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The Evaluation of Physical Performance Test Parameters of Alpine Snowboarders with Competition Scores

Alpine Snowboard Branşı Sporcularının Fiziksel Performans Test Parametrelerinin Yarışma Sonuçları ile Değerlendirilmesi

Buket SEVİNDİK AKTAŞ[1]
Erzurum Technical University, Faculty of Sports Sciences, Department of Coach Education, Erzurum, Türkiye

Fatih KIYICI[2]
Atatürk University, Faculty of Sports Sciences, Department of Coach Education, Erzurum, Türkiye

Kamber KAŞALİ[3]
Atatürk University, Faculty of Medicine, Basic Medical Sciences, Erzurum, Türkiye

ABSTRACT

The aim of the study is to analyze and compare the relationship between anaerobic power, isokinetic leg muscle strength and balance parameters and competition results of snowboarding athletes competing in national team selections. The study included 12 athletes (male and female) in the snowboarding branch with mean age of males and females of 20±1.29-20±1.41 years, mean height of 174.43±6.75-160.4±5.41 cm, mean body weight of 67.40±6.11-57.08±4.83 kg, body mass index of 22.17±1.88-22.22±1.95 kg/m2, and body fat percentage of 10.08±3.7-20.19±4.18. The heights of the athletes were measured using a Holtain (UK) stadiometer and their body weights were determined using BC, 418 Tanita (Japan). Anaerobic power and capacity tests were performed through the Wingate test, and IsoMed 2000® isokinetic strength device was used for strength measurements. Balance tests were performed with six different types of Sportkat 4000 device. The relationship between anaerobic capacity, isokinetic muscle strength, balance parameters and competition results was determined via Spearman correlation test. The study revealed highly significant correlations between the participants' anaerobic power and lower extremity muscle strength and the competition results *(p<.05).* No significant relationship was observed between the participants' balance parameters and the competition results (*p*>.05). The study concluded that certain physical performance of snowboarding athletes with different competition scores is related to anaerobic capacity and lower extremity muscle strength. It is thought that evaluating motoric characteristics in the national team selection criteria would be a correct decision. In the development of athletes' performance, their knowledge levels regarding anaerobic capacity, muscle strength and balance parameters should be increased.

Keywords: Anaerobic power, balance, muscle strength, snowboard

ÖZ

Bu çalışma, milli takım seçmelerinde yarışan snowboard sporcularının anaerobik güç, izokinetik bacak kas kuvveti ve denge parametreleri ile yarışma sonuçları arasındaki ilişkiyi incelemek ve karşılaştırmaktır. Araştırmaya snowboard branşı kapsamında erkek ve kadınların sırasıyla yaş ortalamaları 20±1,29-20±1,41 yıl, boy uzunluğu ortalamaları 174,43±6,75-160,4±5,41 cm, vücut ağırlığı ortalamaları 67,40±6,11-57,08±4,83 kg, beden kitle indeksleri 22,17±1,88-22,22±1,95 kg/m^2, vücut yağ yüzdesi 10,08±3,7-20,19±4,18 ortalamalarına sahip olan 12 (erkek-kız) sporcu dahil edilmiştir. Sporcuların boyları, Holtain (UK) stadiometre ile ölçülmüş, vücut ağırlıkları BC, 418 Tanita (Japan) ile belirlenmiştir. Anaerobik güç ve kapasite testi Wingate testi kullanılarak yapılmış, kuvvet ölçümleri için IsoMed 2000® izokinetik kuvvet cihazı kullanılmıştır. Denge testleri ise altı farklı türde Sportkat 4000 cihazı ile gerçekleştirilmiştir. Anaerobik kapasite, izokinetik kas kuvveti, denge parametreleri ile yarışma sonuçları arasındaki ilişki Spearman korelasyon testi ile belirlendi. Katılımcıların anaerobik güç ve alt ekstremite kas kuvveti ile yarışma sonuçları arasında önemli ölçüde anlamlı korelasyonlar bulunmuştur *(p*<.05). Katılımcıların denge parametreleri ile yarışma sonuçları arasında anlamlı ilişki bulunamamıştır *(p*>.05*).* Çalışmada, farklı yarışma puanlarına sahip snowboard branşı sporcularının belirli fiziksel performanslarının anaerobik kapasite ve alt ekstremite kas kuvveti ile ilişkili olduğu sonucuna varılmıştır. Milli takım seçme kriterlerinde motorik özelliklerin değerlendirilmesinin doğru bir karar olacağı düşünülmektedir. Sporcuların performanslarının geliştirilmesinde, anaerobik kapasite, kas kuvveti ve denge parametreleri hakkındaki bilgi düzeylerinin artırılması gerekmektedir.

Anahtar Kelimeler: Anaerobik güç, denge, kas kuvveti, snowboard

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Sorumlu Yazar/Corresponding author: Buket Sevindik Aktaş
E-mail:buket.sevindik@erzurum.edu.tr

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Introduction

The sport of snowboarding has grown in popularity as both a recreational winter activity as well as a prominent Olympic sport. Both forms are comprised of one of three different disciplines within the sport: freestyle, alpine, and snowboard-cross. In recent years, the increased professionalism and substantial growth of snowboarding as a global sport has increasingly attracted the interest of exercise physiologists and sport scientists. Given the small (but growing) number of studies that have been published, the research analyzing the physiological and performance characteristics and requirements of snowboarding remains limited. The studies conducted thus far have indicated different requirements of physiological and physical traits dependent upon the specific discipline of snowboarding in question (Vernillo et al., 2018).

As an athletic sport, snowboarding challenges the limits of both physical and technical abilities. The more we understand the physiological demands faced by elite snowboarders, the better we can replicate and enhance these qualities in the athletes. Understanding the muscular forces and energy systems involved in snowboarding is crucial for training prescriptions, performance enhancement, and talent identification. However, for many years, research on snowboarding has primarily focused on injuries (Ishimaru et al., 2012; Wijdicks et al., 2014). The physiological requirements in snowboarding are diverse. Athletes need strength, anaerobic fitness, coordination, and more to prevail in a contest and over an entire season. Other factors such as technique, equipment, or psychology are important as well, but this study analyzed only the physiological variables (Platzer et al, 2009). To evaluate physiological factors, fitness testing in sports is absolutely necessary. Laboratory tests are a useful tool to assess the athlete's general fitness (Platzer et al., 2009; Rimmele et al., 2007; Svensson & Drust, 2005). These data are used to monitor training and for training prescription. Tests should have a relevance to the specific sport and be able to predict performance (Battista et al., 2007; Impellizzeri, et al., 2005)

The aim of this study is to determine whether there is a relationship between the sports performance of elite snowboarders such as anaerobic power, strength and balance parameters. In this regard, the study analyzes the relationship between the gain of isokinetic leg strength, the increase in anaerobic capacity and balance parameters and evaluates the effect of performance results on competition scores. The study is accordingly expected to yield important findings to optimize the performance of athletes and make training programs more effective.

Methods

Ethics approval and consent to participate This study was approved by the institutional ethics committee of Atatürk University Ethics Commission (Date: October 24, 2024, Number: 2024-10 Protocol No: 2400346295) and was conducted at Atatürk University Athlete Performance Measurement Center in accordance with the current version of the Declaration of Helsinki. After explaining the possible risks and benefits that may be encountered during the experimental procedures, a written informed consent form indicating their voluntary participation was obtained from the participants. The participants participated in the study completely voluntarily and were free to withdraw from the study at any time without giving any reason otherwise.

The study included 12 athletes (7 males + 5 females) aged 18-20 in the snowboarding branch. Table 1 indicates the descriptive statistics of the participants. The inclusion criteria for the study were determined as being an active national athlete in their own branch, participating in national team selections, not having any known disease or health problem, and volunteering to participate in the study. Participants were informed that they should not exercise 24-48 hours before the tests and should not consume caffeine for at least 8 hours. These precautions were taken to ensure the reliability of the data obtained. Anaerobic power test and isokinetic leg strength test were applied on different days in a predetermined order. The same test order was applied to all participants, thus minimizing the effect of the order on performance.

Data collection tools

Weight and height scale: The heights of the athletes were measured with a stadiometer with ±1 mm precision (Holtain, UK). The weights of the athletes, the calculation of BMI values and body fat percentages were performed using a Tanita brand (BC, 418 Tanita, Japan) body composition analyzer with 100 gram precision.

Test of Anaerobic Power and Capacity: Measurement of Anaerobic Power Performance: Wingate anaerobic power and capacity test (WanT) was performed at the highest possible maximal voluntary pedal speed against a resistance equivalent to

7.5% of the participant's body weight for 30 seconds. The highest peak power, average power, lowest power and percentage power loss of the participants within 30 seconds were recorded from the computer software as anaerobic capacity (Özkan et al., 2011).

Determination of Isokinetic Muscle Strength: In the study, muscle strength measurement and muscle strength training of the participants were performed using the ISOMED 2000® isokinetic device. The study was performed on the knee joint flexor and extensor muscle groups in the lower extremity. After adjusting the back angle of the device, the shaft of the dynamometer was adjusted so that the pivot point would be the lateral femoral condyle. The support pad of the dynamometer was fixed on the tibia. The trunk, pelvis and hip joint were stabilized with a belt. Screws were attached to the specified areas and ROM was fixed mechanically. After the participants were connected to the device, passive knee flexion-extension was performed and the incidence of discomfort was checked. The knee flexion-extension concentric-concentric movements to be used in the evaluation protocol were determined as one set of five repetitions at 60°/s angular velocity on the dominant leg, and one set of fifteen repetitions at 240°/s and 300°/s angular velocities (Kocahan et al., 2017).

Balance Test: The static and dynamic balance tests of the participants will be measured using the Sportkat 4000 brand device. Both static and dynamic balance tests were performed in a total of 6 different ways: right foot, left foot and double foot.

Performance Analysis in Sports: National team selection results of athletes in the same category were obtained from the snowboard database on the Turkish Ski Federation website (Tanyeri et al., 2017)

Data Analysis

SPSS-26 was used to analyze the data obtained from the study. The obtained data are shown as mean and standard deviation. Visual (histogram, probability graphs) and analytical (Kolmogorov-Smirnov test) methods were used to determine whether the obtained data had a normal distribution. The distribution of the data was evaluated with the Shapiro-Wilk test and Spearman correlation analysis was applied for data that did not show normal distribution. The relationship between anaerobic capacity, isokinetic muscle strength, balance parameters and competition scores were determined by Spearman correlation test. The correlation level was classified as negligible (r =0-0.3), low (r =0.31-0.50), medium (r =0.51-0.70), strong (r =0.71-0.90) and very strong (r =0.91-1.0) (Mukaka, 2012). Statistical significance level was accepted as (*p*<.05).

Results

Table 1.
Descriptive information of athletes

		N	X ±SS	Min.	Maks.
Male	Age (year)	7	20±1.29	18	20
	Height (cm)	7	174.43±6.75	165	184
	Weight (kg)	7	67.40±6.11	59	76
	BMI (kg/m²)	7	22.17±1.88	20	25
	BFP%	7	10.08±3.7	3	15
Female	Age (year)	5	20±1.41	18	21
	Height (cm)	5	160.4±5.41	156	169
	Weight (kg)	5	57.08±4.83	53	65
	BMI (kg/m²)	5	22.22±1.95	20	25
	BFP%	5	20.19±4.18	16	25

The descriptive characteristics of the 12 athletes participating in the study indicated that the male and female athletes had an average age of 20±1.29-20±1.41 years, a height of 174.43±6.75-160.4±5.41 cm, a body weight of 67.40±6.11-57.08±4.83 kg, a body mass index of 22.17±1.88-22.22±1.95 kg/m2, and a body fat percentage of 10.08±3.7-20.19±4.18, respectively (Table 1).

Table 2.
The relationship between anaerobic power of the atheletes and their competition scores.

Wingate	Data	Giant Slalom (sec)	Slalom (sec)	Combined (sec)
PP(W)	r	-0.559	-0.559	-.601 *
	p	.059	.059	.039
AP(W)	r	-.706 *	-.678 *	-.734 **
	p	.010	.015	.007
MP(W)	r	-.699 *	-.727 **	-.720 **
	p	.011	.007	.008
PP(W/Kg)	r	-.797 **	-.825 **	-.790 **
	p	.002	.001	.002
AP(W/Kg)	r	-0.477	-0.460	-0.502
	p	.117	.133	.096
MP(W/Kg)	r	-.759 **	-.812 **	-.766 **
	p	.004	.001	.004
PD (%)	r	0.007	0.056	-0.007
	p	.983	.863	.983

PP [W]: Peak power reached by the athlete during the test. AP [W]: Average power applied by the athlete during the test. MP [W]: Lowest power reached by the athlete during the test. PP [W/kg]: Peak power per kilogram reached by the athlete during the test. AP [W/kg]: Average power per kilogram applied by the athlete during the test. MP [W/kg]: Lowest power per kilogram reached by the athlete during the test. PD (%): Percentage power loss of the athlete during the test. *Correlation is significant at the .05 level (2-tailed), **Correlation is significant at the .01 level (2-tailed)

Table 2 demonstrates the relationships between the anaerobic power parameters of the athletes and the competition scores. The study revealed a negative moderate relationship between the peak power and combined rankings of the participants throughout the test (r_{rho}=-.601; $p<.05$), and a negative moderate relationship between the giant slalom/slalom rankings (r_{rho}=-0.559, r_{rho}=-0.559; $p>.05$), respectively. The study also indicated a negative moderate and strong correlation between the average power applied by the athletes throughout the test and their giant slalom/slalom/combined rankings (r_{rho}=-.706, r_{rho}=-678, r_{rho}=-734; $p<.05$), a negative moderate and strong correlation between the lowest power reached during the test and their giant slalom/slalom/combined rankings (r_{rho}=-.699, r_{rho}=-727, r_{rho}=-720; $p<.05$), and a negative strong correlation between the peak power per kilogram reached by the athletes throughout the test and their giant slalom/slalom/combined rankings (r_{rho}=-797, r_{rho}=-825, r_{rho}=-790; $p<.05$) respectively. A weak negative correlation was additionally observed between the athlete's average power per kilogram applied throughout the test and giant slalom/slalom/combined rankings, respectively (r_{rho}=-0.477, r_{rho}=-0.460, r_{rho}=-0.502; $p>.05$); a strong negative correlation was found between the athlete's lowest power per kilogram reached during the test and giant slalom/slalom/combined rankings, respectively (r_{rho}=-759, r_{rho}=-812, r_{rho}=-.766; $p<.05$). A weak positive and negative correlation was also suggested between the athlete's percentage power loss throughout the test and giant slalom/slalom/combined rankings, respectively (r_{rho}=0.007, r_{rho}=0.056, r_{rho}=-0.007; $p>.05$).

Table 3.
The relationship between the isokinetic leg muscle strength of the athletes and their competition scores.

Endurance	Data	Giant Slalom (sec)	Slalom (sec)	Combined (sec)
Peak Torque Flexion	r	-0.587*	-0.580*	-0.545
	p	.045	.048	.067
Peak Torque Extension	r	-0.776**	-0.783**	-0.762**
	p	.003	.003	.004
Peak Power Flexion	r	-0,567	-0,588*	-0.574
	p	.054	.044	.051
Peak Power Extension	r	-0.762**	-0.804**	-0.769**
	p	.004	.002	.003
Average Torque	r	-0.783**	-0.804**	-0.769**
	p	.003	.002	.003
Average Power	r	-0.790**	-0.832**	-0.797**
	p	.002	.001	.002
Nm/Kg	r	-0.699*	-0.713**	-0.671*
	p	.011	.009	.017
W/Kg	r	-0.748**	-0.811**	-0.755**
	p	.005	.001	.005

*Correlation is significant at the .05 level (2-tailed), **Correlation is significant at the .01 level (2-tailed)

Table 3. demonstrates the relationships between the peak torque values of the participants measured at 60°/sec angular velocity and the competition scores .There was a negative moderate relationship between peak torque flexion 60^{o}/sec dominant giant slalom/slalom rankings, respectively (r_{rho}=-.587, r_{rho}=-.580; p<.05), a negative strong relationship between peak torque extension 60^{o}/sec dominant giant slalom/slalom/combined rankings, respectively (r_{rho}=-.776, r_{rho}=-.783, r_{rho}=-.762; p<.05), a negative moderate relationship between peak power flexion 60^{o}/sec dominant slalom rankings, respectively (r_{rho}=-.588; p<.05), and mean torque 60^{o}/sec dominant giant slalom/slalom/combined rankings, respectively (r_{rho}=-.783, r_{rho}=-.804, r_{rho}=-.769;p<.05). A strong negative relationship was observed between the average power 60^{o}/sec dominant giant slalom/slalom/combined rankings (r_{rho}=-.790, r_{rho}=-.832, r_{rho}=-.797; p<.05); the study also revealed a strong negative relationship between the force (Nm/kg) 60^{o}/sec dominant giant slalom/slalom/combined rankings (r_{rho}=-.699, r_{rho}=-.713, r_{rho}=-.671;p<.05)and a moderate-strong negative relationship between the force (Nm/kg) 60^{o}/sec dominant giant slalom/slalom/combined rankings (r_{rho}=-.748, r_{rho}=-.811, r_{rho}=-.755; p<.05), respectively.

Table 4.
The relationship between the isokinetic leg strength of athletes and their competition scores.

Endurance	Data	Giant Slalom (sec)	Slalom (sec)	Combined (sec)
Peak Torque Flexion	r	-0.762**	-0.804**	-0.776**
	p	.004	.002	.003
Peak Torque Extension	r	-0.720**	-0.755**	-0.706*
	p	.008	.005	.010
Peak Power Flexion	r	-0.692*	0.720**	-0.678*
	p	.013	.008	.015
Peak Power Extension	r	-0.671*	-0.699*	0.664*
	p	.017	.011	.018
Average Torque	r	-0.825**	-0.853**	-0.811**
	p	.001	.000	.001
Average Power	r	-0.790**	-0.839**	-0.783*
	p	.002	.001	.003
Nm/Kg	r	-0.713**	-0.762**	-0.720**
	p	.009	.004	.008
W/Kg	r	-0.804**	-0.832**	-0.797**
	p	.002	.001	.002

*Correlation is significant at the .05 level (2-tailed), **Correlation is significant at the .01 level (2-tailed)

Table 4 demonstrates the relationships between the peak torque values of the participants measured at 240°/sec angular velocity and the competition scores. There was a strong negative correlation was found between peak torque flexion at 240°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.762, r_{rho}=-.804, r_{rho}=-.776; p<.05). and a strong negative correlation between peak torque extension at 240°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.720, r_{rho}=-.755, r_{rho}=-.706; p<.05). A moderately strong negative correlation between peak power flexion at 240°/s and the rankings in the dominant slalom event, respectively (r_{rho}=-.692, r_{rho}=-.720, r_{rho}=-.678; p<.05) and a strong negative correlation between average torque at 240°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.825, r_{rho}=-.853, r_{rho}=-.811; p<.05) were also observed. In addition, the study revealed a strong negative correlation between average power at 240°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.790, r_{rho}=-.839, r_{rho}=-.783; p<.05); a strong negative correlation between force (Nm/kg) at 240°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.713, r_{rho}=-.762, r_{rho}=-.720; p<.05); a strong negative correlation between force (Nm/kg) at 60°/s and the rankings in the dominant giant slalom/slalom/combine events, respectively (r_{rho}=-.804, r_{rho}=-.832, r_{rho}=-.797; p<.05).

Table 5.
Relationship between athletes' balance parameters and competition scores.

		Data	Giant Slalom (sec)	Slalom (sec)	Combined (sec)
Dynamic Balance	Double	r	0.063	0.133	0.070
		p	.846	.681	.829
	Left	r	0.000	-0.014	-0.042
		p	1.000	.966	.897
	Right	r	0.259	0.350	0.315
		p	.417	.265	.319
Static Balance	Double	r	-0.329	-0.350	-0.343
		p	.297	.265	.276
	Left	r	-0.140	-0.098	-0.161
		p	.665	.762	.618
	Right	r	0.126	0.168	0.133
		p	.697	.602	.681

Table 5 demonstrates the relationships between the balance parameters of the participants and the competition scores. A positive and low correlation between the dynamic balance (double-left-right) parameters and giant slalom/slalom/combined rankings, respectively (r_{rho}=0.063, r_{rho}=0.133, r_{rho}=0.070, r_{rho}=0.000, r_{rho}=0.259, r_{rho}=0.350, r_{rho}=0.315 *p*>.05), and a positive and low correlation between the dynamic balance (left) parameters and slalom/combined rankings, respectively (r_{rho}=-0.014, r_{rho}=-0.042) were observed. The study also revealed a negative low correlation between the static balance (double-left) parameters and slalom/giant slalom/combined rankings (r_{rho}=-0.329, r_{rho}=-0.350, r_{rho}=-0.343, r_{rho}=-0.140, r_{rho}=-0.098, r_{rho}=-0.161; *p*>.05), and a positive low correlation between the static balance (right) parameters and giant slalom/slalom/combined rankings (r_{rho}=0.126, r_{rho}=0.168, r_{rho}=0.133; *p*>.05), respectively.

Discussion

This study aims to analyze the relationship between anaerobic power, isokinetic muscle strength and balance parameters of snowboarders competing in national team selections and competition scores. The study suggests a possible significant relationship between performance tests and competition scores. In other words, the success of athletes in competitions is believed to be related to certain physical performance parameters (power, strength, balance). The findings revealed a relationship between anaerobic power and isokinetic muscle strength of snowboarders and their competition scores.

When the scientific literature on the anthropometric characteristics of elite snowboarders is examined, the focus is especially on the athletes' height, body mass, and body fat percentage. According to relevant literature, the average height and body mass of elite male skill-based snowboarding athletes range from 172.6 to 178.4 cm and 63.4 to 73 kg, respectively (Back et al., 2014). In a study conducted on elite Austrian male snowboarders, the reported values were (75.4±9.9 kg) (Gathercole et al., 2015). It was reported that the average body fat percentage in elite male Italian snowboarders was between 12%-14% (Vernillo et al., 2015). In the study titled effect of acute fatigue and training adaptation on countermovement jump performance in elite snowboard cross athletes, it was reported that the height of the female athletes was 165.7±4.4 cm and their body weight was 64.4 ± 4.5 kg, respectively (Gathercole et al., 2015). The analysis of the descriptive characteristics of female athletes concluded that their height was 160.4±5.41 cm and their body weight was 57.08±4.83 kg, respectively. No valid research data is currently available to assess whether elite female snowboarding athletes' height and body mass follow similar patterns. Thus, further research on the anthropometric characteristics of female snowboarding athletes is necessary to gain a better understanding of their impact on performance. Based on scientific research, the body fat percentages of elite men and women snowboarding athletes are about 10.6–13.8% and 14.9–19.8%, respectively (Wang et al., 2023). Elite snowboarding athletes often have a significantly lower body fat percentage compared to recreational athletes (Meyer et al., 2004). For snowboarding athletes, having greater muscle mass is more beneficial than carrying fat tissue (Tanyeri et al., 2017). In our study, it was found that male and female athletes had an average body fat percentage of 10.08±3.7-20.19±4.18, respectively. Compared to fat tissue, greater muscle mass is more advantageous for meeting the demands of competition. Therefore, snowboarding athletes should prioritize building muscle mass in their training to support weight gain and reduce body fat. The study suggested that several differences resulted from genetic factors, training levels, nutritional habits and different developmental periods although the anthropometric characteristics of the participants were close to each other. Anthropometric characteristics highlight the potential significance of physique (body composition) for the performance of snowboarders. Body composition characteristics are used by athletes to manage the demands arising from reactive and fast turns and changing edges and to overcome obstacles. However, the study included only a small selection of anthropometric variables. Therefore, there is inadequate amount of a more comprehensive data set on the anthropometric characteristics of elite snowboarders and further research with a more comprehensive number of participants is recommended to thoroughly determine and optimize the anthropometric characteristics that are important for the performance of elite snowboarders.

A wide range of laboratory tests have been used to optimize training loads for athletes (Carey et al., 2003; Higa et al., 2007). However, there are limited studies on the effects of training on the anaerobic capacity of snowboarders (Klous et al., 2014; Platzer et al., 2009). Elite snowboarders have been observed to have significantly higher anaerobic power (Żebrowska et al., 2012). Another study reached the conclusion that the short-term, high-intensity ATP-PC anaerobic energy system played a significant role in the US national snowboarding team (Platzer et al., 2009). The tests indicated that anaerobic metabolism played a dominant role in world-class snowboarders (Kipp, 1998). The anaerobic power of Australian snowboarding athletes was assessed using the 30-second Wingate test, which established elite performance criteria of 16.5 w/kg for men and 13.5 w/kg for women in terms of peak anaerobic power (Hogg, 2003). In a study, it was observed that the anaerobic performance of elite snowboarders was as follows: peak power PP (W) reached during the test as 859.17±111.44, peak power per kilogram PP (w/kg) as 12.68±1.67, average power AP (w) as 593.58±46.81, lowest power MP (w/kg) reached during the test as 362.71±36.82, and percentage power loss PD (%) as 57.63±1.79 (Ozan et al., 2020). Żebrowska et al. conducted the 30-second Wingate test on 10 alpine snowboarding athletes (5 men and 5 women) and reported peak power values of 13.0 ± 1.0 w/kg for men and 10.3 ± 0.2 w/kg for women, along with average power values of 9.7 ± 0.2 w/kg for men and 7.7 ± 0.2 w/kg for women (Żebrowska et al., 2012). In another study, 18-25 years old intercollegiate male athletes found peak power 951 w, relative peak power 11.65 (w/kg) average power 686 W, average power 8.47 w/kg. In the same study wingate anaerobic test power comparisons for women were found to be PP (w) 598, PP (w/kg) 9.59, AP (w) 445, AP (w/kg) 7.16 (Zupan et al., 2009). Our study shows that maximum power per kilogram (PP w/kg) and average power (MP w/kg) stand out as strong determining factors in giant slalom, slalom and combined race performance. These results show that power outputs per kilogram in particular play a major role in performance in ski races. Also the study revealed a negative correlation between the peak power, average power, lowest power, peak power per kilogram, lowest power per kilogram reached by the athletes during the anaerobic power test and the national team selection results. The negative correlation between the anaerobic power parameters and the competition scores means that the quality of athletes' competition scores depends on the increase of their anaerobic power levels. The negative correlation indicates that there is an inverse relationship between the two variables. In the study, it means that the competition scores (results obtained in the competition) of the athletes with high anaerobic power are lower. As a result, anaerobic power is considered to be suitable performance determinant in terms of snowboarding.

Humans tend to use preferentially one side of the body in voluntary motor acts (Carpes et al., 2010). In sports scenarios, lateral preference can influence aspects related to force production due to long term adaptations from repeated use (Shoepe et al., 2003). Accordingly, bilateral asymmetries have been reported in sports with predominant unilateral movements, such as snowboard, soccer (Cheung et al., 2012; Vernillo et al., Pisoni et al., 2016). Muscular strength and power in snowboarders have mainly been assessed in the lower limb muscles, especially the quadriceps. This is likely due to the fact that injuries, particularly those affecting the knee, are common among elite snowboarders (Bakken et al., 2011; Torjussen et al., 2005). Early research found a strong correlation between muscular power, as measured by isokinetic leg press, and snowboarding performance among members of the Austrian snowboarding team (Platzer et al., 2009; Vernillo et al., 2015). Consequently, muscle strength and power are crucial factors in snowboarding competition. It is seen that average torque and average power values stand out as the strongest determining factors on giant slalom, slalom and combined race performance. Peak torque extension and peak power extension values also greatly affect race performance. Power and torque values per kilogram have a significant effect on race performance, a more pronounced relationship is observed especially in the slalom discipline. These findings are thought to be of critical importance to develop 60°/s extension force and power outputs in order to increase performance in snowboard races. In addition, it is seen that 240°/s w/kg (power per kilogram) and nm/kg (torque per kilogram) values are critical factors in increasing performance in ski races. In the peak power flexion and peak power extension results of athletes at 240°/s angular velocity, there is a positive correlation in some disciplines and a negative correlation in some disciplines. This situation suggests that these parameters may vary depending on the use of different muscle groups. The analysis of the relationship between the isokinetic strength level of snowboarders and their competition performance revealed a moderate (60-240°/sec) negative strong and moderate significant correlations between the participants' giant slalom/slalom/combined performance and knee extension and flexion isokinetic strength values. The existence of a negative strong correlation between isokinetic leg strength and competition scores suggests that the competition scores of the athletes are parallel with the level of their muscle strength. These results indicate that the general good muscle strength of snowboarders positively affects their competition performance. Focusing on leg strength and endurance in snowboarders is an indication of an increase in competition performance. In this respect, it is highlighted that isokinetic training that will be carried out by considering the peak torque and average torque values in leg muscle strength at different angular velocities is expected to be more beneficial in terms of performance development of snowboarders.

One of the key parameters representing such an interaction between the body of snowboarders and environment is the balance (Kourtzi, 2010). Balance can be categorized into two types: static balance, which refers to maintaining a specific posture with minimal movement, and dynamic balance, which involves the ability to restore stability while performing a specific posture (Winter et al., 1990). In a study, it was found that elite snowboarders' one-legged static balance test (left and right legs) was between 0.87 and 0.91 (Platzer et al., 2009). In the study conducted with Korean national snowboarders, static balance is strongly correlated ($p < 0.05$) with circumference of the left lower leg (34.49 ± 2.42 cm; $\rho = 0.68$). Center dynamic balance is negatively correlated with the circumference of the right lower leg (34.63 ± 2.38 cm; $\rho = -0.67$), whereas right dynamic balance is positively correlated with left ankle flexion (148.44 ± 5.20°; $\rho = 0.78$) (Jeon et al., 2021). In another study, it was determined that there was no significant relationship between static-dynamic balance parameters and competition (slalom-giant slalom) results. The same study revealed no significant relationship between the body weight, static balance parameters and competition (giant slalom-slalom) results of snowboarders (Arslan et al., 2019). In the present study, no significant relationship was observed between balance parameters and competition scores. In the snowboard branch, since athletes generally use unilateral loading (right or left) more, the balance values of both feet are close to each other. In addition, the fact that the participants consisted of national athletes probably yielded no significant differences in the balance skills of the athletes. Since all athletes have a high level of balance ability, it is considered that the contribution of this skill to competition performance is less noticeable.

Conclusion and Recommendation

It is seen that training aimed at developing strength and power should be emphasized more in order to increase performance in snowboard competitions. Although static and dynamic balance do not directly affect competition performance, they are important in terms of athletes' general physical endurance and their potential to reduce injury risk. Therefore, it is recommended that training programs be organized and optimized in line with these findings.

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Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir-B.S.A,F.K,K.K; Tasarım- B.S.A,F.K,K.K; Denetleme-B.S.A,F.K,K.K; Kaynaklar- B.S.A,F.K,K.K; Veri Toplanması ve/veya İşlemesi; B.S.A,F.K,K.K Analiz ve/ veya Yorum- B.S.A,F.K,K.K; Literatür Taraması- B.S.A,F.K,K.K; Yazıyı Yazan- B.S.A,F.K,K.K; Eleştirel İnceleme-B.S.A,F.K,K.K
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