the bar, as well as at the time of reaching maximum speed. As the weight of the projectile increases, athletes need to exert greater forces to maintain kinematic and spatiotemporal characteristics. An important conclusion is the need to use 95–100% of the weights in order for the spatio-temporal and kinematic characteristics to reach the required values as a result of training.

Keywords: *weightlifting, biomechanical analysis, spatio-temporal characteristics, kinematic characteristics of equipment, high-speed video filming.*

Introduction. Currently, the dynamics of changes in biomechanical characteristics during the performance of three approaches to the barbell snatch under competition conditions have not been sufficiently studied. Studying this issue will make it possible to determine which characteristics and how they change with increasing weight of the projectile, and will also allow us to answer the question of what changes in weight will lead to significant differences in biomechanical characteristics. The relationship between changes in barbell weight and changes in biomechanical characteristics can be used in a training load planning strategy.

Objective of the study was to determination of spatio-temporal and kinematic characteristics, which have significant changes with increasing load intensity.

Methods and structure of the study. Registration of successful and unsuccessful approaches was carried out at the 2023 Russian Weightlifting Cup using high-speed video recording (250 frames/sec) as part of a survey of competitive activity by a comprehensive scientific weightlifting group. 13 athletes from the Russian weightlifting team took part in the study. The weight of the projectile in the third approach is on average higher than in the second by 2,3% and higher than in the first approach by 6,6%. The weight of the projectile in the second approach is higher than in the first by an average of 3,5%.

The work used the concept of the classic snatch technique, developed at the NIIT MGAFC (Khasin L.A.) [1]. During the study, the duration of the classical jerk phases was determined (preliminary acceleration, depreciation, final acceleration, first support dip, unsupported phase), the maximum height of the approach of the bar, the height of the approach of the bar at the end of the final acceleration, the height of the approach of the bar at the end of the unsupported phase, the maximum speed, time of movement from MOSH (moment of lifting off the rod) to reaching maximum speed, speed at the phase boundaries. To determine the height of the barbell approach, the Tracker program was used, with the help of which the trajectory of a point at the end of the barbell was marked and scaled. For scaling, the vertical dimension of the rod disk was used. The trajectory of the end of the barbell has been digitized. The height of the approach of the rod in the indicated phases is the difference between the height of the approach of the rod and the height of the rod in the starting position. To calculate the speed of movement of the end of the bar, a computer program was used [2].

Results of the study and discussion. During the study, the snatch technique of 13 female athletes was analyzed in order to identify differences between approaches. The results are presented in table 1, 2 and 3.

When the weight of the projectile changes by 3,5% (comparing the biomechanical characteristics of approaches 1 and 2), the maximum height of approach of the bar decreases by 1,9% (p = 0,005), the height of approach of the bar at the end of the unsupported phase decreases by 1,8% (p = 0,004), the speed at the boundary of the «preliminary acceleration» - «depreciation» phases by 3,6% (p = 0,004), the speed at the boundary of the final acceleration phase and the first support squat by 3,1% (p = 0,003), with the speed at the boundary the first support squat and non-support phase by 4,4% (p = 0,038), maximum speed by 1,7% (p = 0,015). There is also a tendency towards an increase in the duration of the depreciation phase by 3,9% (p = 0,062), the time to reach maximum speed by 1% (p = 0,099), a decrease in the height of the approach of the bar at the end of the final acceleration by 1% (p = 0,094) and speed at the border of the unsupported phase and the second support drop by 9% (p = 0,069).

When the weight of the projectile changes by 2,2% (comparing the biomechanical characteristics of approaches 2 and 3), the maximum height of approach of the bar decreases by 1,7% (p = 0,004), the height of approach of the bar at the end of the unsupported phase decreases by 1.5% (p = 0,004), speed at the phase boundary «preliminary acceleration» - «depreciation» by 2,9% (p = 0,007), speed at the phase boundary «depreciation» – «final acceleration» by

Table 1. Spatio-temporal and kinematic characteristics of the snatch technique in 1 and 2 successful approaches (n = 13)

Parameter	First approach	Second approach	Significance of differences, p
	μ ± σ	μ ± σ	
Duration of the «preliminary acceleration» phase, s	0,512±0,059	0,521±0,052	0,118
Duration of the «depreciation» phase, s	0,144±0,027	0,150±0,028	0,062
Duration of the «final acceleration» phase, s	0,165±0,008	0,166±0,011	0,457
Duration of the «first support squat» phase, s	0,083±0,016	0,085±0,017	0,256
Duration of the unsupported phase, s	0,108±0,028	0,105±0,028	0,266
Maximum boom height, mm	1117±59	1096±63	0,005
Boom approach height at the end of the «final acceleration» phase, mm	831±50	823±41	0,094
Height of approach of the rod at the end of the unsupported phase, mm	1096±49	1077±48	0,004
Speed at the phase boundary «preliminary acceleration» - «depreciation», m/s	1,209±0,101	1,165±0,102	0,004
Speed at the boundary of the «depreciation» – «final acceleration» phases, m/s	1,300±0,250	1,280±0,265	0,207
Speed at the border between the final acceleration phase and the unsupported phase, m/s	2,102±0,112	2,037±0,140	0,003
Speed at the border of the first support squat and the first support squat, m/s	1,541±0,161	1,479±0,173	0,038
Speed at the border of the unsupported phase and the second support drop, m/s	0,552±0,322	0,502±0,376	0,069
Time to reach maximum speed, s	0,799±0,073	0,807±0,063	0,099
Maximum speed, m/s	2,146±0,109	2,110±0,123	0,015

Table 2. Spatiotemporal and kinematic characteristics of the snatch technique in successful approaches 2 and 3 (n = 11)

Parameter	First approach	Second approach	Significance of differences, p
	μ ± σ	μ ± σ	
Duration of the «preliminary acceleration» phase, s	0,515±0,059	0,533±0,063	0,051
Duration of the «depreciation» phase, s	0,145±0,023	0,141±0,018	0,199
Duration of the «final acceleration» phase, s	0,164±0,011	0,168±0,013	0,135
Duration of the «first support squat» phase, s	0,086±0,019	0,085±0,112	0,435
Duration of the unsupported phase, s	0,105±0,027	0,100±0,027	0,087
Maximum boom height, mm	1108±54	1065±40	0,004
Boom approach height at the end of the «final acceleration» phase, mm	826±32	820±38	0,081
Height of approach of the rod at the end of the unsupported phase, mm	1082±43	1065±40	0,004
Speed at the phase boundary «preliminary acceleration» - «depreciation», m/s	1,223±0,095	1,188±0,110	0,007
Speed at the boundary of the «depreciation» – «final acceleration» phases, m/s	1,320±0,265	1,270±0,256	0,003
Speed at the border between the final acceleration phase and the unsupported phase, m/s	2,063±0,132	2,010±0,140	0,003
Speed at the border of the first support squat and the first support squat, m/s	1,531±0,161	1,459±0,479	0,014
Speed at the border of the unsupported phase and the second support drop, m/s	0,620±0,383	0,580±0,389	0,157
Time to reach maximum speed, s	0,805±0,066	0,819±0,077	0,09
Maximum speed, m/s	2,125±0,105	2,071±0,125	0,0009

Table 3. Spatio-temporal and kinematic characteristics of the snatch technique in 1 and 3 successful approaches (n = 10)

Parameter	First approach	Second approach	Significance of differences, p
	μ ± σ	μ ± σ	
Duration of the «preliminary acceleration» phase, s	0,518±0,064	0,528±0,069	0,156
Duration of the «depreciation» phase, s	0,140±0,027	0,146±0,025	0,116
Duration of the «final acceleration» phase, s	0,162±0,012	0,168±0,017	0,045
Duration of the «first support squat» phase, s	0,081±0,013	0,084±0,068	0,282
Duration of the unsupported phase, s	0,118±0,041	0,109±0,039	0,034
Maximum boom height, mm	1128±52	1092±55	0,002
Boom approach height at the end of the «final acceleration» phase, mm	838±45	822±39	0,038
Height of approach of the rod at the end of the unsupported phase, mm	1107±43	1063±36	0,0005
Speed at the phase boundary «preliminary acceleration» - «depreciation», m/s	1,246±0,094	1,169±0,096	0,0008
Speed at the boundary of the «depreciation» – «final acceleration» phases, m/s	1,334±0,270	1,272±0,282	0,053
Speed at the border between the final acceleration phase and the first support drop, m/s	2,122±0,105	2,026±0,139	0,002
Speed at the border of the first support drop and the unsupported phase, m/s	1,590±0,126	1,473±0,510	0,005
Speed at the border of the unsupported phase and the second support drop, m/s	0,576±0,328	0,555±0,398	0,327
Time to reach maximum speed, s	0,800±0,079	0,824±0,078	0,014
Maximum speed, m/s	2,168±0,091	2,091±0,118	0,008

3,8% (p = 0,003), speed at the border between the phase of final acceleration and the first support squat by 2,6% (p = 0,008), the speed at the border of the first support squat and the unsupported phase by 4,7% (p = 0,014), the maximum speed by 2,6% (p = 0,0009). There is a tendency to increase the duration of preliminary acceleration by 3,5% (p = 0,051), the time to reach maximum speed by 1,7% (p = 0,09), decrease the duration of the unsupported phase by 5% (p = 0,087), and the approach altitude bar at the end of the final acceleration by 0,7% (p = 0,081).

When the weight of the projectile changes by 6,6% (comparing the biomechanical characteristics of approaches 1 and 3), the duration of the final acceleration increases by 3,5% (p = 0,045) and the time to reach maximum speed by 3% (p = 0,014), and the duration of the unsupported phase decreases by 7% (p = 0,034), the height of the approach of the bar at the end of the final acceleration by 1,9% (p = 0,038), the maximum height of the approach of the bar by 3,2% (p = 0,002), the height of the approach of the bar at the end of the unsupported phase by 3,4% (p = 0,0005), speed at the boundary of the «preliminary acceleration» - «depreciation» phases by 6,1% (p = 0,0008), speed at the boundary of the final acceleration phase and the unsupported phase by 4,5 % (p = 0,002), with the speed at the border of the first support squat and the non-support phase by 7,4% (p = 0,005), the maximum speed by 3,5% (p = 0,008). There is a tendency towards a decrease in speed at the boundary of the «depreciation» - «final acceleration» phases by 4,7% (p = 0,053).

Conclusions. As the intensity of the load increases, the speed characteristics of the snatch technique significantly decrease, which corresponds to Hill's law; this, as a consequence, affects the decrease in the height of the approach of the bar at the end of the final acceleration, at the end of the unsupported phase and the maximum height of the approach of the bar, as well as the time to reach maximum speed. With an increase in load intensity by 6,6%, a significant change in the duration of the final acceleration and unsupported phases was recorded. As the weight of the projectile increases, more effort must be made to maintain kinematic and spatiotemporal characteristics. When planning the training process, it is necessary to take this into account and select the number of lifts with a weight of 95-100% in the training process. Determining the number of lifts with a barbell weight of 95-100% of the maximum requires more in-depth study and additional research.

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