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THE STRUCTURE OF A BIATHLON SPRINT COMPETITION

STRUKTURA ŠPRINT TEKMOVANJA V BIATLONU

ABSTRACT

A biathlon sprint competition event consists of a number of segments (variables), i.e. cross country skiing time, range time, so-called time difference (also consisting the time of penalty loops), and shooting performance. In the research part, the study analyzed the interrelations of these variables and their correlations with competitive performance at the Biathlon World Championship sprint competition. Regression analysis showed that total cross country skiing time is the most important determinant of competitive performance (74%). Total shooting performance prone and standing explains for 17%, and total range time accounts for 9% of the criterion variable.

Factorial analysis determined five factors which logically complete the competition outcome in a biathlon sprint competition. These factors are: cross country skiing performance, shooting performance in the first lap – prone shooting, shooting time in the second lap, shooting performance in the second lap – standing shooting, shooting time in the first lap.

In this sprint competition, cross country skiing time was found to be the determining effect on the overall competitive performance under the assumption of a relatively high shooting performance (at that particular event the average shooting accuracy was 89%). Given the large group of potentially successful competitors and the thinning time gaps between them, the demands for competitive performance are increasing. In sprint competitions, cross country skiing speed has joined high shooting accuracy in the group of factors determining competitive performance, and elite biathletes often win advantage over other competitors by demonstrating very fast and accurate shooting.

Key words: Biathlon, sprint competition, competition variables, competitive performance

IZVLEČEK

Šprint tekmovanje v biatlonu je sestavljeno iz posameznih segmentov (spremenljivk) in sicer časa smučarskega teka, časa porabljenega na strelišču, t.i. časa razlike (ki vsebuje tudi eventualne čase kazenskih krogov) in iz natančnosti streljanja. V raziskovalnem delu smo analizirali medsebojno povezanost teh posameznih spremenljivk ter njihovo povezanost s tekmovalno uspešnostjo na šprint tekmovanju na svetovnem prvenstvu. Na osnovi regresijske analize smo ugotovili, da največji doprinos k pojasnjevanju tekmovalne uspešnosti izkazuje skupni čas smučarskega teka (74%). Skupno streljanje leže in stoje pojasnjuje 17%, medtem ko skupen čas porabljen na strelišču 9% kriterijske spremenljivke.

S faktorsko analizo smo ugotovili pet faktorjev, ki logično zaokrožajo samo tekmovalno situacijo na šprint tekmovanju v biatlonu. Faktorje so bili poimenovali: faktor smučarsko tekaške uspešnosti, faktor strelske uspešnosti v prvem krogu – streljanje leže, faktor časa streljanja v drugem krogu, faktor strelske uspešnosti v drugem krogu – streljanje stoje in faktor časa streljanja v prvem krogu.

Na tem šprint tekmovanju je bil tako ugotovljen prevladujoč doprinos smučarskega teka k končni tekmovalni uspešnosti ob predpostavki relativno visoke strelske učinkovitosti biatloncev (na tej tekmi so tekmovalci povprečno zadeli 89% vseh strelov). Zaradi širokega kroga uspešnih tekmovalcev in čedalje manjših razlik med njimi se povečujejo tudi zahteve glede tekmovalne uspešnosti. Na šprint tekmovanjih je poleg že tako visoke strelske učinkovitosti čedalje bolj pomembna hitrost smučarskega teka, pogosto pa si najuspešnejši biatlonci celo z visoko hitrostjo natančnega streljanja pridobijo odločilno prednost.

Ključne besede: biatlon, šprint tekmovanje, spremenljivke tekmovanja, tekmovalna uspešnost.

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INTRODUCTION

Biathlon is a winter sport that combines skate-style cross-country skiing and small-caliber rifle shooting. The first Biathlon World Championship (BWCH) was held in 1958. Biathlon debuted at the 1960 Winter Olympics (Lehotan, Magyar, & Lange, 2008; Nitzsche, 1989). Today the Olympic Games schedule contains four singles competitions (individual, sprint, pursuit, and mass start) and two team competitions (a relay race – men, women, and mixed relay - teams consisting of two men and two women skiers). Sprint competitions made their debut at the BWCH in 1974 and the Olympic Games in 1980 (Niinimaa, 1988). The length of the men's sprint competition is 10 km (three laps of approximately 3.33 km). The biathlete shoots twice from a shooting distance of 50 meters, once prone (target with a hit diameter of 4.5 cm), and then standing (target with a hit diameter of 11.5 cm). For each miss, a 150-meter penalty loop must be skied. On average, the skiers complete the penalty loop within 22 to 25 seconds. The biathletes start individually, in a time interval of 30 seconds. According to the competition rules, biathlon race courses are required to consist of continuously changing flat, uphill and downhill sections (IBU, 2019), forcing frequent alternations between the various skating sub-techniques (Holmberg, 2015).

World-class male and female biathletes demonstrate high maximal oxygen uptakes (VO_2max) of >80 and >65 $mL \cdot kg^{-1} \cdot min^{-1}$, respectively (Tønnessen, Haugen, Hem, Leirstein, & Seiler, 2015).

The best biathletes perform 700 to 900 hours of physical training per season, including endurance training (approximately 80% at low, 4-5% at moderate, and 5-6% at high intensity) and about 10% of strength and speed training. Top biathletes fire more than 20.000 shots during over 200 training sessions per season. About 60% of these shots are made during endurance training [9,000 shots (75%) at low, 2,000 shots (15%) at moderate, and 1,250 shots (10%) at high intensity], i.e., shooting between bouts of cross-country skiing, roller skiing or, to lesser extent, running. The rest of more than 20.000 shots are fired at rest in order to improve the accuracy and/or speed of preparation for shooting, firing, and exiting the shooting range (Laaksonen, Jonsson, & Holmberg, 2018).

Competitive performance in the biathlon depends on the cross-country skiing speed, range time, shooting time, and shooting accuracy (shooting time is a part of range time, while shooting performance consists of shooting accuracy and shooting time). The question raised is what is the impact of each of these segments of a sprint race on a biathlete's competitive performance? An answer to this question would help to improve the effectiveness of the training process for biathlon competitors.

Skattebo in Losnegard (2018) state that the range and shooting times of elite biathletes are similar (even in different types of competitions) and, thus, exert only a minor impact on the final performance. In contrast, cross-country skiing speed and shooting accuracy are the most important determinants of the final outcome.

The aim of the study was to determine the latent structure of captured competition variables on a biathlon sprint competition. The study analyzed the correlation among individual variables and the contribution of individual sets of variables to the explanation of competitive performance in this sporting event.

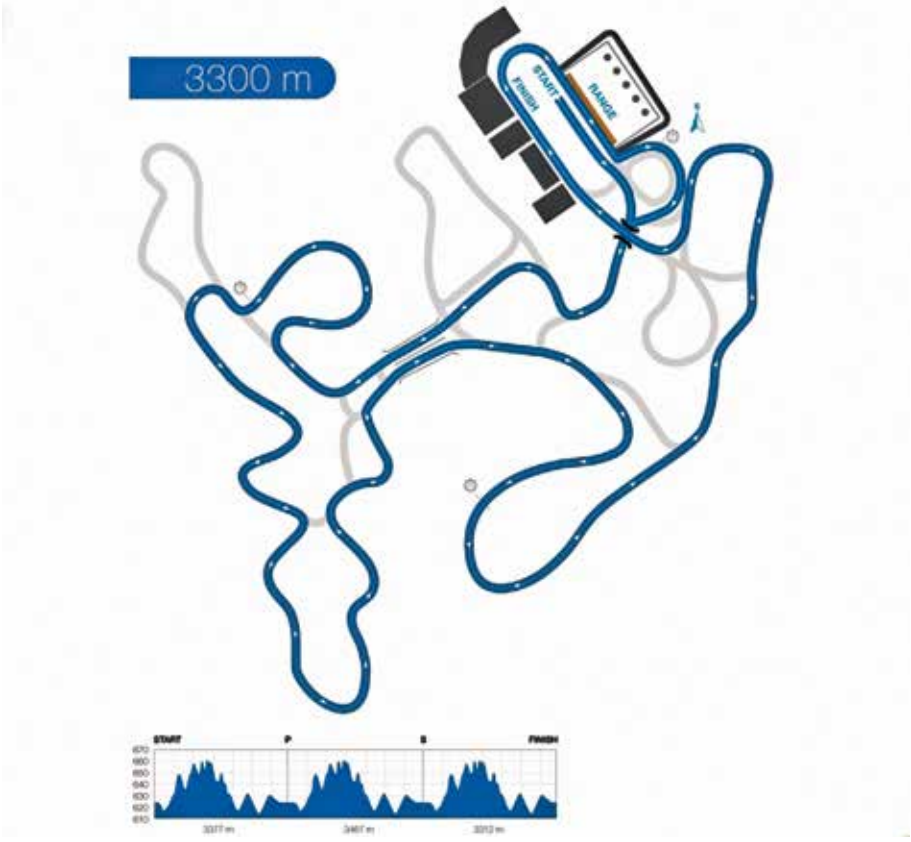
MATERIALS AND METHODS

Participants

The survey included 115 competitors from 39 countries who took part in the sprint competition at the 2013 World Biathlon Championship in Nove Mesto, Czech Republic.

Instruments

The variables were derived from the database of the companies: Siwidata (electronic timing) and Hora 2000 E (electronic target system). These data are the official results of the competition and are publicly available on the website of the International Biathlon Union (IBU, 2013).



Biathlon course	Length	Altitude difference	Max. ascent	Total of ascents
lap	3377 m	47 m	28 m	117 m
lap	3467 m	47 m	28 m	119 m
lap	3312 m	47 m	28 m	115 m
Total	10156 m	47 m	28 m	351 m

Figure 1: Graphical display of the sprint competition course at the 2013 World Biathlon Championship in Nove Mesto, Czech Republic (Biathlon NMNM, 2013).

Dependent variable

TT – total race time (competition result). The criterion variable is determined by the time elapsed between the start and the finish line. Total time consists of cross-country skiing time, range time, and the time difference (which also includes any penalty time).

Independent variables

Cross-country skiing times

TCT – total cross-country skiing time (does not include range time and time difference). It means the time spent by the competitor in the competition from start to finish only in the cross-country skiing. Cross-country skiing time does not include time at the shooting range (time spent to make the last 10m before the shooting range to the shooting lane, time of shooting, and time spent from the shooting lane to the 10m point after the range) and also does not include the time difference (from the 10m point after the shooting range to the mid-lap time measured after the range), which also includes any penalty loop time. Cross-country skiing time was analyzed for each loop separately: L1CT – lap 1 cross-country skiing time (from the start to the 10m point before the shooting range), L2CT – lap 2 cross-country skiing time (from mid-lap time after the shooting range to the 10m point before the shooting range), L3CT – lap 3 cross-country skiing time (from mid-lap time after the range to the finish line).

Range times

TRT – total range time (time spent on the shooting range during both shooting bouts). Range time is measured from the 10 m point before the range to the point which is 10 m after the range. Range time covers the time spent from the 10 m point before the range to the shooting lane, time of shooting, and the time spent from the shooting place to the 10 m point after the range. Range time was analyzed for each lap separately: L1RT – lap 1 range time (from the 10 m point before the range to the 10 m point after the range), L2RT – lap 2 range time (from the 10 m point before the range to 10 m point after the range).

Shooting times

TST – total shooting time (time spent shooting in prone and standing positions). Shooting time is the time a competitor spends shooting only. It is measured from the moment when the competitor lays the poles on the ground to the moment when the competitor picks up the poles after they have fired five shots. Each shooting bout was analyzed separately: ST1 – shooting bout time 1 (prone), ST2 – shooting bout time 2 (standing).

Time difference

TTD – total time difference. Time difference in the competition is measured from the 10 m point after the shooting range to med-lap time after the shooting range (at the end of each lap). In a sprint competition, it also contains any potential penalty loop times. Time difference per loop was also analyzed: L1TD – lap 1 time difference (from the 10 m point after the shooting range to mid-lap time after the shooting range), L2TD – lap 2 time difference (from the 10 m point after the shooting range to mid-lap time after the shooting range).

Lap times

The total time of all three laps means the competitor's total race time (TT) and defines the competitor's ranking. Lap times were analyzed separately: L1TT – lap 1 total time (from the start to mid-lap time after the range), L2TT – lap 2 total time (from mid-lap time after the range to mid-lap time after the range), L3TT = L3CT – lap 3 total time (from mid-lap time after the range to the finish line).

Missed shots

TMS – total number of missed shots prone and standing. Missed shots in specific shooting bouts were analyzed: S1MS – shooting 1 missed shots (prone), S2MS – shooting 2 missed shots (standing).

Procedure

The data were processed using SPSS Statistics software. Basic statistical parameters were computed for all variables. The correlation among independent variables and the correlation between the independent variables and the dependent variable were tested using Pearson's correlation coefficient. A factoral analysis was used in order to determine the latent structure of variables. The inherent relationship between the block of independent variables and an independent variable (competition result) was tested using a multiple regression analysis.

RESULTS

Table 1 shows the basic statistical characteristics of variables in a sprint competition.

Total race time (TT): The winner completed the course in 1413.2 seconds, while the last competitor to cross the finish line completed the course in 1899.1 seconds, or eight minutes behind. Mean race time (1587.1 seconds) is almost three minutes slower than the winner's result. The winner and the runner-up did not clear all targets (each missing one shot), but they managed to make up for the missed shot through faster skiing. The third-place holder had a perfect shooting score (IBU, 2013). In the first 10 places, four biathletes cleared all the targets (among the first 20, six competitors had a perfect shooting score).

Cross-country skiing times (L1CT, L2CT, L3CT, TCT): Cross-country skiing times of the laps are not comparable due to different lengths (the second lap is the longest at 3467 meters and the third lap is the shortest at 3312 meters). In terms of total cross-country skiing time, the last-ranking competitor was 381.2 seconds behind the winner (approximately 127 seconds per lap). On average, total cross-country skiing time accounts for 89.5% of total race time.

Range times (L1RT, L2RT, TRT): The time spent on the shooting range averaged at 107.8 seconds. In standing shooting, the biathletes spent less time on the range than when shooting in a prone position. This indicates that prone shooting on average requires longer preparation. The competitors with the fastest and slowest range times are separated by a relatively high time difference (98.6 seconds), which might result from rifle failure. Similarly, high is the time difference between the fastest competitor on the range and the mean range time (22.2 seconds), which relates to approximately one penalty loop.

Shooting times (ST1, ST2, TST): The fastest shooter finished shooting in a prone position in 22 seconds, while the average prone shooting time is 33.5 seconds. The average standing shooting

Table 1: Statistical characteristics of variables

Variables	MIN	MAX	M	SD	KV (%)
L1CT – cross country skiing time, lap 1	433.9	546.5	469	24.2	5
L1TD – time difference, lap 1	3.8	102.1	25.3	22.4	88
L1RT – range time, lap 1	41.4	88.7	55.3	7.0	13
L1TT – total time, lap 1	485.1	691.5	549.6	41.6	8
S1MS – missed shots, shooting 1 (prone)	0	4	0.9	0.9	105
ST1 – shooting bout time 1 (prone)	22	65	33.5	6.3	19
L2CT – cross country skiing time, lap 2	440.4	580.9	487.0	29.0	6
L2TD – time difference, lap 2	3.6	81.8	32.7	22.6	69
L2RT – range time, lap 2	40.2	126.2	52.5	9.4	18
L2TT – total time, lap 2	498.8	734.9	572.3	45.1	8
S2MS – missed shots, shooting 2 (standing)	0	3	1.2	0.9	77
ST2 – shooting bout time 2	14	105	31.1	9.2	30
L3CT – cross country skiing time, lap 3	412.2	543.1	465.1	29.0	6
L3TT – total time, lap 3	412.2	543.1	465.2	29.0	6
TCT – total cross country skiing time	1286.9	1668.1	1421.2	80.3	6
TTD – total time difference.	7.4	142.6	58.0	33.1	57
TST – total shooting time of two bouts	44	141	64.7	12.7	20
TRT – total range time	85.6	184.2	107.8	13.9	13
TMS – total number of missed shots	0	6	2.2	1.4	64
TT – total race time	1413.2	1899.1	1587.1	104.9	7

Legend: MIN – minimum value, MAX – maximum value, M – mean, SD – standard deviation, KV – variation coefficient

time is 2.4 seconds shorter than the average prone shooting time, while the fastest standing shooting was completed in 14 seconds.

Missed shots (S1MS, S2MS, TMS): The competitors cleared an average of 89% targets. Shooting in a prone position (average shots missed in the first bout – 0.9) was slightly more efficient than shooting in a standing position (average shots missed in the second bout – 1.2). Fourteen competitors cleared all the targets in the first shooting session, and nine in the second. The worst score in a prone shooting was four missed shots and three missed shots in standing shooting. The top shooters, a total of 12 competitors, cleared all targets in both shooting bouts. The worst shooting score on the range was six missed shots (IBU, 2013).

Time differences (L1TD, L2TD, TTD): For each miss, a penalty loop of 150 meters must be skied. The time a competitor needs to complete the penalty loop is added to the time difference. In prone shooting, the shortest time difference was 3.8 seconds and it was achieved by a competitor who had cleared all targets, while the longest time difference was 102.1 seconds. This indicates that the competitor had to ski four penalty loops (one penalty loop is normally completed within 22 to 25 seconds).

Variable correlation analysis

Table 2 states the correlations between the variables of a biathlon sprint competition. All correlations above 0.19 are statistically significant at the 5% risk level ($p<.05$).

Total race time (TT) relative to cross-country skiing times: A high correlation between total race time (TT) and total cross-country skiing time ($r = 0.94$) indicates that cross-country skiing time is one of the most important competition segments determining the final biathlon sprint performance. High-ranking competitors finished the race with better cross-country skiing times. Cross-country skiing times in various laps also show a similarly high correlation with the total race time ($r = 0.91$ – first lap, $r = 0.92$ – second lap, $r = 0.92$ – third lap).

Total race time (TT) relative to the number of missed shots: In addition to the cross-country skiing speed, shooting accuracy is the most important determinant of the final score. In the studied World Cup sprint competition, the correlation between the number of missed shots (TMS) and the final result was relatively low ($r = 0.55$). Even lower was the correlation between missed shots in the first shooting bout (prone) and the total race time ($r = 0.43$), and between missed shots of the second shooting bout (standing) and the total race time ($r = 0.37$).

Total race time (TT) relative to shooting time: Top-performing biathletes are faster shooters, and vice versa. However, the correlation between total race time and the total time of both shooting bouts (TST) is not particularly high ($r = 0.53$), which indicates that the shooting speed does not have a significant impact on the final outcome. Nevertheless, in the tough competition of elite biathletes the speed of shooting might be very important since it can create considerable competitive advantage. In addition, the fastest shooters in the competition needed about 20 seconds less time to complete their shooting bouts than average shooters, which equals one missed shot or penalty loop. Time of shooting in prone position showed higher correlation with the criterion ($r = 0.54$) than the time of shooting in the standing position ($r = 0.37$).

The correlation between total race time (TT) and total range time is ($r = 0.63$). Top-performing biathletes need less time to leave the range zone (10 m before and 10 m after the range).

Cross-country skiing time relative to the number of missed shots: The correlation between the total cross-country skiing time (TCT) and the total number of missed shots (TMS) is $r = 0.25$. A lower correlation ($r = 0.24$) is found between the cross-country skiing in the first lap and the number of missed shots in prone shooting position, while the correlation between the cross-country skiing time in the second lap and the number of missed shots in the standing position is statistically non-significant ($r = 0.11$).

The number of missed shots relative to shooting time: More reliable shooters are also statistically significantly faster shooters. The correlations indicate that the speed of shooting has a relatively minor impact on the shooting efficiency. The correlation between total shooting time (TST) and total number of missed shots (TMS) is ($r = 0.29$). The correlation between shooting time in standing position and the number of missed shots in standing position ($r = 0.32$) is slightly higher than the correlation between the shooting time in the prone position and the number of missed shots (prone) ($r = 0.22$). At competitions, certain competitors will shoot very fast, achieving high target clearage, while other competitors shoot more slowly but with equally high shooting accuracy.

Table 2: Variable correlations

	L1CT	L1TD	L1RT	L1TT	S1MS	ST1	L2CT	L2TD	L2RT	L2TT	S2MS	ST2	L3CT	TCT	TTD	TST	TRT	TMS
L1TD – time difference, lap 1	0.29																	
L1RT – range time, lap 1	0.53	0.31																
L1TT – total time, lap 1	0.83	0.76	0.64															
S1MS – missed shots, shooting 1 (prone)	0.24	0.99	0.27	0.72														
ST1 – shooting bout time 1 (prone)	0.46	0.26	0.98	0.58	0.22													
L2CT – cross country skiing time, lap 2	0.93	0.27	0.54	0.78	0.22	0.47												
L2TD – time difference, lap 2	0.22	0.08	0.19	0.20	0.08	0.14	0.18											
L2RT – range time, lap 2	0.30	0.06	0.41	0.28	0.05	0.38	0.36	0.35										
L2TT – total time, lap 2	0.77	0.23	0.53	0.66	0.19	0.45	0.81	0.69	0.62									
S2MS – missed shots, shooting 2 (standing)	0.14	0.06	0.15	0.14	0.06	0.11	0.11	0.99	0.32	0.63								
ST2 – shooting bout time 2 (standing)	0.21	0.05	0.34	0.20	0.04	0.33	0.24	0.34	0.97	0.53	0.32							
L3CT – cross country skiing time, lap 3	0.90	0.25	0.51	0.75	0.20	0.44	0.95	0.25	0.33	0.81	0.18	0.21						
TCT – total cross country skiing time	0.96	0.28	0.54	0.80	0.23	0.47	0.99	0.22	0.34	0.82	0.15	0.23	0.98					
TTD – total time difference	0.34	0.73	0.33	0.65	0.72	0.27	0.31	0.74	0.28	0.63	0.72	0.26	0.34	0.34				
TST – total shooting time of two bouts	0.38	0.16	0.73	0.43	0.14	0.73	0.41	0.31	0.89	0.60	0.28	0.88	0.37	0.39	0.32			
TRT – total range time	0.48	0.20	0.78	0.52	0.17	0.75	0.52	0.33	0.89	0.69	0.29	0.83	0.48	0.51	0.36	0.97		
TMS – total number of missed shots	0.26	0.72	0.29	0.59	0.72	0.23	0.23	0.74	0.25	0.57	0.73	0.25	0.26	0.25	0.99	0.29	0.32	
TT – total race time	0.91	0.47	0.62	0.89	0.43	0.54	0.92	0.44	0.47	0.91	0.37	0.37	0.92	0.94	0.62	0.53	0.63	0.55

The correlation between prone and standing shooting bouts: Hypothetically, it can be assumed that poorer shooters in prone position are also poor shooters in a standing position, and vice versa. However, this assumption is negated by the established correlation between the number of missed shots in prone (S1MS) and standing (S2MS) positions (r = 0.06). Evidently, the shooting positions and the sizes of targets are so different that no correlation was established at the studied competition.

The latent structure of the sprint competition variables was determined using a factoral analysis. Based on the K-G criterion, five factors were eliminated. The first factor covered 51.6% of total variance (Table 3).

Table 3: Factor analysis of variables with the Oblimin rotation (structure matrix)

Variables	FAC.1	FAC.2	FAC.3	FAC.4	FAC.5	Communalities
Factor of cross country skiing performance						
TCT – total cross country skiing time	**.99**	.24	.30	-.17	-.47	.999
L2CT – cross country skiing time, lap 2	**.98**	.23	.32	-.14	-.47	.975
L3CT – cross country skiing time, lap 3	**.97**	.22	.28	-.21	-.44	.947
L1CT – cross country skiing time, lap 1	**.96**	.26	.27	-.17	-.47	.939
TT – total race time	**.95**	.46	.44	-.41	-.55	.999
L2TT – total time, lap 2	**.84**	.24	.59	-.65	-.46	.991
L1TT – total time, lap 1	**.81**	.73	.27	-.20	-.59	.984
Factor of shooting accuracy in the first lap – prone shooting						
L1TD – time difference, lap 1	.30	**.99**	.07	-.15	-.27	.996
S1MS – missed shots, shooting bout 1	.25	**.99**	.05	-.15	-.23	.994
TTD – total time difference.	.38	**.78**	.28	-.78	-.28	.998
Factor of shooting time in the second lap						
L2RT – range time, lap 2	.35	.06	**.99**	-.30	-.38	.989
ST2 – shooting time 2	.24	.05	**.98**	-.30	-.33	.988
TST – total shooting time of two bouts	.40	.15	**.92**	-.27	-.73	.991
TRT – total range time	.52	.18	**.90**	-.28	-.76	.991
Factor of shooting accuracy in the second lap – standing shooting						
L2TD – time difference, lap 2	.26	.15	.34	**-.99**	-.14	.998
S2MS – missed shots, shooting bout 2	.18	.13	.31	**-.99**	-.11	.998
TMS – total number of missed shots	.30	.77	.25	**-.79**	-.24	.997
Factor of shooting time in the first lap						
L1RT –range time, lap 1	.54	.27	.44	-.15	**-.99**	.991
ST1 – shooting bout time 1	.46	.22	.42	-.11	**-.99**	.992
Lambda	9.79	3.07	2.89	1.98	1.00	
% of Variance	51.56	16.19	15.25	10.43	5.28	

The factor structure matrix was obtained using the Oblimin rotation. Projections of cross-country skiing times and total race time (TT) variables dominated on the first factor. The most

important impact on the final performance at the Biathlon World Cup's sprint competition is attributable to the impact of the cross-country skiing performance. The second factor was dominated by variable projections of missed shots in prone shooting (shooting bout 1), the third factor by variable projections of range time in standing shooting and shooting time in a standing position, the fourth factor was dominated by variable projections of missed shots in standing shooting (shooting bout 2), and the fifth factor was dominated by variable projections of range time in prone shooting and shooting time in a prone position.

Table 4: Component Correlation Matrix

	FAC1	FAC2	FAC3	FAC4	FAC5
FAC1	1.00				
FAC2	.27*	1.00			
FAC3	.32*	.07	1.00		
FAC4	-.22*	-.23*	-.30*	1.00	
FAC5	-.47*	-.24*	-.43*	.11	1.00

* $p < .05$

Table 4 shows the greatest correlation between the first and fifth factors, and the lowest between the second and third factors.

The correlation between the block of predictor variables and the criterion variable was determined on the basis of a regression analysis (Table 5). The variable of the total time difference was not included in the regression analysis since it depends directly on the variable of the total number of missed shots. In sprint competition, time difference also contains the time the competitor spends in penalty loops.

Table 5: Relation between the essential system of competition variables with the dependent variable

Variables		B	BETA	T	Sig T
TCT – total cross country skiing time		1.035	0.792	159.807	0.000
TRT – total range time		1.033	0.137	27.078	0.000
TMS – total number of missed shots		22.596	0.305	67.598	0.000
Mult R	0.999				
R square	0.998				
F	18458.093				
Sig F	0.000				

Legend: B – non-standardized regression coefficient, BETA – standardized coefficients of partial regression, T – value of T–test as an assessment of the statistical significance of regression coefficients, Sig T – statistical significance of standardized regression coefficients (BETA), Mult R – multiple correlation between predictor variables and criterion variable (TT), R square – determination coefficient, F – F value, Sig F – statistical significance of the correlation between the system of predictor variables with the criterion

On the basis of Table 5 results, it is possible to determine the impact of a predictor variable on explaining competitive performance (% of competitive performance, as explained by a variable = r x Beta). Without the predictor variable of time difference, the remaining block of predictor

variables explained 99.8% of competitive performance in a sprint competition (TT variable). In explaining competitive successfulness, the variable of total cross-country skiing time (TCT) has the largest impact (74%); it is followed by shooting efficiency in terms of missed shots in prone and standing position (17%), and then time spent in both shooting ranges (9%).

DISCUSSION AND CONCLUSIONS

The sprint competition held at the Biathlon World Championship was studied with an aim to determine the interrelation of certain independent variables. Furthermore, the study investigated the correlations of specific variables and the block of variables with competitive performance.

With regard to the influence of independent variables on competitive performance, the following findings were made:

Total cross-country skiing time is the key determinant of competitive performance in a sprint competition since it partially demonstrates very high correlation with the criterion ($r = 0.94$). Also cross-country skiing times achieved in individual laps have similarly high correlation with the criterion. Today the average cross-country skiing speed of top 10 biathletes in World Cup sprint competitions is 7.2 m/s for men and 6.3 m/s for women, and is assumed to account for more than 60% of competitive performance in sprint competitions (Luchsinger, Kocbach, Ettema, & Sandbakk, 2018). The regression analysis conducted in our survey showed that total cross-country skiing time can explain 74% of competitive performance of the analyzed race. Biathlon is classified as an endurance sport in which aerobic energy production is a vital determinant of competitive performance, and where endurance performance depends on both aerobic and anaerobic factors, together with exercise economy and/or gross mechanical efficiency (Joyner, & Coyle, 2008; Bassett, & Howley, 2000).

According to Luchsinger, Kocbach, Ettema and Sandbakk (2018), about 35% of total competitive performance in a sprint competition is linked to shooting performance, and this value can rise up to 50% in individual competitions where a missed shot means one minute of added time. In this study, shooting performance accounted to 17% of competitive performance for both types of shooting. Biathlon shooting is a complex task that is affected not only by factors such as physical load before shooting, time pressure, other competitors, and the necessity for fine motor control, but also by psychological and, especially, psychophysiological factors (Laaksonen, Finkenzeller, & Holmberg, 2018). Shooting performance is the result of several factors associated with the shooting technique. In a prone position, elite biathletes differ from other competitors in triggering and rifle sway, and the latter is also an important performance determinant in the standing position (Sattlecker, Buchecker, Gressenbauer, Müller, & Lindinger, 2017). During shooting in a standing position the stability of the rifle had a strong correlation with the clearing of targets (Groslambert, Candau, Hoffman, Bardy, & Rouillon, 1999) and clearly discriminates between high and low performance shooters (Sattlecker, Buchecker, Gressenbauer, Müller, & Lindinger, 2017). The correlation between rifle sway and body sway was discovered (Ihalainen et al., 2018), but is less expressed in top performers (Niinimaa & McAvoy, 1983) and clearly differentiates elite shooters from other biathletes (Groslambert, Candau, Hoffman, Bardy, & Rouillon, 1999). In the Sochi Olympic Games in 2014, the average shooting accuracy for all individual male and female medallists was 97%. Under the more difficult wind conditions encountered in the 2018 Olympic Games in Pyeongchang, the corresponding values were 93% and 95%, respectively (Laaksonen,

Jonsson, & Holmberg, 2018). If the biathletes had missed another shot, none of them would have stood on the podium (IBU, 2019).

Biathletes who were more successful in this sprint competition also left the shooting range faster (r = 0.63). It is very stressful to have to prepare for the shooting, fire five shots, and leave the shooting range in 25 to 30 seconds. Range time and shooting time show very little difference in elite biathletes, and therefore only account for a minor 2 to 4% of competitive performance (Luchsinger, Kocbach, Ettema, & Sandbakk, 2018; Skattebo & Losnegard, 2018). In our study, 9% of competitive performance was explained by total range time. Biathletes who were more successful in this sprint competition were also faster shooters (r = 0.53). Shooting speed is particularly important at the last shooting bout, when it can generate vital time advantage.

As regards the interrelation of independent variables, the following findings were made:

Biathletes who are faster cross-country skiers are also more accurate in shooting but this correlation is relatively low (r = 0.25).

More accurate shooters fire their shots more quickly, but the shooting speed has a relatively low impact on shooting accuracy (r = 0.29). After stopping at the shooting range, biathletes assume their shooting position and fire their first shot within 15 seconds, while the entire series of five shots normally takes about 10 seconds. During this time, the heart rate normally drops from about 90% to 60%, or 70% of $HR_{max,}$ during prone and standing shooting (Hoffman & Street, 1992).

Biathletes who are fast shooters in a prone position are not necessarily very fast when shooting standing, and vice versa (r = 0.33).

Range times (L1RT, L2RT) are correlated (r = 0.41). The competitors who spent less time at the range during prone shooting were also faster at the standing shooting bout.

Logically, faster shooters spend less time in the shooting range zone (r = 0.97), since shooting time is a part of range time. It can be assumed that there are minimum time differences between the competitors in the distance (zone) of 10 m before the shooting range to the laying of the poles on the ground, and on the distance (zone) from the point of picking up the poles to reaching the 10 m mark after the shooting range.

No correlation was discovered between the number of missed shots in the prone and standing positions (r = 0.06).

A factor analysis determined five factors which logically complete the competition outcome in a biathlon sprint race. These factors are: Factor 1: Cross-country skiing performance, factor 2: Shooting accuracy in the first lap – prone shooting, factor 3: Shooting time in the second lap, factor 4: Shooting accuracy in the second lap – standing shooting, and factor 5: Shooting time in the first lap.

The results of the study confirm the findings of other relevant published authors that cross-country skiing time is the key determinant of competitive performance in biathlon sprint competitions. Nevertheless, it needs to be considered that there are no poor shooters among elite biathletes since the shooting accuracy of elite biathletes under normal weather conditions is above 95%. In the recent sprint competitions held at the 2018 Olympics and 2019 World Championship the medalists missed no more than one shot. Any additional miss would have pushed these

competitors off the podium. Range time explains for a significantly lower share of competitive performance (9% in this study), but in the tough competition of top-performing biathletes this factor can be of decisive value.

Our research is just one of the few such studies in biathlon. Further research needs to provide more detailed information on the structure of the biathlon sprint competition. Multiple sprint competitions at the highest competitive levels should be analyzed, including women's sprint competitions. In addition, other biathlon disciplines (types of competitions) for both genders should be analyzed and compared.

In fact, the differences among top performing biathletes in sprint competitions are smaller every year (in the 2018 Olympics the time gap between the winner and the third-place holder in the sprint competition was 7.7 seconds, while it stood at 16.5 seconds in the 2019 World Championship). In the light of the above, biathlon coaches need to keep up with the recent trends in the use of relevant means and methods of training for the shooting and cross-country skiing practice. This means that an individualized training plan has to be prepared for each biathlete with an aim to optimize the athlete's relevant physiological capacity and skating technique of cross-country skiing and improve and retain high shooting efficiency within the short shooting interval.

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