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ORIGINAL ARTICLE

Biathlon Performance: Heart Rate, Hit Rate, Speed and Physiological Variables

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ABSTRACT

Aim: Biathlon is a sport that combines cross-country skiing and rifle shooting. The athlete is fast in the cross-country skiing section, in the gun shooting section, the heart rate should be low. This study aims to determine the hitting rate of the shots made with different training loads on low altitude in elite biathletes in terms of maximum speed and physiological variables.

Methods: To evaluate shooting performances first with the resting pulse and then after 2.5 km skiing respectively with 50%, 70% and 100% pulse rate which is separately calculated for each athlete according to karvonen formula.

Results: Our findings show that while there was negative relation between maximum speed and body fat there was a positive relation with lean body mass. It has been determined that low body fat percentage and high lean body mass are effective at the athletes' maximum speed and the pulse level with the highest target shooting accuracy rate was at rest and 70% in the second level.

Conclusion: Since the pulse of the athlete who comes to the shooting area cannot be reduced to a resting level in a short time, focusing the 70% pulse zone may be beneficial in terms of shooting accuracy and acceleration after the shot. The lowest results in target shooting accuracy were seen at 50% and 100% loads.

Keywords: Athletes, performance, heart, rate, lean body mass.

INTRODUCTION

Biathlon competitions between 25 and 60 minutes. Today, there are 6 different types of biathlon competitions, including the sprint, pursuit, mass start, individual, relay and mixed relay. Athletes shoot in two different styles, standing or lying down (prone). Athletes make five shots at targets determined at the time of shooting. The distance between the shooting range and the target zone is 50 meters.[1] For each shot where the athletes fail to hit the target, 150 meters of extra distance in the area known as the penalty area according to the rule of the competition or one minute in addition to the time to finish the competition is added.[2]

It is known that biathlon type competitions appeared in Scandinavian countries at the beginning of the 18th century. The competitions of the Norwegian army in 1912 in Oslo are the first competition.[3] Combining cross-country skiing and roller ski with rifled marksmanship, the biathlon has participated in the Olympics since the Winter Games held in the Squaw Valley of the United States in 1960.[4] Today, biathlon sport is divided into two as summer and winter. Competitions with roller skiing in summer are held with skiing in winter.[5]

Biathletes should have different characteristics when shooting standing and lying down (prone). Biathlon, which is a complex branch, requires a strong posture in addition to using time quickly and effectively.[6]

Athletes need to be able to distinguish the difference between the most accurate shooting performance and the target at the time of shooting in prone shots, and the precise motor control should be well adjusted. The stability of the body and rifle system of the athletes in standing shots.[4] Biathlon athletes and cross-country skiers have a higher level of endurance than other endurance athletes. When we look at the elite athletes, the $VO2_{max}$ values in female athletes are in the range of 70-80 ml.kg-1.min-1, while this value is in the range of 80-90 ml.kg-1.min-1 for men [7,8,9] found great differences in shooting performance between the athletes' shooting performance at rest and after running 2.1 km of skiing.[9] Also, there is an increase in the oxygen consumption of the athletes when the athletes carried rifles weighing at least 3.5 kg during skiing. This increase increases approximately 1.3% for men and 2.1% for women.[10]

There are many factors that affect the success of the athlete. The most important of these are reaching a low heart rate, maintaining posture, cognitive status, and correct breathing. In biathlon athletes, the maximum number of heartbeats during skiing reaches approximately 93 % .[11] During the shooting, the athlete's heart rate drops to approximately 61-73% of the maximum.[3] The most obvious consequence to athletes' breathing now of shooting is the rifle action resulting in lower grip stability during breathing. For this reason, biathletes often timing one breath for each shot.[12,13] Shooting performance in biathlon is defined as the ability to hit the target repeatedly in a very short time with high precision and accuracy, as in different competitive sports.[14,15]

MATERIAL AND METHODS

Participants: The research was conducted with fourteen volunteers prepared elite biathlon athletes of Turkish Biathlon National Team that were preparing Summer Biathlon World Championships (2017) and the Winter Olympics (2018). Athletes have a mean of age (16.92 ± 4.32 years / year), height (166.7 ± 7.99 cm) and body weight (59.84 ± 7.37kg).

Procedure: The study started in 2017 after the approval of Atatürk University Faculty of Sport Sciences ethics committee. The content of the study was explained to the athletes and their written consent was obtained in line with the Helsinki declaration.

Measurements: Measurements, which is the only registered biathlon track in Turkey, Erzurum Kandilli International Biathlon Center (altitude 1713-1767) have been made.[16] Measurements were made in four national camps, in the summer with roller skiing in June and August (2018), and in the winter with skis in December and February. The TANITA TBF 300 device was used to determine the body composition (Body Weight, Body Fat Ratio (%), Lean Body Weight) of the athletes, and the Polar M400 GPS running watch was used to determine the exercise intensity and speed. The athletes used same brand rifles, which have been used by the national team for a long time, have been calibrated for themselves, 22 calibers (cl), weighing 4.5 kg, and are approved by the International Biathlon Union (IBU). In the summer test of the research, the Marve branded roller skis approved by the IBU, were used and the Rossignol and Fischer brand skis were used for winter test. The reset settings were made by the same official person.

The resting heart rates of the athletes participating in the study were followed for a certain period before the measurements and the average was accepted as the resting heart rate of the athletes. Pulse intensity to be applied by the athletes in the measurements was determined according to the Karvonen formula.[17] In the target hit measurements of the athletes, first they shot at rest, and then in pulse ranges of 50%, 70% and 100% respectively determined according to the Karvonen formula. After running 2.5 km of roller skiing and skiing at any intensity, the athletes shoot a total of 20 times from 5 shots in prone position at 50 meters to the shooting range and 110 mm diameter targets (HoRa 2000 E Fully electronic biathlon shooting range). During the research, a total of 80 shots were made, 40 in summer and 40 in winter.

Statistical analysis: The data obtained were transferred to the electronic environment via SPSS Statistics 20.0 software. Correlation analysis was conducted to determine the relationship between the athletes' heart rate of different intensity (Resting, 50%, 70% and 100% loads) and the shooting accuracy, and the relationship between maximum speed and physiological values (Body Weight, Body Fat, Fat Free Body Mass).

RESULTS

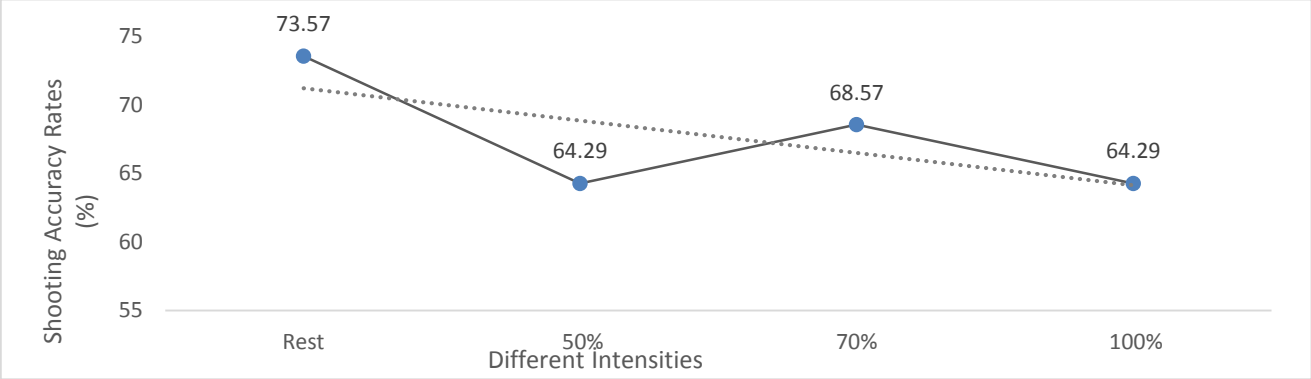

Figure I: Shooting accuracy rates in different intensity pulse

Table I: Correlation coefficients between descriptive characteristics of athletes

		Height	Body weight (kg)	Body Fat (%)
Body Weight (kg)	r	,694**	-	-
	p	0,000	-	-
	n	56	-	-
Body Fat (%)	r	-,666**	-,241	-
	p	0,000	0,074	-
	n	56	56	-
Fat Free Body Mass (%)	r	,870**	,874**	-,678**
	p	0,000	0,000	0,000
	n	56	56	56

**p<0,01

The highest shot accuracy rate was at rest. The second-best value was seen in shots made with 70% load. The same result was found with the shots made with 50% and 100% loading (Figure I).

Table I shows positive correlation was found between body weight and height. Negative correlation was found between body fat and height. There was a positive relationship between fat free body mass and height and body weight, and a negative relationship between body fat.

Table II: Correlations between constant maximum speed variable and other variables

		MS (km/s)	BW (kg)	BF (%)	FFBM (%)	Rest HR	HR at 50% load	HR at 70% load	HR at 100% load
MS (km/s)	r	1	-,057	-,507**	,305*	,147	,114	,031	,121
	p		,677	,000	,022	,280	,401	,823	,375
	n	56	56	56	56	56	56	56	56

*p<0.05, **p<0.01, MS: Maximum speed, BW: Body weight, BF: Body Fat, FFBM: Fat free body mass, HR: Hit rate

Table II shows that there was a significantly negative relationship between the maximum speed and the body fat (%) (r = 0-, 507**), and a positive relationship between the max speed and the fat free body mass (r = 0.305*).

Table III: Correlations between physiological variables and maximum speed and shooting accuracy

		MS (km/s)	Rest HR	HR at 50% load	HR at 70% load	HR at 100% load
BW (kg)	r	,057	,159	,0,322*	0,122	0,039
	p	,677	,240	,0,016	0,371	0,776
	n		56	56	56	56
BF (%)	r	-,507**	-,100	-0,238	-,279*	-,168
	p	,000	,464	,0,077	0,037	,216
	n	56	56	56	56	56
FFBM (%)	r	,305*	,190	,372**	,234	,122
	p	,022	,162	,005	,082	,370
	n	56	56	56	56	56

*p<0.05, **p<0.01, MS: Maximum speed, BW: Body weight, BF: Body Fat, FFBM: Fat free body mass, HR: Hit rate

Table IV: Correlations within the shooting accuracy and between maximum speed and physiological variables

	MS (km/s)		BW (kg)	BF (%)	FFBM (%)	Rest	HR%50	HR %70	HR %100
Rest HR	r	,147	,159	-,100	,190	1	,594**	,382**	,447**
	p	,280	,240	,464	,162		,000	,004	01
	n	56	56	56	56	56	56	56	56
HT at 50% load	r	,114	,322*	-,238	,372**	,594**	1	,624**	,628**
	p	,401	,016	,077	,005	,000		,000	,000
	n	56	56	56	56	56	56	56	56
HR at 70% load	r	,031	,122	-,279*	,234	,382**	,624**	1	,381**
	p	,823	,371	,037	,082	,004	,000		,004
	n	56	56	56	56	56	56	56	56
HR at 100% load	r	,121	,039	-,168	122	,447**	,628**	,381**	1
	p	,375	,776	,216	,370	,001	,000	,004	
	n	56	56	56	56	56	56	56	56

*p<0.05, **p<0.01, MS: Maximum speed, BW: Body weight, BF: Body Fat, FFBM: Fat free body mass, HR: Hit rate

Table III shows there was a positive correlation between the body weight and the pulse range shooting performance variable at 50% intensity (r = 0.322*), between the body fat and the pulse range shooting performance at 70% intensity (r = 0-, 279 *) in the negative correlations, between the fat free body mass and the pulse range shooting performance at 50% intensity (r = 0.372**) in the positive relationship. Table IV shows there was a positive correlation in all shooting accuracy rates at rest and at different loads.

DISCUSSION

Physiological values are important factors for performance in biathlon athletes as in every sports branch. According to the results, strong relationships were found between body weight, body fat and fat free body mass (Table I). In addition, physiological values and 50% and 70% shooting accuracy rate were positively correlated with body weight and fat free body mass, and a negative correlation with body fat (Table III). Malin Jonsson Karstrom et al. their research results support our results.[18]

Many biathletes reduce their speed to a certain extent because they think that when 150-250 m remain in the shooting range, it affects their shooting performance negatively. However, in recent scientific studies, it is recommended that the athletes' speed must be reduced as low as possible while approaching the shooting range. Among many biathletes, the biggest problem to increase performance to higher levels is the loss of time when it comes to the shooting range.[2] In our study, it was determined that shots made with maximum speed do not affect the hit rates of different intensities (Table II).

The World Cup' athletes are the top-level athletes in biathlon, as in every sport. In biathlon where different components (lap time, shooting time, sequencing time, shooting performance, penalty time) affect the competition' result, Luchsinger et al. stated that the track time is the most important factor in the total performance and performance level in the world cup competitions.[19]

In the current study, it was determined that athletes' ability to reach maximum speed is associated with low body fat percentage and high fat free body mass. The biathlon shooting section is a complex task that requires strong stability and body stabilization and should be done as quickly as possible for competition time.[1] It showed that this was affected by the physiological changes of the maximum speed of biathlon athletes (Table II). This result of M.D.Hoffman et al. supports the research.[2]

Biathlon sport is a complex sport that is subjected to great performance variability, and that it is a factor that will affect performance change at high altitude, possibly because of aerobic capacity. The altitude of the track on which our research was conducted is in class> 1400m according to the classification in Lunghi's study.[20] The sprint, individual, mass start, and pursuit competitions in the IBU World Cup and Championship, IBU Cup and Winter Olympics, which Lunghi et al. divided into three different altitude levels, were performed for 8 years (2009-2017) for both women and men prone and standing shooting examined their performances. As a result, it was stated that altitude (between <700 and> 1400 m) had a detrimental effect on shooting performance, which is similar for women and men, but there was no statistical difference between lying and standing shooting, and as expected, it was said that the performance of elite biathletes was affected even at medium altitude.[20] We can say that the altitude factor is a constant factor for all athletes since all measurements of our research were made in the same center and with athletes doing the same training. Other factors that will affect the performance of athletes are skiing (wheeled in summer, normal in winter), weapons, training,

nutrition and heart rate ranges. Since the athletes are national team athletes, the skis, guns and bullets they used were the same brand both in summer and winter.

The most important factor and goal in our research was to examine the differences between the shooting accuracy rates made in different heart rate ranges. In a similar but laboratory study, standing shots after submaximal exercise on a resting and bicycle ergometer were examined by Gallicchio et al. It was stated that the hit rate was supported by the hypothesis that the ballistocardiac rebound produced in each heartbeat was affected by the cardiac cycle phase and that athletes could be trained to beat at a certain stage of the cardiac cycle to achieve the best results.[21]

A study including the total competition time and shooting performance (hit rate) of male and female athletes participating in the world cup held between 2011-2016 was conducted. As a result of this research, it was stated that athletes ranked between 21-30 in terms of total competition time were 3-5% behind the athletes in the first 10 rankings, and female athletes were on average 12% slower than men.[22] Average total hit rates in both genders 92-93% in the ranking and 85% between the 21-30th athletes, and there was no difference in shooting performance between gender. In total, it was stated that males hit 6 seconds faster than females.[23]

Vonheim found in his study that no matter how high the exercise intensity was, it had no effect on the athlete's shooting performance.[1] This result Hoffman et al. contradicts with their study. Hoffman et al. found that there was a significant difference between the low intensity exercise shot and the rest shot.[3] The results of our study support this situation (Figure I). A significant difference was found in the analysis of the shooting performance of the athletes at rest and after loading at different intensity (50-70-100%). It has been observed that the best result is with the shots made at rest. The second-best result was found in loading with 70% (Figure I). Another study with opposite conclusion was conducted with experienced biathletes. Five shots were fired at the target at 50 m at rest and after loading (90% of the heart rate on a bicycle ergometer). As a result, it was stated that heart rate and physical exertion rate increased under cardiovascular load, but target shooting accuracy did not change. It has been concluded that this situation allows biathletes who are physically well trained to shoot accurately in harsh conditions.[24]

CONCLUSION

Based on the data obtained in the study, athletes need to have high lean body mass to be faster. It was determined that the pulse level with the highest target shooting accuracy rate was at rest and 70% in the second level. In this case, since the pulse of the athlete who comes to the shooting area cannot be reduced to a resting level in a short time, targeting the 70% pulse zone may be beneficial in terms of shooting accuracy and acceleration after the shot. Planning for these two goals in training programs applied to athletes can contribute to sportive success.

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