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Original Article

Impact of training and competitions in alpine skiing on the anaerobic capacity of adolescent athletes

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Abstract:
The physiological requirements for practicing alpine skiing are both aerobic and anaerobic power, as well as muscle strength and a complex of motor abilities. Alpine skiing competitions consist of four separate disciplines: downhill – duration of 2-3 minutes at a speed of over 90 km / h; super giant slalom - shorter than the downhill – 1-2 minutes; giant slalom - is held on very steep terrain with a duration of 60 to 90 seconds; slalom - includes very fast turns on steep terrain, consists of two attempts lasting 45-60 seconds for attempt. The purpose of this study is to track the changes of anaerobic capacity of adolescent alpine skiers during competition season using the Wingate test and the Sargent test.
As a result of the study, several major conclusions could be drawn: - As a result of the training and competitions during the period between the two tests, the participants in the study increased their average power ($p = 0.02$); - there were significant correlations between muscle mass and maximum power (December - 0.93 ***, April - 0.84 **), average power (December - 0.90 **, April - 0.87 **) and relative power (m December - 0.73 *, April - 0.62 *; *** - $p < 0.001$; ** - $p < 0.03$; * - $p < 0.05$; ns - $p > 0.05$); - moderate correlations were found between the maximum and average power of the Wingate test and the ranking on the national level of the subjects; - the fatigue index of the athletes increased on the second measurement, probably as a result of the busy training and competition program.
The research shows that training and competitions in alpine skiing disciplines allow the development of anaerobic capacity of athletes, which are extremely important for better performance during a race.
KeyWords*:* ski,Wingate test, young athletes, anaerobic capacity, blood lactate concentration

Introduction

Alpine skiing is a winter Olympic sport under the auspices of the International Ski Federation (FIS). The physiological requirements for practicing alpine skiing are both aerobic and anaerobic power, as well as muscle strength and a range of motor abilities. For the first time in 1978 Karlsson et al. (1978) note that there are different energy needs in different disciplines and in different competitions. Alpine skiing competitions consist of four separate disciplines: downhill - duration of 2-3 minutes at speeds above 90 km / h; super giant slalom - shorter than the descent 1-2 minutes; giant slalom - held on very steep terrain with a duration of 60 to 90 seconds; slalom - includes very fast turns on steep terrain, consists of two dives with a duration of 45-60 sec for descent.

Various studies have been conducted to try to determine the energy costs of giant slalom and slalom. Saibene et al. (1985) and Veicsteinas et al. (1984) determined aerobic needs for giant slalom from 120% to 160% of VO_2max and for slalom 200% VO_2max. The conclusion of these studies is that 65% of total energy in alpine skiing is produced anaerobically. Anderson & Montgomery (1987) report that the main characteristics of elite alpine skiing are high aerobic power and very high anaerobic capacity.

Alpine skiing requires a lot of power (Haymes & Dickinson, 1980). A number of studies have been conducted to show the relationship between anaerobic strength and performance during race in men and women alpine skiers. Haymes & Dickunson (1980) demonstrated such an association with the use of the ladder cross-country test and the vertical jump of the men's alpine skiers. However, the desired maximum anaerobic power of a bicycle ergometer and its relation to performance during competition had not yet been fully elucidated. Muira (2015) examined the relationship between maximum anaerobic power and performance during competition and found a significant correlation between them.

The purpose of this study is to track the changes of anaerobic capacity of adolescent alpine skiers during competition season using the Wingate test and the Sargent test.

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Material & methods

Participants

The study involved 9 athletes (age 13.6 ± 1.2 years, height 162.9 ± 7.2 cm, weight 55.8 ± 11.3 kg). The measurements were conducted at the end of the preparation season, the beginning of December and after the end of the competition season in April. Prior to the study, participants were asked to abstain from exercise, food, and fluid intake. The parents of each participant in the study signed a statement of informed consent, and the study was approved by the Ethics Committee of the SWU "N. Rilski". The subjects came twice to the Center for Functional Research in Sport and Kinesitherapy (CFRSKT) of South-West University "Neofit Rilski" - Blagoevgrad, where anthropometric measurements and anaerobic tests were made.

Anthropometric measurements

Height and weight were measured as well as a body composition with a bioelectric impedance analyzer Ioi 353. From the obtained results Body Mass Index (BMI), Body Fat Mass (MBF) and Soft Lean Mass (SLM) were used. MBF was calculated by subtracting lean body mass from weight. SLM consists of total body water and proteins.

Wingate test

The test was carried out with the Monarch 828 E mechanically-braked cycle ergometer. Following a five-minute warm-up, which includes three sprints at varying resistances, the athlete may get off the bike during a three-minute recovery or stay on the bike and spin lightly. The athlete then begins to pedal as fast as possible without any or minimal resistance. Within three seconds, a fixed resistance (7% of the athlete's body weight) is applied to the flywheel and the athlete continues to pedal "all out" for the duration of the test (30 seconds). At the end of the test, the maximum power (Peak Power) is set for 5 seconds. This is the maximum power the person can develop during the first 5 seconds. The relative maximum power was determined by dividing the maximum power to the subject's weight. The system also allows determining the average power for 30 seconds.

Determination of blood glucose and lactate

Measurement was performed with BIOSEN C Line biochemical analyzer of the German company EKF Diagnostic. The determination of glucose and lactate in the blood is based on electrochemical measurement with a chip sensor. Blood was collected four times: before warm-up procedure and three times after the Wingate test – on the first, third and fifth minute.

Sargent test

Sargent test, also known as vertical jump, is suitable for tracking the development of elastic leg strength. The test is easy to perform as the equipment is extremely affordable and inexpensive. All we need is a wall, a centimeter and chalk. The athlete warmed-up for 10 minutes. They stood against the wall and extended their hand, indicating the position in cm of the stretched arm (M1). Then, from a static position, the subject jumped as high as possible, extending his hand again and touching the wall (M2). Three consecutive jumps were made and the highest value was taken. The difference M2-M1 in cm was determined. The test was performed once on the second visit.

Data collection and analysis

GraphPad Prism (Ver 3.0) was used to process and analyze the data. The mean values and standard deviations of all variables were calculated by descriptive statistics. Experimental data were presented in two ways: - as mean ± SD; and - as individual values for each subject. For statistical analysis of the results t-test, Wilcoxon Signed Rank Test, One Way ANOVA, Kruskal-Wallis test and Dunn's Multiple Comparison Test as a post-test were used, the Graph Pad Prism statistical software was used to determine the Pearson's correlation coefficient and to generate graphs.

Results

The study involved 9 alpine skiers. Their anthropometric measurements were presented in Table 1.

Table 1. Anthropometric data of the subjects.

ID	Age, years	Height, cm		Weight, kg		BMI, kg/m^2		MBF, kg		SLM, kg	
		1	2	1	2	1	2	1	2	1	2
AB1	13	163.50	166.00	62.70	64.60	23.60	23.40	16.70	16.90	42.40	43.90
AB2	13	163.00	163.00	63.20	64.00	20.00	20.30	11.00	12.00	39.10	38.80
AB3	16	160.00	160.00	58.30	60.20	22.80	23.50	16.90	17.30	38.10	39.50
AB4	15	180.00	180.00	75.90	74.70	23.40	23.10	12.70	12.30	58.80	58.00
AB5	14	167.00	168.00	53.30	55.90	19.10	19.80	5.40	6.60	44.80	46.00
AB6	14	160.00		59.60		23.30		13.00		43.20	
AB7	13	158.00	163.00	42.10	47.00	16.90	17.70	1.70	2.70	37.90	41.50
AB8	13	159.00	164.00	44.80	46.40	17.70	17.30	4.70	3.70	37.50	39.90
AB9	12	156.00	158.00	42.10	42.60	17.30	17.10	3.90	2.70	35.70	37.30
Mean	13.67	162.94	165.25	55.78	56.93	20.46	20.28	9.56	9.28	41.94	43.11
±SD	1.22	7.19	6.73	11.35	11.03	2.84	2.78	5.74	6.14	7.00	6.64

BMI– body mass index, **MBF**– body fat mass, **SML** – soft lean mass, 1 – December 2018, 2 – April 2019.

A 30-second Wingate test was conducted in the two visits in December 2018 and April 2019. The test results for both visits are presented in Table 2.

Table 2. The Wingate test results.

ID	Wingate test, December			Wingate test, April			FI %		Ranking points
	PP (W)	AP(W)	RAP(W/kg)	PP (W)	AP(W)	RAP(W/kg)	December	April	
AB1	508.59	390.92	6.31	595.6	439.1	7.99	42.65	46.11	250
AB2	458.72	367.48	6.93	474.14	362.93	7.39	35.35	48.43	185
AB3	484.42	368	6.35	547.15	390.83	8.41	48.42	57.45	176
AB4	795	568.84	7.48	779.47	581.78	9.34	52.25	48.37	245
AB5	582.86	399.89	7.55	559.08	418.83	7.31	43.69	36.96	194
AB7	305.89	230.16	5.48	402.1	312.8	6.51	45.68	49.61	235
AB8	320.9	232.97	5.18	303.31	242.36	4.48	37.09	42.13	162
AB9	294.46	208.79	4.97	339.22	260.56	6.44	39.55	42.52	70
Mean	468.86	345.88	6.28	500.01	376.15	7.23	43.09	46.45	190
±SD	169.10	119.85	1.00	154.80	109.37	1.47	5.71	6.13	59

PP(W) - peak power, **AP(W)** - avarage power, **RAP(W/kg)** - relative average power

Correlations were found between muscle mass and maximum, average, and relative power, respectively (Figure 1). A moderate correlation was found between the maximum and average power of the Wingate test and the ranking of state level of the subjects studied (Figure 2).

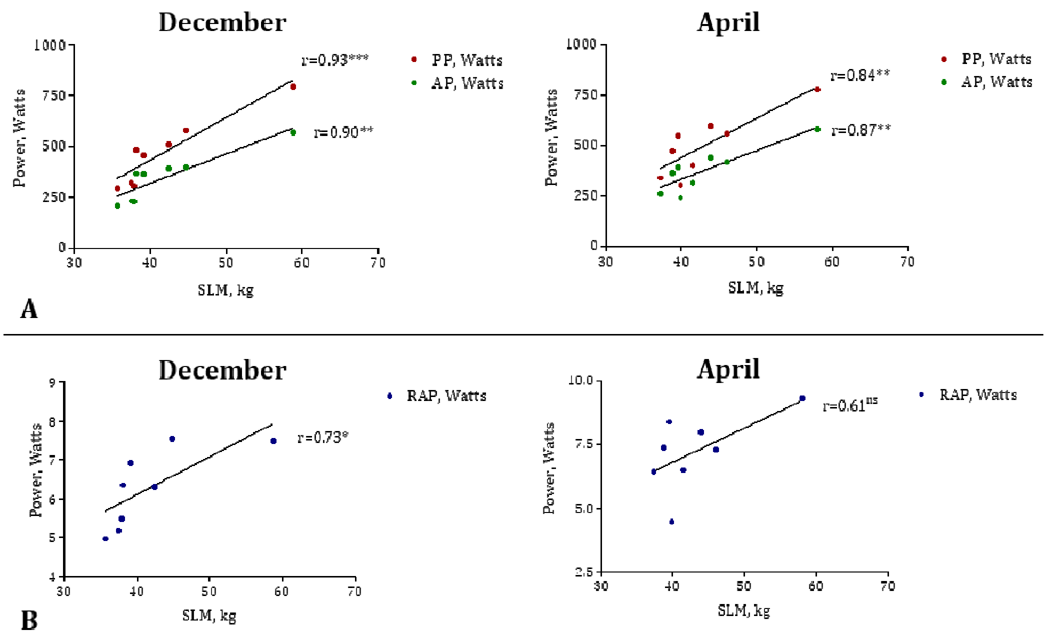

Figure 1. Correlations between muscle mass (SLM) and maximal power (PP) and mean power (AP) - A and relative power (RAP) - B (*** - p <0.001; ** - p <0.03; * - p <0.05; ns - p> 0.05).

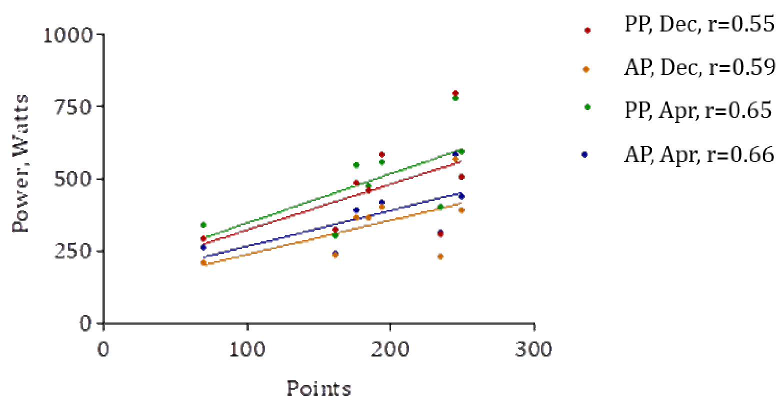

Figure 2. Relationship between state-level rankings and average WingateTest power.

Blood lactate concentrations reached their highest value at 5th min during of the maximum test in December and April and are respectively 11.76 ± 1.28 mmol / l and 11.83 ± 2,16 mmol / l (Figure 3, Table 3).

Table 3. Blood lactate concentration before WingateTest and at 1, 3 and 5 minutes after its end.

ID	Lactate, mmol/l							
	December				April			
	Before	1 min	3 min	5 min	Before	1 min	3 min	5 min
AB1	2.36	9.63	10.57	11.72	2.04	10.06	11.75	10.04
AB2	2.31	7.68	11.59	12.24	3.82	11.82	15.16	13.38
AB3	2.44	14.80	14.94	13.50	2.81	15.74	15.00	15.68
AB4	4.17	6.54	9.08	11.66	3.70	10.50	12.54	13.13
AB5	1.45	10.18	12.74	11.72	2.49	10.57	11.25	11.51
AB7	1.67	7.60	7.92	9.36	2.57	9.70	9.03	11.64
AB8	2.89	8.86	9.38	13.04	3.77	8.12	9.00	9.11
AB9	2.55	10.84	10.59	10.85	4.51	9.84	9.94	10.12
Mean	2.48	9.52	10.85	11.76	3.21	10.79	11.71	11.83
±SD	0.83	2.58	2.23	1.28	0.85	2.25	2.43	2.16

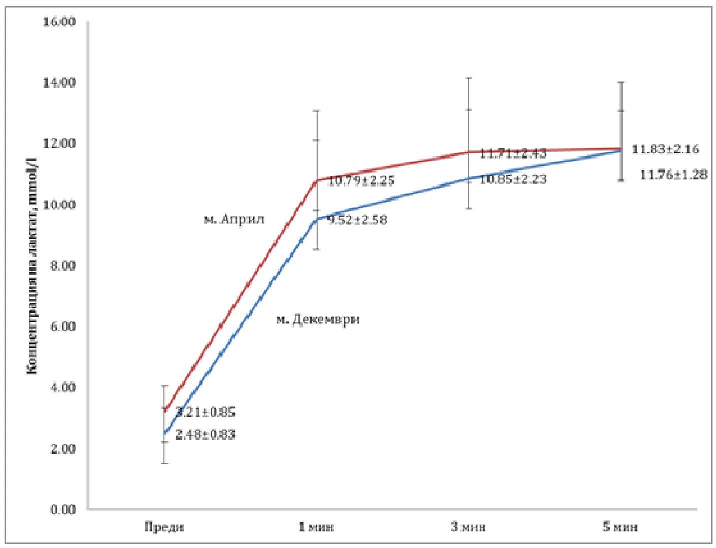

Figure 3. Increase in mean blood lactate concentrations in both measurements - December (blue) and April (red).

At the first measurement in December, there was a statistically significant difference in lactate concentration before the start of the test and 1 minute after its end (P <0.05, Kruskal-Wallis test), between the first and third minutes (P <0.01, Kruskal-Wallis test) and between the first and fifth minutes after the study (P <0.001, Kruskal-Wallis test). There was no statistically significant difference between blood lactate concentrations in the two measurements (December and April) (Figure 4).

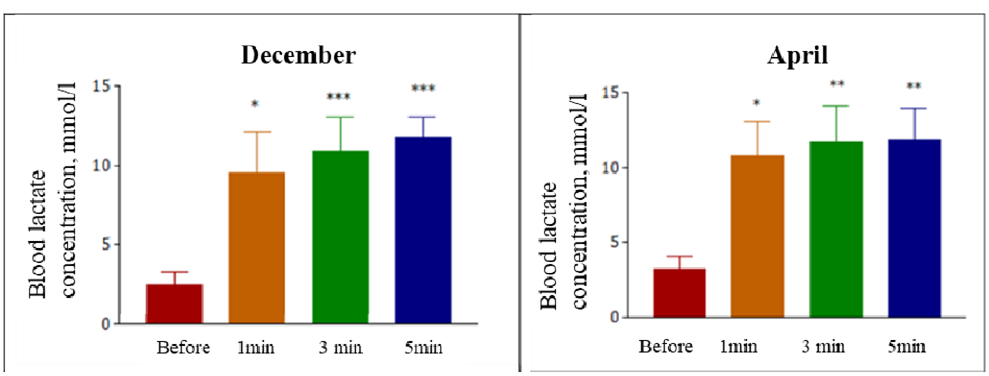

Figure 4. Lactate concentration for the two measurements in December and April before and 1, 3 and 5 minutes after the Wingate test. (* P <0.05, ** P <0.01, *** P <0.001).

A correlation was found between fatigue index and lactate concentration (Pearson r = 0.75, P = 0.03) at 5th min after exercise in April (Figure 5).

The resting glucose of the subjects was 4.41 ± 0.51 mmol /l (December) and 4.34 ± 0.44mmol/l (April) and there is no statistically significant difference between the individual values. A significant increase in glucose concentration was observed only in December and 3th min after the test compared to the pre-test concentration. Although the delta (difference in glucose concentration at 5th min after loading and initial concentration) was slightly higher in December (0.75 ± 0.57 mmol/l) compared to April (0.55 ± 0.56 mmol/l), there was no statistically significant difference between individual values (Table 4).

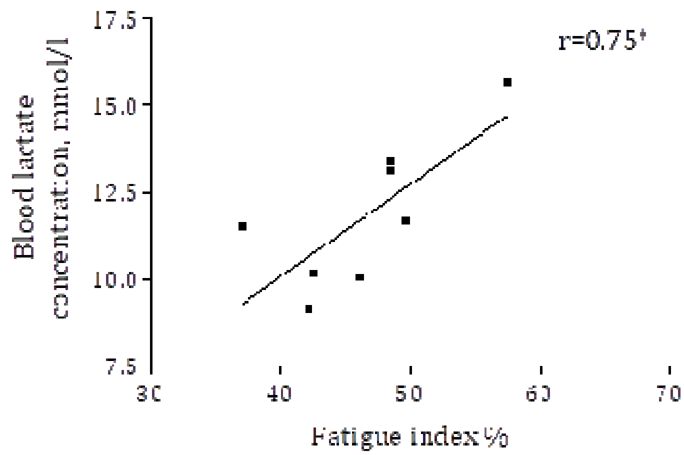

Figure 5. Relationship between fatigue index and lactate concentration 5 minutes after Wingate test in April (* p = 0.03).

Table 4. Blood glucose concentration before WingateTest and at 1, 3 and 5 minutes after its end.

ID	Glucose, mmol/l									
	December					April				
	Before	1 min	3 min	5 min	Δ	Before	1 min	3 min	5 min	Δ
AB1	4.42	5.15	4.74	5.52	1.10	4.55	4.53	4.96	5.62	1.07
AB2	5.27	4.79	5.44	5.42	0.15	3.91	4.96	5.10	5.10	1.19
AB3	3.90	4.93	5.85	5.22	1.32	4.80	4.85	5.27	4.86	0.06
AB4	4.29	4.69	4.98	5.27	0.98	3.81	4.47	4.73	5.01	1.20
AB5	4.74	5.15	5.88	5.25	0.51	5.00	5.01	5.17	5.67	0.67
AB7	3.92	4.15	4.49	4.56	0.64	3.88	3.83	3.70	4.10	0.22
AB8	4.83	4.57	5.00	4.64	-0.19	4.44	4.54	4.54	4.21	-0.23
AB9	3.87	4.89	5.24	5.32	1.45	4.31	4.81	4.91	4.52	0.21
Mean	4.41	4.79	5.20	5.15	0.75	4.34	4.63	4.80	4.89	0.55
±SD	0.51	0.33	0.50	0.35	0.57	0.44	0.38	0.50	0.59	0.56

There was a statistically significant difference in glucose concentration before the start of the test and on the 3rd min after its end (P> 0.0028, Kruskal-Wallis test) and before the start of the test and on the 5th min after its end (P> 0.0028, Kruskal-Wallis test) in December, but the concentrations do not differ statistically during April (Figure 6).

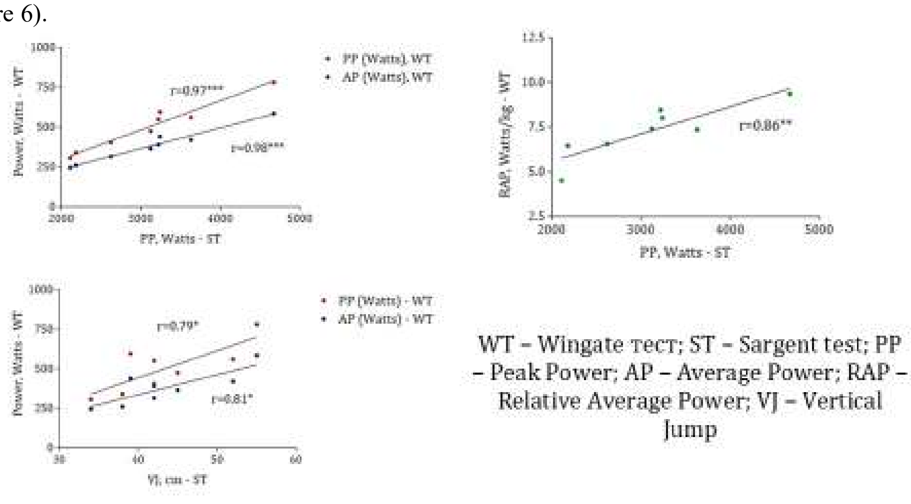

Figure 6. Correlation dependencies between the parameters from the Wingate and Sargent tests.

Correlations were found between the Sargent vertical jump test and the Wingate test. These tests were designed to assess the strength of the athlete's lower limbs. There was a strong correlation between the maximum ($r = 0.97$, $p < 0.001$), the average ($r = 0.98$, $p < 0.001$) and the relative average power ($r = 0.86$, $p < 0.006$) of the Wingate test and the maximum power calculated using the Sayers formula, and between the maximum ($r = 0.79$, $p < 0.02$) and the average power ($r = 0.81$, $p < 0.02$) of the Wingate test and the vertical jump height (Figure 6).

Dicussion

On the second visit, one of the subjects did not come due to illness, so the analysis of changes was commented on for eight of them. Since the study subjects are children, their anthropometric data are not constant and as expected in the second measurement, they have changed. They are in a state of growth and development at the moment. These data could be used to track the changes of body height, weight and composition as a result of normal growth and development and as a result of training. Although there is no statistically significant difference between the two measurements (Mann Whitney test), the table 1 clearly shows that only 3 of the subjects did not change their height, and all changed their weight. With the exception of one all have gained weight. These changes also led to a change in BMI, which is directly dependent on height and weight.

A number of studies have shown that body fat mass does not affect the performance of adult alpine skiers (Vermeulen, et al., 2017) and children (Lešnik & Žvan, 2014). A study involving the best alpine skiers (Neumayr, et al., 2003) showed that there was no relationship between anthropometric indicators and performance during a race, as endurance, strength, speed, flexibility and coordination, as well as psychological factors, were more important. such as motivation, concentration and ability to overcome stress.

To date, Wingate anaerobic laboratory test with a bicycle ergometer has been accepted as the gold standard for determining anaerobic capacity. During the test, children rotate the pedals at constant resistance for 30 seconds. The test requires a combination of phosphoryl, glycolytic and aerobic power. Peak power (PP) corresponds to the ability of a muscle to produce short-term mechanical power (peak phosphoryl power), while mean power (AP) best represents the glycolytic power of the legs. Some authors propose shortening the Wingate test for children and conducting it instead of 30 seconds for 20 seconds (Chia et al., 1997), the reason being that children work mainly in aerobic mode, even at high intensity loads.

The analysis of the data shows that the subjects increased their peak power, although there was no statistically significant difference (Wilcoxon signed rank test, $p = 0.25$). The differences of average power between the two tests were highly statistically significant (Wilcoxon signed rank test, $p = 0.02$). The relative average power also did not differ statistically in the two tests (Wilcoxon signed rank test, $p = 0.05$). The individual analysis of the data showed that all the athletes increased their maximum power in April, compared to December. The average power of the study participants also increased in the second measurement. However, the relative average power in two of the subjects decreased in the second measurement. This parameter depends on the weight of the subject. The two participants with a decrease in the relative average power changed their weight significantly in April (increased by an average of 2 kg), which also affected the power.

Correlations were found between muscle mass and maximum, average, and relative power, respectively (Figure 1) as we found in our previous study (Hadzhiev & Dzimbova, 2020). This relationship was expected because power depends directly on the amount of muscle mass.

Some important features between children and adults and their responses to physical activity indicate that children have not matured enough. The biggest differences were related to the anaerobic energy generation, with children having serious functional disadvantages compared to adults when performing heavy (supramaximal) loads with a duration of 10 to 60 s. At an early age, both boys and girls have significant similarities, but they develop functionally better during adolescence, leading to better athletic performance. Average power and fatigue index (the difference between the maximum and minimum Wingate test power as a percentage of maximum power) indicate the capacity of the glycolytic system, especially in combination with measurement of post-loading blood lactate concentration (Lee, 1993). In the study group, the fatigue index increased at the second measurement compared to the December (Table 2). Only in two of the persons this index decreased. This is probably due to the heavy training and racing program over the past period and the large amount of fatigue accumulated in the athletes. There was no correlation between the fatigue index and the muscle mass of the study participants.

A number of studies aim to find a link between muscle strength and ranking during a race (Bacharach & Petelin von Duvillard, 1995; Muira, 2015). There are two different ways to evaluate the ranking of alpine skiing athletes. Internationally, FIS points were obtained by the Slalom (SL) and Giant Slalom (GS) racing scores. The higher the athlete's ranking, the fewer points (the best is zero points). Only one of those subjects competes internationally and receives points from the International Ski Federation. All other competitors are promising skiers at the national level and the formation of the points on which they qualify are regulated by an ordinance for conducting competitions in alpine skiing disciplines for the 2018/2019 season of the Bulgarian Ski Federation. This ordinance also defines the way to obtain points for the Cup of Bulgaria and the Cup of Hope, which the participants in the study are competing for. Information about the ranking of the athletes was obtained from the site of the Bulgarian Ski Federation (https://www.bfski.com/article/735) and in the study group we have a winner of the Cup of Bulgaria for women, winner of the Cup of Hope for older boys and winner of the Hope

Cup for young girls. The individual points of the subjects, received by the Bulgarian Ski Federation were presented in Table 2.

The result confirms previous results for a link between average power and slalom and giant slalom (Muira, 2015) rankings at a national level. This result showed that Alpine skiers must have maximum power to compete at national level.

Veicsteinas et al (1984) and Saibene et al (1985) investigated the relative contribution of energy during downhill skiing. Both groups of researchers reported that 65% of the energy contribution during the ski race was at the expense of the anaerobic system, and suggested that the workload should focus on energy production and neuromuscular coordination. In addition, they determined lactate concentration in the blood and energy metabolism, assuming that the lactate concentration of 1 mmol/l in the blood corresponds to 3.15 mlO_2/kg (Saibene et al., 1985; Veicsteinas et al., 1984) .The authors warned that this equation includes some errors and some conditions such as altitude and load intensity could also contribute to wrong results(Saibene et al., 1985; Veicsteinas et al., 1984). Both groups of researchers Veicsteinas et al (1984) and Saibene et al (1985) concluded that the contribution of anaerobic energy was greater than the aerobic contribution to alpine skiing. It was also suggested that greater aerobic power led to a greater reduction in the load on the neuromuscular system and thus reduced dependence on anaerobic power and energy production.

Blood lactate levels could be used to determine metabolic acidosis and the degree of contribution of energy systems during exercise (Turnbull et al., 2009). In this study, blood lactate concentrations reached their highest value at 5^{th} min after the test in December and April and were respectively 11.76 ± 1.28 mmol/l and $11.83 \pm 2{,}16$ mmol/l (Figure 1). After giant slalom, on the contrary, blood lactate concentrations reached their maximum value on 3^{rd} min (Polat, 2016). During the race, the lactate concentrations of the athletes were about 74% of those measured in the lab. Lactate concentration values measured after a giant slalom race showed that anaerobic contribution was high during such a race. A previous study reported that Italian national racers had a blood lactate concentration of 9.0 mmol/l after a giant slalom race with an average duration of 82 s. Karlsson et al (1978) reported that Swedish elite skiers had concentrations of 13.0 mmol/l lactate after a giant slalom that averaged 93 s. Elite alpine skiers had been found to have higher levels of blood lactate concentrations than lower-class skiers.

As skiing competitions are mostly organized at high altitudes, the amount of lactate accumulated by skiers during a giant slalom could be further increased due to the hypoxic environment (Saibene et al., 1985). Aerobic metabolism had also been reported to be impeded by vascular occlusion resulting from isometric contractions during skiing (Turnbull et al., 2009). This occlusion leads to a greater increase in lactate production, as in the hypoxic environment at high altitudes. Cold and hypobaric hypoxic environment causes shrinkage of the alveoli and arterial oxygen pressure. When a load done under these circumstances was compared to the same load done at a lower altitude and a higher temperature, the glycolytic indices show a greater increase and glycogen storage showed a greater decrease, which led to a greater difficulty for the anaerobic system (Roberts, 2005; Seifert et al., 2005). In addition, it has been reported that prolonged muscular contractions and high knee flexion, which are typical of ski racing, caused a decrease in VO_2max.

The blood perfusion of the active muscles decreased due to a greater decrease in blood volume, an increase in lactate accumulations and disproportionately high heart rates. This situation had been reported to result in muscle ischemia and higher dependence on anaerobic metabolism (Turnbull et al., 2009). Although the major success factor in giant slalom is anaerobic capacity, alpine skiers should be encouraged to have higher VO_2max levels (Spirk, et al., 2012). An effective aerobic system had been reported to be important for recovery between each cycle and between long and tiring races and to ensure continuity in snow training (Neumayr, et al., 2003).

A correlation between fatigue index and lactate concentration (Pearson $r = 0.75$, $P = 0.03$) at 5^{th} min after exercise in April shows that, as a result of heavy training and racing activity, increased lactate concentration had a strong effect on fatigue. In this case, lactate is one of the main determinants of lowering the load result.
A statistically significant difference in glucose concentration before the test and on the 3^{rd} min after its end ($P > 0.0028$, Kruskal-Wallis test) and on the 5^{th} min after its end ($P > 0.0028$, Kruskal-Wallis test) in December, but the concentrations do not differ statistically during April could be associated with greater efficiency of glycolytic processes in athletes (Stolecka-Warzecha et al., 2016) although there is little data in the literature on how glucose concentration changes after a supramaximal test, such as the Wingate Test. In one study (Vincent, et al., 2004), results showed that plasma glucose concentrations increased after the Wingate test, with a significantly greater increase in women than in men.

On the second visit in April, we conducted a Sargent vertical jump test (Suppl. Table 3). The idea for the test was provoked by literature that we have collected in the meantime, although there is a slight correlation between the height of the jump and the results during a race. The Sargent Vertical Jump Test (Sargent, 1921) showed a weak correlation with the results of competitions in the group of athletes. The dependence of the jump height and points of the ranking ($r = 0.44$) and the jump power and points ($r = 0.62$), though was not as significant, but still exists. Weak correlations have been found in the past between the performance of the alpine skiers and the results of the test (Andersen et al., 1990). The authors noted that in vertical jumps, plantar flexion of the ankle is a large part of the overall movement. Plantar flexion is quite limited and is not allowed to this extent, since the alpine skier has solid ski boots on his feet. This limited range of motion could greatly affect the mechanics of jumping and therefore the ultimate achievement. This test showed a poor ability to predict the performance of an alpine ski racer. But its results correlated well with the results of Wingate test (Suppl. Figure 5). The existence of such a strong correlation between the results of the two tests shows that they give an equally good idea of the anaerobic power of the subjects. Despite the limitations of the Sargent test in that sport, it is very easy to conduct and could be used successfully to evaluate the explosive power of alpine skiers.

Conclusions

As a result of the study, several main conclusions could be drawn:

The subjects changed, albeit slightly, their anthropometric indicators: height, weight and BMI over a period of 4 months; As a result of training and competitions, participants in the study increased their average power during the period between the two tests ($p = 0.02$); There are significant correlations between muscle mass and maximal power (December - 0.93 ***, April - 0.84 **), average power (December - 0.90 **, April - 0.87 **) and relative power (December - 0.73 *, April - 0.62 *; *** - $p < 0.001$; ** - $p < 0.03$; * - $p < 0.05$; ns - $p > 0.05$); Moderate correlations were found between the maximum and average power of the Wingate test and the state level ranking of the subjects studied; The fatigue index of the subjects increased at the second measurement, probably as a result of the busy training and competition program; Blood lactate concentrations peaked at 5 minutes during the maximum test in December and April and were 11.76 ± 1.28 mmol / l and 11.83 ± 2.16 mmol / l, respectively. confirms the literature; Correlations were found between the Vertical jump test and the Wingate test. Despite the limitations of the Sargent test in the sport, it is very easy to conduct and could be used successfully to evaluate the explosive power of alpine skiers.

The conducted research shows that training and competitions in alpine skiing disciplines enable the development of anaerobic capacity of athletes. From the analyzed results, it is clear the great importance of the anaerobic abilities of the athletes for better performance during the competition. The findings of the study will be used to track the development of athletes as they are expected to enter their periodic functional studies.

Conflicts of interest. The authors declare that there is no conflict of interest.

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