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THE RELATIONSHIP BETWEEN BIOMECHANICAL INDICATORS OF THE SNATCH TECHNIQUE AND FEMALE WEIGHTLIFTERS' LEVELS

PAULINA SZYSZKA¹, ANDRZEJ MASTALERZ²

¹PhD studies Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education

²Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education, Department of Biomechanics

Mailing address: Paulina Szyszka, Józef Piłsudski University of Physical Education, 34 Marymoncka Street, 00-968 Warszawa, tel.: +48 783823710, fax: +48 22 8651080, e-mail: pszyszka87@gmail.com

Abstract

Introduction. The snatch technique is a discipline in Olympic weightlifting. The lifter has to raise the barbell from the platform directly above their head in one movement. While reviewing the literature on biomechanical analysis of the techniques of weightlifting, one can find positions on the analysis of parameters, such as barbell track, horizontal displacement, and angular positions of the joints in the individual phases of the lifter's movement. Many texts concern female and male lifters taking part in World or European Championships. The parameters of the best competitors are outlined – mostly those who finish in the top five places in competition. Mostly these are parameters regarding male lifters, and less frequently those of female lifters. In the literature review, an overlooked aspect is that of the definition of the diversity of indicators as regards the snatch technique practiced by female lifters depending on score. **Material and methods.** In the research, registered snatch attempts during the World Championship were used. Videos were used by judges to establish a maximum weight limit for female lifters. The attempts were registered by two cameras and were later digitally processed by the APAS 2000 system. Barbell parameters, maximum speed, average of the bar, and the parameters of the lifter-bar collocation (horizontal displacement of barbell weights and height elevation) were assessed. **Results.** The analysed attempts show the margin of error for measurement of the average speed of the barbell as 0.03 m/s. The difference in maximum speed of analysed attempts is 15%. The height of clearance of the first-placed female lifter's barbell was 12.7 cm, 30 cm for the last-placed. **Conclusions.** The sporting level of weightlifting by female lifters influences the analysed biomechanical indicators of the snatch. Those indicators, which are similar in the case of both the World Championship winner and the female lifter who came last, may be described as the average speeds of the barbell. The high sporting level of female lifters performing heavy lifting is characterized by the clearance of the barbell.

Key words: barbell snatch, barbell track, height of barbell lift

Introduction

The snatch technique is one discipline in Olympic weightlifting. The lifter has to raise the barbell from the platform directly above their head in one movement which, according to Nawrat [1], lasts around four seconds. Oleszko [2], on the other hand, states that the time of lifting is 0.76 seconds for the best lifters and 0.84 seconds for less specialized lifters. While reviewing the literature one can observe a division of movement into a number of parts, phases and elements. Alongside the three-part lift [3] and the four-part lift [4], a seven-phase lift was proposed by Vorobyev [6]. Dziedzic distinguishes four phases: the first phase is suspension during which the lifter straightens their knee joints, the second is pick up, in which the lifter aligns their body with their hip joints, the third phase is non-resistant, in which the lifter performs a squat under the barbell and the barbell is raised, and the last phase consists of a resistant squat, in which the barbell descends and is blocked above the head. From the mechanical point of view, a straightforward track of the barbell is the most favorable

[7]. Some authors however, indicate a more favorable curvilinear track of the barbell [8, 9]. The lifter performing the snatch overcomes the weight of the barbell and their own body, hence the importance of a common center of gravity of lifter and barbell. The most common form of the assessment of efficiency of the snatch technique is visual observation of the movement. Along with the regular betterment of sporting results combined with lifters' abilities this method becomes immeasurable and remains subjective. In order to improve the method of assessment of technique, certain components of the motion of each lifter should be biomechanically analysed individually. The specificity of the weightlifting discipline allows the isolation of criteria for the assessment of movement based on different parameters. The criterion of the height of the barbell lift [10] is considered based on the lifter's height as well as height of the barbell lift. The lower the height of the barbell lift, the more economical the movement is. A greater height of barbell suggests a lower technical level of the lifter.

At the highest level of sporting competition, the barbell is

lifted to a minimum height, which prevents unnecessary loss of energy. This is a criterion that is possible to assess based on the observation of lifters' attempts during both tournaments and training. Another criterion of assessment of the snatch technique is the horizontal displacement of the barbell relative to the lifter's body, which has been analysed by many authors. Table 1 shows the review of literature on the analysis of indicators of weightlifting technique.

Table 1. Review of literature on the analysis of indicators of weightlifting technique

Parameter	Year	Author	Study group
Barbell track	1959	Borejsza	Men
	1964	Arutiunian	Men
	1968	Dziedzic	Men
	1998	Kruszewski	Men
	1998	Grahammer	Women
	2000	Gourgoulis	Men
	2002	Schelling	Men
	2009	Hori	Men
	2012	Hasan	Women
	2012	Ikeda	Women
	2012	Erbil	Women / Men
Height of barbell lift	1966	Czerniak	Men
	2006	Hoover	Women
Analysis of horizontal displacement of the barbell	1972	Trzaskoma	Men
	1985	Grahammer	Men
	1998	Kruszewski	Men
	2006	Hoover	Women

Many papers concern female and male lifters taking part in World or European Championships. Parameters described are largely those of lifters placed in the top five in competition. The included description of parameters is based mostly on data regarding male rather than female lifters. The variation of parameters of lifters' snatch techniques depending on the sporting outcome is an aspect overlooked in the literature. Hence the idea of juxtaposing the parameters of the snatch technique of female lifters in first and last places in all weight categories i.e. 48 kg, 53 kg, 58 kg, 63 kg, 69 kg, 75 kg and over 75 kg during the

weightlifting World Championship. Female competition on the world stage started in 1987 in Daytona Beach and the 23rd edition of this event took place in Wrocław in 2013.

The aim of this paper is the presentation of the variation of biomechanical indicators of the barbell snatch among female lifters depending on their sporting level and the provision of an indication of parameters that differentiate the attempts of the best and worst female lifters.

Material and methods

In the research, the registered attempts of the barbell snatch during the World Championship in 2013 were used. The attempts analyzed include the largest lifters in first and last places in each weight class. Table 2 shows the juxtaposition of analysed attempts.

Attempts with the maximum weight as decided by judges during the championships were analysed. Attempts were registered by two PAL cameras with a 50 Hz frequency, which were then later processed digitally by the APAS 2000 system. Cameras were set four meters from the bridge at an angle of 45°, while maintaining an angle of 90° there between. The image transformation (DLT) and calibration were done with a cuboid consisting of 8 points. Barbell parameters were assessed in terms of average speed as well as the maximum speed of the entire movement to stabilize the barbell squat, and the parameters of the lifter-bar collocation: horizontal displacement of barbell and height of barbell elevation. Displacement of the barbell with regard to phases I and II during the raising of the bar indicate the elevation gain of weights defined as the difference in elevation of the barbell and the height of the grip during the barbell squat.

Results

The assessed parameter of the barbell is its speed. The significance of the movement sequence efficacy examination is affected by the maximum speed of the barbell obtained during the snatch phase (Phase II).

Table 3 shows the average values of the barbell speed in the first and second phases of the snatch until the moment of stabilization of the barbell in the squat, and the maximum speed of the barbell during the snatch in individual weight categories.

Table 2. The characteristics of analysed attempts

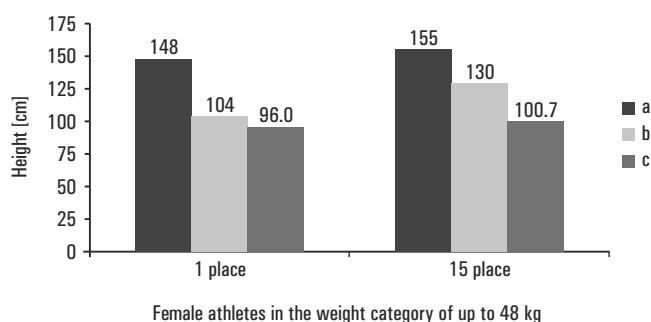
Weight category	First place			Last place			Difference in lifted weight (kg)
	Body mass of the female lifter (kg)	Body height (cm)	Lifted weight (kg)	Body mass of the female lifter (kg)	Body height (cm)	Lifted weight (kg)	
48 kg	47.67	148	84	47.56	155	68	16
53 kg	52.39	153	100	52.6	150	72	28
58 kg	57.27	158	108	57.58	155	65	43
63 kg	61.58	158	112	62.99	160	74	38
69 kg	68.51	161	123	68.61	158	79	44
75 kg	74.61	165	126	69.01	163	88	38
75+ kg	133.02	175	146	91.39	167	90	56

Table 3. The value of maximum speed V_{\max} (m/s) and average $V_{\bar{x}}$ (m/s) of the barbell snatch in a group of female lifters in first and last places

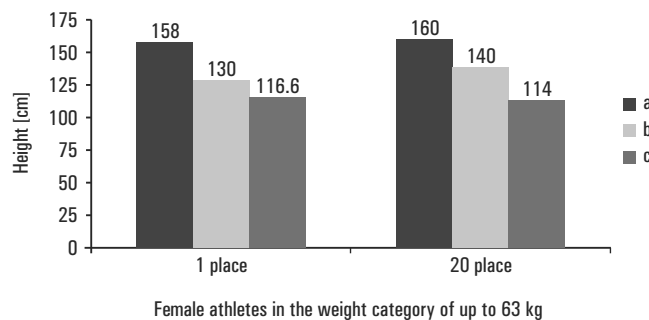
Weight category	Place taken in the competition	V_{\max} (m/s)	$V_{\bar{x}}$ (m/s)
48 kg	1	2.07	0.88
	15	1.36	0.85
53 kg	1	1.98	0.91
	13	1.74	0.75
58 kg	1	1.93	0.82
	15	1.61	0.73
63 kg	1	2.04	0.89
	20	1.36	0.75
69 kg	1	1.61	0.93
	25	1.36	0.9
75 kg	1	1.96	0.85
	13	1.41	0.8
75+ kg	1	2.05	0.9
	14	1.74	0.91

The average values of the barbell speed do not differ significantly among female lifters in first and last places in individual weight categories. The biggest differences of maximum speed value (34.5%) is observed in female lifters in the lowest weight category of up to 48 kg. The smallest differences (12.1%) is observed in female lifters in the category of up to 53 kg.

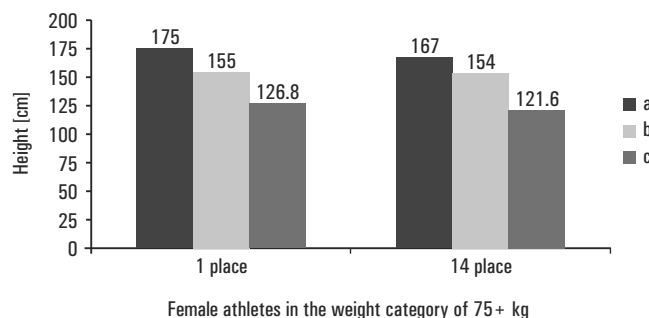
The first analysed parameter of the barbell-lifter collocation was the height of the barbell lift but a very important element in the effectiveness of the technique is the height of barbell clearance understood as the difference between the elevation of the bar and the height of the handle in the snatch squat. Figure 1 shows the juxtaposition of height parameters of the barbell lift of female lifters in the weight category of up to 48 kg.

**Figure 1.** The height of the barbell lift (b) of female lifters in the weight category of up to 48 kg in reference to body height (a) and the height of the grip in the snatch squat (c)

The height of the lift during the barbell snatch of the lifter that took the first place was 8 cm, and that of the lifter that took last place in the same weight category was 29 cm. Figure 2 shows the height of the barbell lift of the first and thirteenth-placed female lifters that took part in the World Championship in the weight category of up to 63 kg.

**Figure 2.** The height of the barbell lift (b) of female lifters in the weight category of up to 63 kg in reference to body height (a) and the height of the grip in the snatch squat

The values of horizontal displacement of the barbell of female lifters in the weight category of up to 63 kg varied by 48.46%. The female lifter that took first place lifted the barbell with an elevation of 13.4 cm and the twentieth-placed female lifter obtained an elevation of 26 cm.

**Figure 3.** The height of the barbell lift (b) of the female lifters in the weight category of 75+ kg with respect to body height (a) and the height of the grip in the snatch squat (c)

Female lifters in the highest weight category lifted the barbell to 155 cm and 154 cm. The first-placed female lifter, lifting a barbell with a mass of 146 kg, obtained 28.2 cm elevation, while the female lifter that took fourteenth place, lifting a barbell of 90 kg obtained an elevation of 32.4 cm.

Another biomechanical indicator of the snatch technique is the horizontal displacement of the barbell as shown in table 4.

Table 4. The values of horizontal displacements of barbells in phases I and II of lifts of the female lifters that took first and last places in individual weight categories

Weight category	Place taken in the competition	I phase of the lift (cm)	II phase of the lift (cm)
48 kg	1	-5	-9
	15	-7	-12
53 kg	1	-6	-4
	13	4	14
58 kg	1	2	4
	15	6	9
63 kg	1	5	7
	20	-6	-12
69 kg	1	-6	-4
	25	5	6
75 kg	1	-5	-7
	13	4	9
75+ kg	1	-3	-8
	14	-6	-9

Positive values – technique 'from the athlete' negative technique 'to the athlete'.

Positive barbell displacement indicates a 'forwards' technique, whereas negative values indicate a 'push'. From the analysed attempts the highest value of displacement for an athlete in the first phase of the lift was 7 cm and in the second phase of the lift it was 12 cm. The highest displacement from the athlete 'forwards' in the first phase of the lift was 6 cm and in the second phase it was 14 cm.

Discussion

Many authors show the results of barbell snatch research [9, 10, 11, 17] by using the indicators of barbell speed, height of barbell lift, and horizontal barbell displacement. Such research was conducted mostly in the group of weightlifting men. Through analysis of the obtained values of maximum speed, one can conclude that all female gold medalists' maximum speeds, as well as average speeds of the barbell, were higher than those of female athletes that took last place in competition. This is an indicator differentiating the sporting level of the female athletes. The results of the research presented by Hoover [9] show a decrease of speed in the second phase of the lift in 5 out of 11 analysed attempts. Stone [11] claims that the maximum speed values are present in the second phase of the lift and take a value of 1.85 (m/s) +/- 0.11 (m/s). The results of the author's research indicate that the maximum value of female gold medalists ranges from 2.07 (m/s) to 1.61 (m/s), while amongst last-placed female athletes it is between 1.74 (m/s) and 1.36 (m/s). All speed values were obtained in the second phase of the lift.

The rules of weightlifting specifically describe the snatch technique. Analysis of the barbell snatch technique by female athletes at the highest level shows the individual styles of the barbell lift. By assessing the technique of weightlifting, parameters characterizing the different phases of the movement, which were taken as the criteria for assessing the technique of the individual phases, and the entire exercise are analysed.

Trzaskoma [12] lists following analysed parameters:

- the approach to the barbell in the first phase of the suspension (cm);
- the distance from the barbell in phase II – the pickup (cm);
- the maximum speed of lifting of the barbell in the first

phase (m/s);

- the maximum speed of the barbell in the second phase (m/s);
- the height of the barbell lift from the bridge (cm).

Grahammer [13] proposed three positions assessed in the horizontal displacement of the barbell:

1. Maximum deviation in the first stage from the pick up to phase I of the lift.
2. Maximum horizontal displacement in the second phase of the snatch.
3. Maximum horizontal displacement after phase II of the snatch to the maximum height of the barbell.

Norms for respective phases are:

1. 3-9 cm positive on a weightlifter – horizontal displacement in the athlete's direction;
2. 3-18 cm positive from a weightlifter – horizontal displacement in the athlete's direction,
3. 3-9 cm positive on a weightlifter – horizontal displacement in the athlete's direction [14, 15, 16].

Kruszewski [17] analysed the span of the track of the barbell in leading athletes taking part in World and European Championships. The range in 1974 was 5 to 25 cm, while in 1983 it ranged from 10 to 11.7 cm. Results of the author's research show horizontal displacement in the first phase in the 2-6 cm range, 6-14 cm in the second phase, and positive values that indicate a technique 'from the athlete'. Negative values of displacement point to a technique 'to the athlete' in the first phase and varied from 5 to 7 cm, in the second phase of the lift the figures were 4 to 12 cm. Hoover [9] shows similar values of horizontal displacement with positive values in the first phase of the lift from 0 to 8 cm and 0 to 14 cm in the second. Negative values in the first phase of the lift were from 1 to 3 cm, and between 1 and 14 cm in the second phase.

Among analysed attempts five out of seven female gold medalists achieved negative horizontal displacement 'to the athlete'. All those athletes represented one country – China. However other female gold medalists obtained positive values of horizontal displacement, which is 'from the athlete'. Analysis of the attempts does not give a clear answer as to which type of snatch technique – to or from the athlete – is more efficient and determines the outcome.

The most differentiating parameter in the researched group of female athletes was the parameter of barbell elevation. All female gold medalists in the World Championship had lower elevation values than the athletes in last place. The biggest variation of (21.3 cm) was observed among female athletes in the weight category of up to 48 kg with a difference of 16 kg in lifted weight. The smallest variation in barbell elevation was observed in the group of athletes of the highest weight category (75+ kg), the difference in lifted weight was 56 kg, whereas the barbell elevation difference between first and last female athlete was 4.2 cm. This shows that the speed and strength capabilities of lifting the barbell in the first and second phases by female athletes were not used. Female athletes were lifting the barbell 'on high' and then lowering their position to a snatch squat.

The high level of these athletes is characterized by the height of barbell elevation. The lower the value of elevation, the more effective the mastery of the technique.

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