GÜSBD 2024; 13(1): 506 - 513 | **Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi** | **Araştırma Makalesi**
GUJHS 2024; 13(1): 506 - 513 | Gümüşhane University Journal of Health Sciences | Original Article

Slalom ve Büyük Slalom Sporcularına Uygulanan İnterval Antrenman Programının Aerobik ve Anaerobik Performans Üzerine Etkisinin İncelenmesi

The Analysis of the Effects of Interval Training Program on Aerobic and Anaerobic Performance in Slalom and Giant Slalom Athletes

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ABSTRACT

The aim of this study is to analyze the effects of interval training on the aerobic and anaerobic performance of elite-level athletes in slalom and giant slalom disciplines. The study consisted of thirteen male athletes voluntarily in the alpine skiing discipline (slalom-giant slalom). The heights of the athletes were measured with a stadiometer with a precision of ±1mm (Holtain, UK). Weight measurements were conducted using a Tanita brand body composition analyzer (BC, 418 Tanita, Japan) with a precision of 100 grams. For aerobic power and capacity testing, a breath-by-breath measurement method was employed using the Cosmed K5 portable gas analysis system (Italy). The VO_2max protocol was performed on a cycle ergometer, and the anaerobic power and capacity test were conducted using the Wingate method. An Independent Samples T-Test was used to identify differences between pre-test and post-test values of athletes. Significant relationships were found between pre-test and post-test values of VO_2max, peak power, average power, and power drop percentage for slalom and giant slalom athletes subjected to interval training ($p<0.05$). No significant changes were observed in peak power attainment time and lowest power between pre-test and post-test values for other parameters ($p>0.05$). In conclusion, interval training was observed to increase body muscle mass, reduce body fat percentage, and enhance aerobic and anaerobic capacity in slalom and giant slalom athletes. Including interval training in the content of athletes' training programs when creating annual training plans is considered to positively influence aerobic and anaerobic performance using the interval training method.

Keywords: Alpine Skiing, Aerobic/Anaerobic Performance, Interval Training

ÖZ

Bu araştırmada slalom ve büyük slalom branşlarındaki elit düzeyde yer alan sporculara uygulanan interval antrenmanın aerobik ve anaerobik performans üzerine etkilerinin araştırılması amaçlanmıştır. Araştırmaya alp disiplini (slalom-büyük slalom) branşları kapsamında 13 erkek sporcu gönüllü katılım sağlamıştır. Sporcuların boyları (Holtain, UK) stadiometre ile ölçülmüştür. Sporcuların vücut ağırlıkları ölçümü, BKI değerlerinin ölçümü Tanita marka (BC, 418 Tanita, Japan) 100 gram hassaslığındaki vücut kompozisyon analizörü ile yapılmıştır. Sporcuların aerobik güç ve kapasite testi için, ölçümlerde breath-by-breath (nefesten nefese otomatik taşınabilir gaz analiz sistemi Cosmed K5, İtalya) kullanılmıştır. VO_2max protokolü bisiklet ergometresinde gerçekleştirilmiş olup, anaerobik güç ve kapasite testi ise Wingate ile yapılmıştır. Sporcuların ön test ve son test değerleri arasındaki farklılığı bulmak için T-Testi (Independent Samples T-Test) kullanılmıştır. Slalom ve büyük slalom sporcularına uygulanan interval antrenmanlarının ön test ve son test değerleri VO_2max, zirve güç, ortalama güç, güç düşüş yüzdesi arasında anlamlı ilişki olduğu tespit edilmiştir ($p<0,05$). Diğer parametrelerde zirve güce ulaşma süresi ve en düşük güç ön test son testlerinde anlamlı bir değişim gözlemlenmemiştir ($p>0,05$). Sonuç olarak interval antrenmanın slalom ve büyük slalom sporcularında vücut kas kütlesini artırarak vücut yağ yüzdesinin azalttığı ayrıca aerobik ve anaerobik kapasiteyi artırdığı gözlemlenmiştir. Yıllık antrenman planlaması oluşturulurken sporcuların antrenmanlarının içeriğinde interval antrenmanlarına da yer verilmesi, interval antrenman metodu ile aerobik ve anaerobik performanslarını olumlu yönde etkileyeceği düşünülmektedir.

Anahtar Kelimeler: Alp Disiplini, Aerobik/Anaerobik Performans, İnterval Antrenman

Çalışmaya ait etik kurul izni, Erzurum Teknik Üniversitesi Etik Kurulu'ndan 06 nolu ve 09.11.2023 tarihli kararla alınmıştır.

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Geliş Tarihi / Received: 28.12.2023
Kabul Tarihi/Accepted: 26.03.2024

INTRODUCTION

Alpine skiing competitions consist of two technical races, slalom and giant slalom, which vary based on speed, course length, gate placements, and turn radii, as well as two speed races, downhill and super-giant slalom. Technical races, slalom and giant slalom, are races performed on a steeper slope at a slower pace, where athletes can reach speeds of 20-60 km/h. Speed races, downhill and super-giant slalom, are races where athletes can reach speeds of up to 130 km/h by following the fall line. [1, 2]

Sports scientists, conditioning experts, and coaches constantly seek new training methods to enhance the performance of athletes and address health-related factors associated with a sedentary lifestyle. Due to the presence of various components in training and the need for individualized preparation to improve each athlete's performance, different training methods exist based on the motor skills targeted for improvement. One of the methods that has attracted attention from sports scientists and is frequently preferred by coaches is high-intensity interval training (HIIT).

High-intensity interval training is defined as the combination of exercise periods with different intensities and static and dynamic rest intervals.[3] Although the history of high-intensity interval training dates back to the early 20th century, research on the topic has increased in recent times [4-6]. High-Intensity Interval Training not only improves physiological parameters and performance but also attracts the attention of sports scientists by defining training protocols that involve athletes sustaining performance above 90% of VO_2max for an extended period. [7]

Increasing evidence suggests that interval training is a more effective alternative to traditional endurance training. [8] Studies have observed that interval training stimulates an increase in anaerobic enzymes and more efficient utilization of lactate, the primary energy source during exercise. [9] High aerobic and anaerobic performance is considered a key factor for success in many sports. [10, 11]

In the sport of skiing, which requires endurance and emphasizes both aerobic and anaerobic oxygen utilization, interval training is particularly relevant. Although there are studies in the literature examining the effects of high-intensity interval training on physical and physiological performance. [12-14] There is limited research specifically investigating the effects of high-intensity interval training in different forms within the alpine skiing discipline. In this regard, there is a lack of studies focusing on the specific application of high-intensity interval training in the context of alpine skiing.

Considering the nature of the sport and the importance placed on aerobic and anaerobic performance, which are crucial aspects of alpine skiing, the current study is expected to contribute to the literature by offering alternative methods for the rapid improvement of these performance aspects through interval training. This is particularly relevant as it aligns with the inherent priorities of coaches within the alpine skiing discipline. The current study analyzed the effects of the interval training, where loading and rests were adjusted based on heart rate intervals, applied to slalom and giant slalom athletes on aerobic and anaerobic performance parameters.

MATERIAL AND METHOD

The study consisted of thirteen male athletes in the age average volunteer 16-22, participating in the alpine skiing disciplines of slalom and giant slalom. Descriptive statistics for the participants are presented in Table 2. After providing the participants with necessary information about the tests to be conducted, voluntary consent forms were signed. The inclusion criteria for participants in the study were the absence of any known illnesses or health issues, the ability to perform the performance tests planned for the study, and voluntary willingness to participate.

Procedures

All performance tests for the athletes were conducted at the Atatürk University Sports Sciences Application and Research Center. Aerobic/anaerobic power values of athletes were measured twice, before and after a 4-week interval training program. Aerobic capacity was measured on the first day of the tests and anaerobic capacity was measured on the second day. To determine the aerobic capacities of the athletes, a breath-by-breath automatic portable gas analysis system (Cosmed K5, Italy) was used. The VO_2max protocol was performed on a cycle ergometer. For the determination of the aerobic capacities of the athletes, a test protocol was applied on a cycle ergometer starting at 50 watts after a 2-minute warm-up at the same resistance. The test started at 50 watts and increased by 0.5 watts every second (30 watts per minute). The cycling speed (rpm) was maintained at 85-90 rpm. The test was terminated if the athlete remained below 80 rpm for more than 10 seconds.[15]

The Wingate Anaerobic Power and Capacity Test (Wingate 894E) for the athletes were conducted against a resistance equivalent to 7.5% of the player's body weight, aiming to achieve the highest possible maximal voluntary pedal speed for a duration of 30 seconds. A 5-minute warm-up protocol was applied to the athletes, including two or three sprints of 4-8 seconds duration, at a pedal speed of 60-70 rpm, with 20% of the test loads calculated on the bicycle ergometer. After the warm-up, passive rest was given for 3–5 minutes. The anaerobic power was recorded as the highest relative power value exhibited by the athletes within the 30-second period, and the average relative power displayed during the 30 seconds was recorded as anaerobic capacity. These values were recorded by computer software. [14, 16]

Ethical Aspects of Research

The study was carried out in accordance with the Declaration of Helsinki. In addition, the method of this study was in conformity with the framework of "Higher Education Institutions Scientific Research and Publication Ethics Directive." Ethics committee approval of the study was obtained from Erzurum Technical University, Scientific Research and Publication Ethics Committee (09.11.2023-06 numbered article).

Acknowledgments

I would like to thank the Atatürk University Athlete Performance Measurement, Evaluation and Rehabilitation Center for the measurements of the study. In addition, I would like to thank Prof. Dr. Fatih Kıyıcı and Serhat Aktaş who contributed to the measurements of the study.

Tablo 1. Content of High-Intensity 4-Week Interval Training Program

Week	The intensity of training	The frequency of training	Monday	Bicycle Ergometer (15 min Warm-up) -Streching	Wednesday	Bicycle Ergometer (15 min Warm-up) -Streching	Friday	Sprint (15 dk Warm-up -Streching)
1st week	Maximum 4th Zone Heart Rate Range	3 times a week	2x40 m 2x50 m 2x100 m 2x 200 m 2x400 m		8x1 min.Sprint		1x1200 m 1x1000 m 1x800 m 1x600 m 1x400 m	
2nd week	Maximum 4th Zone Heart Rate Range	3 times a week	1x1200m 1x1000m 1x800m 1x600m 1x400m		9x1 min.Sprint		2x40 m 2x50 m 2x100 m 2x 200 m 2x400 m	
3rd week	Maximum 4th Zone Heart Rate Range	3 times a week	2x40 m 2x50 m 2x100 m 2x 200 m 2x400 m		9x1 min.Sprint		1x1200m 1x1000m 1x800m 1x600m 1x400m	
4th week	Maximum 4th Zone Heart Rate Range	3 times a week	1x1200m 1x1000m 1x800m 1x600m 1x400m		10x1 min.Sprint		2x40 m 2x50 m 2x100 m 2x 200 m 2x400 m	

***Note**: Loading and rest intervals are performed based on the athletes' heart rate ranges.*

Analysis

SPSS 26.0 software package was used for the analyses. Descriptive statistics were utilized in the data analysis, and the results were presented as mean ± standard deviation. A significance level of $p < 0.05$ was accepted. To determine the differences between the pre-test and post-test values of the groups, Independent Samples T-Test analysis was employed.

RESULTS AND DISCUSSION

Tablo 2. Descriptive Information About the Participants

Variables	Tests	N	Mean	Std. Deviation	Std. Error Mean	Min	Max
Year	Pre-test	13	18,23	2,00	0,55	16	22
	Post-test	13	18,38	1,98	0,54	16	22
Body weight (kg)	Pre-test	13	70,41	11,41	3,16	52	86,3
	Post-test	13	69,25	12,00	3,32	54,3	84,6
Height(cm)	Pre-test	13	172,92	6,99	1,93	168	184
	Post-test	13	174,15	6,64	1,84	168	184
BMI (kg/m^2)	Pre-test	13	23,49	2,67	0,74	20,6	28,4
	Post-test	13	23,26	3,02	0,83	20	26,2
BFP%	Pre-test	13	13,42	5,36	1,48	4,99	16,25
	Post-test	13	12,94	5,03	1,39	5,09	16,3

BMI: Body Mass Index BFP: Body Fate Percente

The descriptive characteristics of the 13 elite athletes participating in the study indicates that their ages were 18.23 ± 2 years, body weights were 65.73 ± 10.79 kg, heights were 172.92 ± 6.99 cm, and body mass indices were on average 22.91 ± 2.80 kg/m^2 (Table 2).

Tablo 3. Descriptive Statistics of Athletes' VO_2max Wingate Test Results Before and After the Training

Variables	Tests	N	Mean ± SS	Mean Differences	t	p
VO_2max	Pre-test	13	52,11± 3,98	-1,03	-3,83	**0,002***
	Post-test	13	53,14±3,72			
TPP (ms)	Pre-test	13	1,41± 0,47	0,22	2,22	0,05
	Post-test	13	1,19± 0,22			
PP (w/kg)	Pre-test	13	13,22± 1,68	-1,45	-6,04	**0,000****
	Post-test	13	14,68± 1,99			
AP(w/kg)	Pre-test	13	8,45± 1,23	-1,25	-5,81	**0,000****
	Post-test	13	9,7± 1,02			
MP(w/kg)	Pre-test	13	4,87± 1,04	-0,52	-1,86	0,09
	Post-test	13	5,39± 0,82			
PD (%)	Pre-test	13	62,42±8,08	6,67	4,86	**0,000****
	Post-test	13	55,75± 6,25			

***p<0,01 *p<0,05*
TPP [ms]: The time it takes for the athlete to reach peak power. PP [w/kg]: The peak power achieved by the athlete during the test.AP [w/kg]: The average power applied by the athlete during the test.MP [w/kg)]: The minimum power reached by the athlete during the test.PD [%]: The percentage of power loss by the athlete during the test.

The test results for VO_2max and anaerobic performance parameters before and after the 4-week training period applied to the athletes are provided in Table 2. The current study revealed the athletes' VO_2max pre-test (52.11 ± 3.98), post-test (53.14 ± 3.72), time to reach peak power pre-test (1.41 ± 0.47), post-test (1.19 ± 0.22), peak power pre-test (13.22 ± 1.68), post-test (1.19 ± 0.22), average power pre-test (8.45 ± 1.23), post-test (9.7 ± 1.02), minimum power pre-test (4.87 ± 1.04), post-test (5.39 ± 0.82), power drop percentage pre-

test (62.42 ± 8.08), post-test (55.75 ± 6.25). The analysis of the relationship between aerobic and anaerobic performance parameters before and after the pre-test and post-test indicated a significant relationship for VO_2max, peak power, average power, and power drop percentage ($p < 0.05$). In the other parameters, no significant change was observed in time to reach peak power and minimum power between pre-test and post-test ($p > 0.05$).

The current study analyzed the effects of the interval training, where loading and rests were adjusted based on heart rate intervals, applied to slalom and giant slalom athletes on aerobic and anaerobic performance parameters. The findings obtained revealed a statistically significant increase in aerobic performance parameters, specifically in VO_2max and anaerobic performance parameters, based on the pre-test and post-test results of the interval training method.

In this study, the average weights of the study groups were measured as 70.41 ± 11.41 kg before training and 69.25 ± 12 kg after training, indicating a decrease of 1.64% when evaluated percentage-wise. A study applying 6-week running-based high-intensity interval training to physically active individuals recorded weight reductions [17]. Another study implementing a 6-week high-intensity interval training program for mountain bikers reported weight loss among the participants. [18] The findings obtained from the literature review align with the observed decrease in body weight parameters in the experimental groups of the current study. There was no significant difference in BMI values between pre-test and post-test measurements for the groups. The BMI value was 23.49 ± 2.67 in the pre-test, and it measured 23.26 ± 3.02 after the training. The lack of difference in BMI tests between pre-test and post-test is considered to result from participants continuing their regular training. When examining the body fat percentage variable, a decrease of 3.57% was observed between pre-test and post-test values for the study groups. A 7-week interval training study on inactive young individuals reported a significant decrease in body fat percentage. [19] Another study investigating the effects of different forms of high-intensity interval training on body fat percentage reported that high-intensity interval training is highly effective in reducing body fat percentage.[20] The observed decrease in body fat percentage in the experimental groups of this study aligns with the findings obtained from the literature review.

While studies investigating the impact of high-intensity interval training on athletic performance exist in the literature [14, 21, 22], the studies are still conducted by sports scientists to explore applications of high-intensity interval training in different forms for achieving optimal performance. In a study, as a result of two-week high intensity interval training, significant increases were found in percentage terms such as VO_2max (4.44%), PeakVo2 (8.09%), and TTE (7.4%) at the end of 2 weeks. [23] It has been indicated that high-intensity interval training improves aerobic capacity, and various studies have suggested that this method could be an alternative to continuous aerobic training. [6, 24-27] In a study, 21 moderately active university students, both male and female, were subjected to high-intensity interval training for eight weeks, resulting in a statistically significant increase in VO_2max after the eight weeks. [14] Another study applied high-intensity interval training and repeated sprint training to taekwondo athletes, and the findings indicated a 17.01% improvement in VO_2max values for the high-intensity interval training group. [28] Similarly, in a study with 52 male soccer players undergoing 8 weeks of high-intensity interval training and repeated sprint training, the group that underwent high-intensity interval training displayed a 5.83% improvement in VO_2max values. [29] Elite alpine skiers require both aerobic and very high levels of anaerobic power, ranging from moderate to high levels. [30] The results of the current study align with the literature, suggesting that the data obtained in terms of aerobic performance are similar. An increase in VO_2max levels is considered crucial in terms of improving aerobic capacity, which holds significance in the field of exercise science. The increase in VO_2max levels is believed to enhance the

athlete's ability to sustain intense effort with the interval training method and improve their endurance level. The percentage of maximum oxygen consumption at the anaerobic threshold, occurring at a high percentage of maximum, indicates that alpine skiers are well-trained, utilizing their endurance capacity significantly.

High-intensity interval training (HIIT) is a training method characterized by short-duration high-intensity efforts followed by brief rest intervals, typically ranging between 45 seconds and 2-4 minutes. The current study focuses on the effects of short-duration supramaximal efforts. [7] Compared to traditional aerobic exercises, HIIT has gained significant interest for being more time-efficient, offering better performance and health improvements for both athletes and sedentary individuals. [7, 31] The studies that analyze the different forms of HIIT have reported improvements in anaerobic performance. For instance, it was concluded in one study that professional soccer players enhanced anaerobic performance as a result of an 8-week HIIT program supported by additional strength training twice a week. [32] In the current study, the Wingate test was used to measure and assess the anaerobic capacity of skiers. The test was conducted twice, before and after the study. Another study examining the impact of HIIT on anaerobic performance in soccer players reported significant improvements in vertical jump values, an indicator of anaerobic performance. [33] In a study with recreational active males, participants experienced significant increases in peak power and average power values after HIIT. [34] Similarly, in a study with male handball players, HIIT significantly improved anaerobic power. [35] The findings of the current study align with the literature regarding anaerobic performance parameters. Comparisons between anaerobic parameters within groups reveal that the performance variables obtained after interval training have a significantly positive effect on peak power, average power, and power drop percentage. Although the time to reach peak power shows no significant changes, a decrease in this duration is observed. For athletes with delayed time to reach peak power, explosive strength training is recommended. Additionally, an increase in the lowest power parameter is observed, although it is not statistically significant. In general, the determination of interval durations is based on the time it takes for an individual to complete the targeted running distance. For a sprinter covering 100m in 11 seconds, the designated time for this distance may range between 12-13 seconds. Similarly, for an athlete completing 400m in less than 50 seconds, the 100m distance can be set at 14-15 seconds. [36] When examining the durations of slalom and giant slalom races, which range from 40 to 120 seconds, and considering the average heart rate, they correspond to Zone 4 anaerobic threshold training. Based on this, it is suggested that the durations and heart rate intervals of slalom and giant slalom races are equivalent to 400m sprint races.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the current study revealed that interval training increases muscle mass and reduces body fat percentage in individuals engaged in alpine skiing. Additionally, it enhances both aerobic and anaerobic capacity. Adapting these methods and variables to enhance both aerobic and anaerobic capacity. Adapting these methods and variables to be specific to athletes and sub-disciplines within skiing could positively impact athletic performance outcomes. Furthermore, it is significant to compare the effects of interval training in different forms on both land and snow (on the slopes). Based on this information, it is recommended that athletes receive new training programs for performance improvement, and coaches explore various planning approaches to enhance athlete development and performance.

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