

**NATIONAL SPORTS ACADEMY  
“VASIL LEVSKI”  
Department of Theory of Sports Training**



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**TECHNICAL-TACTICAL MODELS IN  
ELITE SHORT TRACK COMPETITORS**

**ABSTRACT BOOK**

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**София, 2025**

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of a dissertation for the award of the educational and scientific degree “Ph.D.”, in field of higher education 7. “Healthcare and Sports”, professional field 7.6. “Sports”, doctoral program “Theory and Methodology of Sports Science”

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The dissertation was discussed and directed for public defense before a scientific jury at an extended meeting of the Department of Theory of Sport at NSA “Vasil Levski”.

The dissertation contains 193 standard typewritten pages. It is illustrated with 35 tables and 18 figures. A total of 186 information sources were used, of which 57 in Cyrillic, 125 in Latin and 4 Internet sites.

***Note:** The numbering of the tables and figures in the abstract corresponds to their numbering in the dissertation.*

The public defense of the dissertation will take place on January 21, 2025, at 2:00 PM in Hall A3 of NSA “Vasil Levski”, Studentski grad, Sofia.

The materials for the defense of the dissertation are available in the library of NSA “Vasil Levski”.

## **INTRODUCTION**

Short track speed skating is a dynamic winter Olympic sport performed on a standard hockey rink, allowing close proximity to spectators. It is characterized by constant tactical changes and unpredictable situations, such as collisions and falls, which often determine the outcome of the competition. This requires athletes to develop the ability to adapt their strategies and implement effective technical-tactical solutions.

In light of these characteristics, this study examines the technical-tactical models employed by elite athletes and the key factors driving optimal performance. Consequently, predictive models have been developed to enhance the training process and improve tactical preparation. The central question of the study – what actions competitors should take to optimize their performance – emphasizes the role of tactics as an active tool that teaches us how to plan, adapt and win in sport.

## **I. THEORETICAL STATEMENT AND JUSTIFICATION OF THE PROBLEM**

The specific features of short track speed skating, as emphasized by various authors (Anisimov et al., 2016a; Razinov & Zhalyaletdinova, 2013; Holodova & Kozlova, 2016), are mainly defined by the structure of the competitions and the rules for determining the winner.

In short track competitions, the “head-to-head” structure (direct eliminations) requires athletes to progress through multiple rounds to reach the final, where the winner is determined by their finishing position rather than the time achieved (Konings & Hettinga, 2018a, 2018b). This format, where the primary objective is to finish first, necessitates a profound understanding of tactics and the ability to manage strategic actions effectively.

It is well known that, under otherwise equal conditions, the performance of athletes depends on their ability to make the right decisions and adapt their actions to specific competitive situations. This is especially important in short track which requires a constant assessment of the possibilities – when to lead and when to follow.

The analysis of sources reveals that success in short track speed skating is influenced less by achieving and maintaining maximum speed and more by tactical positioning and speed management. Strategies such as speed control and “drafting” are pivotal, as successful completion of distances depends on tactical decisions that are aligned with the athlete’s specific training preparation.

In this context, modeling tactical actions can provide effective tools for developing predictive models tailored to the sport’s specifics and the athletes’ training needs. Well-defined models would support speed management, optimal positioning, and adaptation to competitive conditions. However, short track lacks sufficient predictive models that effectively guide the training process and enhance athletes’ tactical skills. This identified the focus of the present study.

Based on the analysis and synthesis of the literature on short track speed skating and current sports practices, we formulated the following **WORKING HYPOTHESIS**:

**This study hypothesizes that the systematization and analysis of technical-tactical models for completing the 1000m competitive distance by elite**

**female short track skaters will enable the development of predictive models to optimize the training process and enhance competitive performance.**

## **II. PURPOSE, OBJECTIVES, METHODOLOGY, AND ORGANIZATION OF THE RESEARCH**

### **II.1. Purpose of Research**

The purpose of this dissertation is to optimize the competitive performance of elite female short track skaters by developing predictive models for strategies in completing the 1000 m distance.

### **II.2. Research Objectives**

To achieve the stated purpose, the following tasks must be accomplished:

1. To analyze and synthesize available scientific literature on the specific aspects of short track speed skating and technical-tactical preparation to identify current trends.
2. Systematize and analyze the time analysis data of the best final times (per competition) achieved by female

skaters participating in the 1000 m distance at the European Championships (EC) and World Championships (WC) during the 2010/2011 to 2019/2020 seasons.

3. Systematize and analyze data on tactical positioning for each lap of the first-place finishers compared to the other participants in the semifinals and finals heats of the EC and WC in the 1000<sup>1</sup> m distance during the 2010/2011 to 2019/2020 seasons.

4. Systematize and analyze the lap-by-lap time indicators that reflect changes in pacing during the 1000 m distance for athletes competing in the SF and finals races of the EC and WC during the 2010/2011 to 2019/2020 seasons.

5. Conduct a comparative analysis of the results obtained from the analyzed competitions to determine trends in pacing, tactical positioning, and final times in the 1000 m distance in women's events.

6. Develop predictive final times and models for completing the 1000 m distance in women's events, based

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<sup>1</sup> The 1000 m distance includes 9 laps. One lap on the track measures 111.12 m.



on key factors influencing athletes' successful performance.

### **II.3. Object of Research**

The object of the study is the final time and changes in the technical-tactical models applied by elite female short track skaters in the 1000 m distance, expressed through:

- ✓ Lap time indicators that reflect changes in pace.
- ✓ Tactical behavior, represented by positioning strategies during the race.

### **II.4. Subject of Research**

The subject of the study is the competitive performance of elite female short track skaters in the 1000 m distance during the EC and WC for the period from the 2010/2011 season to the 2019/2020 season.

### **II.5. Research Methodology**

The research methods include:

**1. Theoretical Information Review** – a variety of sources in Cyrillic and Latin from accessible scientific and methodological literature with a specialized focus were

analyzed and summarized, including textbooks, teaching aids, research papers, as well as data from the Internet.

**2. Mathematical-Statistical and Analytical Methods for Data Processing and Analysis** – the final time for the distance, the lap times and the tactical positioning of the skaters, for each of the nine laps were analyzed using the following:

- ✓ *Variation analysis* – to characterize the average level and variability of the studied parameters.

- ✓ *Frequency analysis* – to assess the distribution of examined variables.

- ✓ *Correlation analysis* – to determine the existence of dependencies between the studied parameters, as well as to measure their strength and direction.

- ✓ *Variance analysis* (One-Way ANOVA) – to compare more than two independent samples.

- ✓ *Algorithm development* – to create predictive tactical models for competitive performance.

**3. Modeling Method** – Statistical Modeling:

- ✓ *methods for developing standards* – percentile method used to create predictive final times for the 1000 m distance.

**4. Theoretical Content Analysis** – used to summarize the obtained results and formulate conclusions and recommendations.

**5. Instrumental Methods** – the lap times were measured using the MYLAPS ProChip electronic timing system, which is based on optical detectors that are automatically triggered by the starting pistol and record the times automatically until each skater finishes.

The parameters analyzed and statistically processed are presented in Table 2.

**Table 2.** Parameters for analysis and statistical processing

PARAMETERS	INDEX	UNITS
Lap	Sequence	N
Positioning	Skater's place in the group (intermediate and final)	N
Lap time	t	sec.
Final time for the distance	t	sec.

## **II.6. Organization of Research**

The main contingent of the research is presented in Table 3, while detailed information about the competitions and the number of heats included in the study can be found in Appendix 2.

**Table 3.** Main research contingent

<b>Research Contingent</b>	<b>EC</b>	<b>WC</b>	<b>Total</b>
Competitions	10	9	19
Times for 1000 m	332	357	689
<b>Examined Heats</b>	<b>EC</b>	<b>WC</b>	<b>Total</b>
Semifinals (SF)	20	18	38
Finals B (FB)	6	4	10
Finals A (FA)	10	9	19
Total Heats	36	31	67

Written consent for the use of the data was obtained from the International Skating Union (ISU) (Appendix 4).

The organization of the research progressed through **three stages:**

**1. First Stage** – determining the topic of the dissertation; formulating the working hypothesis, purpose, and objectives of the study; selecting the object and subject of the research; and reviewing scientific and methodological sources with a specialized focus on the studied problem.

**2. Second Stage** – consultation with a technical expert from MYLAPS Sports Timing regarding the timing system used and approved by the ISU for short track competitions; obtaining written consent from the ISU for the use and analysis of the results; systematizing data on final times, lap times, and the tactical positioning of

skaters participating in the semifinals and finals of the EC and WC in the 1000 m distance during the 2010/2011 to 2019/2020 seasons; processing the data; creating an algorithm based on the identified factors influencing successful performance during the 1000 m distance for women; and developing predictive models for strategies to complete the competitive 1000 m distance for women.

**3. Third Stage** – detailed description and analysis of the data; preparation of tables and figures illustrating the results; formulation of key conclusions and recommendations for optimizing training programs aimed at improving the technical-tactical preparation of skaters; and final technical editing and presentation of the dissertation for the initiation of defense procedures.

### **III. RESULTS AND ANALYSIS**

#### **III.1. Results and Analysis of Final Times Achieved in the EC and WC in the 1000 m Distance for Women**

The final times of skaters from the EC and WC were examined and categorized into three groups: 1-8, 9-16, and 17-32. The results indicate stability and consistency within

the first eight times, highlighting the high level of competition at the elite level. The 9-16 and 17-32 groups show greater variability and a tendency toward slower times, reflecting differences in the skaters' performance levels.

### **III.2. Results and Analysis of the Tactical Positioning of Female Skaters in the 1000 m Distance at the EC and WC**

The tactical behavior of the skaters was analyzed, including their starting position, intermediate positioning by laps, and final ranking. The results indicate that successful performance depends primarily on tactical positioning during the final laps. While taking an early lead may provide an advantage, it is not decisive for the final outcome.

### **III.3. Results and Analysis of the Pacing Dynamics of Female Skaters in the 1000 m Distance at the EC and WC**

The analysis of pacing dynamics revealed a trend toward decreasing lap times as the race progresses. Skaters

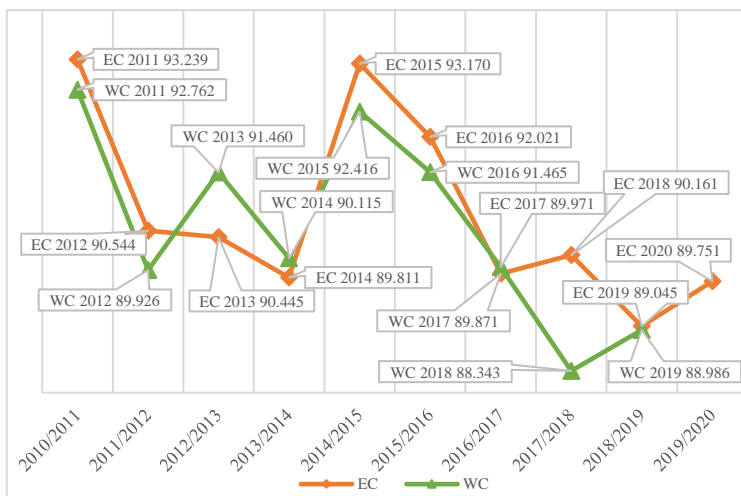
significantly increase their speed after the first lap, which is the slowest due to the standing start. As the distance advances, lap times continue to decrease, with the highest speeds observed during the final laps. This trend is evident in both the EC and WC, with minimal differences across the various competition rounds.

#### **III.4. Comparative Analysis of the Results from the Studied Competitions**

##### **III.4.1. Comparative Analysis of Final Times in the 1000 m Distance for Female Skaters Achieved in the Studied Competitions**

The comparative analysis covers the final times in the 1000 m distance for women, considering the competition rank, qualification round, and the final placement in the distance of the skater with the best time in the respective competition.

The chart of the best times shows that the fastest time was 88.343 seconds (WC 2018), and the slowest – 93.239 seconds (EC 2011) (Figure 11).



**Figure 11.** Chart of the best times achieved during the EC and WC from the 2010/2011 to 2019/2020 seasons

The average time for the studied period is 90.711 seconds, with small variation and high homogeneity, highlighting the stability of the results (Table 24).

**Table 24.** Variation analysis of final times achieved in the EC and WC in the 1000 m distance for women

n	R (sec.)	X <sub>min</sub> (sec.)	X <sub>max</sub> (sec.)	$\bar{X}$ (sec.)	SE $\bar{X}$ (sec.)	S (sec.)	V (%)	As	Ex
19	4,90	88,340	93,240	90,711	0,334	1,455	1,60	0,428	-0,837

Of all competitions studied, the majority of times (36.84%) were recorded in the quarterfinals and SF,



followed by the FA (21.05%), with the smallest share (5.26%) in the heats. The results also show that 57.90% of skaters, with the best times, finished first in the 1000 m distance, while 15.80% finished fourth (Table 27).

In competitions where the skaters finishing first did not achieve the fastest time for the respective competition (a total of 8 cases), their final placement was generally within the top 12, with only two skaters falling outside the top four.

Based on the analysis, the following conclusion can be drawn: *achieving high sports results is closely related to both the final time and the placement of elite skaters in the 1000 m distance in the EC and WC. These parameters serve as indicators of their capabilities and are important factors for developing predictive models for completing the distance.*

**Table 27.** Qualification round and final placement of skaters achieving the best times in the EC and WC (in %)

Qualification Round	Competition	EC			WC			Total		
		Count	% for EC	% for round	Count	% for WC	% for round	Count	% for time	% Total
	Heats	1	10	100	0	0	0	1	5,26	100
	Quarter-finals	3	30	42,90	4	44,50	57,10	7	36,84	100
	SF	3	30	42,85	4	44,50	57,15	7	36,84	100
	FA	3	30	75	1	11	25	4	21,05	100
	Total	10	100	55	9	100	45	19	100	100
Final placement of skaters achieving the best times	Competition	EC			WC			Total		
		Count	% for EC	% for Placement	Count	% for WC	% for Placement	Count	% for time	% Total
	1	5	50	45,50	6	66,70	54,50	11	57,90	100
	2	1	10	100	0	0	0	1	5,26	100
	3	0	0	0	2	22,20	100	2	10,50	100
	4	2	20	66,70	1	11,10	33,30	3	15,80	100
	5	1	10	100	0	0	0	1	5,26	100
	11	1	10	100	0	0	0	1	5,26	100
	Total	10	100	52,60	9	100	47,40	19	100	100

### III.4.2. Comparative Analysis of the Tactical Positioning of Female Skaters in the 1000 m Distance in the Studied Competitions

The analysis of tactical positioning examines the strategies employed by skaters during the distance, focusing on their starting position, intermediate lap-by-lap positioning, and final placement, with an emphasis on the competition rank and qualification round.

The results from the EC indicate that the starting position has a significant impact in the early laps, but this influence diminishes as the distance progresses. The strongest correlation between intermediate positions is observed between the 6th and 7th laps. The intermediate positions in the 7th and 8th laps have the greatest influence on the final placement (Table 29).

**Table 29.** Kendall's tau-b Correlation Coefficient Between Starting Position, Intermediate Lap-by-Lap Positioning (Lap 1-Lap 8), and Final Placement (Lap 9) of Skaters in the SF, FB, and FA Rounds of the EC

Kendall's tau b ( $\tau_b$ ) EC Total = N 139	Starting Position	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	6 Lap	Lap 7	Lap 8	Lap 9
Starting Position	1,000									
Lap 1	,271**	1,000								
Lap 2	,260**	,767**	1,000							
Lap 3	,299**	,631**	,744**	1,000						
Lap 4	,304**	,547**	,635**	,767**	1,000					
Lap 5	,270**	,493**	,601**	,707**	,870**	1,000				
Lap 6	,246**	,470**	,598**	,672**	,721**	,842**	1,000			
Lap 7	,274**	,413**	,545**	,603**	,691**	,778**	,901**	1,000		
Lap 8	,237**	,265**	,379**	,421**	,472**	,507**	,598**	,696**	1,000	
Lap 9	,216**	,215**	,297**	,326**	,410**	,424**	,439**	,527**	,791**	1,000

\*\* Correlation is significant at the 0.01 level (p).

\* Correlation is significant at the 0.05 level (p).

Similar results were observed in the WC, showing that the starting position has a significant yet decreasing impact as the race progresses. The final laps are the most

crucial, with the highest correlation with final placement recorded in the 8th lap (Table 30).

**Table 30.** Kendall's tau-b Correlation Coefficient Between Starting Position, Intermediate Lap-by-Lap Positioning (Lap 1-Lap 8), and Final Placement (Lap 9) of Skaters in the SF, FB, and FA Rounds of the WC

Kendall's tau b ( $\tau_b$ ) WC Total = N 122	Starting Position	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7	Lap 8	Lap 9
Starting Position	1,000									
Lap 1	,347**	1,000								
Lap 2	,345**	,700**	1,000							
Lap 3	,296**	,666**	,821**	1,000						
Lap 4	,280**	,571**	,675**	,751**	1,000					
Lap 5	,326**	,497**	,605**	,610**	,833**	1,000				
Lap 6	,317**	,478**	,582**	,544**	,766**	,906**	1,000			
Lap 7	,308**	,424**	,507**	,418**	,590**	,714**	,800**	1,000		
Lap 8	,303**	,336**	,345**	,278**	,446**	,549**	,606**	,780**	1,000	
Lap 9	,259**	,258**	,275**	,197**	,369**	,483**	,524**	,674**	,852**	1,000

\*\* Correlation is significant at the 0.01 level (p).

\* Correlation is significant at the 0.05 level (p).

The results of tactical positioning by rounds indicate that in all three rounds (SF, FB, and FA), the leading position is most often occupied by the winners, particularly in the final laps, with percentages increasing significantly toward the finish. In the 8th lap, the percentage is 88.4% for SF, 72.7% for FB, and 90.5% for FA. The second position is more commonly held in the early laps but decreases toward the end of the distance. It

is rare for a skater in the 3rd or 4th position in the final laps to finish in first place (Table 31).

**Table 31.** Tactical Positioning of Skaters Who Finished First Compared to Other Participants in the SF, FB, and FA Rounds of the EC and WC

<b>SF</b>		<b>Starting Position</b>	<b>Lap 1 (%)</b>	<b>Lap 2 (%)</b>	<b>Lap 3 (%)</b>	<b>Lap 4 (%)</b>	<b>Lap 5 (%)</b>	<b>Lap 6 (%)</b>	<b>Lap 7 (%)</b>	<b>Lap 8 (%)</b>	<b>Lap 9 Final</b>	<b>Total (%)</b>
Position	1	41,9	46,5	48,8	51,2	67,4	76,7	79,1	83,7	<b>88,4</b>	100	68,4
	2	27,9	30,2	34,9	27,9	9,3	4,7	4,7	7	9,3		15,6
	3	16,3	14	7	11,6	11,6	9,3	9,3	4,7	2,3		8,6
	4	7	7	7	7	9,3	7	4,7	4,7			5,3
	5	7			2,3	2,3	2,3	2,3				1,6
	6		2,3	2,3								0,5
Total		100	100	100	100	100	100	100	100	100	100	100
<b>FB</b>		<b>Starting Position</b>	<b>Lap 1 (%)</b>	<b>Lap 2 (%)</b>	<b>Lap 3 (%)</b>	<b>Lap 4 (%)</b>	<b>Lap 5 (%)</b>	<b>Lap 6 (%)</b>	<b>Lap 7 (%)</b>	<b>Lap 8 (%)</b>	<b>Lap 9 Final</b>	<b>Total (%)</b>
Position	1	36,4	27,3	45,5	45,5	54,5	72,7	63,6	63,6	<b>72,7</b>	100	58,2
	2	18,2	45,5	36,4	27,3	18,2		18,2	27,3	18,2		20,9
	3	27,3		9,1	18,2	18,2	27,3	18,2		9,1		12,7
	4	18,2	18,2		9,1	9,1			9,1			6,4
	5		9,1	9,1								1,8
Total		100	100	100	100	100	100	100	100	100	100	100
<b>FA</b>		<b>Starting Position</b>	<b>Lap 1 (%)</b>	<b>Lap 2 (%)</b>	<b>Lap 3 (%)</b>	<b>Lap 4 (%)</b>	<b>Lap 5 (%)</b>	<b>Lap 6 (%)</b>	<b>Lap 7 (%)</b>	<b>Lap 8 (%)</b>	<b>Lap 9 Final</b>	<b>Total (%)</b>
Position	1	61,9	28,6	42,9	47,6	52,4	66,7	57,1	61,9	<b>90,5</b>	100	61
	2	19	38,1	23,8	19	23,8	9,5	23,8	23,8	9,5		19
	3	19	23,8	23,8	19	14,3	14,3	14,3	9,5			13,8
	4		4,8	9,5	14,3	9,5	9,5	4,8	4,8			5,7
	5		4,8									5
Total		100	100	100	100	100	100	100	100	100	100	100

Similar results were reported in another study, which found that 55% of future winners held the leading position in the 5th lap, with this percentage progressively increasing toward the finish (Noorbergen et al., 2016).

*Based on the analyses and summaries regarding the tactical positioning of female skaters, we recommend that when applying an energy-saving strategy (drafting), skaters should take action to overtake and move into the leading position around the 4th lap.*

#### **III.4.3. Comparative Analysis of Pacing Dynamics in the 1000 m Distance Among Female Skaters Participating in the Studied Competitions**

*Summary of results:* In the FB round, female skaters start with slower times but accelerate after the 4th lap, which may reflect a different tactical strategy. In the SF and FA rounds, lap times are closer, indicating higher competition levels and similar tactical dynamics. Consequently, greater differences are observed in the early laps, while time differences decrease significantly toward the end of the distance (Table 32).

**Table 32.** Comparative Analysis of Lap Times

Lap	N	$\bar{x}$ (sec.)	S (sec.)	SE $\bar{x}$ (sec.)	$x_{\min}$ (sec.)	$x_{\max}$ (sec.)	
Lap 1	SF	38	13,593	0,521	0,085	12,56	14,54
	FB	10	16,531	2,628	0,831	14,73	22,85
	FA	19	13,778	0,832	0,191	12,84	15,32
	Total	67	14,084	1,535	0,188	12,56	22,85
Lap 2	SF	38	10,409	0,461	0,075	9,49	11,58
	FB	10	12,805	2,508	0,793	10,56	18,55
	FA	19	10,657	0,765	0,176	9,77	12,30
	Total	67	10,837	1,356	0,166	9,49	18,55
Lap 3	SF	38	10,137	0,443	0,072	9,51	11,01
	FB	10	11,608	1,629	0,515	10,20	15,07
	FA	19	10,195	0,642	0,147	9,33	11,66
	Total	67	10,373	0,926	0,113	9,33	15,07
Lap 4	SF	38	9,889	0,258	0,042	9,45	10,40
	FB	10	10,596	0,853	0,270	9,78	12,48
	FA	19	9,778	0,364	0,083	9,19	10,51
	Total	67	9,963	0,496	0,061	9,19	12,48
Lap 5	SF	38	9,767	0,276	0,045	9,20	10,36
	FB	10	9,881	0,300	0,095	9,40	10,47
	FA	19	9,722	0,228	0,052	9,41	10,28
	Total	67	9,771	0,268	0,033	9,20	10,47
Lap 6	SF	38	9,663	0,278	0,045	9,27	10,36
	FB	10	9,549	0,152	0,048	9,33	9,76
	FA	19	9,572	0,247	0,057	9,33	10,14
	Total	67	9,620	0,256	0,031	9,27	10,36
Lap 7	SF	38	9,492	0,271	0,044	9,04	10,19
	FB	10	9,366	0,149	0,047	9,11	9,62
	FA	19	9,425	0,270	0,062	8,91	9,90
	Total	67	9,454	0,258	0,031	8,91	10,19
Lap 8	SF	38	9,496	0,287	0,047	9,07	10,45
	FB	10	9,304	0,188	0,060	8,91	9,54
	FA	1	9,369	0,268	0,062	8,90	10,03
	Total	67	9,431	0,277	0,034	8,90	10,45
Lap 9	SF	38	9,681	0,371	0,060	9,25	11,21
	FB	10	9,407	0,140	0,044	9,19	9,63
	FA	19	9,469	0,294	0,067	9,16	10,33
	Total	67	9,580	0,342	0,042	9,16	11,21

**Table 33.** ANOVA Results

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	70,804	2	35,402	26,752	,000
Lap 1 Within Groups	84,695	64	1,323		
Total	155,499	66			
Between Groups	46,293	2	23,146	19,745	,000
Lap 2 Within Groups	75,025	64	1,172		
Total	121,317	66			
Between Groups	17,971	2	8,985	14,901	,000
Lap 3 Within Groups	38,591	64	,603		
Total	56,562	66			
Between Groups	4,866	2	2,433	13,671	,000
Lap 4 Within Groups	11,391	64	,178		
Total	16,257	66			
Between Groups	,168	2	,084	1,180	,314
Lap 5 Within Groups	4,558	64	,071		
Total	4,726	66			
Between Groups	,165	2	,082	1,265	,289
Lap 6 Within Groups	4,172	64	,065		
Total	4,337	66			
Between Groups	,148	2	,074	1,121	,332
Lap 7 Within Groups	4,233	64	,066		
Total	4,382	66			
Between Groups	,393	2	,196	2,698	,075
Lap 8 Within Groups	4,658	64	,073		
Total	5,050	66			
Between Groups	,918	2	,459	4,307	,018
Lap 9 Within Groups	6,818	64	,107		
Total	7,736	66			

The results indicate significant differences between rounds in the first few laps (Lap 1 to Lap 4) and the final lap (Lap 9), likely due to varying tactical approaches to



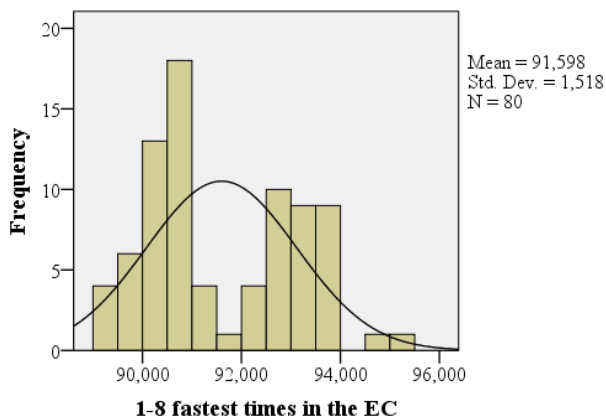
pace at the beginning and end of the distance. In the middle laps (Lap 5 to Lap 7), no significant differences between rounds are observed, suggesting a consistent pace in this part of the distance (Table 33).

### **III.5. Predictive Final Times and Tactical Models for Completing the 1000 m Distance in Women's Events**

To create statistically reliable standards reflecting the actual distribution of time results, we analyzed the final times achieved by female skaters in the 1-8, 9-16, and 17-32 rankings in the EC and WC over a 10-year period. The analysis focused on key statistical measures as well as percentiles, which provide benchmarks for various performance levels of the skaters.

Figure 13 represents a histogram illustrating the distribution of the top eight times, visualizing the frequency of different times. The highest concentration of times is between 90 and 93 seconds, which can be considered typical for elite female skaters. Approximately 20 skaters finish with times between 91-92 seconds,

highlighting the consistency in performance within this class of athletes.

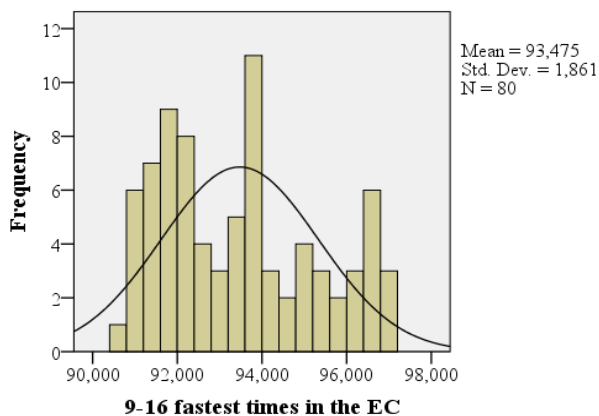


**Figure 13.** Histogram of the fastest 1-8 final times achieved in the EC 1000 m distance in women's events

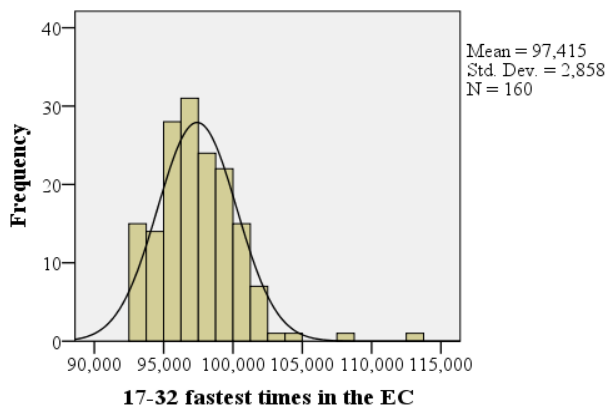
Figure 14 represents a histogram showing that the distribution of final times for the 9th to 16th fastest skaters in the EC has a slight right skew, indicating a higher concentration of times between 92 and 94 seconds. These skaters demonstrate good, but not elite, performance.

Figure 15 represents a histogram showing that the distribution of final times for the 17th to 32nd fastest skaters in the EC has a slightly right-skewed shape and greater dispersion. Most values are concentrated between 95-100 seconds. The data distribution is approximately

normal, but there are several columns indicating values significantly above 105 seconds.

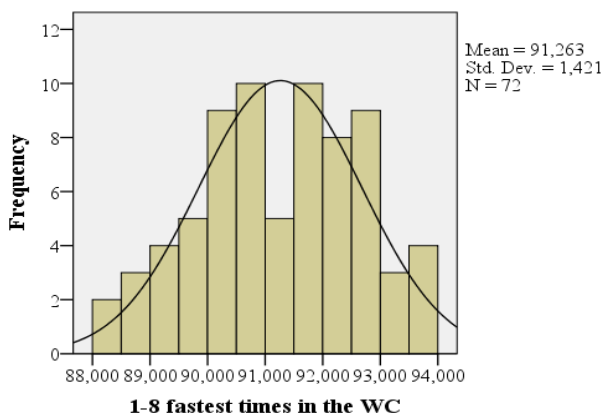


**Figure 14.** Histogram of the fastest 9-16 final times achieved in the EC 1000 m distance in women's events



**Figure 15.** Histogram of the fastest 17-32 final times achieved in the EC 1000 m distance in women's events

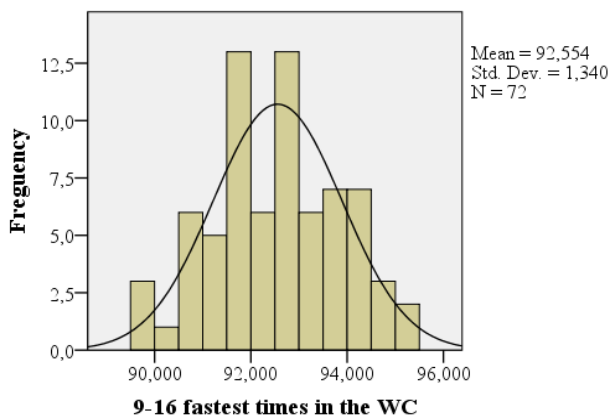
The results of the 1-8 fastest times in the WC show a symmetrical distribution, resembling a normal curve (bell-shaped). Times are dispersed within the range of 88-94 seconds, with the most frequent times between 90-92 seconds. This again highlights the high level of consistency among elite female skaters (Figure 16).



**Figure 16.** Histogram of the fastest 1-8 final times achieved in the WC 1000 m distance in women's events

Figure 17 represents a histogram showing the distribution of times in the 9-16 fastest group in the WC. The distribution is nearly symmetrical and close to normal, with a slightly platykurtic (flattened) shape. The highest

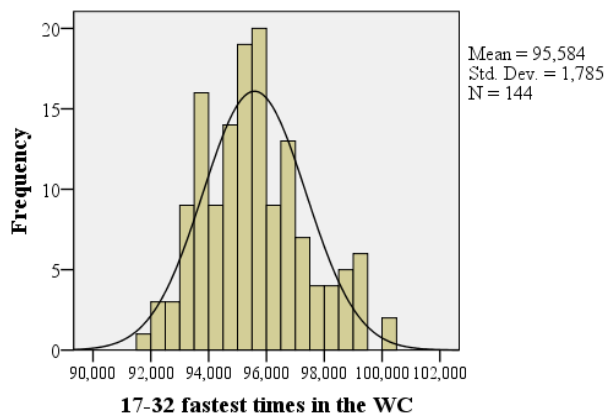
concentration of times is between 91-94 seconds, which is typical for skaters with good, but not leading, results.



**Figure 17.** Histogram of the fastest 9-16 final times achieved in the WC 1000 m distance in women's events

Figure 18 represents a histogram showing the distribution of times in the 17-32 fastest group in the WC. The distribution is relatively symmetrical around the peak, located near the mean (95.584 seconds). The most frequent times are between 94-97 seconds. The data approximate a normal distribution, though with a slight right skew. This group shows considerable variability in times, ranging from 91.876 to 100.467 seconds. This wide range indicates

significant differences in the performance levels of the skaters.



**Figure 18.** Histogram of the fastest 17-32 final times achieved in the WC 1000 m distance in women's events

Based on the analysis, the following standards have been established:

**Standards for 1-8 fastest times:** Skaters in this group are considered elite if their times are around or below 91 seconds.

**Standards for 9-16 fastest times:** Skaters with times between 92 and 94 seconds are those who perform well but are not in the top 8.

**Standards for 17-32 fastest times:** Skaters with times around or above 95 seconds, up to approximately 99-100 seconds, fall within the mid-to-lower performance range.

These values can be used to set target times for the training process or as benchmarks for participation in competitions.

### **Predictive Tactical Models for Completing the 1000 m Distance in Women's Events**

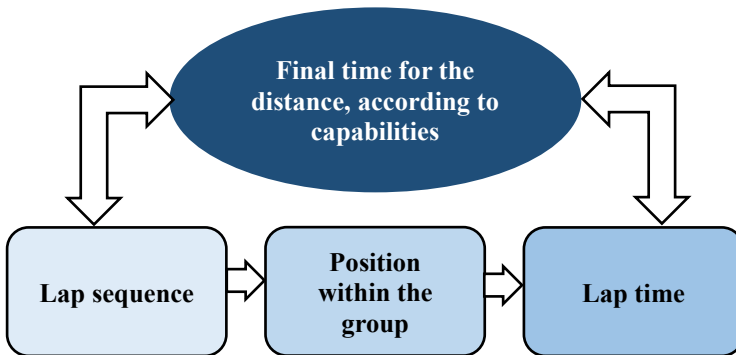
The review of specialized literature and the analysis of technical-tactical performances in the 1000 m distance by elite female short track skaters enabled the development of an algorithm describing key actions for implementing tactical models in this discipline.

From the scientific literature and sports practice, two primary models for completing the distances have been identified:

☑ **Speed control model** – where the skater assumes the leading position in the early laps of the distance and strives to maintain it until the finish line. This is commonly referred to as the Leader tactic.

☑ **Drafting tactic** – where the skater closely follows their opponent, conserving energy for a final acceleration.

Regardless of which of these main strategies the skater chooses to apply, the sequence of actions in the algorithm is as follows:



Predictive Tactical Models for Completing the 1000 m Distance in Women's Events:

### **1. Leader Tactic – speed control:**

✓ The skater assumes the leading position from the early laps (most often from the 1st or 2nd lap) and strives to maintain it until the end of the distance.

✓ The main goal of this tactic is complete speed dominance from the start, controlling the opponent's actions.



✓ *Recommendation for taking the lead:* After the 1st or 2nd lap.

## **2. Drafting Tactic – energy saving:**

✓ The skater follows closely behind the main competitor, maintaining a drafting position to save energy for a final acceleration.

✓ The lead is taken in the last 3-4 laps, when the skater accelerates and overtakes the opponent.

✓ *Recommendation for taking the lead:* Between the 6th and 8th lap.

## **Recommended Lap Times for Different Tactical Models:**

<b>Lap</b>	<b>Slower Model (FB)</b>	<b>Faster Model (SF, FA)</b>
Lap 1	13,50 – 16,00 sec.	12,50 – 13,50 sec.
Lap 2	10,50 – 12,50 sec.	10,20 – 10,70 sec.
Lap 3	10,00 – 11,00 sec.	9,80 – 10,50 sec.
Lap 4	9,70 – 10,50 sec.	9,60 – 10,20 sec.
Lap 5	9,50 – 10,00 sec.	9,40 – 9,80 sec.
Lap 6	9,40 – 9,80 sec.	9,30 – 9,60 sec.
Lap 7	9,30 – 9,60 sec.	9,20 – 9,50 sec.
Lap 8	9,20 – 9,50 sec.	9,10 – 9,40 sec.
Lap 9	9,10 – 9,40 sec.	9,00 – 9,20 sec.

### **Final Time:**

1. Around or below 91 seconds – optimal for fast-paced models (FA, SF).
2. 92-94 seconds – acceptable for a moderate pace.
3. 95-99 seconds – typical for slower-paced models (FB).

### **Algorithm for Completing the Distance:**

1. Consider the tactic – “Leader” or “Drafting”.
2. Start lap – choose the moment to assume the leading position:
  - ✓ If following the “Leader” tactic – take the lead in the first one or two laps,
  - ✓ If following the “Drafting” tactic – wait until the 6th or 7th lap.
3. Speed control – based on the tactical models:
  - ✓ “Leader” tactic: Control the speed, maintaining the established lap time dynamics.
  - ✓ “Drafting” tactic: Conserve energy and apply a strategy for final acceleration.
4. Execute the acceleration – the final acceleration should occur between the 6th and 9th laps.

**Additional guidelines for developing models based on the individual capabilities of skaters:**

**Leader tactic (speed control):**

☑ *Initial laps (laps 1-3):* the skater takes the leading position within the first 1–2 laps. The main goal is speed control, with a gradual increase in skating pace.

☑ *Mid-Distance laps (laps 4-6):* speed remains stable, and between laps 4 and 6, the skater must establish herself as the leader while conserving energy for the final sprint.

☑ *Final laps (laps 7-9):* the last 3 laps (7-9) are characterized by maximum speed and effort. This is the critical phase where maintaining the leading position until the finish line is essential.

☑ *Final time:* the distribution of speed dynamics across the distance should allow elite skaters to complete the 1000 m distance in approximately 91 seconds.

**Drafting tactic (energy conservation and final acceleration):**

☑ *Initial laps (laps 1-3):* during the first 2-3 laps, the skater follows closely behind her main competitor, adapting her speed to match the leader.

☑ *Mid-distance laps (laps 4-6):* in these laps, the skater monitors opportunities for overtaking while conserving energy for the final acceleration.

☑ *Final laps (laps 7-9):* the skater must overtake the leader no later than laps 7-9 through maximum acceleration and a strong attack toward the finish line.

**IV. CONCLUSIONS, RECOMMENDATIONS, AND CONTRIBUTIONS OF THE DISSERTATION**

**CONCLUSIONS**

1. The review and analysis of scientific sources in the field of short track confirm that technical-tactical preparation is a decisive factor for successful performance. Speed dynamics and strategic positioning significantly influence the final competitive outcome.

2. A trend toward improved times over the years has been identified through the analysis of the final times of skaters competing in the 1000 m distance at the EC and WC. Although time has secondary importance for the competitive result, the ability of athletes to complete the distance within a specific time frame is a key element in executing the tactical plan. The results confirm that the times of the winners are usually among the fastest in the respective competition.

3. The tactical positioning of skaters finishing in first place demonstrates that successful athletes often assume leading positions from the middle laps (laps 4-5) and consolidate their lead until the end of the distance. This highlights the importance of proper positioning throughout the race.

4. Trends in speed dynamics reveal that successful skaters gradually accelerate after the 4th lap. The results also indicate that skaters may apply different tactical decisions regarding speed adjustments depending on the qualification round.

5. Similarities and differences in speed dynamics and tactical strategies were identified in the performance of

skaters at the EC and WC. There is a trend toward increased speed in the middle and final laps, suggesting a more aggressive approach and optimal positioning in the concluding stage of the race.

6. Predictive models for final times and tactical approaches to the 1000 m distance were developed based on key success factors: the ability to achieve optimal final times, proper positioning within the group, and effective speed management during the race. The algorithmic approach used in these models allows for precise combination and analysis of tactical and time-based indicators, which are critical for effective performance in short track speed skating.

## **RECOMMENDATIONS**

The main conclusions of the dissertation allow for the formulation of fundamental recommendations for the theory and practice of short track speed skating:

1. It is necessary to develop individualized tactical models for completing the distance, which account for the specific physical and technical capabilities of each skater. Such tailored training programs will enhance both the

technical-tactical preparation and the effectiveness of competitive performance.

2. It is recommended that the training process emphasizes improving efficiency and speed during the middle laps of the distance (laps 4-6), as this is where decisive positioning actions take place.

3. We recommend regularly monitoring and analyzing the tactical approaches of competitors, which will enable skaters to adapt their positioning models according to the behavior of other participants.

4. It is important to focus on speed control during training, including managing pace dynamics in the initial laps and achieving maximum acceleration in the final laps. This will allow skaters to successfully apply their tactical models under real competitive conditions.

5. We recommend using the developed normative times both for monitoring specific endurance, particularly speed endurance over the distance, and as a criterion for participation in high-level competitions.

## **CONTRIBUTIONS OF THE DISSERTATION**

1. The dissertation expands the existing scientific literature in the field of short track speed skating by providing a systematic analysis of tactical preparation and creating a new database. These findings complement contemporary scientific research and offer valuable information for future studies and developments in this dynamic sport discipline.

2. The study offers new insights into speed dynamics and the importance of tactical positioning for achieving optimal results. The findings provide new perspectives for optimizing competitive strategies and include specific recommendations for the training process, which can enhance the competitiveness of skaters at the international level.

3. The development of predictive models for optimal completion of the 1000 m distance in women's events provides valuable information and guidance for coaches and skaters. These models can contribute to improving preparation efficiency and strategic planning, supporting the development of personalized tactical approaches.



## **PUBLICATIONS      RELATED      TO      THE DISSERTATION:**

1.    Ivanova, D., Andonov, H., Ivanov, D., Yordanova, T., (2018). *Foundation and Development of the International Skating Union – ISU* // Sport & Science, XLII, 2018, No. 2, pp. 132–145, ISSN 1310-3393.

2.    Ivanova, D., Andonov, H., (2020). *Trends in the Development of Olympic Short Track Disciplines* // Annual of the National Sports Academy “Vasil Levski”, Vol. 1. (Sofia). - Sofia: NSA Press, 2020, pp. 236–246, ISSN 2682-9908.

3.    Ivanova, D., Andonov, H., (2020). *Dynamics in the Development of Olympic Short Track Disciplines* // Annual of the National Sports Academy “Vasil Levski”, Vol. 2. (Sofia). - Sofia: NSA Press, 2020, pp. 222–231, ISSN 2682-9908.