

Model Indicators and Evaluation Criteria of Strength Readiness of Highly Qualified Arm-Wrestlers

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DOI: 10.22178/pos.68-1

LCC Subject Category:
GV711

Received 19.02.2021
Accepted 28.03.2021
Published online 31.03.2021

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Abstract. In the arm-wrestling technique, the main element is the attack phase, which aims to achieve a quick superiority over the enemy. Researchers Zhivora and Usanov classified four main attack methods: top attack, hook attack, push attack, and side attack. During a side attack, a great deal of stress is placed on the flexors of the hand. In connection with this, four strength exercises were selected as test indicators: flexion of the fingers, stretch with a hammer, hook and bending of the hand. These exercises were chosen to determine the level of strength readiness of highly qualified arm-wrestlers. The work aimed to determine the model indicators of strength readiness of highly qualified arm-wrestlers of different weight categories. The study involved 24 arm-wrestlers, 8 in the weight category up to 80 kg, 8 – from 80 to 100 kg and 8 – over 100 kg. Three test athletes are world champions in arm-wrestling, 7 are winners of European and world championships, 9 are participants in European and world championships, 5 are winners of national championships of Ukraine. The following research methods were used in work: theoretical analysis and generalization of scientific, methodological and notable information, pedagogical observation, pedagogical experiment, methods of mathematical statistics. The analysis of the strength capabilities of highly qualified arm-wrestlers and their strength readiness models made it possible to develop assessment criteria for the level of strength readiness of highly qualified arm-wrestlers of three weight categories. Three levels of strength readiness have been identified: low ($\bar{x} - \sigma$), high ($\bar{x} + \sigma$) and medium – more ($\bar{x} - \sigma$), but less ($\bar{x} + \sigma$).

The conducted research allowed to establish the peculiarities of the levels of strength readiness development among highly qualified arm-wrestlers by weight categories. Model indicators of strength readiness of highly qualified arm-wrestlers were also determined. The analysis made it possible to state that athletes of lightweight categories (up to 80 kg and 80-100 kg) are more harmoniously developed according to the test results. Heavy arm-wrestlers (over 100 kg) showed worse results than expected.

Keywords: arm-wrestling; model characteristics; weight categories; power indicators.

INTRODUCTION

According to the analysis of competitive exercises' fulfilment, arm-sport belongs to the sports group of a speed-strength nature. The structure of competitive movements and the value of overcoming the opponent's resistance indicates the need for full dynamic manifestation and in-

creased resistance from the opponent, static efforts [1, 8].

The nature of dynamic efforts when overcoming resistances can be different: explosive, fast, slow. Explosive strength is characterized by overcoming resistances that do not reach the limit values with maximum acceleration.

The fast nature of efforts, or fast force, manifests itself during overcoming resistances that do not reach their limit values with acceleration below the maximum. The slow nature of efforts, or slow force, manifests itself during overcoming boundary resistances at a constant speed [9].

It is essential to distinguish that explosive strength is manifested only with overcoming muscle work. Rapid strength is manifested in both overcoming and yielding movements, also during their combination. Quiet strength is manifested during overcoming or yielding muscle work [10]. During slow force manifestation, the limiting stresses' duration is more excellent than during explosive force manifestation.

Sports and special studies' practice indicates no direct connection between developing certain dynamic and static strength types. [5]. Research results have shown that high static force does not allow for its rapid manifestation [12]. Comparing individual indices of manifestation of static and dynamic strength indicates no direct connection between developing certain muscle strength types in athletes. Thus, from a methodological point of view, this means that the effective development of any strength in highly qualified athletes' training involves using a specialized methodology [6]. In this regard, the determination of the ability to show strength capabilities in various strength exercises allows you to control and correct the training process to develop strength effectively.

Several studies [4, 11, 16] determine the structural orientation of special strength training, thereby determining arm-wrestlers' particular strength development structure. The study results show that the structure of exceptional strength training ensures the predominant development of specific muscle groups. Structurality also contributes to technical improvement, which helps increase the magnitude of the manifestation of strength.

It was found that highly qualified arm-wrestling athletes have a relatively equally high level of technical readiness. Therefore, the fight's result will mainly depend on strength readiness level [13, 14, 16].

In the arm-wrestling technique, the main element is the attack phase, which aims to achieve quick superiority over the opponent. According to [22], there are three primary attacks: top attack, hook attack and push attack. A questionnaire survey of specialists and research by [4]

showed that highly qualified athletes use hook attack in 55% of cases, top roll attack in 40 % and push attack in 5 %. It was found that when performing a hook attack, the tremendous load is applied to the flexors of the hand and forearm. Top roll attack requires excessive flexor force of the fingers and hand. During the push attack, the most excellent load falls on the elbow joint and fingers. Authors [20] classified the fourth method of attack – a side attack. During this technique, a great deal of stress falls on the flexors of the hand.

In connection with the above, four strength exercises were selected as test indicators: flexion of the fingers, stretch with a hammer, hook and bending of the hand. These exercises were chosen to determine the level of strength readiness of highly qualified arm-wrestlers.

The work *aimed* to determine the model indicators of strength readiness of highly qualified arm-wrestlers of different weight categories.

MATERIALS AND METHODS

The study involved 24 arm-wrestlers, 8 in the weight category up to 80 kg, 8 – from 80 to 100 kg and 8 – over 100 kg. Three test athletes are world champions in arm-wrestling, 7 are winners of European and world championships, 9 are participants in European and world championships, 5 are winners of national championships of Ukraine.

The following research methods were used in work: theoretical analysis and generalization of scientific, methodological and noteworthy information, pedagogical observation, pedagogical experiment, methods of mathematical statistics.

Based on the analysis of the results of the study [14, 21], questioning the coaches and athletes, four strength test exercises were identified that have a significant impact in wrestling on the hands: flexion of the fingers, stretch with a hammer, hook and bending of the hand. The strength of the flexors of the fingers was measured using a dynamometer DK-140 (Ukraine). Strength indices in the last three test exercises were measured in a static mode with an electric tenzodynamometer of the FBk series (Poland) with an accuracy class up to 100 g, fixed on a specialized arm-wrestling table using a specially made block device - "Device ARM1". During the measurement of the arm muscles' strength, the subject stood facing the table, grabbed the instrument holders with his hand, and squeezed them with maxi-

imum force without lifting the elbow of the working hand from the table. The distance between the device holders was easy to change and was selected individually for each athlete. A particular computer program AXIS FM made it possible to process measurement data in real-time (on-line) and previously collected data from the memory of an electric tenzodynamometer (off-line). AXIS FM is compatible with Windows 7, 10 operating systems.

Statistical analysis of the obtained data was carried out using the licensed program STATISTICA 10. Statistical Analysis calculated the following parameters: arithmetic mean (\bar{x}), standard deviation (σ), error of representativeness (m) and the coefficient of variation (V). Based on the obtained digital data, three strength readiness levels were determined: low, medium and high.

RESULTS AND DISCUSSION

Comparative analysis in the studied test exercises shows that most arm-wrestlers do not accidentally use a hook attack during the competition. Because in all weight categories in this exercise, athletes demonstrate the highest strength indicators compared to the data of other strength exercises (Table 1).

Analysis of the coefficient of variation (V) indicates that the results of test exercises of all groups of athletes were homogeneous. This is confirmed by the fluctuation of the numerical reflections of the static population's variability from 2.03 % to 5.84 % (Table 1). Comparison of the overall final indicators of the coefficients of variability (V) allows us to note that athletes weighing from 80 to 100 kg are distinguished by the most remarkable homogeneity ($\Sigma V = 28,88$ %). The most significant variability characterizes the group weighing more than 100 kg in strength indicators ($\Sigma V = 34,50$ %).

Table 1 – Model indicators of the strength readiness of highly qualified arm-wrestlers (n=24)

Arm	Weight category (kg)	Strength indicator \bar{x} (kg)	m	σ	V (%)
Flexion of the fingers					
left	< 80	44,34	0,89	2,52	5,68
	80-100	54,23	1,10	3,11	5,74
	> 100	50,69	0,93	2,63	5,19
right	< 80	45,55	0,94	2,66	5,84
	80-100	56,81	0,91	2,57	4,53
	> 100	54,48	1,14	3,22	5,02
Stretch with a hammer					
left	< 80	47,08	0,68	1,92	4,09
	80-100	62,24	0,91	2,57	4,14
	> 100	57,52	0,45	1,27	2,21
right	< 80	47,86	0,44	1,24	2,61
	80-100	64,98	0,92	2,60	4,01
	> 100	60,88	0,81	2,29	3,76
Hook					
left	< 80	59,64	0,82	2,32	3,89
	80-100	84,65	0,69	1,95	2,31
	> 100	75,85	1,19	3,36	4,44
right	< 80	64,46	0,81	2,29	3,56
	80-100	87,98	0,84	2,38	2,70
	> 100	80,28	0,98	2,77	3,4
Bending of the hand					
left	< 80	47,16	0,55	1,56	3,31
	80-100	69,67	0,50	1,41	2,03
	> 100	60,54	1,04	2,94	4,86
right	< 80	48,74	0,39	1,10	2,27
	80-100	73,73	0,89	2,52	3,42
	> 100	64,93	1,05	2,97	4,57

So, for athletes in the weight category up to 80 kg, the difference ranges from 25 % to 40 %, in the weight category from 80 to 100 kg – from 25 to 55 % and by 25-50 % - in athletes weighing over 100 kg (Table 2).

Table 2 – Generalized indicators of strength capabilities in test exercises of highly qualified arm-wrestlers (n=24)

Test exercise	Weight category, kg					
	< 80		80-100		> 100	
	left hand	right hand	left hand	right hand	left hand	right hand
flexion of the fingers, kg	44,34	45,55	54,23	56,81	50,69	54,48
stretch with a hammer, kg	47,08	47,86	62,24	64,98	57,52	60,88
hook, kg	59,64	64,46	84,65	87,98	75,85	80,28
bending of the hand, kg	47,16	48,74	69,67	73,73	60,54	64,93
Σ indicators of arm strength, kg	198,22	206,61	48,74	283,50	244,60	260,57
General indicator of arm strength, kg	404,83		554,29		505,17	
Total indicator, V %	31,25		28,88		34,50	

According to comparing the strength capabilities of the left and right hands in athletes of the group over 100 kg, an increased difference in strength indicators of the left and right hands is observed. Power capabilities of the right hand are higher by 15, 97 kg (10.91%). In other weight categories (up to 80 kg and 80-100 kg), the difference, respectively, was 8.39 kg (4.23%) and 12.71 kg (4.69%). Thus, athletes' indicators up to 80 kg and 80-100 kg are stable and homogeneous.

In athletes weighing up to 80 kg, the immediate results of testing the left hand ranged from 44.34 ± 0.89 kg to 59.64 ± 0.82 kg; right - from 45.55 ± 0.94 kg to 64.46 ± 0.81 kg. In the weight category from 80 to 100 kg, the strength of the left hand ranged from 54.23 ± 1.10 kg to 84.65 ± 0.69 kg; right - from 56.81 ± 0.91 kg to 87.98 ± 0.84 kg. In athletes weighing over 100 kg, the strength indices of the left hand ranged from 50.64 ± 0.93 kg to 75.85 ± 1.19 kg; right - from 54.48 ± 1.14 kg to 80.28 ± 0.98 kg. The data obtained indicate that athletes weighing 80-100 kg demonstrate high strength indicators compared to athletes' strength data in the heavyweight category. Thus, this group's overall indicator is better by 9.7% (554.29 kg versus 505.17 kg) (Table 2).

The analysis of the strength capabilities of highly qualified arm-wrestlers and their strength readiness models is presented; it is possible to develop assessment criteria for the strength readiness of highly qualified arm-wrestlers of three weight categories (Table 3). Three levels of strength readiness have been identified: low ($\bar{x} - \sigma$), high ($\bar{x} + \sigma$) and medium - more ($\bar{x} - \sigma$), but less ($\bar{x} + \sigma$).

Table 3 – Evaluation criteria for the level of strength readiness of highly qualified arm-wrestlers

Arm	Weight category, kg	Low level, kg	Medium level, kg	High level, kg
Flexion of the fingers				
left	< 80	< 41,82	41,82 - 46,86	> 46,86
	80-100	< 51,12	51,12 - 57,34	> 57,34
	> 100	< 48,08	48,08 - 53,22	> 53,22
right	< 80	< 42,89	42,89 - 47,08	> 47,08
	80-100	< 54,24	54,24 - 59,38	> 59,38
	> 100	< 51,26	51,26 - 57,70	> 57,70
Stretch with a hammer				
left	< 80	< 45,08	45,08 - 48,92	> 48,92
	80-100	< 59,64	59,64 - 64,81	> 64,81
	> 100	< 56,25	56,25 - 58,79	> 58,79
right	< 80	< 46,62	46,62 - 49,10	> 49,10

Arm	Weight category, kg	Low level, kg	Medium level, kg	High level, kg
	80-100	< 62,38	62,38 - 67,58	> 67,58
	> 100	< 58,59	58,59 - 63,17	> 63,17
Hook				
left	< 80	< 57,32	57,32 - 61,96	> 61,96
	80-100	< 82,70	82,70 - 86,60	> 86,60
	> 100	< 72,49	72,49 - 79,21	> 79,21
right	< 80	< 62,17	62,17 - 66,75	> 66,75
	80-100	< 85,60	85,60 - 90,36	> 90,36
	> 100	< 77,51	77,51 - 84,05	> 84,05
Bending of the hand				
left	< 80	< 45,60	45,60 - 48,72	> 48,72
	80-100	< 68,26	68,26 - 71,08	> 71,08
	> 100	< 57,60	57,60 - 63,48	> 63,48
right	< 80	< 47,64	47,64 - 49,84	> 49,84
	80-100	< 71,21	71,21 - 76,25	> 76,25
	> 100	< 61,96	61,96 - 67,90	> 67,90

Comparative analysis of the ratios of different levels of strength indicators allowed to establish that there are completely low or high levels of strength indicators among highly qualified arm-wrestlers in none of the weight categories.

But in the weight category of 80-100 kg, one athlete in all test exercises recorded the average level of strength indicators. In athletes weighing up to 80 kg, 12 cases out of 64 (18.8%) of low level, 37 - medium (57.8%) and 15 - high (23.4%) were recorded (Table 4).

Table 4 – Ratios of strength readiness levels of highly qualified arm-wrestlers (n = 24)

Level	Flexion of the fingers	Stretch with a hammer	Hook	Bending of the hand	Σ, un.	Σ, %
< 80 kr						
low	1 2	1 2	2 2	1 1	12	18,8
medium	6 5	5 4	3 4	5 5	37	57,8
high	1 1	2 2	3 2	2 2	15	23,4
80-100 kr						
low	2 1	1 2	1 1	1 1	10	15,6
medium	4 5	5 4	6 6	6 6	42	65,6
high	2 2	2 2	1 1	1 1	12	18,8
> 100 kr						
low	1 1	1 3	3 3	3 3	18	28,1
medium	5 5	5 4	3 2	3 3	30	46,9
high	2 2	2 1	2 3	2 2	16	25

In the weight category of 80-100 kg, a low level was registered in 15.6% (n = 10) cases, a medium level in 65.6% of indicators (n = 42), and a

high level in 18.8% (n = 12). In the heavy weight category (over 100 kg) 28.1% (n = 18) indicators of low level, 46.9% (n = 30) - medium and 25% (n = 16) - high (Table 4).

Thus, the comparison of the ratios of the levels of strength capabilities of athletes of three weight categories shows that athletes weighing from 80 to 100 kg have the highest indicators of strength training. These figures are achieved through an overall increase in mid-level strength indicators.

Arm wrestling refers to sports in which performance directly depends on strength readiness, particularly arm strength development. It was confirmed that the main predictors of success in hand wrestling include: muscle development, physical strength, the value of conditional moments of the strength of limb segments [18]. Strength fitness in many sports is used to assess athletes' physical fitness [5, 11]. According to [21], in arm wrestling, the strength component is of decisive importance in highly qualified athletes in competitive exercises.

Confirmed data based on ergonomic approaches by [15] that high-level arm-wrestlers have a significantly higher hand strength indicator, hand flexion, forearm muscle strength, arm pronation and supination.

Hand strength indicators are the most important in hand wrestling. All athletes are characterized by high results of hand power indices, and the higher the results of these indices, the higher the success of a competitive activity. Similar data are provided by [19]. The results of [2] also confirm that the indicators of arm muscle strength are a

significant predictor of success in arm-wrestling [19].

Victory largely depends on the athlete's ability to squeeze the opponent's hand as much as possible. This technique was used by Iermakov et al. [7] to predict success in martial arts.

CONCLUSIONS

The conducted research established the peculiarities of strength readiness development levels among highly qualified arm-wrestlers by weight categories. Model indicators of strength readiness of highly qualified arm-wrestlers were also determined. The analysis made it possible to state that athletes of lightweight categories (up to 80 kg and 80-100 kg) are more harmoniously developed according to the test results. Heavy arm-wrestlers (over 100 kg) showed worse results than expected. This group of athletes has not fully realized in terms of strength capabilities. These arm-wrestlers need to improve the training methodology, considering the organism's anthropo-physiological and weight characteristics.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the cooperation of the athletes, coaches and support staff who participated in this study.

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