

The role of body composition in determining athletic performance in adolescent female cross-country skiers

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Abstract

Body composition, speed, strength and jumping ability are important factors for athletic performance. The aim of this study was to determine the relationship between body composition parameters and speed, strength and jumping performance in adolescent female cross-country skiers. 13 adolescent female (age: 14.62±0.77 years) cross-country skiers participated in the study voluntarily. Body analysis measurements and 10m and 20m speed, back strength, hand grip strength and countermovement jump tests were applied to the participants. Cross-sectional relational model was used in the study. SPSS package program was used in the statistical analysis of the data. Shapiro-Wilk test was applied to determine the normality level of the data. It was determined that the data had a normal distribution. Pearson correlation test was used in the relational analysis of the data. According to the correlation test findings, negatively significant relationships were determined between fat-free mass, muscle mass, mineral mass, fluid mass and basal metabolic rate and 10m and 20m speed tests ($p < 0.05$). There was no significant relationship between body composition and strength and jumping performance ($p > 0.05$). The results showed that body composition positively affects speed. Especially high lean body mass, muscle mass and fluid mass can increase the capacity to move faster and develop speed. These parameters can support the speed of athletes by improving speed performance. While muscle mass increases the power and explosive strength required for speed, low body fat ratio enables faster movement by reducing unnecessary weight. In addition, since adolescence is a period of accelerated physical development, body composition can be optimized with proper nutrition and training. This can also help increase speed performance.

Received:
February 21, 2025

Accepted:
March 26, 2025

Online Published:
March 27, 2025

Keywords:
Body composition, cross-country skiing, jumping, speed, strength.

Introduction

Skiing is one of the oldest sports that emerged as a result of mankind's struggle for life against nature. In ancient times, skiing has been a tool that met people's basic needs for communication, hunting or fighting (Arslan, 2018). Today, skiing has become a performance sport. One of the important branches of skiing, which has many sub-disciplines, is cross-country skiing. Cross-country skiing has been competed in the Olympics since the first Winter Games held in Chamonix, France in 1924. Since then, cross-country skiing has evolved to include two different styles (skating and classic) and a range of race distances (from sprint to long-distance events ranging from 800 m to 50 km) (Hébert-Losier et al., 2017).

Cross-country skiing is a sport performed using skis of different characteristics on slopes of different lengths, heights and slopes or on snowy surfaces (Ulker, 2006).

Cross-country skiing is a branch of sports that is less dangerous compared to other sports. Since the skis are long, narrow and light, the heel of the foot moves easily. In cross-country skiing, the hands are designed to push the long stick called the baton, which helps to gain speed. Cross-country skiing is a sport that requires high endurance (Yarim, 2010).

Cross-country skiing is a sport that requires endurance and is performed in medium altitude areas and cold weather conditions (Holmberg, 2015). Cross-country skiing is performed especially in regions with harsh climates and more snow, and endurance, strength and speed are at the forefront in this sport (Ateş, 2014). Since cross-country skiing involves going uphill and downhill, technical competence, anaerobic power and strength parameters are also important for athletic performance in addition to aerobic capacity (Polat et al., 2018).

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Physical fitness is just one of the characteristics required for high-level performance (Asan, 2023). Effective application of technical and tactical skills requires a strong physical and motoric foundation (Kızılca, 2023). One of the physical and physiological characteristics that is important for athletic success is body composition. Understanding the relationship between body composition and athletic performance is a complex but important topic in sports science (Martín-Rodríguez et al., 2024). Body composition is the basic structures of the human body, which are muscle, bone and fat tissue components (Campa et al., 2021). This concept is of critical importance in terms of body fitness and athletic performance, because the balance of muscle mass and body fat directly affects both physical capacity and general health. Having a high fat percentage in athletes not only creates extra weight in the body but also negatively affects speed, strength and jumping performance. Therefore, high fat percentage, low bone mineral and muscle ratio also have negative effects on athletes' performance. However, the relationship between body composition and athletic performance is sport-specific (Lukaski et al., 2021). Higher muscle mass may provide positive effects on performance in athletes who participate in sports requiring explosive power and strength, while leaner body composition is important in endurance athletes (Heydenreich et al., 2017). Body composition data provides valid evidence in examining the performance in relation to how much physical gain athletes make after training (Sundgot & Tørtveit, 2010).

Although developing physical fitness at an optimal level is an important issue, reaching a body composition suitable for the branch is necessary for performance. Ideal fat mass, muscle ratio and bone mineral density will positively affect speed, strength and jumping performances. From this point of view, it is important for coaches to implement training programs that will eliminate the negativities affecting athletic performance by bringing branch-specific body composition components to an optimal level in order to increase athlete performance. Especially in cross-country skiing, which requires endurance, body composition components are the most important factors for achieving athletic success. There are studies in the literature that reveal the relationship and effect between body composition and endurance in cross-country skiers (Larsson & Henriksson-Larsén, 2008; Grzebisz-Zatońska et al., 2021). However, studies directly determining the relationship between body composition and speed, jumping and strength abilities

in adolescent female cross-country skiers are limited. Sports are extremely important in terms of health and development during adolescence. During adolescence, physical development processes such as hormonal changes, bone development, muscle mass increase and changes in body fat ratio occur. Sports help this development process by increasing bone density, developing muscle mass and balancing body fat ratio in young women. Speed, jumping and strength are critical abilities that determine performance in dynamic and demanding sports such as cross-country skiing. Speed allows athletes to react quickly, move quickly on the course and stay ahead of their competitors. Jumping is especially important for meeting explosive strength requirements in overcoming obstacles and landings. Strength is necessary for effective pushing, maintaining balance, and maintaining high performance over long periods of time in sports that require speed and power, such as cross-country skiing. When these three abilities come together, they can help athletes be faster, stronger, and more agile, helping them be more successful in competitions. In this context, this study aimed to determine the relationship between body composition components and speed, strength and jumping performance in adolescent female cross-country skiers.

Methods

This study was designed as a cross-sectional correlational study. In this model, it is tried to determine whether there is a joint change between two or more variables and its degree (Karasar, 2011). The study was conducted in accordance with the Declaration of Helsinki. Before starting the study, Ethics Approval was obtained from the Scientific Research and Publication Ethics Committee of Muş Alparslan University (Decision number: 16/34, date: 27.12.2024).

Participants

The determination of the minimum sample size for this study was conducted utilizing G-power software 3.1.9.7, developed by Düsseldorf University, Germany (Faul et al., 2009). A robust power analysis was undertaken, accounting for the study's design parameters, namely t-tests and a correlation point biserial model. These considerations encompassed an α error probability set at 0.05, a power of 0.80 (1- β error probability), and an effect size of 0.50. The resultant analysis delineated that a cohort of at least 10 participants would be indispensable to attain the desired power. Thirteen

adolescent female cross-country skiers (age: 14.62 ± 0.77 years) participated in the study. The athletes participated in the study voluntarily.

Procedure

The athletes were selected from athletes with at least 3 years of cross-country skiing experience in Muş province. Before the study, each participant was given detailed information about the risks and discomforts that could be encountered in the study. The voluntary consent form was read to the participants and signed. The parents of the participants were informed about the study and had the parental consent form signed. Athletes with any discomfort were not included in the study. The athletes were instructed not to participate in any heavy exercise program one day before the tests. Before the measurements, 13 female cross-country skiers who made up this study were given a 20-minute general warm-up, then a 5-minute special warm-up for each branch, and the athletes were measured.

Data Collection Tools

Height

The height of the athletes was measured in cm after they were positioned in anatomical posture, barefoot, heels together, holding their breath, head in the frontal plane, headrest touching the vertex point, using a stadiometer (Holtain Ltd., UK) that measures ± 1 mm (Tatlici, 2017).

Body composition measurements

The body weight and body composition values of the participants were determined with a bioelectrical impedance analyzer (Tanita Body Composition Analyzer MC-780 MA, Japan) while wearing shorts and t-shirts (Thompson et al., 2010). Participants' height, age and gender information were entered into the data screen of the device. Participants were asked not to enter a Turkish bath or sauna at least 24 hours before the measurements and also not to consume any food at least 4 hours before the measurements. Measurements were applied between 09:00-11:00 in the morning and participants did not exercise on the day the measurements were made. During the measurement, care was taken to ensure that the feet were not wet and the hands and heels were placed on the electrodes and the athletes held the handles connected to the electrodes on the device throughout the measurement period. After the device completed the measurements, the values of the parameters fat-free mass, fat-free proportion, muscle mass, muscle proportion, mineral mass, mineral proportion, fluid mass, fluid proportion,

fat mass, fat proportion and basal metabolic rate were recorded.

Hand grip strength measurement

The subjects' grip strength measurements were made using a Takei brand (Japan) hand grip dynamometer that measures with ± 10 gr precision. For hand grip strength, after the digital hand dynamometer was adjusted according to the subject's hand length, they were asked to squeeze the dynamometer with both hands separately and the results seen on the digital screen were recorded. The participants had two trials for both hands and the best degree was recorded (Pense & Serpek, 2010).

Back strength measurement

The athletes' back strengths were measured with a Takei brand (Japan) back dynamometer. While the subject pulled the hand grip of the dynamometer with maximum force while the legs and back were straight and the hand grip of the dynamometer was at hip level, the leg strength was adjusted so that the hand part of the dynamometer was at the subject's knee level. The subject brought their knees to approximately 90 degrees and pulled the arm with the maximum force they could apply while the hand grip was between their legs. The best results obtained from the subjects as a result of two trials were accepted as the highest value (Mannion et al., 1999).

Countermovement jump (CMJ)

Athletes' vertical jump skills were tested with a jumping mat (Fusion Sport Smart Jump, Australia) with both hands on their waists, feet shoulder-width apart and posture upright. When the athletes were ready on the mat, they were asked to jump to the highest point they could without taking a step and bending their knees 90°. After jumping, the athletes fell back onto the mat and their jump heights were measured with an accuracy of 0.1 cm and the two attempts were recorded and the highest degree was evaluated (Markovic et al., 2004).

10m and 20m sprint tests

The 10 m and 20 m speed tests were measured with a photocell (Fusion Sport Smartspeed PRO, Australia). Photocell gates were placed at the start, 10 m and 20 m points along a straight line. The photocell gates were set at 1 m above ground level and athletes started the test 0.5 m behind the gate. The test was repeated twice and the best value was recorded (Young et al., 1995).

Data Analyses

Data were given as mean and standard deviation for general characteristics and variables. SPSS package program was used in statistical data analysis. Before data analysis, Shapiro-Wilk test was used to evaluate whether the data showed normal distribution. In the study, the correlation test was preferred to determine the direction and strength of the relationship between two or more variables. Pearson correlation test was used in correlation analyses for data showing normal distribution. Evans coefficient classifications ($r \geq 0.80$ very strong, 0.60–0.79 strong, 0.40–0.59 moderate, 0.20–0.39 weak and <0.20 very weak correlation) were used to interpret the correlation coefficient results (Evans, 1996). $P < 0.05$ was accepted as statistical significance value.

Results

Descriptive statistics regarding the general characteristics of adolescent female cross-country skiers participating in the study are presented in Table 1, body composition statistics in Figure 1, and bio motor characteristics statistics in Figure 2.

Table 1

Descriptive statistics of the general characteristics of the athletes ($n=13$).

Variables	Mean	Std. Dev.	Min.	Max.
Age (years)	14.62	0.77	14.00	16.00
Height (cm)	161.77	5.73	154.00	175.00
Body Weight (kg)	48.68	3.42	44.80	57.20
BMI (kg/m^2)	18.59	0.92	17.40	20.30

Correlations regarding the relationship between athletes' body composition and speed, strength, and jumping performance are presented in Table 2.

A moderate negative significant correlation was found between the lean mass, muscle mass, mineral mass, fluid mass and basal metabolic rate (BMR) of the adolescent female cross-country skiers participating in the study and the 10m and 20m sprint values ($p < 0.05$). These results mean that the increase in lean mass, muscle mass, mineral mass, fluid mass and BMR will cause a decrease in the 10m and 20m sprint values, i.e., an increase in sprint performance. No statistically significant correlation was found between the body composition parameters and back strength, handgrip strength and CMJ ($p > 0.05$).

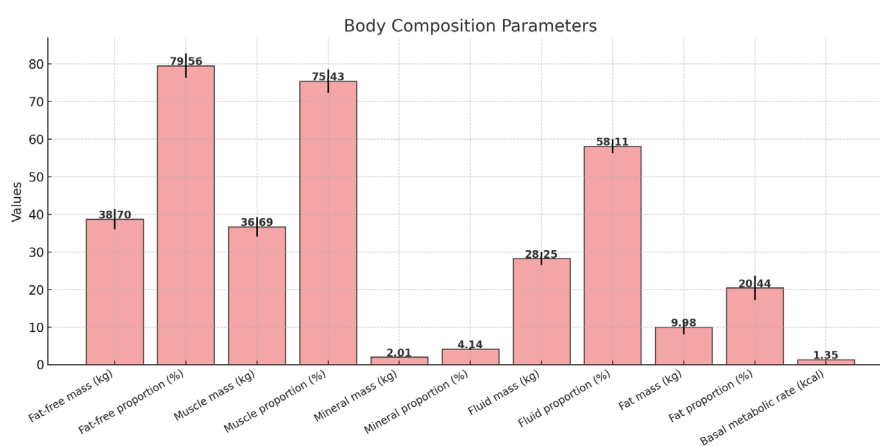


Figure 1. The participants' body composition parameters.

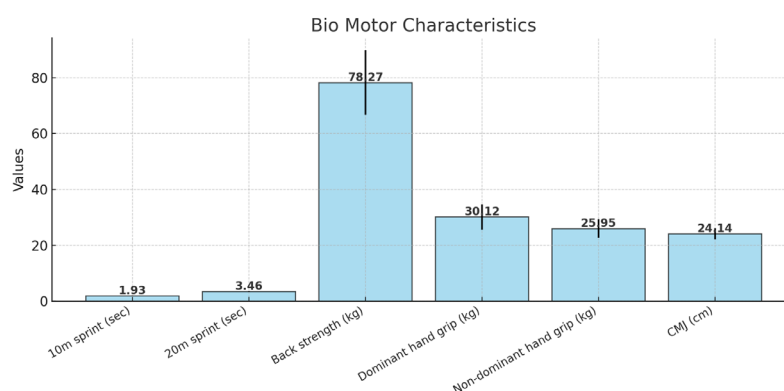


Figure 2. The participants' bio motor characteristics.

Table 2

Relationship between body composition and speed, strength and jumping performance.

Parameters		10m sprint	20m sprint	Back strength	DomHGS	NonDomHGS	CMJ
Fat-free mass (kg)	r	-.680*	-.578*	.113	.263	-.064	-.234
	p	.011	.039	.713	.386	.835	.442
	R ²	.462	.334	.013	.069	.004	.055
Fat-free proportion (%)	r	-.150	-.005	-.407	-.134	-.084	.005
	p	.625	.988	.168	.662	.784	.987
	R ²	.022	.000	.165	.018	.007	.000
Muscle mass (kg)	r	-.680*	-.578*	.113	.263	-.064	-.234
	p	.011	.038	.714	.386	.835	.442
	R ²	.463	.334	.013	.069	.004	.055
Muscle proportion (%)	r	-.150	-.005	-.407	-.134	-.084	.005
	p	.624	.986	.168	.662	.785	.987
	R ²	.023	.000	.165	.018	.007	.000
Mineral mass (kg)	r	-.673*	-.572*	.114	.262	-.067	-.236
	p	.012	.041	.711	.387	.828	.438
	R ²	.453	.327	.013	.069	.004	.056
Mineral proportion (%)	r	-.152	-.006	-.407	-.135	-.084	.009
	p	.621	.983	.167	.659	.785	.976
	R ²	.023	.000	.166	.018	.007	.000
Fluid mass (kg)	r	-.675*	-.652*	.160	.342	.012	-.192
	p	.011	.016	.601	.252	.968	.531
	R ²	.456	.425	.026	.117	.000	.037
Fluid proportion (%)	r	.051	.056	-.462	-.112	.062	.165
	p	.869	.855	.112	.716	.840	.589
	R ²	.003	.003	.213	.013	.004	.027
Fat mass (kg)	r	-.104	-.224	.442	.226	.053	-.084
	p	.736	.463	.131	.458	.865	.785
	R ²	.011	.050	.195	.051	.003	.007
Fat proportion (%)	r	.150	.005	.407	.134	.084	-.005
	p	.625	.988	.168	.662	.784	.987
	R ²	.022	.000	.165	.018	.007	.000
Basal metabolic rate (kcal)	r	-.637*	-.601*	.162	.411	.105	-.235
	p	.019	.030	.597	.163	.733	.439
	R ²	.405	.361	.026	.169	.011	.055

DomHGS: Dominant hand grip strength; NonDomHGS: Non-dominant hand grip strength; CMJ: Countermovement jump; * Correlation is significant at the 0.05 level.

Discussion

According to the results of our study, which we conducted to determine the relationship between body composition parameters and speed, strength and jumping performance in adolescent female cross-country skiers, negative significant relationships were found between lean mass, muscle mass, mineral mass, fluid mass and BMR and 10 m and 20 m sprint. Increases in lean mass, muscle mass, mineral mass, fluid mass and BMR values provide improvements in sprint performance. In a study conducted on elite skiers, determined a strong relationship with body mass, trunk mass and trunk lean mass and double pole maximum speed performance, while a positive relationship was

found between absolute and relative lean mass and cross-step maximum speed, and a negative relationship was found between fat mass and cross-step maximum speed (Stöggl et al., 2010). Carlsson et al. (2014) stated that lean mass (whole body, upper body, and lower body) had a significant relationship with sprint-prologue performance in both genders of elite cross-country skiers, whereas it was significantly related to distance-race performance only in women. Hébert-Losier et al. (2017) indicated that higher lean mass benefits the performance of sprint skiers. Lean mass has been determined to be an important predictor of competitive sprint performance in elite female cross-country skiers (Carlsson et al., 2016). Kahraman &

Arslan (2023) reported a negative significant relationship between fluid ratio and 20m sprint performance in football players.

Although Mikkola et al. (2010) reported a relationship between body mass and selected sprint ski performance in elite male cross-country skiers, no relationship was found in another study (Andersson et al., 2010). Seitz et al. (2014) found that increases in lower body strength were significantly associated with improvements in sprint performance. Zaric et al. (2020) stated that successful players in basketball have higher skeletal muscle mass and lower body fat percentage. Hyka Bicoku & Mysliu (2017) determined that there is a weak positive relationship between body fat percentage and 50 m sprint in football players. It has been determined that athletes with higher performance have higher lean body mass values compared to those with lower levels of performance (Micheli et al., 2014). Anwar & Noohu (2016) found a moderate positive significant relationship between body fat percentage and 30 m sprint in football players studying at university. Sevindik Aktas (2023) found positive relationships between body fat percentage and 10m and 30m sprint values in cross-country skiing athletes. A high body fat percentage negatively affects the sprint abilities of athletes. It can be said that the results in our study are similar to the results in the literature.

High muscle mass can increase strength, enabling faster movement during cross-country skiing. However, excessive muscle development can have negative effects on endurance, as excess muscle mass can increase oxygen consumption and strain endurance (Åstrand et al., 2003). Low body fat, on the other hand, increases speed and jumping performance, while extremely low body fat and energy deficits present a significant physiological challenge to the body (Trexler et al., 2014). Ideal body composition requires a balance between low body fat and high muscle mass; however, exceeding this balance can negatively affect aerobic activities (McArdle et al., 2010). Therefore, body composition should be optimized according to the individual needs and appropriate training programs to enhance the performance of athletes.

Limitations of the Study: One of the important limitations of this study is that it was conducted with a small sample size of thirteen participants, which may reduce the generalizability of the findings. In addition, the study focused only on adolescent female cross-country skiers. Since the study preferred tests of anaerobic energy metabolism for athletic performance,

aerobic capacity could not be studied. Future studies with larger and more diverse sample sizes are needed to confirm the findings of the study and to provide broader insights into the relationship between body composition and athletic performance.

Conclusion

The results showed that body composition positively affects speed. Especially high lean body mass, muscle mass and fluid mass can increase the capacity to move faster and develop speed. These parameters can support the speed of athletes by improving speed performance. While muscle mass increases the power and explosive strength required for speed, low body fat ratio enables faster movement by reducing unnecessary weight. In addition, since adolescence is a period of accelerated physical development, body composition can be optimized with proper nutrition and training. This can also help increase speed performance.

Authors' Contribution

Study Design: SO, MZK; Data Collection: SO; Statistical Analysis: MZK; Manuscript Preparation: SO, MZK.

Ethical Approval

The study was approved by the Muş Alparslan University of Scientific Research and Publication Ethics Committee (27.12.2024-16/34) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

Funding

The authors declare that the study received no funding.

Conflict of Interest

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

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