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ORIGINAL RESEARCH

The analysis of the relationship between respiratory functions and body compositions of alpine discipline and cross-country skiing athletes

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Abstract

The aim of this study was to evaluate the relationship between respiratory functions and body compositions of elite athletes in alpine disciplines and cross-country skiing through their comparison. The study included 32 male athletes (age: 18.3±2 year, height: 172.1±6.05 cm, body weight: 65.73±10.79 kg, and body mass index (BMI): 22.91±2.80 kg/m2) within the scope of alpine disciplines and cross-country skiing. The heights of the athletes were measured with a stadiometer (Holtain, UK) with an accuracy of ±1mm. The weights of the athletes and BMI values were measured using a Tanita brand (BC, 418 Tanita, Japan) body composition analyzer with a precision of 100 grams. The respiratory function and respiratory muscle strength of the athletes were evaluated using a digital spirometer (Pony FX Cosmed, Italy). Pearson's correlation analysis was used to determine the relationships between respiratory functions and anthropometric structures of the groups. The results indicated that cross-country skiing athletes had higher averages in FVC, FEV1, FEV1/FVC, PEF, MIP, MVV, and MEP parameters compared to alpine discipline athletes, with only the MIP value being higher in alpine discipline athletes. The results revealed positive correlations between age and FVC (0.563), FEV1 (0.521), PEF (0.679), and MVV (0.511) in cross-country skiing athletes. Negative correlations were found between body weight and FEV1/FVC (r=0.578), FEV1/FVC (r=0.545), height and MVV (r=0.541), and body mass index and FEV1/FVC (r=0.541), FEV1/FVC (r=0.676) in cross-country skiing and alpine discipline athletes, respectively ($p<0.05$). The study revealed no significant relationship in other variables ($p>0.05$). In order to achieve maximum performance, it is very important to identify and keep under control the factors affecting respiratory functions. The current study demonstrated that the characteristics of the sport have an impact on physiological changes in the respiratory system and also affect body compositions and respiratory functions.

Introduction

The Siporemetry (SFT) is a physiological test that demonstrates the volume and flow of air inhaled and exhaled by an individual within a specified time function (Miller et al., 2005). Athletes with better cardiovascular function, increased stroke volume, and higher maximal cardiac output also develop different physiological adaptations in the respiratory system. There are a great number of studies that compare the respiratory functions of, identifying significant differences between groups (MacAuley et al., 1999; Doherty & Dimitriou, 1997). The adaptations that occur can vary depending on the type of sport performed (Durmic et al., 2015).

Alpine skiing is a sport that requires a constant change of speed and balance position, as well as short-term, intense efforts, and is practiced in a hypobaric, hypoxic, and cold environment (Neumayr et al., 2003). Alpine skiing races consist of two speed and two technical categories that are differentiated by turning radius, speed, and course length. The speed category includes downhill and super-giant slalom (GS; super-G) races. In downhill events, the racer follows the natural slope of the mountain and can reach speeds of up to 130 km/h. A downhill contest is generally over in 2–3 minutes. The super-G, by contrast, is a combination of downhill and GS races (White & Johnson, 1993) and includes more turns on a shorter course (Szmedra et al., 2001). A typical super-G race takes 1–2 minutes to complete. The technical category comprises the slalom and GS disciplines. Whereas the GS race takes 60–90 seconds, the slalom is over in 45–60 seconds and necessitates very quick and short turns (Szmedra et al., 2001).

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Cross-country skiing is an Olympic sport that requires rapid power production and high maximal oxygen consumption in both the upper and lower body on snowy surfaces with varying heights, distances, and inclinations. Training athletes mainly seek to enhance both muscular and cardiovascular endurance levels to perform technical skills specific to the sport with minimal fatigue over an extended period, often in collaboration with ski teams (Marsland et al., 2012). Aerobic capacity is defined as the amount of oxygen consumed during maximal exercise and is associated with the athlete's ability to transport oxygen within the body. A higher oxygen consumption by the athlete indicates a higher aerobic capacity (Arslan & Melekoğlu, 2019). Unlike the circulatory and muscular systems, the respiratory system is not typically evaluated as a factor affecting aerobic performance. However, there are studies suggesting that the respiratory system plays a key role in aerobic performance (Amann, 2012).

Respiratory function measurements are used to obtain information about the health and structure of the respiratory pathways and lungs, aiming to determine the impact of training on the respiratory system. Test methods for respiratory function are significant in determining the overall respiratory health of athletes (Miller, 2008). The study that are conducted to uncover the effects of applied training on athletes are expected to help interpret the changes occurring in the bodies of both healthy individuals engaged in sports and those who are not. In this regard, the aim of the study was to determine the relationships between respiratory function and body composition in alpine discipline and cross-country skiing athletes. The study also attempted to determine whether certain body composition parameters are correlated with pulmonary function.

Methods

The participants consisted of 32 male athletes in the alpine discipline and cross-country skiing categories, with an age range of 15-22 years (age: 18.3±2.34 years, height: 172.1±6.05 cm, body weight: 65.73±10.79 kg, body mass index (BMI): 22.91±2.80 kg/m^2). After providing mandatory information about the tests to be conducted, the athletes were kindly requested to sign voluntary consent forms. Necessary permission was obtained from the Erzurum Technical University Scientific Research and Publication Ethics Committee (Number of Meetings: 11 Number of Decisions: 07 Date: 28.09.2023), and the study was conducted in accordance with the Helsinki Declaration. Inclusion criteria for participants were the absence of any known diseases or health problems, the ability to perform the performance tests planned for the study, and voluntary willingness to participate. The participants were also required to have been a member of the national team in the skiing category (alpine discipline and cross-country skiing) for at least 5 years.

Procedure

All tests were performed at Ataturk University Sport Sciences Application and Research Center. The heights of the athletes were measured via a stadiometer with a precision of ±1mm (Holtain, UK). The measurement of athletes' weights and the calculation of Body Mass Index (BMI) values were performed using a Tanita brand body composition analyzer with a precision of 100 grams (BC, 418 Tanita, Japan). The evaluation of athletes' respiratory function was conducted through a digital spirometer (Pony FX Cosmed, Italy). Athletes were briefed about the tests before starting the process. Before the tests, athletes were instructed to fast for at least two hours, and they were provided with at least a 15-minute rest between each test. The tests were administered in a comfortable sitting position. During the tests, athletes were required to close their noses with a clip, and they were instructed to cover the mouthpiece of the spirometer with their lips to ensure no gaps were left for air to escape. The tests were conducted by instructing respiratory maneuvers through the spirometer mouthpiece. To understand the procedure and adapt to the device, several trial tests were conducted before the actual tests. Each test was performed three times, and the best measurement score was used (Giatsis et al., 2004; Akınoğlu et al., 2019).

Data Analyses

The SPSS 26.0 software package was employed in order to perform analysis. Descriptive statistics were used for data analysis, and the results were presented as mean ± standard deviation. The $p<0.05$ was considered as a significance level. The assumption of normal distribution for the data was assessed using the Shapiro-Wilk test, indicating that the data showed a normal distribution. Pearson's correlation analysis was utilized to determine the relationships between respiratory functions and anthropometric structures of the groups.

Results

The respiratory function tests revealed that cross-country skiing athletes, compared to alpine discipline athletes, exhibit higher averages in FVC (Forced Vital

Capacity), FEV1 (Forced Expiratory Volume in 1 second), FEV1/FVC (Forced Expiratory Volume in 1 second/Forced Vital Capacity), PEF (Peak Expiratory Flow), MIP (Maximum Inspiratory Pressure), MVV (Maximum Voluntary Ventilation), and MEP (Maximum Expiratory Pressure) parameters. Only the MIP value was found to be higher in alpine discipline athletes (Table 2).

Table 1

Descriptive information for athletes.

Variables	Alpine Discipline (n=16)		Cross-Country Skiing (n=16)		Total (n=32)	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Age	18.13±2.36	15-22	18.31±2.39	16-23	18.22±2.34	15-23
Body Weight (kg)	69.63±11.29	52-89	66.94±8.93	49-84	65.73±10.79	49-89
Height (cm)	172.94±5.26	160-181	171.19±7.26	155-184	172.1±6.05	155-184
BMI	23.19±2.99	20-29	22.63±2.66	17-28	22.91±2.80	17-29

Table 2

Statistics on respiratory function parameters by discipline.

Variables	Alpine Discipline		Cross-Country Skiing		Total	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
FVC	4.42±1.02	2.68-5.99	4.45±1.16	2.49-6.49	4.43±1.07	2.49-6.49
FEV1	3.80±0.81	2.17-5.11	3.83±1	2.02-5.54	3.82±0.89	2.02-5.54
FEV1/FVC	85.55±6.06	76.20-97.20	86.22±6.62	75.60-97.90	86.38±6.24	75.60-97.90
PEF	6.74±1.87	3.25-10.54	7.53±2.2	4-12.54	7.13±2.04	3.25-12.54
MVV	128.48±34.44	17.90-157.70	140.86±45.72	45.60-221.50	134.67±40.31	17.90-221-50
MEP	118.18±31.80	59-174	140.43±29.72	104-198	129.31±32.32	59-198
MIP	99.31±24.26	60-144	93.50±17.28	69-127	96.40±20.93	60-144

FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in 1 second; FEV1/FVC: Forced Expiratory Volume in 1 second/Forced Vital Capacity; PEF: Peak Expiratory Flow; MVV: Maximum Voluntary Ventilation; MEP: Maximum Expiratory Pressure; MIP: Maximum Inspiratory Pressure.

Table 3

The relationship between respiratory functions and anthropometric characteristics of cross-country skiing and alpine discipline athletes.

Variables	Disciplines		FVC	FEV1	FEV1/FVC	PEF	MVV	MEP	MIP
Age	Cross-country Skiing	r	.563*	.521*	-.141	.679**	.511*	.288	.453
		p	.023	.039	.603	.004	.043	.279	.078
	Alpine Discipline	r	-.373	-.362	.057	-.186	-2.89	-.185	-.331
		p	.154	.169	.835	.491	.277	.493	.211
Body Weight	Cross-country Skiing	r	0.297	0.130	-.578*	0.041	0.366	0.240	-0.027
		p	0.264	0.631	0.019	0.879	0.164	0.371	0.922
	Alpine Discipline	r	0.163	-0.003	-.545*	-0.150	-0.143	0.062	0.041
		p	0.546	0.991	0.029	0.579	0.597	0.820	0.881
Height	Cross-country Skiing	r	0.462	0.399	-0.184	0.276	.541*	0.370	0.383
		p	0.071	0.126	0.494	0.302	0.030	0.158	0.143
	Alpine Discipline	r	0.254	0.225	-0.201	-0.070	-0.087	-0.063	-0.137
		p	0.343	0.402	0.455	0.797	0.747	0.817	0.612
BMI	Cross-country Skiing	r	0.006	-0.139	-.541*	-0.099	0.021	0.033	-0.273
		p	0.982	0.608	0.031	0.716	0.940	0.902	0.306
	Alpine Discipline	r	0.175	-0.044	-.676**	-0.122	-0.061	0.111	0.118
		p	0.517	0.871	0.004	0.653	0.823	0.683	0.665

**p<0.01; *p<0.05.

The analysis concluded that the comparison of the respiratory function and anthropometric characteristics of cross-country skiing athletes diplayed positive correlations between age and FVC (0.563), FEV1 (0.521), PEF (0.679), and MVV (0.511); negative correlation was found between body weight and FEV1/FVC (0.578); positive correlation was found only between height and MVV (0.541); and negative correlation was found between body mass indexes and FEV1/FVC (0.541). The comparison of the respiratory function and anthropometric characteristics of alpine discipline athletes indicated the following findings: negative correlation was found between body weight and FEV1/FVC (0.545); and also between body mass indexes and FEV1/FVC (0.676) (Table 3). No significant differences were observed in respiratory muscle strength and body compositions in other parameters (p>0.05).

Discussion

The study determined a specific balance or interaction between respiratory parameters (functional capacity) and body compositions of alpine discipline and cross-country skiing athletes. Pearson's correlation analysis was conducted to determine the impact of anthropometric measurements on respiratory functions, aiming to establish the degree of influence of variables related to the structure on respiratory function (cause-and-effect relationships).

There are many factors that affect lung capacity. In addition to regular athletic activities starting in childhood, genetic factors, chest width, and respiratory system-affecting diseases during childhood are among these factors (Fox et al., 1993). The study of Stanejevic et al. indicated that the variables FEV1 and FVC change depending on age, which shows a difference between early childhood and old age and reaches their lowest values in early adulthood (Stanojevic et al., 2008). In this regard, the insignificant difference in the study group, which arises from the similarity in age, the same ethnic background, and the absence of any respiratory system diseases, can be attributed to the physical characteristics required by the sport practiced. A cross-sectional examination was conducted on the respiratory functions of 24,536 healthy individuals in different levels of physical activity groups (high, moderate, low, other, sedentary). High-intensity physical activity (male: 987; female: 193) was found to increase FVC (5.14-3.61), FEV1 (4.02-2.86) and FEV1/FVC (78.30-79.36) (Cheng et al., 2003). The current study determined the FVC (4.42 ± 1.02 L), FEV1 (3.80 ± 0.81 L), FEV1/FVC (85.55 ± 6.06) for alpine discipline athletes and FVC (4.45 ± 1.16 L), FEV1 (3.83 ± 1 L), FEV1/FVC (86.22 ± 6.62) for cross-country skiing athletes. It is possible to suggest that the results of the current study align with other studies that investigated high-intensity exercises.

The related literature suggests that average values for FVC (6.16-4.18), FEV1 (5.58-3.50), FEV1/FVC (88.80-80.72), and MVV (216.66-186.70) vary among male athletes in similar age groups (Kroff & Terblanche, 2010). There are studies that prove even mild exercise in sedentary individuals has the potential to increase FEV1 and FVC ratios, affecting lung volumes. Compared to sedentary individuals, elite athletes exhibit FEV1 values 10-20% higher due to the impact of intense exercise (Nourry et al., 2005; Galanis et al., 2006; Belda et al., 2008). In a study, it was suggested that basketball, water polo, and rowers had higher FVC, FEV1, and VC values compared to sedentary individuals. The study also noted that the MVV value was higher in athletes engaged in water polo and rowing compared to sedentary individuals (Nourry et al., 2005; Galanis et al., 2006; Belda et al., 2008). In the current study, it was determined that cross-country skiing athletes have higher FVC, FEV1, and MVV values than alpine discipline athletes. The higher respiratory function, especially MVV values, in cross-country skiing athletes compared to alpine discipline athletes is considered to be associated with their genetic makeup, training programs, and high aerobic capacities. However, in rugby players, the lower amount of FEV1 is attributed to their higher body weights (Mazic et al., 2015). The current study indicated higher FEV1 values in cross-country skiing athletes and lower body weight, which offers a different perspective from the literature. For athletes with lower-than-expected MVV values, it is recommended to engage in diaphragmatic breathing exercises (breathing into the abdomen).

It is obvious that men and women have different physical and physiological structures, and this is also an influential variable on the respiratory system. In a study, the respiratory muscle strength (RMS) and respiratory function test (RFT) values of 186 male participants were compared with BMI values. The analysis indicated a relationship between MIP (119.54 cmH2O), MEP (144.48 cmH_2O), and BMI (23.29 kg/m^2) averages of men (Karaduman, 2020). Studies have suggested that in similar age groups, men and women respectively have MIP (100.40-67.80), MEP (87.40-73.90) (Santos et al., 2011) in swimmers, MIP (121.17-112.38), MEP (131.33-108.75) (Silapabanleng &

Buranapuntalug, 2018) in rowers, and MIP (147.00-110.00), MEP (156.00-125.00) in athletes competing in different sports (Kroff & Terblanche, 2010). The current study aimed to analyze MIP, MEP and BMI values of alpine skiing and cross-country skiing athletes. MIP values reflect the strength of athletes' inspiratory (breathing in) muscles. Values up to 90% of the expected are considered acceptable, and athletes with values below this range are recommended to perform respiratory exercises. Respiratory exercises are highly recommended to help strengthen respiratory muscles and increase respiratory capacity, enabling athletes to breathe more effectively and enhance their performance.

MEP values indicate the strength of expiratory (breathing out) muscles. These values reflect the level of effectiveness of abdominal muscles and other expiratory muscles. An athlete with MEP values below the expected range is possibly considered to have weak or improperly functioning respiratory muscles. Athletes with MEP values below the expected range may be advised to engage in exercises that strengthen abdominal muscles, such as core muscle exercises, planks, etc. Strengthening the respiratory system is crucial for overall health and sports performance. Therefore, respiratory muscle strengthening exercises are considered to contribute to improved overall performance and endurance in athletes.

It is clear that body weight and compositions have significant effects on respiratory functions (Cheng et al., 2003; Oke & Agwubike, 2015). The BMI values suggest that the alpine skiing group has a higher average (23.19±2.99 kg/m²), while the cross-country skiing group has a lower average (22.63±2.66 kg/m²). Respiratory functions are significantly influenced by age, height, body weight, gender, race, and various environmental factors, showing variations among athletes (Quanjer et al., 2012; Bamne, 2017; Neogi et al., 2018). The relevant study conducted on elite athletes showed a relationship between age and FVC, FEV1 and MVV (Akınoğlu et al., 2019). In sports that involve a combination of skills, strength, agility, and endurance, a similar relationship was observed between age and FVC (r=0.099) and MVV (r=0.138) (Lazovic et al., 2015). However, in the current study, it was observed that there was a positive relationship between age and parameters such as FVC (0.563), FEV1 (0.521), PEF (0.679), and MVV (0.511) in cross-country skiers, but not with FEV1/FVC, MEP, MIP. The lack of significant differences in FEV1/FVC, MEP, MIP may be attributed to the fact that the athletes in the study are at an elite level, experienced, and likely to have been practicing their sports for a longer period. Additionally, no significant relationship was found among alpine skiing athletes.

In a study on triathletes, it was found that there is a significant relationship between height and FVC (r=0.79) and FEV1 (r=0.886) in male athletes, while in female athletes, only height was significantly related to FEV1 (r=0.807) (Johari et al., 2016). However, in male athletes from different disciplines (basketball, handball, soccer, water polo), there was a relationship between height and FVC (r=0.652), FEV1 (r=0.619), MVV (r=0.275), body weight, and BMI, with FVC (r=0.741; 0.396), FEV1 (r=0.675; 0.307), FEV1/FVC (r=-0.235; -0.263), and MVV (r=0.496; 0.460), respectively (Durmic et al., 2015). In our study, a negative relationship was found between body weight and FEV1FVC (0.578), a positive relationship between height and MVV (0.541), and a negative relationship between body mass index and FEV1FVC (0.541) in cross-country ski athletes. No relationship was found between respiratory functions and height, body weight and BMI of alpine ski athletes.

In a study conducted on 1630 athletes, significant relationships were found between body weight and height and the averages of FVC (r=0.197; r=0.552), FEV1 (r=0.119; r=0.428), and MVV (r=0.332; r=0.356) (Lazovic et al., 2015). In addition, a negative relationship was observed between BMI and FVC (r=-0.143) and FEV1 (r=-0.128), while a positive relationship was found with MVV (r=0.132). There are studies that have revealed similar results in the literature(Akınoğlu et al., 2019; Neogi et al., 2018; Carten, 2007; Triki et al., 2013). The current study suggested a negative relationship only between the body weight of cross-country skiing athletes and FEV1/FVC (0.578). However, it is proven that lung volumes are highly correlated with body size (Neogi et al., 2018; Bhatti et al., 2014). The related literature demonstrates that different results have been obtained regarding the relationship between anthropometric characteristics and respiratory function parameters. The variation in physical characteristics among the compared athletes possibly causes this situation as the anthropometric characteristics of athletes in these groups can vary based on the sports they are engaged in. Reviewing the literature, it is possible to suggest that age, height, and body weight are important anthropometric variables affecting respiratory functions in the current study as well when population is anaylzed.

In a study was conducted on 97 men with BMI ranging from 19.8 to 37.1, the relationships between respiratory functions, anthropometric variables, body composition, and physical performance were investigated. In the relevant study, positive correlations were found between height, body weight, BMI, chest depth, chest width, chest, neck, and waist circumference, and VC, FVC, and FEV1 ($p<0.05$), while a negative correlation was found with FEV1/FVC (Santana et al., 2001). The pearson's correlation analysis between lung capacities and anthropometric measurements (Table 3) indicated statistically significant relationships between age, body weight, height, and BMI measurements ($p<0.05$).

In conclusion, the current study conducted on alpine discipline and cross-country skiing athletes revealed both positive and negative relationships, as well as cause-and-effect relationships between lung functions and physical structure. It is crucial to identify factors affecting respiratory functions and control variables to achieve maximum performance. Research results have shown that BMI significantly affects the respiratory functions of athletes.

Authors' Contribution

Study Design: BSA, MMI; Data Collection: BSA; Statistical Analysis: BSA, SA; Manuscript Preparation: BSA,; Funds Collection: BSA

Ethical Approval

The study was approved by the Erzurum Technical University Scientific Research and Publication Ethics Committee (Number of Meetings: 11 Number of Decisions: 07 Date: 28.09.2023) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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