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Original Article

Homologation of the Olympic ski stadiums as the basis for the requirements for the technical, tactical and functional training of cross country athletes

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Abstract
The article is devoted to the analysis of the homologous characteristics of the Olympic ski tracks as the basis for the requirements for the technical, tactical and functional preparation process of the ski athletes.There is known fact, that the effectiveness of competitive activities in the ski races is largely dependent on the homologous characteristics of ski tracks, imposing certain requirements to the functionality level of the athletes, the election of athletes of the running technique and tactics of overcoming the competitive distance. During the research, we have foundedthe connection of homologous characteristics with the results of competitions at the different distances of ski races. The analysis of the correlation straps of the homologous characteristics of the tracks with the speed and density of the results of the competitions showed that the leading ski athletes of the world on the speed of the race is most affected by the sum of height differences (r = 0.37), the number of laps in the distance (r = 0.26), and length of maximum lifting (r = 0.25), whereas the density of the results in the race is influenced by the length of the lap of the sporting distance (r = 0.48).We were determined the speed characteristics of the modern ski races. The average speed in skiing is about 6-7 $m \cdot sec^{-1}$depending on the race settings. During the ski running with increasing distance, there is a progressive decrease in the average speed. Thus, the best ski athletes in the world overcome the marathon distance (30 km) by an average of 19% slower than the distance of 5 km, and the distance of 10 km - by 5-7% slower. This is due to the fact that the organizers of the competition, use for laying long lines of the ski track areas with a smaller height difference.
Key words: crosscountry, homologous indicators, athletes,Olympic ski tracks.

Introduction

The effectiveness of competitive activities in the cross country rases depends from a large extent of the homologous characteristics of ski tracks, imposing certain requirements on the level of the athlete's functionality(ShustinB.N.,1995; RamenskyaT.I., 2002;KroptaR.V.,2004).

The term "homologation" comes from the ancient Greek verb ὁμολογεῖν – "become" – in the original sense characterized the compliance of court documents to certain requirements. At the present time, this concept is used very widely. In the skiing, it means the compliance of the racetracks with the regulations of the International Federation of Skiing (IFS), namely - certain standards regarding their complexity, length of the track, length and number of climbs and descent and height difference. Naturally, the requirements for different ski disciplines are various(AllenE.,JohnB., 2005; KhmelnytskaJ.K., 2016).

Knowledge about the peculiarities of ski tracks hasgreat importance for the preparation of ski athletes.Leading ski specialists, astheB.N. Shustin(1995);I.N. Khokhlov(1997); T.I. Ramenska(2002); A.H. Batalog,N.A. Khramov(2002)etal.,note that in order to increase the systematic and targeted tactical and functional training for theski athletes, first of all, must be bringing the metric and temporal parameters of the competitive load on the various components of the relief of distances, laid on difficultly crossed terrain.

Thus, in the frameworks of the satisfactory and poor slipping in the plain and ascents and descents of different steepness, the alternate two-stage ski run is most often used. Rarely used an alternate four-step course to overcome the ski when the repulsion with sticks deteriorated. On the sloping descents are widely used simultaneous moves (one-step and two-step); stepless is most often used on ice sloping sections of the ski race and during descents of average steepness. Provided good and excellent slip in the plain, alternate two-stage and simultaneous moves are more often used, but at the first opportunity it is preferable to simultaneously, since it provides the athlete with an advantage in speed and noticeable saving of physical forces(RamenskyaT.I., 2002; KhokhlovG.G., 2010;KroptaR., HruzevychI.,2018).

At the present time, the strongest ski athletes, due to the high level of physical (speed and force level) and functional (endurance level) preparedness, as well as the fact that the trails of modern ski races are prepared very

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carefully (with the help of machines), the use of ski runs slightly narrowed. Ski athletes began to use methods of skiing, which ensure the highest speed of movement in the different conditions, is an alternating two-step, simultaneous (straight-line and one-step). The choice of a ski run in many respects depends on the degree of mastery of them and on the individual characteristics of the ski athlete, as the strength of the muscles of his upper limbs and the trunk. The speed of movement largely depends on the combination of moves and the choice of the moment of transition from one run to another, depending on the condition and the microrelief of the ski and conditions of sliding (HoffmannM., CliffordP., GaskillsE., *GarretW.,KirkendallD., 2000;* BatalovA.G., 2002*)*.

To a greater extent (as in the relation to slip conditions), the structure of the ski athletes movements depends on the relief of the ski run, which changes the competitive velocity in the range from 2-3 $m \cdot sec^{-1}$on the ascents to 10-12 $m \cdot sec^{-1}$and more on descents (RamenskyaT.I., 2002; KhokhlovG.G., 2010).

Purpose of the research

The research is devoted to the definition of the peculiarity and homology of modern Olympic ski tracks, with the further advancement of the requirements for technical, tactical and functional preparation process of the ski athletes.

Materials & Methods

For determination the most significant for ski athletes homologous characteristics of the ski tracks, wehave analyzed the protocols of the results of the World Championships and Winter OlympicsGames from 1998 to 2014. When processing protocols studied the following characteristics of ski trails, there are followed: the length of the distance (km); height difference - HD (m); maximum lift - ML (m); the sum of height difference - TC (m); lap length (m); the number of laps.The complexity of the route (m) was calculated according to the T.I.Ramenskaya method (RamenskyaT.I., 2002).

In addition to the homologous characteristics of ski tracks, time and speed characteristics of competitive activities that we analyzed, this results allowed to study the dynamics of sporting results and tendencies of ski races development, there are follows: indicators of the best time at the distance, indicators of average speed of its overcoming competitive distance.

Results

Analysis of the protocols of the results of international competitions has allowed allocating 4 groups of competitive distances, differing in the main characteristics under study, there are followed: sprinting distances, long race distances, marathon distances, relay race distances.

As a result of the analysis of the protocols of the competition it was found that sprint trails, which include distances from 1.1 to 1.6 km for women and from 1.3 to 1.8 for men, corresponding to the following characteristics, there are followed: the elevation difference on average is 21.5 m for women and 23.00 m for men, the sum of height difference is 37.83 m for women and 44.54 m for men, the maximum lift for women is 17.42 m, for men the same indicator is 19.15 m. Table 1 presents the main characteristics of sprint distances in male and female startups of the world and Olympic level.

Table 1. Basic characteristics of the homologation of ski tracks of sprint distances at the World Championships and the Winter Olympic Games in 1998-2014

Indicator	**Female**		**Male**	
	$\bar{x}$	*S*	$\bar{x}$	*S*
Length of the distance, km	1,30	0,04	1,55	0,03
Height difference (HD), m	21,50	1,77	23,00	1,83
Maximum lift (ML), m	17,42	1,42	19,15	1,49
Sum of height difference (TC), m	37,83	4,87	44,54	4,39
Lap length, m	1262,00	0,74	1424,38	0,69
Number of laps	1	0,00	1	0,00
The complexity of the track, m	29,16	2,13	28,52	2,27

The average lift of the height of a ski athlete on each kilometer of sprint distance is 29.16 m for women and 28.52 m for men, while the international standard of difficulty for all tracks is between 35 and 41.9 m. The low complexity of the route is explained by the small distance and the weakly transposed relief on which the trails are laid.

The analysis of the relief of ski tracks of the long race distances, which includes distances from 5 to 15 km for women and 10 to 20 km for men, has shown that the height difference is 62.12 m for women and 65.37 m for men, sum of height difference is 336.36 m for women and 464.00 m for men, maximum lift is 46.12 m for women, 47.87 m for men. The main characteristics of long race distances in male and female startups are

presented in Table 2.The complexity of the ski tracks for stationary courses for women was 36.16 m for every 10 km, and for men is 37.89 m, which complies with the international standards of ski tracks.

Table2. Basic characteristics of the homologation of ski tracks of the long race distances at the World Championships and the Winter Olympic Games in 1998-2014

Indicator	**Female**		**Male**	
	$\bar{X}$	S	$\bar{X}$	S
Length of the distance, km	12,38	0,76	14,67	1,47
Height difference (HD), m	62,12	2,96	65,37	5,43
Maximum lift (ML), m	46,12	1,40	47,87	2,35
Sum of height difference (TC), m	336,36	22,28	464,00	24,74
Lap length, m	4923,29	326,45	5735,77	511,12
Number of laps	2,24	0,19	2,60	0,43
The complexity of the track, m	36,16	0,88	37,89	0,87

The marathon distance for women in ski race is 30 km and for men 30 and 50 km. The height difference on this track was on average 69.38 m for women, 63.78 m for men, the sum of the height difference - 942.38 m for women and 922.63 for men, maximum lifting is 50.13 m for women and 46.48 m for men. The main characteristics of marathon race distances for male and female starts are presented in Table 3.

Table 3.Basic characteristics of the homologation of the ski tracks of marathon race distances at the World Championships and the Winter Olympic Games in 1998-2014.

Indicator	**Female**		**Male**	
	$\bar{X}$	S	$\bar{X}$	S
Length of the distance, km	30,00	0,001	38,15	1,96
Height difference (HD), m	69,38	9,80	63,78	3,72
Maximum lift (ML), m	50,13	2,54	46,48	1,42
Sum of height difference (TC), m	942,38	16,16	922,63	79,37
Lap length, m	6863,63	0,44	5477,85	0,24
Number of laps	3,75	3,25	3,74	1,00
The complexity of the track, m	31,41	7,50	33,49	6,59

The complexity of the ski tracks of marathon races for women is 31.41 m for every 10 km, and for men is 33.49 m, that's according to the international standards.

Analysis of the track relief, which conducted relay races at the World Championships and the Olympic Games, shows that for women the track included a distance of 4x5 km, for men is 3x10 km. The main characteristics of the relay distances in male and female starts are presented in Table 4.

Table 4.Basic characteristics of the homologation of the ski tracks of relay race distances at the World Championships and the Winter Olympic Games in 1998-2014.

Indicator	**Female**		**Male**	
	$\bar{X}$	S	$\bar{X}$	S
Length of the distance, km	5,00	0,00	10,00	0,00
Height difference (HD), m	57,80	4,94	59,29	4,15
Maximum lift (ML), m	43,00	2,68	44,63	1,73
Sum of height difference (TC), m	202,10	36,00	376,83	56,18
Lap length, m	3744,00	436,00	4024,13	256,18
Number of laps	1,5	0,18	3,83	0,92
The complexity of the track, m	40,42	7,33	37,68	8,34

Evaluating the complexity of the tracks designed for the selected groups of distances, one can conclude that it reaches the large values at the long race distances and relay races, the smaller ones are marathon and sprint (Fig. 1).

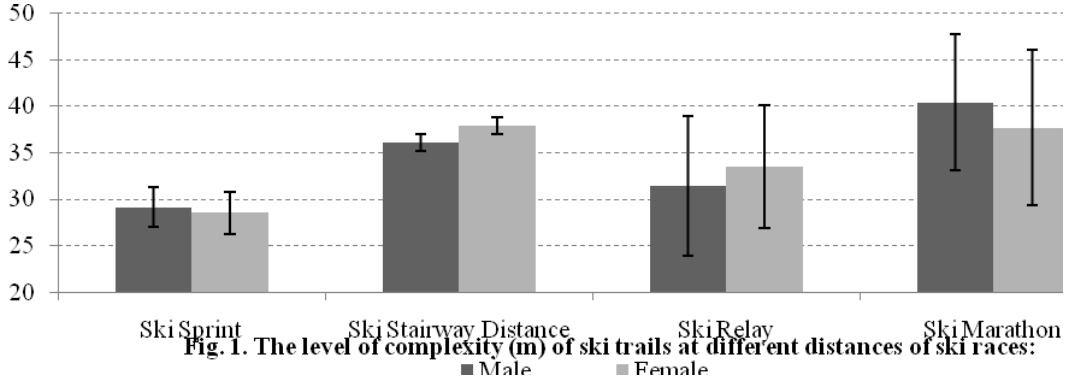

Fig. 1. The level of complexity (m) of ski trails at different distances of ski races:

Analysis of time and speed characteristics of competitor activity of ski athletes allowed to study the dynamics of sporting results and tendencies in the development of the ski tracks, as today athletes and coaches need to bringing the dynamics of the speed of locomotion of an athlete on a distance, both personal and comparable with the main competitors.

Indicators of the best time on the distance and the average speed of overcoming it are presented in table5.

Table 5.Time and speed of overcoming competitive distances of different lengths at the World Championships and the Winter OlympicGames in 1998-2014.

Distances	Best time, hours:min:sec			Medium speed, m·sec^{-1}		
	C	F	C\F	C	F	C\F
Females						
Sprint (1,3 km)	0:02:17,7			9,4		
5 km	0:13:06,1			6,4		
10 km	0:23:58,4	0:24:58,4		6,9	6,7	
15 km		0:39:54,4	0:39:58,1		6,3	6,2
30 km	1:27:06,0	1:14:30,0		5,7	6,7	
Relay race 4x5km			0:49:31,0			6,8
Males						
Sprint (1,5 km)	0:02:33,5			9,8		
10 km	0:26:20,0			6,3		
15 km	0:35:47,5	0:33:36,3		6,9	7,4	
30 km	1:12:29,0		1:11:31	6,9		7,0
50 km	2:05:35,0	1:54:25		6,6	7,3	
Relay race 4x10km			1:30:49			7,3

Notes: C - classic style; F -free style; C \ F - the racein the classic and free style (pursuit).

During the analysis of the protocols of the World Championships and the Winter Olympic Games, it was confirmed that the highest speed of skier-racers was observed at short distances.

As an example, we will analyze the change in speed and time of passing 30-kilometer distance by the males-athletes at the XVIII-XX Winter Olympic Games. The participants showed the least time at the XIX Winter Olympic Games, held in Salt Lake City in 2002, time was 1:11:31. The average speed of passing the distance on these games was higher (6,93±0,02 m·sec^{-1}), than at the XVIII games in Nagano, winter 1998. (5,15±0,02 m·sec^{-1}). At the 20th Winter Olympic Games in Turin (2006), the average speed of overcoming 30km by male participants was lower than at the 19th Winter Olympics and it was 6,5±0,03 m·sec^{-1}.

Similarly,wehave analyzed the results of females competitive activities on the distance of 30 km. In Nagano, in 1998, women overcame a 30km distance faster than 1:22:02 (Δ59,9 c), than in Salt Lake City in 2002, time was 1:30:57 (Δ 66,0 c). The reasons for the increasing of time in our opinion could serve as a more complex relief of ski tracks and adverse the weather conditions.

It seemed interesting to us to analyze the success of the passing tracks of various lengths at the Olympic Games and World Championships by elite and Ukrainian ski athletes. For this aimwe have performed the correlation analysis of the statistical results of ski athletes performance at international competitions, which allowed to investigate the relationship between the indicators of homologation of ski tracks, as well as to determine their impact on the sporting outcome of athletes. The performed research of the correlation between allocated qualitative indicators of homology and sporting results in the ski races has allowed distinguishing the characteristics that are decisive for achieving the result in ski races.

Correlation analysis allowed to study the degree of interconnection between the following indicators: height difference (HD); maximum lift (ML); sum of height difference (TC); lap length; number of laps per distance; complexity of the ski track; time winner of the race; the time of the first six participants (according to the density of the results); the best time of passing the competition by the Ukrainian athletes; the best place for the Ukrainian athletes; lack of the first six participants from the race leader (as the race density); lack of the Ukrainian athlete from the winner; place of the Ukrainian athlete in the final protocol of the competition.

As a result of the correlation analysis of the homologous characteristics of the tracks with the speed and density of the race it was discovered that the World's leading skiathletes on the outcome of the race are most affected by the sum of height differences (r = 0,37), number of laps per distance (r = 0,26) and the maximum lifting length (r = 0,25). The density of the results in the race is influenced by the length of the lap of the sporting distance (r = 0,48).

As shown by the results of correlation analysis, at the time of competing distance, athletes from the Ukrainian team are affected by the sum of the difference in height (r = 0,45) and the number of laps in the distance (r = 0,23).Interestingly, the more the number of heights and the number of laps per distance, the closer to the leader was the place of theUkrainianathletes in the final minutes. There was also a negative correlation between the place of the Ukrainianathletes in the final protocol and the height difference (r = -0,29), maximum lift (r = -0,33), and lap's length (r = -0,24).The obtained results testify that the Ukrainian athletes in the course of preparation for the competition use predominantly crossed relief of the track and longer distance, which does not always correspond to the track conditions of future competitions.

Discussion

Analysis of the homologous characteristics of modern ski tracks, their impact on the performance of competitive activities of theski athletes, suggests that successful performances in the ski races to a large extent depend on the using of training information about the homologous characteristics of tracks, holding the competitions and information on the reaction of the athletes body with to overcome different parts of the distance, especially that's climbing of different lengths and slopes. All of this allows individualized tactical and functional training of the ski athletes.The decision of these tasks requires a more detailed analysis of the functional preparedness of athletes specializing in ski races and the peculiarities of their implementation in various competitive activities.Consequently, based on the obtained data, we can assume that the advantage of sprint races should be ski athletes with a more pronounced high-speed endurance, increased anaerobic capabilities, which is not typical for "traditional" ski long distance races.

During the analysis of the protocols of the World Championships and the Winter Olympic Games, it was noted that the athlete of the international competitions are often universal, that is, they participate in various disciplines of competitions (sprinters, long races, marathons) and can take a prize place, either in the sprint, or in the marathon. This suggests the absence of high specialization of the athletes in ski races since until recently there were no competitions for skiathletes onshort distances. But in the future, we should expect an increase in entertainment at the sprint distances and differentiation by the division of ski athletes by specialization.

Also, these traditional ski races require from the athlete an expression of aerobic endurance with a fairly high percentage of the implementation of anaerobic power, especially during the overcoming the climb. Thus, the analysis of the above-mentioned homologous characteristics of ski tracks revealed the fundamental differences in the peculiarities of laying these tracks only at sprint distances that are less crossed.

Indicators of the elevation difference at long distance races and marathon distances do not have significant differences, as well as indicators of maximum lifting. During the male races, the maximum lift in the marathon was less than at the long distances.Accordingly, competitions on the distances and during the relays are carried out on heavier and crossed paths, which is explained by the length of distances and the spectacle of the sport struggle. Thus, it is the overcoming of these distances by skiathletes to a large extent limited by the possibilities of implementation of anaerobic and aerobic energy supply mechanisms with a large contribution of anaerobic sources.

Conclusions

In modern conditions of training of world-class ski athletes it is necessary to bringing the dynamics of speed of locomotion of an athlete over a distance: both personal and comparative with the main competitors, which is the result of analysis of time and speed characteristics of competitor activity of ski athletes with regard to specific homologous characteristics of ski tracks. On the basis of the performedanalysis, there is an opportunity to study the dynamics of sports results, trends in the development of ski races and to establish requirements for technical, tactical and physical training of the ski athletes.

All homologous characteristics have a certain impact on the results of the competition.The analysis of the correlation boundaries of the homologous characteristics of the tracks with the speed and density indicators of the results of the competitions showed that the leading skiathletes of the world on the speed of the race is most affected by the sum of differences in heights (r=0,37), the number of laps per distance (r=0,26) and the

maximum lifting length (r=0,25), while the density of the results in the race is influenced by the length of the laps of the sporting distance (r=0,48).

Analysis of the presented results shows that the average speed in the ski races is close to 6-7 $m \cdot sec^{-1}$depending on the conditions of the race. During the ski running with increasing distance, there is a progressive decrease in average speed. So, for example, the best skiers in the world overcome the marathon distance (30 km) on average by 19% slower than a distance of 5 km, and a distance of 10 km by 5-7% slower. This is due to the fact that the organizers of the competition, as a rule, use for laying long lines of tracks with a lower difference is hight.

Correlation analysis of the results of the performance of Ukrainian athletes at the World Championships and Winter Olympic Games allowed to determine the high degree of interconnection between the following indicators: height difference (HD); maximum lift (ML); sum of height difference (TC); lap length; number of laps per distance; complexity of the ski track; time winner of the race; the time of the first six participants (according to the density of the results); the best time of passing the competition by the Ukrainian athletes; the best place for the Ukrainian athletes; lack of the first six participants from the race leader (as the race density); lack of the Ukrainian athlete from the winner; place of the Ukrainian athlete in the final protocol of the competition.

Conflicts of interest – If the authors have any conflicts of interest to declare.

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