

# Influence of arm speed strength abilities on the sports result of elite cross-country female skiers in competitions at various distances

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**Abstract.** The article presents the correlation dynamics between indicators of arm speed strength abilities (explosive arm power, speed strength endurance) and sports results of elite cross-country female skiers at various distances of races for the final year of Olympic training. The analysis involved the results of 18 elite female athletes specializing in various types of competitive activities, aged 20 to 27 years. Functional surveys of arm speed strength abilities were conducted in the laboratory of cyclic Olympic sports of the All-Russian Scientific Research Institute of Physical Culture & Sport (Moscow). The test program included the maximum muscle load on a ski ergometer Concept-2 (SkiErg), simulating the work of the hands with competitive intensity in several modes (pushing with maximum power and 5 minutes of work in competitive mode). The obtained indicators of explosive arm power and speed strength endurance were subjected to a correlation analysis with the results at the goal-setting starts of the sports season 2017-2018. The research results allowed to establish the most informative indicators and the differential significance of arm speed strength abilities in ensuring the effectiveness of performance at various distances of ski races.

## 1 Introduction

Increasing competition in women's skiing at all distances, regardless of the competition format and the length of the distance, requires a systematic improvement in the training process of the Russian national ski team athletes. At the same time, the search for such rational ways to increase the efficiency of the training process to achieve the highest possible level performance relative to the model level, taking into account the specific requirements of competitive activity, is a key trend of modern sports science and practice [1-8].

An analysis of the modern research results carried out by leading foreign experts in cross-country skiing [2, 4-6, 9-18] confirms the opinion of experts [19, 20] that studies on highly skilled skiers are extremely rare and make up only six part [4, 10, 13, 17, 20] of the

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total amount of work. However, most of them have no common methodological framework and based on the use of various test procedures and protocols [2, 8, 9, 20].

The current situation complicates the programming of the training process and does not allow the comparison of performance indicators at various stages of training, considering the specific specialization of muscle activity. At the same time, the universality of athletes is most clearly manifested in women's skiing. It poses new challenges for researchers and practitioners of domestic sports to improve methodological approaches to building the training process, as well as approaches to a comprehensive assessment of performance at various stages of the annual cycle [8, 21].

The study of correlation relationships and the establishment of the performance indicators significance (arm speed strength abilities in particular) in ensuring the effectiveness of performance at various distances of ski races is one of the possible directions for improving the training process in the current conditions. In this regard, for scientifically based management of elite female skiers training process, it is very important to have information not only about the level of athletes physical preparedness, but also about the degree of interconnection of sports results with leading physical qualities both at the lead competitions and at the main start of the season [1, 3, 9, 21, 22,23].

The study of the relationship between physical preparedness indicators of elite cross-country female skiers and the effectiveness of competitive activity at different distances of skiing is a sequential part of the study conducted by specialists of the cyclic Olympic sports laboratory of the All-Russian Scientific Research Institute of Physical Culture & Sport (Moscow) as part of the research work "Individual Typological Features of the highly qualified cross-country skiers physical preparedness formation at the stages of the Olympic training cycle" for 2018-2020.

The correlation analysis is dictated by the need to establish differentiated significance indicators of explosive arm power and speed-strength endurance in the tests with the utmost muscular load, simulating the competitive mode of operation with a selective effect on the achievement of the final result at different distances of ski races.

The aim of the present study is to develop the influence of the arm speed strength abilities indicators (explosive arm power, speed strength endurance) and sports results of elite cross-country female skiers at various distances of the 2017-2018 sports season ski races.

Research objectives:

1. To study the dynamics of the correlation between the indicators of explosive arm power and speed strength endurance of elite cross-country female skiers with sports results at different distances of ski races.

2. To establish the main patterns of indicators manifestation of explosive arm power and speed strength endurance, depending on the specifics of competitive activity at different distances of skiing.

## **2 Statement of problem**

The research was carried out on the basis of the following research methods: pedagogical (collection, processing and analysis of competitive activity documentation; ergometric research methods (performing a test procedure on a ski ergometer Concept-2 (SkiErg); mathematical and statistical research methods (calculation of arithmetic mean, standard deviation, correlation analysis, etc.).

The test program included the maximum muscle load on a ski ergometer Concept-2 (SkiErg), simulating the work of the hands with competitive intensity in several modes in accordance with the recommendations [1, 2, 4, 9, 18, 21, 22]:

- measurement of mechanical work in one movement of the hands, performed with maximum power while simulating a double polling technique (pushing with maximum power, assessment of explosive arm power);

- measurement of mechanical power in a 5-minute maximum muscle load simulating the movement of a skier in double polling at competitive mode (5 minutes of work in competitive mode, assessment of speed strength endurance).

The analysis involved the results of 18 elite female athletes specializing in various types of competitive activities, aged 20 to 27 years.

To solve the aim and objectives of the study, the magnitude and orientation of the correlation coefficients was considered through the nature of the relationship “selected indicator” – “goal-setting significance of the selected competition”. That is why, in order to identify the influence of arm speed strength abilities on a sports result, we studied the dynamics of correlation between the main indicators of explosive arm power, speed strength endurance and the results of performances at various distances in goal-setting starts (individual sprint, individual race at 10 km, skiathlon (15 km) and mass start (30 km). The list of goal-setting starts of the Olympic cycle 2017-2018 final year included the following competitions: All-Russian competition of skiers in Tyumen, held at the end of a snowless stage of the preparatory period and associated with the completion of the basic stage snowless training (end of September), the Final of the Russia Cup and Winter Olympic games in Pyeongchang, held in the middle of the competitive period and associated with reaching a peak (February) at the main start of the season, the Russian national championship in Syktyvkar at the end of the competition period and associated with the opportunity to be selected for the national team for the next sports season (April).

### 3 Results and Discussion

For the correlation analysis, the following recorded and calculated indicators were used: absolute and relative value of arm force (one repeated movement) (Aabs / Arel), absolute and relative value of arm 5-minute power (Nabs / Nrel), HR after 5-minute work and speed of overcoming the distance at the main start of the season. The group average data of the studied indicators for assessing the arm speed strength abilities, sports results at the main start of the season (taking into account the specifics of competitive activity in the sports season 2017-2018) and the dynamics of the correlation coefficients are presented in Tables 1-2.

**Table 1.** Dynamics of arm speed strength abilities and sports results of elite cross-country female skiers in competitions at various distances in the sports season 2017-2018 (mean ± SD) (n=18).

Parameter	Achieved values
<b>EXPLOSIVE ARM POWER</b>	
Absolute arm force (one repeated movement) (Aabs), kg-m	18,67±0,82
Relative value of arm force (one repeated movement) per 1 kg of weight (Arel), kg-m/kg	0,309±0,025
<b>ARM SPEED STRENGTH ENDURANCE</b>	
Absolute arm 5-minute power (Nabs), kg-m/min	1164±34
Relative value of arm 5-minute power (Nrel), kg-m/min/kg	19,2±1,4
HR after 5-minute work, beats/min	163,5±11,2
<b>SPORTS RESULT (speed of overcoming the distance at the main start of the season)</b>	
Individual sprint (Qualification Speed), m/s	6,23±0,55
Individual race 10km, m/c	5,68±0,37

Skiathlon (race 15km), m/s	5,65±0,21
Mass start (race 30km), m/s	5,75±0,33

**Table 2.** Correlations of the arm speed strength abilities with sports result in cross-country skiing competitions at various distances in the sports season 2017-2018.

Competition	Parameter				
	Explosive arm power		Arm speed strength endurance		
	Aabs	Arel	Nabs	Nrel	HR
<b>INDIVIDUAL SPRINT</b>					
1,4 km C, 08.09.2017 All-Russian skiing competitions in Tyumen	0,538	0,296	0,291	0,172	-0,217
1,4 km F, 25.02.2018 Russian Cup Final in Kononovskaya	0,886*	0,536*	0,513*	0,611*	-0,663*
1,14 km C, 13.02.2018 Winter Olympic Games in Pyeongchang	0,635*	0,696*	0,602*	0,370	0,819*
1,4 km F, 24.03.2018 Russian Championship in Syktyvkar	0,488	0,144	0,639*	0,330	-0,791
<b>INDIVIDUAL RACE 10KM</b>					
15 km F, 09.09.2017 All-Russian skiing competitions in Tyumen	0,115	0,434	0,448	0,323	0,665*
10 km F, 24.02.2018 Russian Cup Final in Kononovskaya	0,803*	-0,209	0,414	-0,679*	0,386
10 km F, 15.02.2018 Winter Olympic Games in Pyeongchang	-0,174	0,783*	0,751*	0,535*	0,618*
10 km C, 27.03.2018 Russian Championship in Syktyvkar	0,574*	0,454	0,699*	-0,205	-0,156
<b>SKIATHLON (RACE 15KM)</b>					
Skiathlon 15/15km C/F, 28.02.2018 Russian Cup Final in Kononovskaya	0,354	0,474	0,659*	0,815*	-0,814*
Skiathlon 15/15km C/F, 10.02.2018 Winter Olympic Games in Pyeongchang	0,825*	0,137	0,161	0,440	0,249
Skiathlon 15/15km C/F, 25.03.2018 Russian Championship in Syktyvkar	-0,112	0,436	-0,246	-0,194	-0,408
<b>MASS START (RACE 30KM)</b>					
30 km C Mst, 25.02.2018 Winter Olympic Games in Pyeongchang	0,493	0,241	0,502*	0,513*	0,045
30 km F Mst, 31.03.2018 Russian Championship in Syktyvkar	0,050	0,677*	0,821*	0,280	-0,712*

\* - correlation coefficients corresponding to a significance level  $p < 0.05$

The dynamics of the absolute value correlation coefficients in pushing with maximum power (Aabs), which reflects the level of explosive arm power development, is characterized by a unidirectional change of the relationship in the range from 0.488 to

0.886 in an individual sprint and from 0.050 to 0.493 in masstart, and opposite in sign from -0.174 to 0.803 in an individual race and from -0.112 to 0.825 in skiathlon. At the same time, the peak level of correlation coefficients falls on the main start of the sports season: sprint races, skiathlon and masstart at the Winter Olympic Games (0.635, 0.825 and 0.493, respectively), as well as individual races of Russian Cup Final (0.803).

The dynamics of the correlation coefficients of the relative value of of arm force in pushing with maximum power (Aotn), reflecting the balance of morphological indicators (primarily body weight) and the volume of work performed, is characterized by a unidirectional change of the relationship in the range from 0.144 to 0.696 in an individual sprint, from 0.137 to 0.474 in skiathlon and from 0.241 to 0.677 in masstart, and in different directions from -0.209 to 0.783 in an individual race. The achievement of the peak level of correlation coefficients (as in the dynamics of absolute values) falls on the main starts of the sports season: sprint and individual races 10 km at the Winter Olympic Games (0.696 and 0.783, respectively), as well as competitions in skiathlon of Russian Cup Final (0.474 ). In competitions with a total start at a distance of 30 km, the peak value is reached at the starts of the Russian Championship in Syktyvkar with the addition to the team ( $R_{tk} = 0.677$ ). In masstart 30 km, the peak value is reached at the starts of the Russian Championship in Syktyvkar with the addition to the team (0.677).

The dynamics of the absolute arm power correlation coefficients in 5 minutes of work in competitive mode (Nabs), which reflects the level of speed-strength endurance development, is characterized by a unidirectional change of the relationship in the range of 0.291-0.639 in sprint, 0.414-0.751 in an individual race 10 km and 0.502-0.821 in masstart, and multidirectional in sign from -0.246 to 0.659 in skiathlon. The achievement of the peak value of statistically reliable correlation coefficients of the studied parameter falls on the main start of the sports season – Winter Olympic Games: in sprint (0.602), in individual race (0.751), as well as in the races of Russian Cup Final qualifying competitions in skiathlon (0.659) and the selection to the team in Russian Championship in Syktyvkar at masstart (0.821), indicating the high importance of the absolute indicator of speed-strength endurance, coupled with the overall dimensions of body weight.

The dynamics of the correlation coefficients of the 5-minute work relative power in competitive mode (Nrel) is characterized by a unidirectional change of the relationship in the range of 0.330-0.611 in sprint and 0.280-0.513 in masstart, and multidirectional in sign from -0.679 to 0.715 in an individual race and from -0.194 to 0.815 in skiathlon. Achievement of correlation coefficients peak value with a positive sign: in sprint races in competitions of Russian Cup Final (0.611) and in the Winter Olympic Games (0.370), in an individual race in the Winter Olympic Games (0.535) and Russian Championship in Tyumen (0.323), but already at this distance in the sports seasons negative correlation relationships are noted and present: races of Russian Cup Final (-0.679) and masstart (-0.205). The peak level at skiathlon was established at races of Russian Cup Final (0.815) with preserved positive attitude to racing at the Winter Olympic Games (0.440) and a changed designation for racing at Russian Championship in Syktyvkar (-0.194). In masstart, the peak level came at the Winter Olympic Games (0.513), with a further decrease in Russian Championship in Syktyvkar (0.280).

The dynamics of the heart rate correlation coefficients at the finish of the 5-minute work (HR) is characterized by a multidirectional change of the relationship in the range from -0.791 to 0.819 in sprint, from -0.156 to 0.665 in an individual race, from -0.814 to 0.249 in skiathlon and from -0.712 to 0.045 in masstart. Moreover, the achievement of the peak value of statistically significant correlation coefficients with a positive sign falls on the period of the sports season main start: an individual sprint and race 10 km in Winter Olympic Games (0.819 and 0.618, respectively), while maintaining positive direction in skiathlon (0.249) and with a minimum value in masstart (0.045). Just as the cardiovascular

system demonstrates modern trends, there are more opportunities to provide functional systems provided mobilization at the main starts of the season. In most of the studied races of sports season, the correlation with sports results is negative (see Table 2), indicating the importance of the functional economization influence (due to the establishment of regulatory mechanisms within the sports season), reflecting the specific requirements for ski racing.

## 4 Conclusion

The research results allowed to establish the most informative indicators and the differential significance of arm speed strength abilities in ensuring the effectiveness of performance at various distances of ski races. A characteristic feature of the studied indicators correlation relationships dynamics is the balanced development of morphological indicators (primarily body weight) with the amount of work performed in the case of evaluating the explosive arm power and the power of work. In the case of speed-strength endurance, a tendency to maximize the functioning of the cardiovascular system while increasing the significance of the season start (leading, qualifying, main) and maintaining the significance of the functional economization growth effect (leading to a change of sign to a “minus”) with an increase in the duration of the competitive distance was revealed.

The results of the research allowed to formulate the following patterns of indicators manifestation of explosive arm power and speed-strength endurance, depending on the specifics of the female skiers competitive activity:

- success of performance in individual sprint is determined by the high level of explosive arm power development (and, first of all, the absolute indicator) against the background of the speed-strength endurance (absolute and relative indicators) balanced development and the ability to maximize the manifestation of the cardiovascular system activity;

- success of performance in the individual race 10 km is determined by the balance of the explosive arm power and speed-strength endurance development (with a slight dominance of absolute values), against the background of continuing requirements to maximize the functioning of the cardiovascular system;

- success of performance in a skiathlon (15 km race) is determined by the balanced development of explosive arm power (and, first of all, absolute value) against the background of a prevailing absolute level of speed-strength endurance development and all this while maintaining a positive orientation (albeit at a low level) the relationship with the willingness of the cardiovascular system to function at its maximum;

- success of performance in masstart (30 km race with a common start) is determined by the dominant level of speed-strength endurance development (and mostly of an absolute value) in relation to the explosive arm power (absolute and relative values) and all this against the background of only maintaining a positive orientation of the relationship with the activity of the cardiovascular system, but already from the position of the systemic influence of the economization component, leading to a change in sign to “minus”.

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