ANALYSIS OF STRUCTURE OF THE BIATHLON RUNS

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The biathlon is an Olympic sport discipline, which is a combination of two events, Nordic skiing and precision shooting. Combining events of such different psychophysical background creates great demands on the athlete and coach. The main objective of this paper was to determine which of these events has a greater impact on the final result considering the distance and sports level. The results of the World Cup and the Olympic Games in the 2001/02 season were analyzed statistically. The data indicates that the results of the run influence the final result to a higher degree than shooting does. This is especially true in the sprint and in relation to biathletes of higher sports level. At long distances, the level of shooting and the time of the run influence the final result to the same extent. The influence of the time of shooting on the final result is dependent on the distance of the run.

Keywords: Biathlon, analysis of sport results.

INTRODUCTION

The biathlon is an Olympic sport discipline, which is a combination of Nordic skiing and precision shooting. Combining such different physical efforts is very difficult, thus making this sport discipline very attractive to television and live viewers, especially in Europe.

During biathlon competition the athletes cover a distance of 6 to 20 km which is interrupted by shooting, which occurs 2 to 4 times depending on the event. Shooting takes place from a distance of 50 m and each time the athlete takes 5 shots to an electronic or mechanical target composed of 5 black circles. If the target is hit the black circle closes automatically.

There are two shooting positions in the biathlon, standing and lying down. The order of these positions depends on the event. Penalties for missed shots include an additional minute added to the final time in the individual run or an additional 150 m round performed immediately after the shooting in all other events. During competition the athletes choose the shooting spots themselves (except for the first shooting in competitions with a greater number of participants as well as in relays). The athletes control the performance of penalties themselves.

The biathlon includes several events: individual run, sprint, pursuit run, mass run, and relays. In this work, data from individual runs and sprints was analyzed. In the individual run men cover a distance of 20 km (5 × 4 km), while women compete at 15 km (5 × 3 km) with 4 shooting sessions in the lying and standing positions in this order: lying, standing, lying, standing. As mentioned earlier, each missed shoot is penalized by an addition of 1 min to the final time. The sprint is performed at shorter distances, 10 km for men and 7.5 for women respectively. Shooting takes place only twice in the sprint, beginning with the lying position and followed by the standing one. Each miss is penalized by an additional run over a distance of 150 m, performed immediately after the shooting. The penalty run usually takes 22 to 25 s. The start of successive competitors begins at 30 s intervals.

Factors influencing shooting results:

The biathlonist shoots under completely different conditions than athletes specializing in this event. The biathlonist shoots for precision but performs this task within a limited time. The biathlonist approaches shooting under a certain level of fatigue caused by previous running. The shooting occurs at an elevated heart rate, with increased ventilation and increased stimulation of the CNS (Klusiewicz, 2000).

The biathlete faces drastic changes in weather conditions: temperatures, wind, sun, fog, and snow. The biathlete also has to adjust to the conditions of shooting related to the position and to the limited time for performing the shooting tasks (Hoffman et al., 1992).

The final result is also affected by the types of targets used – mechanical or electronic as well as the mechanical efficacy of the gun, especially optical devices (Wasilewski, 1977).

Factors effecting running time:

The time of the run includes the time the biathlete spends on the course without the time spent for shooting. Many factors affect running time in the biathlon

of which the most important include weather conditions which directly influence the quality of snow and configuration of the course (amount of hills and their difficulty level). The quality of skiing equipment also affects running time (Ewstratow et al., 1989). The most important factor influencing running time includes the level of physical fitness as well as technical and tactical preparation.

Because of the complexity of tasks in the biathlon, achieving a world class level by a talented athlete requires 8–12 years of systematical training, aimed at developing a high level of physical and psychomotor fitness as well as great skiing and shooting skills (Ewstratow et al., 1989; Krasicki et al., 1995; Łarionow, 2002; Ryguła, 2002; Rundel & Szmere, 1998). It is evident that creating proper external conditions allows for the development of the internal potential of a particular athlete, which guarantees the achievement of world class results (Kłodecka-Różalska, 2002; Raczek, 1986; Rundell & Bacharach, 1995).

The final result is an outcome of two main elements: the time of the run and the shooting score. Skiing requires a high level of aerobic endurance, while shooting demands precision and mental control. From a scientific point of view it is important to determine which of these elements has a decisive effect on the sport result. Answering such a question will allow for more effective planning of the training program.

It is evident that other factors such as: weather conditions, type of course and snow as well as the quality of equipment influence the result in the biathlon (Ewstratow, 1989; Krasicki, 1999; Nunar et al., 1998), yet they were omitted from this research report.

AIM AND RESEARCH QUESTIONS

The main objective of the paper was to determine the influence of shooting results and running time on the final result in the biathlon.

The following research questions were formed.

1. What is the relationship between the running time, shooting efficiency, quickness of shooting and the end result in particular events of the biathlon?
2. How do particular components of the biathlon change depending on the distance and sports level?

MATERIAL AND METHODS

The data included results of the World Cup and Olympic Games during the 2001/2002 season. The number of subjects varied from 67 to 110 in particular events. The athletes represented 35 nations. The average age of the athletes was 28.4 ± 8.5 years while the training experience equaled 12.8 ± 6.3 years. Career analysis indicated that 29% of the considered athletes began as Nordic skiers while 71% specialized in the biathlon from the beginning.

All of the information related to the athletes was obtained from the JBU Biathlon Calendar 2001/2002, which included basic data of national representatives.

The results were analyzed statistically. For this purpose precise information from official bulletins of individual runs from the 2001/2002 season were used. World Cup runs from Osbrlie, Pokljuka, Antholz-Anterselva and the Olympic run from Salt Lake City were analyzed. Also sprint runs from Ostersund, Ruhpolding, Osbrlie and the Salt Lake City were considered. Athletes who performed occasionally in World Cup events were excluded from the analyses, especially in view of the fact that their results were 30% worse than those of the elite biathlonists. The smallest number of athletes considered included 67 at Ostersund, while the most were analyzed in Ruhpolding during the World Cup. The analysis was conducted for all the athletes as well as for the top 30 in each run.

All of the collected data was analyzed statistically with the use of a PC program called "Statistica". The results were presented as means ($\bar{x}$), variance (V), standard deviation (SD) and extreme results (E). In order to determine the relationships between particular components of the biathlon run (time, shooting efficiency) and the final result, Pearson's correlation coefficients were calculated. The level of significance was set at $p < 0,05$.

RESULTS AND DISCUSSION

The obtained results are presented in TABLE 1–6 and Fig. 1–4.

The analysis of the correlation coefficients (TABLE 5, 6) indicates a great variability of results. The highest relationship between the final result of the biathlon and particular elements of the run was observed for the sprint. The value of the coefficients between the time of the run and the final result ranged from 0.78 to 0.90. The relationship between shooting efficiency and the final result ranged from 0.50 to 0.70. In those cases where the time of the run had the highest influence on the end result, the relationship between shooting efficiency had the lowest values of coefficients, which may be related to very even competition and only two shooting sessions.

In the individual run, the running time has the greatest influence on the final result (r = 0.80–0.86). Shooting efficiency has a much greater impact on the final result (r = 0.67–0.77), which is most likely related to

more frequent shooting during the competition (the possibility of committing more mistakes).

The final results as well as the times of the run and shooting results of all athletes and the top 30 show great variation. The similarity of results is very high for the top 30 athletes as confirmed by small values of SD and variation. Excellent shooting, understood as 0 penalties or 1 penalty, guarantees a place in the top 30 if the time of the run is close to the average result. The dispersion of the time of the 20 km run of the top 30 athletes equaled: 5.32; 5.43; 5.53; 6.55 (TABLE 2). These are high differences yet those athletes placed high.

The elite biathletes possess a very similar level of shooting, which is obtained when the amount of misses are close to the average (3.5 to 4.5 missed shots) in the long distance runs.

Shooting efficiency, analyzed on the basis of the top 30 athletes reduces the range of penalties from 1.7 to 2.4 for each 20 shots (approximately 90% efficiency), where as the worst shooting biathlete got 4 penalties during the Olympic Games and 5–6 penalties at the World Cup. This does not indicate directly that the biathlete who received 5 penalties reached a lower position.

During the sprint runs the average amount of missed shots equals from 1.7 to 2.3 with the worst result reaching 6–8 penalties. Such shooting eliminates the possibility of obtaining a good final result. The top 30 biathletes in the sprint runs reached an average of 0.9–1.5 missed shots (90%) efficiency with the worse result equal to 5 penalties.

The research also included the influence of shooting time on the final results. This time is measured from the moment the athlete takes the shooting spot until the last shot. It includes body alignment and the motor tasks necessary for performing 5 shots. The relationships of this time with the final result are dependent on the distance covered and time of the run. Shooting time is of greater importance in the sprint in comparison to long distance competitions. The worse the final time the higher the influence of shooting time on the final result. A higher sports level in the biathlon is accompanied by a smaller influence of the shooting time on the final result because of small differences in this variable in elite athletes. The differences in shooting time among top biathletes is insignificant.

In comparison of correlation coefficients among all analyzed variables among all competitors and the top 30 biathletes, smaller values of these coefficients were observed among the elite athletes. Small standard deviations in all variables in the elite biathletes indicate a very even level of physical, technical and mental preparation among them. It can be suggested that other factors not considered in this work may influence the final result among elite biathletes.

A review of the literature shows little data regarding the analysis of the structure of the biathlon. The obtained results are consistent with those presented by other authors. In analyzing the final results of the men's 20 km biathlon, Pustovrh et al. (1995) stated that there were great differences in the influence of particular components of the run depending on the sports level of the competitors. He considered the top 10 and last athletes of the World Championships. Among the top biathletes, all of the components had a similar influence on the final result, while in the athletes with poor final results, the time of the run was crucial.

Rundell et al. (1995) demonstrated a high relationship between the final result and the time of the run, which was dependent to a large degree on the VO_{2max} of the athlete.

Groslambert et al. (1997) considered the influence of other factors on the final result in the biathlon, yet they came to the conclusion that maintaing high running velocity before shooting was the dominant factor.

CONCLUSION

1. Depending on the sports level, the influence of shooting efficiency and the time of the run is varied. Among the elite biathletes the influence of the time of the run on the final result is smaller than in athletes of lower sports level.
2. Because of the great similarity of results in shooting among the top biathletes the decisive factor includes running velocity. The highest correlation between the time of the run and the final result occurs in the sprint.
3. Shooting efficiency has a significant influence on the end result during individual competition, where shooting occurs 4 times and the possibility of committing mistakes is greater.
4. The influence of shooting time on the final result is dependent on the distance and time of the run. The lower the value of the final time (individual run, sprint) the greater the influence of shooting time.

TABLE 1
The statistical analysis of the final time and the time of the run

Time and place of competition	n	Min	Max	$\bar{x}$	V	S	Min	Max	$\bar{x}$	V	S
		Final time					**Time of the run**				
Individual											
Osbrlie PŚ	106	0:54:08	1:08:41	1:00:45	17'33''	3'58''	0:51:56	1:00:41	0:55:53	14'18''	2'34''
Pokljuka PŚ	100	1:00:02	1:16:46	1:06:23	16'42''	3'51''	0:56:32	1:13:41	1:02:25	17'09''	2'51''
Antholz PŚ	91	1:04:58	1:20:20	1:10:57	15'22''	3'44''	1:00:14	1:15:01	1:07:48	14'42''	2'47''
Salt Lake City IO	84	0:51:03	1:05:58	0:57:08	14'55''	3'05''	0:49:03	0:58:58	0:53:43	9'55''	2'07''
Sprint											
Ostersund PŚ	67	0:26:39	0:33:04	0:28:48	6'25''	1'15''	0:24:06	0:28:07	0:25:48	4'01''	0'50''
Ruhpolding PŚ	110	0:24:05	0:29:19	0:26:32	5'14''	1'18''	0:20:44	0:24:58	0:23:30	4'14''	0'58''
Osbrlie PŚ	106	0:28:18	0:31:15	0:31:15	7'55''	1'45''	–	–	–	–	–
Salt Lake City IO	84	0:24:51	0:27:31	0:27:31	6'42''	1'21''	0:22:59	0:26:46	0:24:39	3'47''	0'52''

$\bar{x}$ – means
V – variance
S – standard deviation

TABLE 2
The statistical analysis of the final time and the time of the run among 30 top biathletes

Time and place of competition	n	Min	Max	$\bar{x}$	V	S	Min	Max	$\bar{x}$	V	S
		Final time					**Time of the run**				
Individual											
Osbrlie PŚ	30	0:54:08	0:58:02	0:56:28	3'54''	0'66''	0:51:56	0:57:51	0:54:04	5'43''	1'18''
Pokljuka PŚ	30	1:00:02	1:04:11	1:00:09	6'09''	1'17''	0:56:32	1:02:25	0:59:59	5'53''	1'10''
Antholz PŚ	30	1:04:58	1:08:39	1:07:15	3'41''	0'58''	1:00:19	0:07:14	1:04:46	6'55''	1'35''
Salt Lake City IO	30	0:51:03	0:55:35	0:53:52	4'32''	1'20''	0:49:03	0:54:35	0:52:07	5'32''	1'20''
Sprint											
Ostersund PŚ	30	0:26:39	0:28:34	0:27:44	1'55''	0'31''	0:24:06	0:26:20	0:25:12	2'14''	0'29''
Ruhpolding PŚ	30	0:24:05	0:25:35	0:25:03	1'30''	0'21''	0:20:44	0:22:32	0:21:33	1'48''	0'24''
Osbrlie PŚ	30	0:28:18	0:30:06	0:29:33	1'18''	0'26''	–	–	–	–	–
Salt Lake City IO	30	0:24:51	0:26:50	0:26:15	1'19''	0'29''	0:22:59	0:24:38	0:23:51	1'39''	0'26''

TABLE 3
The statistical analysis of shooting time and penalties

Time and place of competition	n	Min	Max	$\bar{x}$	S	Min	Max	$\bar{x}$	S	1 missed shot expressed in % of the best final time
		Quickness of shooting				**Shooting efficiency**				
Individual										
Osrblie PŚ	106	1'49''	4'03''	2'18''	0'26''	0	11	4.5	2.3	1.8%
Pokljuka PŚ	100	–	–	–	–	0	11	4.1	2.2	1.6%
Antholz PŚ	91	1'45''	3'05''	2'18''	0'16''	0	9	3.9	1.8	1.6%
Salt Lake City IO	84	1'41''	3'16''	2'11''	0'15''	0	7	3.3	1.7	2.0%
Sprint										
Ostersund PŚ	67	0'44''	1'44''	1'00''	0'09''	0	8	2.2	1.6	1.4%
Ruhpolding PŚ	110	0'47'	1'58''	1'05''	0'11''	0	6	1.9	1.3	1.5%
Osrblie PŚ	106	–	–	–	–	0	6	2.3	1.5	1.3%
Salt Lake City IO	84	0'48''	2'02''	1'06''	0'11''	0	6	1.7	1.1	1.6%

TABLE 4
The statistical analysis of shooting time and penalties among the 30 top biathletes

Time and place of competition	n	Min	Max	$\bar{x}$	S	Min	Max	$\bar{x}$	S	1 missed shot expressed in % of the best final time
		Quickness of shooting				**Shooting efficiency**				
Individual										
Osrblie PŚ	30	1'49''	3'29''	2'13''	0'19''	0	5	2.4	1.2	1.8%
Pokljuka PŚ	30	–	–	–	–	0	6	2.4	1.4	1.6%
Antholz PŚ	30	1'45''	2'35''	2'03''	0'12''	0	5	2.4	1.3	1.6%
Salt Lake City IO	30	1'41''	2'27''	2'04''	0'11''	0	4	1.7	1.0	2.0%
Sprint										
Ostersund PŚ	30	0'44''	1'16''	0'56''	0'07''	0	4	1.3	1.0	1.4%
Ruhpolding PŚ	30	0'47'	1'18''	0'58''	0'08''	0	3	0.9	0.9	1.5%
Osrblie PŚ	30	–	–	–	–	0	5	1.5	1.1	1.3%
Salt Lake City IO	30	0'48''	1'21''	1'00''	0'07''	0	2	1.1	0.7	1.6%

TABLE 5
Correlation coefficient for the considered variables

	Individual				Sprint			
Time and place of competition	Osrblie PŚ	Pokljuka PŚ	Antholz PŚ	Salt Lake City IO	Ostersund PŚ	Ruhpol-ding PŚ	Osrblie PŚ	Salt Lake City IO
(n)	106	100	91	84	67	110	106	84
Relationship between final result and time of the run	0.80	0.82	0.86	0.85	0.78	0.87	–	0.90
Relationship between the final result and shooting efficiency	0.77	0.67	0.71	0.77	0.70	0.51	0.61	0.57
Relationship between the final result and quickness of shooting	0.47	–	0.25	0.49	0.50	0.52	–	0.52

TABLE 6
Correlation coefficient for the considered variables among the top 30 biathletes

	Individual				Sprint			
Time and place of competition	Osrblie PŚ	Pokljuka PŚ	Antholz PŚ	Salt Lake City IO	Ostersund PŚ	Ruhpol-ding PŚ	Osrblie PŚ	Salt Lake City IO
(n)	106	100	91	84	67	110	106	84
Relationship between final result and time of the run	0.47	0.33	0.50	0.71	0.58	0.55	–	0.82
Relationship between the final result and shooting efficiency	0.38	0.61	0.14	0.38	0.35	0.31	0.47	0.27
Relationship between the final result and quickness of shooting	0.14	–	0.21	0.19	0.47	0.16	–	0.26

Fig. 1
Correlation coefficient for the considered variables in the individual run

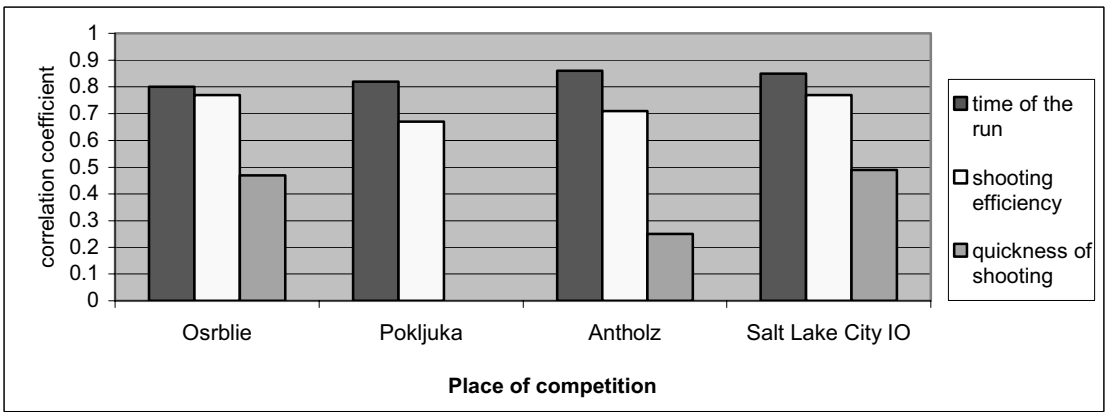


Fig. 2
Correlation coefficient for the considered variables in the sprint

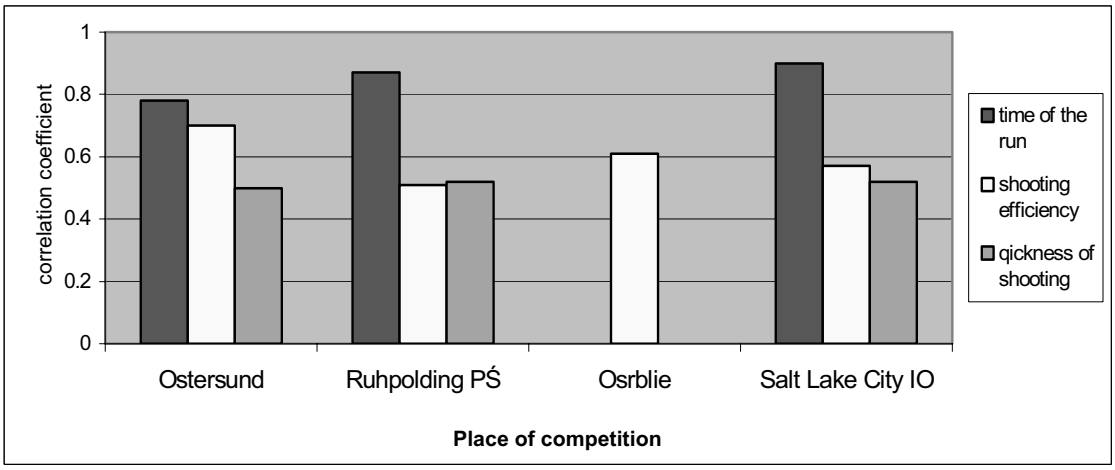


Fig. 3
Correlation coefficient for the considered variables in the individual run, among the top 30 biathletes

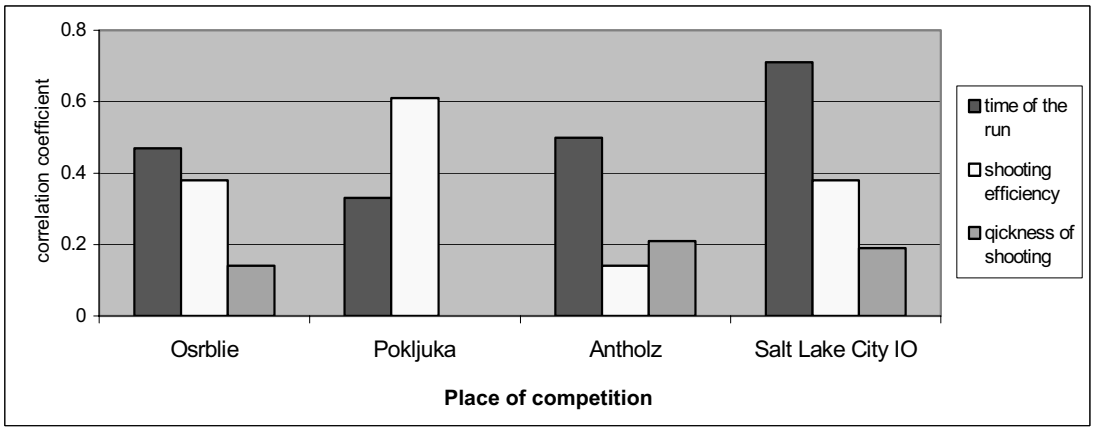
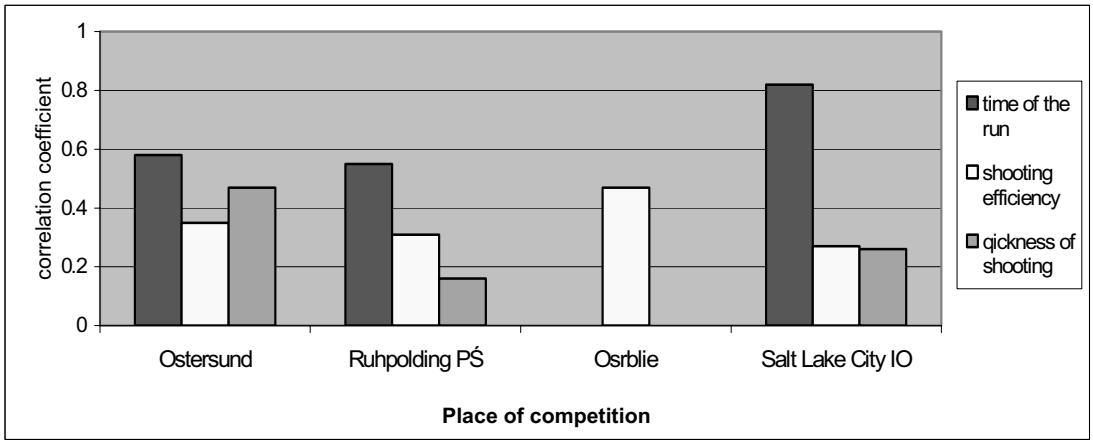


Fig. 4
Correlation coefficients for the considered variables in the sprint, among the top 30



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ANALÝZA STRUKTURY BIATHLONOVÉHO BĚHU

(Souhrn anglického textu)

Biathlon je olympijská disciplína spojující v sobě vlastně dvě sportovní disciplíny: lyžařský běh a střelbu ze sportovní pušky. Spojení těchto odlišných sportovních disciplín o různých psychofyzických požadavcích klade na závodníky i trenéry velmi vysoké požadavky. V práci se autoři snažili najít odpověď na otázku: která složka je důležitější pro dosažení konečného výsledku v závislosti na proběhnuté vzdálenosti, jakož i sportovní úrovni závodníků. Statistické analýze byly podrobeny výsledky vybraných závodů Světového poháru i olym-

pijských her v sezóně 2001/02 v kategorii mužů. Analýze byl podroben čas běhu, přesnost střelby, čas střílení i sportovní výsledek. Na základě výsledků získaných z předmětné analýzy byl zjištěn větší význam běhové přípravy v sprintérském běhu u závodníků na vyšší sportovní úrovni vzhledem k vysoké vyrovnané úrovni střelby. V běhu na dlouhých tratích byl zjištěn přibližně stejný význam přesnosti střelby a času běhu. Vliv času střelby na konečný výsledek závisí na délce proběhnuté vzdálenosti.

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