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Original RESEARCH

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Factors of the effectiveness of competitive activity of arm wrestlers aged 14-15 years at the stage of preliminary basic training

Dmytro Bezkorovainyi[1,2ABCD], Artur Oderov[3ABCDE], Anton Kravchenko[4ABDE], Leonid Plotnytskyi[1ABDE], Liudovyk Tetiana[3,5BCDE], Volodymyr Ozharevskyi[6BCDE]

[1]O. M. Beketov National University of Urban Economy in Kharkiv, Ukraine
[2]Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine
[3]Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
[4]Municipal Establishment «Kharkiv Humanitarian–Pedagogical Academy» of the Kharkiv regional council in Kharkiv, Ukraine
[5]Stepan Gzhytsyi National University of Veterinary Medicine and Biotechnologies of Lviv, Ukraine
[6]Defence Intelligence Research Institute, Ukraine

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

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Corresponding Author: Dmytro Bezkorovainyi, bezkor@ua.fm

Abstract

Background and Study Aim. Considering that there are no studies aimed at identifying the components of physical and functional fitness in arm wrestling at the stage of preliminary basic training, and it is not advisable to transfer training of adult athletes to training of young men, then determining the influence and comparison of various aspects of fitness on the effectiveness of competitive activity of arm wrestlers acquires both theoretical and practical importance. Hence the purpose of the study – to determine the significance of the influence of various aspects of fitness (functional, physical) to identify factors influencing the effectiveness of competitive activity of junior armwrestlers aged 14-15.

Material and methods. The study involved 29 young men aged 14–15 years involved in arm wrestling, they were divided into two groups: 9 athletes (14.67 ± 0.17 years) who were distinguished by high competitive performance and 20 athletes (14.45 ± 0.11 years) of the general group. Morphofunctional data, indicators of general physical, special strength and speed-strength preparedness were determined using test exercises. Statistical analysis of the obtained data was performed using licensed programs Microsoft Excel and STATISTICA 10. In the course of statistical analysis, the following parameters were determined and calculated: maximum (F) and relative ($F_1 = \Sigma F / m$) strength, kg; total strength index in four strength exercises ($\Sigma F = F1 + F2 + F3 + F4$), kg; average strength, index of four exercises ($\bar{F} = \Sigma F / 4$), kg; time to reach maximum strength ($\Sigma t = t1 + t2 + t3 + t4$), s; speed-strength index ($J = \Sigma F / \Sigma t$), $kg*ms^{-1}$; total strength gradient of four exercises ($\Sigma t_{0,5F}$), ms; speed-strength index in the first 500 ms ($J_{500} = \Sigma F_{500} / \Sigma t_{500}$), $kg*ms^{-1}$; time to reach 1 kg force ($t_1 = \Sigma t_{0.5F} / (0.5 \times F)$), $ms*kg^{-1}$; factor analysis.

Results. According to anthropometric parameters, the leaders have significantly better results in weight and height ($p < 0.01$), and the body mass index was higher in the general group, but the difference was not significant ($p > 0.05$). Functional parameters differed significantly only in the Stange and Genchi tests ($p < 0.01$), as well as in the strength index of both arms ($p < 0.05$). Analysis of the general physical fitness of the leaders and the general group parameters revealed significant differences in 5 of the 6 exercises tested. The significantly high result of the arm wrestlers is supported by high parameters of special physical fitness, namely: strength parameters in two test exercises (hook and wrist bending), as well as the overall total strength parameter of the left and right arms ($p<0.05$). The speed-strength indicators of both hands also differed significantly in the average strength indicator, strength gradient, strength at 500 ms, speed-strength index at 500 ms, relative strength, and time to achieve a force of 1 kg (Student's t-test ranged from 2.06 to 5.84 at $p < 0.05–0.001$). Factor analysis confirmed the high influence of anthropometric data and speed-strength fitness indicators on the effectiveness of arm wrestlers' competitive activities at the studied stage of preparation.

Conclusions. In order to create the foundations for high results and sports improvement at the stage of preliminary basic training, it is necessary to provide for a predominantly significant development of strength and

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speed-strength capabilities, since the results obtained indicate that the growth of athletes' performance with the appropriate system of sports training is accompanied by a significant increase in maximum strength, an improvement in the indicators of starting, acceleration and fast strength in the first 500 ms of muscle tension, due to an improvement in the index and gradient of strength, the time to achieve a strength of 1 kg.

Key words: armwrestling, armwrestlers, long-term preparation, dynamic strength, strength indicators, speed-strength preparedness.

Анотація

Фактори результативності змагальної діяльності армрестлерів 14-15 років на етапі попередньої базової підготовки

Дмитро Безкоровайний, Артур Одеров, Антон Кравченко, Леонід Плотницький, Тетяна Людовик, Володимир Ожаревський

Передумови та мета дослідження. Зважаючи на те, що досліджень спрямованих на виявлення складових фізичної та функціональної підготовленості в армрестлінгу на етапі попередньої базової підготовки не виявлено, а переносити тренування дорослих спортсменів на тренування юнаків не є доцільним, то як теоретичної, так і практичної важливості набуває визначення впливу та порівняння різних боків підготовленості на результативність змагальної діяльності армрестлерів. Звідси витікає мета дослідження – визначення значимості впливу різних боків підготовленості (функціональної, фізичної) для виявлення факторів, що впливають на результативність змагальної діяльності юніорів-армрестлерів 14–15 років.

Матеріал і методи. В дослідженні взяли участь 29 юнаків, які займаються армрестлінгом віком 14–15 років, їх було поділено на дві групи: 9 спортсменів (14,67 ± 0,17 років), які відрізнялися високою змагальною результативністю та 20 спортсменів (14,45 ± 0,11 років) загальної групи. Визначалися морфофункціональні виміри, показники загальнофізичної та спеціальної силової та швидкісно-силової підготовленості за допомогою тестових вправ. Статистичний аналіз отриманих даних проводили за допомогою ліцензованих програм Microsoft Excel і STATISTICA 10. Під час статистичного аналізу були визначені та розраховані наступні параметри: максимальна (F) та відносна сила ($F_1 = \Sigma F / m$), кг; сумарний індекс сили в чотирьох силових вправах ($\Sigma F = F1 + F2 + F3 + F4$), кг; середній індекс сили ($\bar{F} = \Sigma F / 4$), кг; час досягнення максимальної сили ($\Sigma t = t1 + t2 + t3 + t4$), с; швидкісно-силовий індекс ($J = \Sigma F / \Sigma t$), кг/с; градієнт загальної сили чотирьох вправ ($\Sigma t_{0,5F}$), мс; швидкісно-силовий індекс в перші 500 мс ($J_{500} = \Sigma F_{500} / \Sigma t_{500}$), час досягнення сили 1 кг ($t_1 = \Sigma t_{0,5F} / (0,5 \times F)$), мс*кг$^{-1}$; проведено факторний аналіз.

Результати. За показниками антропометрії лідери мають достовірно кращі результати у вазі та зрості ($p < 0,01$), а індекс маси тіла був вищій у загальній групі, але різниця була не достовірною ($p > 0,05$). Функціональні показники достовірно різнилися лише у пробах Штанге та Генчі ($p < 0,01$), а також у силовому індексі обох рук ($p < 0,05$). Аналіз загальної фізичної підготовленості лідерів і загальногрупових показників виявив достовірні відмінності в 5 з 6 випробуваних вправ. Достовірно високий результат армрестлерів підкріплений високими показниками спеціальної фізичної підготовленості, а саме: силовими показниками у двох тестових вправах (гаку та згинанні кисті) і загальному сумарному показнику сили як лівої, так і правої рук ($p < 0,05$). Швидкісно-силові показники обох рук також достовірно різнилися загальному показнику сили, градієнті сили, силі на 500 мс, швидкісно-силовому індексу на 500 мс, відносній силі, градієнті сили і часі досягнення сили в 1 кг (t-критерій Стьюдента коливався від 2,06 до 5,84 при $p < 0,05–0,001$). Факторний аналіз підтвердив високий вплив антропометричних даних і показників швидкісно-силової підготовленості на результативність змагальної діяльності армрестлерів на досліджуваному етапі підготовки.

Висновки. Для створення основ високих результатів і спортивного вдосконалення на етапі попередньої базової підготовки необхідно передбачити переважно значний розвиток силових і швидкісно-силових можливостей, оскільки отримані результати свідчать, що зростання результативності спортсменів при відповідній системі спортивного тренування супроводжується значним зростанням максимальної сили, покращенням показників стартової, прискорювальної та швидкої сили в перші 500 мс м'язової напруги, як наслідок покращення індексу та градієнту сили, часу досягнення сили в 1 кг.

Ключові слова: армрестлінг, армрестлери, багаторічна підготовка, динамічна сила, силові показники, швидкісно-силова підготовленість.

Introduction

The entire long-term training from a beginner to an athlete of the highest skill is considered as a single process, as a complex specific system, functioning with its inherent features and patterns [1].

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The age limits of young athletes at the studied stage of preliminary basic training coincide with adolescence, when the body of young athletes bears a double load - the load of intensive biological development and the load under the influence of physical exercises [2, 3]. Therefore, at this stage, it is recommended to carefully observe reasonable dynamics of increasing the volume and intensity of training loads [4, 5].

According to the authors [6, 7, 8], the main goal of training sessions in the specified age period is in-depth mastery of the chosen sport. The main objectives of training at this stage are strengthening health and comprehensive physical development; improving speed-strength preparedness taking into account the formation of the basic skills inherent in the chosen sport; developing speed properties; creating a solid foundation of physical and technical preparedness, based on mastering the technique of a large number of auxiliary and specially preparatory exercises; forming a base of sports skills; increasing aerobic and anaerobic capabilities; gradually bringing athletes to the highest level of training loads; gradually bringing them to competitive struggle by using the means necessary for the athlete's volitional preparation [9, 10].

A number of researchers [11, 12, 13] claim that the factors limiting the load at this stage are: functional characteristics of the adolescent's body in connection with puberty; disproportion in the development of the body and the cardiovascular system; uneven growth and development of different body systems.

As indicated in special sources of information, the main means used at the stage under study are general developmental exercises, sets of special preparatory exercises, jumping exercises, sets of basic, competitive exercises, exercises with weights, outdoor and sports games, exercises on exercise machines [13, 14, 15]. Methods of performing exercises: uniform, repeated, interval, variable, game, circular, control, competitive [16, 17].

When planning training sessions, the main focus is on comprehensive training. Physical training mainly involves the comprehensive development of physical qualities [12]. Along with this, physical training becomes more targeted. During technical training, various motor actions are mastered, based on the material of the chosen sport. The most important basis for the technical training of young athletes should be an independent search for a solution to optimal motor problems when performing a particular exercise. Starting from this stage, the volume of strength, speed-strength training and special endurance increases [18, 19, 20].

In arm wrestling, the preliminary basic training stage covers the age of young men aged 14-15, and in the all-Ukrainian sports classification they belong to the junior group. According to the rules of armwrestling competitions, young armwrestlers of this age take part in competitions at the regional, all-Ukrainian and even international levels [20, 21, 22]. Since the number of participations in competitions depends on the level of training, the competition calendar, the fulfillment of rank requirements, the need to perform for one's team, and studies aimed at studying competitive activity in arm wrestling at this stage of preparation have not been identified, hence the relevance of the work [23, 24].

Taking into account the above and taking into account that studies aimed at identifying the components of physical and functional fitness in arm wrestling at the stage of preliminary basic training have not been identified, and it is not advisable to transfer the training of adult athletes to the training of young men, then determining the influence and comparison of different aspects of fitness on the effectiveness of competitive activity of armwrestlers acquires both theoretical and practical importance.

The purpose of the study is to determine the significance of the contribution of different aspects of preparedness (functional, physical) to identify factors influencing the effectiveness of competitive activities of junior armwrestlers aged 14–15 years.

Material and Methods

Participants

According to the International Rules for conducting Armwrestling sports competitions, the age category of athletes aged 14–15 years has the following weight categories: 45 kg, 50 kg, 55 kg, 60 kg, 65 kg, 70 kg and over 70 kg. But given that in modern armwrestling in Ukraine there is not yet a sufficient number of athletes of this age category, then at the stage of preliminary basic training in the study, the weight categories were combined into a weight group of 60–70 kg. This unification corresponds to the regulations for holding all-Ukrainian armwrestling competitions, which notes that the weight category occurs if the number of participants is not less than five.

The study involved 29 young men aged 14–15 years involved in arm wrestling, they were divided into two groups: 9 athletes (14.67 ± 0.17 years) who were distinguished by high competitive performance and 20 athletes (14.45 ± 0.11 years) of the general group.

Procedure

To determine the morphofunctional state of the study participants, height, weight, heart rate (HR), blood pressure (BP), vital capacity (VC),

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and wrist dynamometry (WD) were measured.

The following test exercises were used to determine general physical fitness: 60 m run, 1 km run, pull-ups on a horizontal bar, arm flexion and extension in a support position, long jump from a place, sitting torso bends for 1 minute.

The strength and speed-strength capabilities in the test exercises were determined by an electrical tenzodynamometer FL 1K 0.5N, 1000N from Kern & Sohn GmbH (China) with an accuracy class of up to 50 g, fixed on a specialized armwrestling table using a specially made block device. The strength capabilities of the armwrestlers were determined based on the results of four test exercises covering the main muscle groups that ensure the performance of the competitive action, namely: finger flexion, hammer pull, hook, and wrist flexion [9, 10, 12, 24]. All exercises were performed with both the left and right hand.

When measuring the strength of the arm muscles and the speed-strength indicators, the subject stood facing the table, grabbed the special handles of the device with his hand and squeezed them with maximum force, trying to show maximum force as quickly as possible. Finger bending was performed with a special eccentric 3D handle, which the athlete grabbed and pressed with his fingers into the platform, the pressing vector was directed to the chest. Tensioning was performed with a fabric loop, the pressing vector was directed to the forehead. The hook was performed with a rotating handle with a diameter of 30 mm, which the athlete grabbed and tried to pull to the chest, simulating hook wrestling. The block was located on the left or right side of the table, respectively. Wrist bending was performed with a rotating handle with a diameter of 45 mm, which the athlete grabbed and tried to bend the hand, directing it to the chest. The distance and angle between the handles of the device were easily changed and selected for each exercise.

A special computer program AFH-FASTFD was used to process the data. The program allows processing measurement data in real time (on-line) and previously collected data from the memory of the electrical tenzodynamometer (off-line). AFH-FASTFD is compatible with Windows operating systems.

Statistical analysis

Statistical analysis of the obtained data was performed using licensed programs Microsoft Excel and STATISTICA 10. The following parameters were determined and calculated: maximum (F) and relative ($F_1 = \Sigma F / m$) strength, kg; total strength index in four strength exercises ($\Sigma F = F1 + F2 + F3 + F4$), kg; time to reach maximum strength ($\Sigma t = t1 + t2 + t3 + t4$), s; speed-strength index ($J = \Sigma F / \Sigma t$), $kg*ms^{-1}$; average strength, index of four exercises ($\bar{F} = \Sigma F / 4$), kg; total strength gradient of four exercises ($\Sigma t_{0,5F}$), ms; speed-strength index in the first 500 ms ($J_{500} = \Sigma F_{500} / \Sigma t_{500}$), $kg*ms^{-1}$; time to reach 1 kg force ($t_1 = \Sigma t_{0.5F} / (0.5 \times F)$), $ms*kg^{-1}$; factor analysis was conducted.

Results

The study of morphofunctional data, indicators of general physical, special strength and speed-strength fitness of athletes with high competitive performance and the general group in the junior weight category 60–70 kg revealed that according to anthropometric indicators, the leaders have significantly better results in weight by 2.55 % (68.09 kg versus 66.40 kg; $t = 2.47$; $p < 0.05$) and height by 3.23 % (179.11 cm versus 173.50 cm; $p < 0.01$ at $t = 2.88$), and the body mass index was higher in the general group, but the difference was insignificant ($t = 1.85$; $p > 0.05$) (Table 1; Fig. 1).

Functional indicators differed significantly only in the breathing tests of Stange by 14.31 % (61.65 s versus 53.85 s; $t = 3.72$; $p < 0.001$) and Genchi by 12.14 % (41.83 s versus 37.30 s; $t = 2.77$; as well as in the strength index of the left hand by 11.90 % (73.26 % versus 65.47 %; $p < 0.05$ at $t = 2.33$), and the right – by 11.71 % (78.62 % versus 70.38 %; $p < 0,05$ at $t = 2,21$).

An analysis of the general physical fitness of the leaders and the overall group indicators revealed reliable differences in almost all test exercises. The leaders turned out to be significantly better in 5 out of 6 exercises performed, for example, in the 60 m run the result was 9.04 sec versus 9.58 sec ($p < 0.01$ at $t = 3.11$), in the 1 km run – 4.07 min versus 4.72 min ($p < 0.001$ at $t = 4.07$), pull-ups on the horizontal bar – 12.22 times versus 8.65 times ($p < 0.001$ at $t = 4.15$), in the standing long jump – 193.33 cm versus 182.20 cm ($p < 0.01$ at $t = 3.00$), sitting torso bends for 1 min – 42.22 times versus 35.15 times ($p < 0.001$ at $t = 5.75$). The results of arm flexion-extension in the support position were also better for the leaders, but they were not significant – $p > 0.05$ at $t = 1.86$ (Fig. 1, Table 1).

The reliably high result of armwrestlers weighing 60–70 kg is supported by high indicators of special physical fitness, namely: strength indicators in two test exercises (hook and wrist bending) and the overall total strength indicator of both the left and right hands. In the test exercises finger bending and hammer pull on both the left and right hands, the highest result of strength indicators turned out to be unreliable, which can be explained by the formation of armwrestling techniques at this stage of training. Thus, according to studies [10, 12, 22], it is the hook attack that is the most effective attack method and the

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Table 1. Reliability of the difference in the studied indicators (general group and leaders) of arm-wrestlers aged 14–15 years weighing 60–70 kg

Indicator	General group ± m (n = 20)	Leaders ± m (n = 9)	Level of significance (p)	Student's test (t)
Morphofunctional indicators				
Height, cm	173.50 ± 1.07	179.11 ± 1.65	**< 0.01**	**2.88**
Weight, kg	66.40 ± 0.38	68.09 ± 0.56	**< 0.05**	**2.47**
Heart rate, bpm	3.99 ± 0.09	4.22 ± 0.10	> 0.05	1.52
Pulse pressure, mmHg	60.03 ± 1.39	62.09 ± 1.77	> 0.05	0.86
Vital Capacity of the Lungs, l	22.09 ± 0.23	21.27 ± 0.43	> 0.05	1.85
Stange test, s	79.10 ± 1.65	78.11 ± 1.81	> 0.05	0.34
Genchi test, s	50.05 ± 1.85	47.33 ± 2.03	> 0.05	0.88
GI, ml/kg	53.85 ± 1.20	61.56 ± 1.56	**< 0.001**	**3.72**
SI (left hand), %	37.30 ± 0.79	41.83 ± 1.29	**< 0.01**	**2.77**
SI (right hand), %	65.47 ± 1.76	73.26 ± 3.10	**< 0.05**	**2.33**
BMI, kg/m2	70.38 ± 2.11	78.62 ± 3.02	**< 0.05**	**2.21**
Adaptation potential, c.u.	2.21 ± 0.03	2.17 ± 0.06	> 0.05	0.66
Endurance coefficient, c.u.	16.15 ± 0.59	16.72 ± 0.71	> 0.05	0.56
Robinson index, c.u.	99.85 ± 2.42	98.08 ± 3.55	> 0.05	0.41
Indicators of general physical fitness				
60 m run, s	9.58 ± 0.10	9.04 ± 0.12	**< 0.01**	**3.11**
Run 1 km, min	4.72 ± 0.19	4.07 ± 0.07	**< 0.001**	**4.07**
Pull-ups on the bar, times	8.65 ± 0.52	12.22 ± 0.52	**< 0.001**	**4.15**
Bending and unbending arms in support, times	31.25 ± 1.11	34.67 ± 1.17	**> 0.05**	**1.86**
Standing long jump, cm	182.20 ± 2.06	193.33 ± 3.09	< 0.01	3.00
Seated torso bends for 1 min, times	35.15 ± 0.94	42.22 ± 1.09	**< 0.001**	**5.74**
Indicators of special physical fitness				
Finger curl (left hand), kg	29.96 ± 0.71	32.23 ± 0.84	> 0.05	1.89
Finger curl (right hand), kg	31.32 ± 0.65	32.03 ± 1.37	> 0.05	0.53
Hammer pull (left hand), kg	30.60 ± 0.70	33.18 ± 1.10	> 0.05	2.02
Hammer pull (right hand), kg	32.09 ± 0.81	34.00 ± 0.97	> 0.05	1.39
Hook (left hand), kg	32.43 ± 0.77	38.82 ± 1.38	**< 0.001**	**4.36**
Hook (right hand), kg	34.11 ± 0.89	41.05 ± 1.55	**< 0.001**	**4.12**
Wrist flexion (left hand), kg	36.23 ± 0.70	42.41 ± 0.53	**< 0.001**	**5.55**
Wrist flexion (right hand), kg	39.34 ± 0.70	44.93 ± 0.76	**< 0.001**	**4.78**
ΣF (left hand), kg	129.21 ± 1.80	146.64 ± 1.91	**< 0.001**	**5.84**
ΣF (right hand), kg	136.87 ± 2.21	152.02 ± 2.49	**< 0.001**	**4.08**
Speed-strength indicators				
(left hand), kg	32.30 ± 0.45	36.66 ± 0.48	**< 0.001**	**5.84**
(right hand), kg	34.22 ± 0.55	38.00 ± 0.62	**< 0.001**	**4.08**
Σt, (left hand), ms	8892 ± 367	9353 ± 633	> 0.05	0.67
Σt, мс (right hand), ms	8784 ± 357	8646 ± 266	> 0.05	0.24
J, (left hand), kg/ms	15.04 ± 0.68	16.21 ± 1.03	> 0.05	0.96
J, (right hand), kg/ms	16.26 ± 0.91	17.76 ± 0.75	> 0.05	1.04
F_1, (left hand), kg/kg	1.95 ± 0.03	2.16 ± 0.03	**< 0.001**	**4.09**
F_1, (right hand), kg/kg	2.06 ± 0.04	2.23 ± 0.03	**< 0.05**	**2.72**
$\Sigma t_{0,5F}$, (left hand), ms	1472 ± 71	1381 ± 100	> 0.05	0.73
$\Sigma t_{0,5F}$, (right hand), ms	1497 ± 71	1192 ± 55	**< 0.05**	**2.71**
$\mathbf{\Sigma F}_{500}$ (left hand), kg	79.45 ± 1.98	90.47 ± 1.85	**< 0.01**	**3.43**
$\mathbf{\Sigma F}_{500}$ (right hand), kg	85.69 ± 2.35	92.75 ± 2.52	**< 0.01**	**4.21**
J_{500}, (left hand), kg/ms	158.90 ± 3.96	180.94 ± 3.70	**< 0.01**	**3.43**
J_{500}, (right hand), kg/ms	167.37 ± 4.71	185.51 ± 5.04	**< 0.01**	**4.21**
t_1, (left hand), ms/kg	22.91 ± 1.18	18.84 ± 1.33	**< 0.05**	**2.06**
t_1, (right hand), ms/kg	22.13 ± 1.41	15.75 ± 0.87	**< 0.01**	**2.90**

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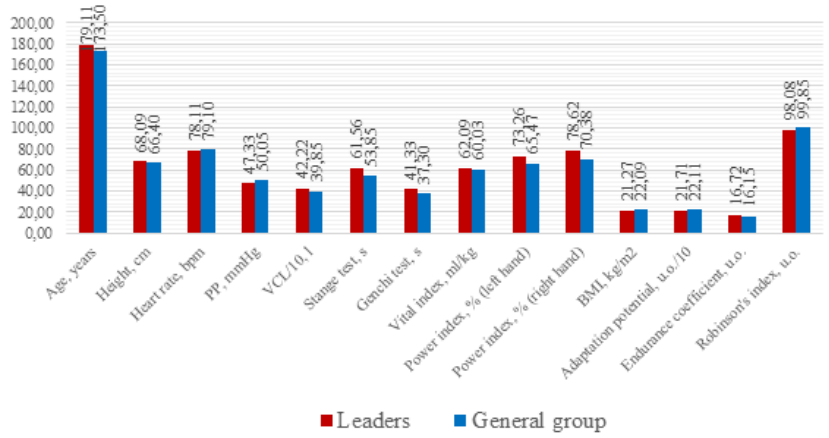
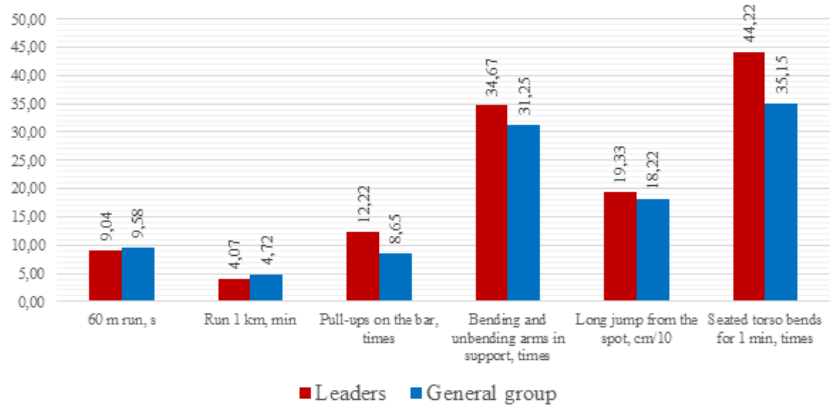
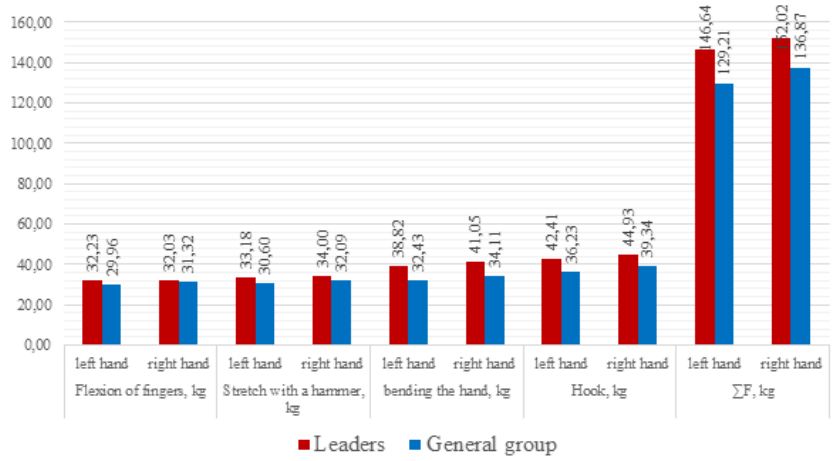
Morphofunctional indicators



Indicators of general physical fitness



Indicators of special physical fitness



Speed-strength indicators

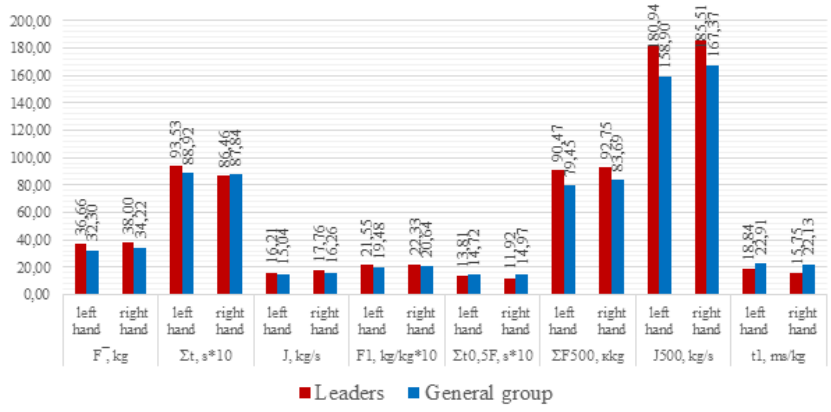


Figure 1. The level of studied indicators of armwrestlers weighing 60-70 kg leaders (n = 9) and general group (n = 20)

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most accessible for assimilation, used by athletes at the next stage of specialized basic training.

The speed-strength indicators of both hands also differed significantly in the average strength indicator, strength gradient, strength at 500 ms, in the speed-strength index at 500 ms, relative strength, strength gradient and time to achieve a force of 1 kg (Student's t-test ranged from 2.06 to 5.84 at $p < 0.05–0.001$). The indicator of time to achieve maximum strength and the speed-strength index did not differ significantly, which indicates that these indicators do not have a decisive influence on the result of a competitive match in armwrestling at the studied stage of preparation (Table 1).

Thus, in the 60–70 kg weight group of 14–15 year old boys, the increase in the sports performance of armwrestlers is facilitated by a higher

Table 2. Factors determining the sports results of young armwrestlers at the stage of preliminary basic training

Group characteristics	Factor 1	Factor 2	Factor 3	Factor 4	Σ factors	Unaccounted factors
leaders	32.03	23.38	16.15	9.50	81.06	18.94
general group	21.96	18.11	14.54	11.14	65.75	34.25

Table 3. Study of factors determining the sports result of the general group of armwrestlers aged 14–15 years weighing 60–70 kg at the stage of preliminary basic training

Indicator	Factor 1	Factor 2	Factor 3	Factor 4
Height, cm	-0.463286	-0.368450	0.058391	0.337487
Weight, kg	0.105902	-0.460742	0.230134	0.017705
Heart rate, bpm	-0.156349	0.110972	-0.632262	0.016324
Pulse pressure, mmHg	-0.667577	-0.103980	-0.296380	0.017933
Vital Capacity of the Lungs, l	**-0.751337**	-0.169242	-0.003685	0.286174
Stange test, s	**-0.764656**	-0.242284	-0.255920	-0.082154
Genchi test, s	-0.662790	-0.358556	-0.181138	0.089811
GI, ml/kg	**-0.791156**	-0.049505	-0.061392	0.291729
SI (left hand), %	-0.666020	-0.049952	0.114609	0.328073
SI (right hand), %	**-0.784713**	0.048401	-0.069643	0.279389
BMI, kg/m2	0.616965	0.196304	0.058671	-0.398902
Adaptation potential, c.u.	0.242736	-0.236799	-0.662494	0.290373
Endurance coefficient, c.u.	0.583939	0.205659	-0.101593	0.005764
Robinson index, c.u.	-0.179121	-0.078298	**-0.761091**	0.209658
ΣF, (left hand), kg	-0.453655	0.398193	0.484326	-0.069014
ΣF, (right hand), kg	-0.573027	0.558832	0.229050	-0.237165
Σt, (left hand), ms	0.130236	0.013194	0.594543	**0.757595**
Σt, мс (right hand), ms	0.236522	-0.220314	0.543883	0.633577
J, (left hand), kg/ms	-0.329390	0.103055	-0.481243	**-0.768834**
J, (right hand), kg/ms	-0.380119	0.324464	-0.427540	-0.632312
F_1, (left hand), kg/kg	-0.451242	0.524943	0.357246	-0.059506
F_1, (right hand), kg/kg	-0.535005	0.621224	0.135679	-0.205153
$\Sigma t_{0,5F}$, (left hand), ms	0.033788	0.121571	-0.484443	0.563151
$\Sigma t_{0,5F}$, (right hand), ms	0.261494	-0.474407	-0.581923	-0.017261
J_{500}, (left hand), kg/ms	-0.494492	-0.352038	-0.199597	0.001093
J_{500}, (right hand), kg/ms	**-0.762897**	0.145713	-0.041749	0.156354
t_1, (left hand), ms/kg	0.164983	-0.000030	-0.594819	0.527829
t_1, (right hand), ms/kg	0.388574	-0.579829	-0.558938	0.042423
60 m run, s	0.062169	**0.818200**	-0.311497	0.254372
Run 1 km, min	0.057406	0.643747	-0.521112	0.190377
Pull-ups on the bar, times	-0.076808	**-0.828930**	0.132680	-0.194870
Bending and unbending arms in support, times	-0.271642	**-0.728986**	0.190502	-0.262534
Standing long jump, cm	-0.416674	-0.570257	0.160424	-0.233306
Seated torso bends for 1 min, times	-0.019040	**-0.879656**	0.146528	-0.243844
Total variance	**7.467369**	**6.156943**	**4.943521**	**3.786697**
Total share	**0.219628**	**0.181087**	**0.145398**	**0.111373**

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weight and height, a higher strength index, higher aerobic-anaerobic capabilities, increased strength indicators in the strength exercises used in the competitive fight, as well as higher explosive capabilities and accelerating force.

To determine the magnitude of the factor load of different aspects of readiness for the overall dispersion of the sample, a factor analysis was carried out, which allows us to confirm the results of the study obtained above (Table 2).

Analysis of the general group data of factor loads of armwrestlers weighing 60–70 kg shows that the general dispersion of the sample is 65.75 %. Moreover, the first factor accounts for 21.97 % of the total sample (Table 2, 3). Such factor load is created mainly by functional indicators and indicators of special speed-strength preparedness.

The second factor loading is equal to 18.11 %, which was determined by the relative strength and indicators of general physical fitness, with significance registered in all tests of general physical fitness (Table 3).

The third factor load, 14.54 % of the total sample, consisted of functional indicators of cardiac activity (Adaptation potential), time characteristics of athletes' strength development: the gradient of the strength of the right hand and the time to achieve a strength of 1 kg in both hands.

The fourth factor loading of 11.14% was determined by the time indicators of strength development: time to reach maximum strength, speed-strength index of both hands and the gra-

Table 4. **Study of factors determining the sports result of leader armwrestlers aged 14–15 years weighing 60–70 kg at the stage of preliminary basic training**

Indicator	Factor 1	Factor 2	Factor 3	Factor 4
Height, cm	**-0.82280**	-0.335778	-0.141082	-0.300515
Weight, kg	0.31207	**-0.771149**	0.081764	-0.390844
Heart rate, bpm	0.30541	**0.788350**	0.160886	0.186758
Pulse pressure, mmHg	-0.47402	0.653384	-0.015354	0.547117
Vital Capacity of the Lungs, l	**-0.94114**	0.140364	-0.058939	0.209623
Stange test, s	**-0.84482**	-0.112534	-0.342708	-0.202170
Genchi test, s	-0.69752	0.301265	-0.328427	-0.195852
GI, ml/kg	**-0.86605**	0.335854	-0.080909	0.286825
SI (left hand), %	-0.51579	-0.404113	-0.420751	0.352013
SI (right hand), %	-0.66718	-0.679010	-0.039668	0.187547
BMI, kg/m2	**0.88865**	-0.025758	0.147240	0.137439
Adaptation potential, c.u.	0.49775	0.622071	0.494470	-0.160009
Endurance coefficient, c.u.	**0.70904**	-0.282742	0.031988	-0.524710
Robinson index, c.u.	0.22947	**0.865152**	0.325205	0.064557
ΣF, (left hand), kg	-0.54936	0.237931	0.386405	0.192616
ΣF, (right hand), kg	-0.33009	-0.646601	0.435093	0.424128
Σt, (left hand), ms	**0.84966**	-0.041047	0.047245	0.297216
Σt, мс (right hand), ms	-0.15775	**0.786372**	-0.165541	-0.331506
J, (left hand), kg/ms	**-0.84760**	-0.043135	0.094350	-0.158370
J, (right hand), kg/ms	0.07793	**-0.795142**	0.269376	0.439917
F_1, (left hand), kg/kg	-0.58270	0.587461	0.259857	0.344313
F_1, (right hand), kg/kg	-0.50389	-0.278417	0.408932	0.644767
$\Sigma t_{0,5F}$, (left hand), ms	0.36625	**0.763113**	0.037457	0.133564
$\Sigma t_{0,5F}$, (right hand), ms	-0.42931	0.489301	-0.300030	0.034120
J_{500}, (left hand), kg/ms	**-0.73281**	0.273959	-0.302035	-0.401931
J_{500}, (right hand), kg/ms	-0.54259	-0.030828	-0.244940	-0.525485
t_1, (left hand), ms/kg	0.47150	**0.716573**	-0.021627	0.119874
t_1, (right hand), ms/kg	-0.26028	0.632791	-0.387021	-0.083626
60 m run, s	0.10506	0.143245	**-0.757784**	0.237028
Run 1 km, min	0.50482	0.125695	-0.685652	0.220182
Pull-ups on the bar, times	-0.46706	0.317476	**0.724730**	-0.240865
Bending and unbending arms in support, times	-0.39265	0.109670	**0.745466**	-0.340534
Standing long jump, cm	-0.23144	0.009690	**0.936758**	-0.100963
Seated torso bends for 1 min, times	-0.22170	0.066523	**0.755026**	-0.166297
Total variance	**10.88876**	**7.949000**	**5.489860**	**3.228435**
Total share	**0.32026**	**0.233794**	**0.161466**	**0.094954**

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dient of strength of the left hand.

The total dispersion of the sample of arm wrestlers weighing 60–70 kg, who demonstrated a high level of competitive activity, is 81.06%. Of these, the first factor accounts for 32.03% and, for the most part, this factor load is determined by anthropometric data (height, BMI), functional (Vital Capacity of the Lungs, Stange test, Genchi test, GI, Endurance coefficient) indicators and special speed-strength preparedness (time to achieve maximum strength and speed-strength indices of maximum strength and strength at 500 ms) (Table 4).

The second factor with a load of 23.38 % consisted of the weight of the athletes and the indicators of the cardiorespiratory system (HR and Pulse pressure), functional indicators (PI, AP, Robinson index) and the results of speed-strength readiness (time to achieve maximum strength, speed-strength index of maximum strength, strength gradient and time to achieve a strength of 1 kg).

The third factor accounts for 16.15 % of the total sample and is determined by indicators of general physical fitness.

The fourth factor loading, accounting for 9.50 % of the total sample variance, represented relative strength.

Unaccounted factors in this group account for 18.94 %.

Thus, for armwrestlers weighing 60–70 kg, the leading factors are morphofunctional indicators and indicators of speed-strength fitness, especially the time characteristics of strength development prevail. The lowest force of factor load is for indicators of general physical fitness. Comparison of the indicators of leaders and general group data indicates that the leading group of athletes has a more uniform distribution of factor loads to the general dispersion of the sample, and the value of unaccounted factors is significantly lower than the general group indicators, which contributes to achieving the highest results of competitive activity.

Discussion

High achievements in modern armwrestling mostly depend on the quality of strength and speed-strength preparedness of athletes, since the technical and tactical preparation of highly qualified armwrestlers is currently at the highest level in all weight categories [10, 11]. However, training methods and loads for adult athletes cannot be used in training young men and juniors who are at the initial stages of preparation and differ from adults in the level of technical, special physical, and most importantly, functional preparedness.

In special sources of information [7, 8] it is noted that at the stage of preliminary basic training in strength sports, such as weightlifting, powerlifting, anthropometric indicators, functional data and results of special strength training are of great importance in achieving high results of competitive activity, and in martial arts – indicators of general physical and technical training [11]. Since armwrestling has features of both strength sports and martial arts, combined in individual elements of the technique of competitive exercises, hence the relevance of determining the components of sports training that affect the results of performance in armwrestlers' competitions. For the studied stage of preparation, no studies related to the study of the results of competitive activity of juniors aged 14–15 years were found, but there are methodological recommendations of a number of researchers [12, 19], revealing the essence of the training process for the specified age of athletes. Thus, the direction of the study was chosen. Moreover, the listed problems are not sufficiently covered in the available sources of information, therefore, the search for an answer regarding the determination of the factors of the effectiveness of competitive activity of armwrestlers is of particular importance for both the theory and practice of sports.

According to our preliminary studies [1, 9, 12, 22], it was found that armwrestlers can be divided by genetic predisposition into those who have a tendency to quickly perform competitive exercises and those who have the ability to strength endurance. Based on this, both strength and speed-strength abilities were determined in the athletes under study.

Considering that the listed factors have a direct impact on the results of competitive activity, it was important to determine the degree of their influence on the strength abilities of athletes and the characteristics of muscle efforts that most affect the athletic achievements of armwrestlers at different stages of training [17, 19, 20].

At the stage of preliminary basic training, 14–15-year old armwrestlers were found to have special strength training using high-intensity training loads. The results of the study revealed that young athletes aged 14 to 15 years' experience an intensive increase in height from 4 cm to 8 cm and weight from 5 kg to 9 kg. At this rate of change in the height and weight of athletes, the process of innervation and blood supply to muscle fibers does not have time to support the development of the physical and functional capabilities of their body at the proper level. In this regard, at the stage of preliminary basic training, special attention must be paid to physical exercises of general physical and auxiliary orientation, performed in aerobic mode. [18, 27].

It was hypothetically assumed that the absolute strength indicators of armwrestlers do not

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have a decisive significance in the effectiveness of a competitive fight. Thus, in the works of Mazurenko [4] it was noted that athletes with weaker strength indicators emerged victorious in competitions. This is confirmed by the results of the factor analysis of the components of the preparedness of 14-15 year old armwrestlers, according to which the decisive importance is given to the anthropometric indicators, functional data, as well as the indicators of special speed-strength preparedness (time to reach maximum force (0.850), speed-strength index (-0.847) and speed-strength index at 500 ms (-0.733), while absolute strength indicators are of secondary importance.

At the studied stage of preparation, according to the results of testing special strength preparedness, it was established that the strength indicators in two test exercises (hook and wrist bending) have reliably high results in contrast to the finger bending and hammer pull exercises, which is explained by the formation of armwrestling techniques at this stage of preparation. This at one time confirms the results of studies in other sports (weightlifting, powerlifting, kettlebell lifting) [7, 8, 17].

Conclusions

1. Comparative analysis of the dynamics of changes in the indicators of general physical, functional, special physical and speed-strength preparedness of armwrestlers at the stage of preliminary basic training allows us to state that the share of special work using special physical training tools has noticeably increased in the training process of these athletes.

2. Analysis of the dynamics of changes in special strength preparedness in the test exercises hook and wrist bending on both the left and right hands revealed a reliably increased result of the strength indicator, indicating the formation of armwrestling techniques at this stage of preparation.

3. Comparison of the dynamics of factor loads and the share of unaccounted factors by age and weight indicators at the stage of preliminary basic training allowed us to determine that with age and weight increase of athletes, the degree of significance of specialized and technical preparedness gradually increases. At this stage of preparation, both for leaders and especially for athletes of the general group, the gap between the factor loads of the first and subsequent factors – for leaders the gap fluctuates from 29.37 % to 36.08 %, and in the general group – from 41.36 % to 71.36 %. Such a phenomenon according to the analysis of the training work of athletes is explained by the forcing of specialized training loads using exercises in interval and repeated modes.

4. To create the foundations for high results and sports improvement at the stage of preliminary basic training, it is necessary to provide for a predominantly significant development of strength and speed-strength capabilities, since the obtained results indicate that the growth of athletes' performance with the appropriate system of sports training is accompanied by a significant increase in maximum strength, an improvement in the indicators of starting, acceleration and fast strength in the first 500 ms of muscle tension, as a consequence of an improvement in the index and gradient of strength, the time to achieve a force of 1 kg.

Further research. The issue of selecting optimal means and methods of development, volume and intensity of training loads requires experimental development, which is planned to be devoted to further research.

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Supplementary Information

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Authors details

IDmytro Bezkorovainyi
https://orcid.org/0000-0001-9719-6131,
Dmitro.Bezkorovayniy@kname.edu.ua
O. M. Beketov National University of Urban Economy in Kharkiv
17, Marshal Bazhanov Street, Kharkiv, 61002, Ukraine
Kharkiv State Academy of Physical Culture, str. Klochkivska, 99, Kharkiv 61022, Ukraine

Artur Oderov
https://orcid.org/0000-0002-7791-0825,
stroyova@ukr.net
Hetman Petro Sahaidachnyi National Army Academy, 32, Heroes Maidana Street, 79026, Lviv, Ukraine

Kravchenko Anton
https://orcid.org/0000-0001-9627-8952,
kra.ant21@hgpakh.ukr.education
Municipal Establishment «Kharkiv Humanitarian–Pedagogical Academy» of the Kharkiv regional council in Kharkiv, 7, Rustaveli Lane Kharkiv, 61001, Ukraine

Leonid Plotnytskyi
https://orcid.org/0000-0003-4218-4023,
leonid.plotnytskyi@kname.edu.ua
O. M. Beketov National University of Urban Economy in Kharkiv
17, Marshal Bazhanov Street, Kharkiv, 61002, Ukraine

Tetiana Liudovyk
https://orcid.org/0000-0002-2407-0447,
tluidovyk@gmail.com
Hetman Petro Sahaidachnyi National Army Academy, 32, Heroes Maidana Street, 79026, Lviv, Ukraine
Stepan Gzhytsyi National University of Veterinary Medicine and Biotechnologies of Lviv, 50, Pekarska street, 79010, Lviv, Ukraine

Volodymyr Ozharevskyi
https://orcid.org/0000-0001-6788-5024,
ozharevskiy@bigmir.net
Defence Intelligence Research Institute, 9, Povitroflotsky Prospect, 04176, Kyiv, Ukraine

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