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The Association of Whole and Segmental Body Composition and Anaerobic Performance in CrossFit® Athletes: Sex Differences

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Abstract: The purpose of this study was to establish the association between total and segmental body composition (BC) variables and anaerobic performance and to create optimal models that best predict such performance in CrossFit® (CF) athletes. Fifty athletes, 25 males and 25 females (age: 33.26 ± 6.81 years; body mass: 72.57 ± 12.17 kg; height: 169.55 ± 8.71 cm; BMI: 25.06 ± 2.31 kg·m−2) were recruited to participate and underwent BC analysis using dual-energy X-ray absorptiometry (DXA) and an all-out laboratory test on a cycle ergometer (Wingate) to determine their anaerobic performance. The results show a significant correlation between BC values and performance, ranging from moderate ($r = -0.34$, $p = 0.015$) to near-perfect ($r = 0.96$, $p < 0.01$). Furthermore, the created performance prediction models exhibited predictive capacities ranging from 19% ($p = 0.017$) to 93% ($p < 0.001$). All prediction models were created using total or segmental lean mass variables, excluding others. BC and performance variables found significant differences between males and females. The findings demonstrate that BC variables are crucial indicators of anaerobic performance in CF athletes. Professionals responsible for athlete performance should use this information to monitor athletes and design training programs.

Keywords: sports performance; anaerobic performance; lean body mass; athletes; high-intensity functional training

1. Introduction

Body composition (BC) refers to the ratio of the different components of the human body. One of the most widely used body composition models in research is the 2-compartment model. It refers to dividing the body into two main components: fat mass and fat-free mass. Fat-free mass, also known as Lean Body Mass (LBM), includes everything that is not fat in the body, such as muscle, bone, organs, and water. Instead, fat mass refers to the amount of adipose tissue in the body. The proportion of each of these components varies according to an individual's age, gender, ethnicity, and physical activity level [1,2]. BC can be studied in total values (of the whole body) or segmentally (by regions). Segmental BC is an approach to measuring BC that evaluates different body segments. This method involves dividing the body into various anatomical regions, such as the arms, legs, trunk, and head, and measuring lean and fat mass in each region. Segmental BC provides detailed information on body mass distribution and can help assess body asymmetry. The applications of BC are diverse and range from health evaluation to the design of personalized training and nutrition programs. Therefore, accurate measurement of BC can provide valuable information about health, fitness, and sports performance.

In sports, some BC components are used as a selection method, monitoring throughout the year, and predicting athletes' performance [3]. In addition, athletes and coaches are aware of the importance of BC in sports performance and injury prevention [4] since BC can significantly affect

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athletic performance by influencing an athlete's strength, power [5] and agility. Some authors have studied the relationship between some of the components of BC and performance in different physical tests in athletes [6,7]. For example, excess fat mass has been shown to have a negative impact on physical performance [8–11]. Similarly, lean body mass (LBM) has been shown to be directly related to athletic performance [12–14]. Higher LBM is associated with greater muscle strength and power performance, which can improve performance in sports that require explosive strength, such as weightlifting [14], soccer [15,16] or hockey [17]. Thus, higher levels of LBM are associated with better anaerobic performance.

Anaerobic performance refers to the capacity of the human body to generate energy quickly and efficiently during high-intensity and short-duration activities, ranging from 1 second (e.g., maximum Olympic lift, 100-meter sprint) to 100 seconds (e.g., 400-meter sprint), predominantly through anaerobic metabolic pathways. Even in short maximal efforts of 30 seconds, there is a contribution from aerobic systems of approximately 16-18% [18,19]. Anaerobic performance is characterized by two key aspects: power and capacity. Anaerobic power refers to the maximum peak power that an individual can generate during a short-duration maximal effort, typically observed within the exertion's first 5-10 seconds. On the other hand, anaerobic capacity is defined as the average power that can be sustained throughout the effort. These components of anaerobic performance are associated with the ability to perform explosive actions such as sprints, jumps, throws, or maximum lifts, as well as the capacity for rapid recovery between repeated efforts. They have been shown to be determining factors for performance in high-intensity sports and those with predominantly lower intensity but intermittent peaks of higher intensity. Therefore, improving anaerobic performance can be fundamental for competitive success in individual and team sports that demand intense and intermittent efforts.

In recent years, CrossFit® (CF) has emerged as a popular high-intensity sport, attracting a growing number of participants worldwide. CF involves multi-modal training or competition events incorporating exercises from gymnastics, weightlifting, running, jumping, and heavy object lifting at high intensities. Athletes must demonstrate good anaerobic performance due to the sport's inherent high-intensity nature [20]. Like in other sports, body composition (BC) may significantly impact athletes' performance in CF. Therefore, it would be crucial to determine optimal BC values to enhance their capacities and achieve optimal results.

Several authors have attempted to determine the predictors of performance in official CF tests, also called WOD (from workout of the day) [10,11,21,22]. However, significant heterogeneity in the investigated performance and BC variables makes formulating definitive and appropriate conclusions challenging. Therefore, the main objective of this study is to determine the total and segmental BC values associated with anaerobic performance, measured using a widely employed standard laboratory test (Wingate). Secondary objectives include developing prediction models that best explain the dependent performance variables and conducting comparison between sexes. We hypothesized that both total and segmental BC would be associated with anaerobic performance, and sex differences would be present.

2. Materials and Methods

2.1. Participants

Fifty CF athletes from various local centers were recruited to participate in the current study, comprising 25 men (age: 33.32 ± 5.83 years; body mass: 82.76 ± 7.47 kg; height: 176.90 ± 4.16 cm; BMI: 26.43 ± 2.03 kg·m−2) and 25 women (age: 33.20 ± 7.78 years; body mass: 62.37 ± 5.50 kg; height: 162.20 ± 5.01 cm; BMI: 23.70 ± 1.70 kg·m−2). All participants voluntarily agreed to take part after responding to an advertisement posted at these centers. The primary inclusion criterion was a minimum of one year of CF practice. Individuals with injuries or medical conditions that could hinder their ability to perform the maximum effort test were excluded from the study.

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2.2. Study Design

A cross-sectional study was conducted over four weeks, in which participants underwent three separate sessions with a minimum of 48 hours between each session. The first session involved a personal interview to provide volunteers with comprehensive information about all procedures, obtain informed consent, and familiarize them with the performance test. The second session included anthropometric measurements and BC analysis, while the final session was dedicated to performing the maximum effort test. Participants were advised to refrain from engaging in strenuous physical activity within 24 hours before the all-out test. All procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki and had received prior approval from the ethics committee at the University of Málaga (43-2018-H).

2.3. Anthropometrics & Body Composition Analysis

At the second session, all participants were scheduled to the laboratory. Height in cm was measured using a stadiometer with a precision of 1 mm (SECA® 206; SECA, Hamburg, Germany), body mass in kilograms was measured using a scale with a precision of 100 g (SECA® 803; SECA, Hamburg, Germany). Subsequently, BC analysis was conducted using dual-energy X-ray absorptiometry (DXA) (Horizon A, Hologic Inc., Bedford, MA, USA). Athletes were instructed to arrive at the laboratory fasting, having abstained from eating or drinking for at least 4 hours and consuming alcohol within the past 24 hours or diuretics within the previous week.

From the data provided by the system software, the variables of total LBM (WBLM), total fat mass (WBFM), and percentage of body fat (WBFMP) were extracted. Values of the trunk, upper limbs, and lower limbs were used for segmental BC. Absolute values or the average of the percentages of both the right and left limbs were summed for the upper and lower limbs. Head values were excluded from the segmental analysis. Final segmental BC variables used were: trunk lean mass in kg (TRLM), trunk fat mass in kg (TRFM), percentage of trunk fat mass (TRFMP), upper extremity lean mass in kg (UELM), upper extremity fat mass in kg (UEFM), percentage of upper extremity fat (UEFMP), lower extremity lean mass in kg (LELM), lower extremity fat mass in kg (LEFM), and percentage of lower extremity fat (LEFMP). All values reported in grams by the software were converted to kilograms.

2.4. Anaerobic Performance

Anaerobic performance was measured using the Wingate Anaerobic Test (WG) with a resistance of 0.075 kp per kg body mass [23]. This test was chosen because it has been shown to have a significant relationship with performance in various official CF events [22,24]. The test was conducted using a Monark 894E cycle ergometer (Monark Exercise AB, Vansbro, Sweden). To determine peak power output (WGPP), average power output (WGXP), and minimum power output (WGMP), power values were recorded every 5 seconds.

2.5. Statistical Analysis

The statistical package for the social sciences (SPSS 26, IBM Corp., Armonk, NY, USA) and the statistical software MedCalc (MedCalc 18.6, MedCalc Software Ltd., Ostend, Belgium) were used for statistical analyses. Descriptive statistics (mean and standard deviation) were calculated for all variables. Normality of the variables was assessed using the Shapiro-Wilk test. As some variables did not meet the assumption of normality, the relationships between all independent variables and anaerobic performance were quantified by Spearman's Rho correlation coefficients. The strength of the observed relationships was interpreted using the following criteria: trivial (<0.10), small (0.10–0.29), moderate (0.30–0.49), high (0.50–0.69), very high (0.70–0.90), or nearly-perfect (>0.90). Independent samples t-tests were conducted to assess differences between sexes. Effect sizes for sex comparisons were calculated using Cohen's d (d). Effect size values were interpreted as small ($d = 0.2$), medium ($d = 0.5$), or large ($d = 0.8$). The statistical significance level for all tests was set at $p < 0.05$. Finally, stepwise multiple regression analyses were performed to determine the relationship between the independent and dependent variables and to create models that best explained the variance of

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the anaerobic performance variables. A stepwise multiple linear regression analysis was conducted for each dependent variable (WGPP, WGXP and WGMP) using total or segmental BC data. The significant variables selected by the statistical software were used to create a predictive model for the performance variables.

3. Results

Table 1 presents descriptive statistics for the entire group and for males and females, along with the comparison between sexes and the effect size of all study variables. Table 2 presents correlation data between all variables.

3.1. Whole Body BC Correlations

In the total BC, grouping men and women in a single group, the WBLM showed a significant positive correlation with WGPP, WGXP and WGMP. Likewise, WBFMP also showed a significant negative correlation with WGPP, WGXP and WGMP.

When splitting the sample by sex, in the male group, the WBLM showed a significant positive correlation with WGPP, WGXP and WGMP. In the female group, the WBLM also showed a significant correlation with WGPP, WGXP and WGMP.

3.2. Segmental BC Correlations

3.2.1. Trunk

In the pooled sample, TRLM turned out to have a significant positive correlation with WGPP, WGXP, and WGMP; and TRFMP negatively correlated with WGPP, WGXP and WGMP.

In male, TRLM significantly correlated with WGPP, WGXP and WGMP; and, in female, significant correlation was found between TRLM and WGPP, WGXP and WGMP.

3.2.2. Upper Extremity

In the analysis of the upper limbs, in the pooled sample analysis, it turned out that UELM correlated significantly with WGPP, WGXP and WGMP; UEFMP showed significant negative correlation with WGPP, WGXP and WGMP.

Male athletes exhibited a significant correlation between UELM and WGPP, WGXP and WGMP. Female athletes showed a significant positive correlation between UELM and WGPP, WGXP and WGMP.

Table 1. Descriptive data of the variables, sex comparison and effect size.

	Group (n=50)			Male (n=25)			Female (n=25)				
	Mean	**SD**	**SEM**	**Mean**	**SD**	**SEM**	**Mean**	**SD**	**SEM**	**t**	***d***
Age (years)	33.26	6.81	0.96	33.32	5.84	1.17	33.20	7.78	1.56	0.951	0.02
Body Mass (kg)	72.57	12.17	1.72	82.76	7.47	1.49	62.37	5.50	1.10	0.000	3.11
Height (cm)	169.55	8.71	1.23	176.90	4.16	0.83	162.20	5.01	1.00	0.000	3.20
BMI ($kg·m^{-2}$)	25.06	2.31	0.33	26.43	2.03	0.41	23.70	1.70	0.34	0.000	1.46
WBLM (kg)	58.20	12.15	1.72	69.01	6.15	1.23	47.39	4.46	0.89	0.000	4.02
WBFM (kg)	15.49	3.14	0.44	15.15	3.25	0.65	15.82	3.05	0.61	0.459	0.21
WBFM (%)	21.45	4.95	0.70	17.95	3.09	0.62	24.96	3.86	0.77	0.000	2.01
TRLM (kg)	27.24	5.49	0.78	32.14	2.77	0.55	22.35	2.00	0.40	0.000	4.06
TRFM (kg)	6.26	1.77	0.25	6.72	1.94	0.39	5.79	1.47	0.29	0.062	0.54
TRFM (%)	18.80	4.46	0.63	17.14	3.91	0.78	20.47	4.42	0.88	0.007	0.80
UELM (kg)	7.02	2.19	0.31	8.99	1.13	0.23	5.05	0.65	0.13	0.000	4.27
UEFM (kg)	1.68	0.38	0.05	1.69	0.38	0.08	1.67	0.39	0.08	0.855	0.05
UEFM (%)	20.25	5.94	0.84	15.73	2.51	0.51	24.77	4.82	0.96	0.000	2.35
LELM (kg)	20.45	4.28	0.61	24.10	2.44	0.49	16.80	1.91	0.38	0.000	3.33

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LEFM (kg)	6.46	1.57	0.22	5.55	1.18	0.24	7.37	1.38	0.28	0.000	1.41
LEFM (%)	24.55	7.04	1.00	18.67	3.32	0.66	30.42	4.29	0.86	0.000	3.06
WGPP (W)	700.93	224.08	31.69	895.41	135.75	27.15	506.45	72.75	14.55	0.000	3.57
WGXP (W)	511.58	160.89	22.75	653.11	91.80	18.36	370.06	51.92	10.38	0.000	3.80
WGMP (W)	311.27	112.64	15.93	387.99	101.22	20.24	234.55	58.28	11.66	0.000	1.86
WGFI (%)	54.84	10.31	1.46	56.59	9.24	1.85	53.09	11.20	2.24	0.235	0.34

SD: standard deviation; SEM: standard error of the mean; t: significance of t-student analysis; d: Cohen d effect size; BMI: body mass index; WBLM: whole body lean mass in kg; WBFM: whole body fat mass in kg; WBFMP: whole body fat mass as percentage; TRLM: trunk lean mass in kg; TRFM: trunk fat mass in kg; TRFMP: trunk fat mass percentage; UELM: upper extremity lean mass in kg; UEFM: upper extremity fat mass in kg; UEFMP: upper extremity fat mass as percentage; LELM: lower extremity lean mass in kg; LEFM: lower extremity fat mass in kg; LEFMP: lower extremity fat mass as percenatge; WGPP: peak power in watts; WGXP: mean power in watts; WGMP: minimal power in watts; WGFI: fatigue index.

3.2.3. Lower Extremity

Pooled sample results showed that LELM correlated significantly with WGPP, WGXP and WGMP; LEFM showed significant negative correlation with WGPP, WGXP and WGMP; LEFMP showed significant negative correlation with WGPP, WGXP and WGMP.

In male athletes, LELM correlated significantly with WGPP, WGXP and WGMP. In females, LELM showed a significant correlation with WGPP, WGXP and WGMP.

Table 2. Spearman's correlation coefficient between total and segmental body composition and the anaerobic power values in the whole group, male and females athletes.

	Group (n=50)			**Male (n=25)**			**Female (n=25)**		
	WGPP	**WGXP**	**WGMP**	**WGPP**	**WGXP**	**WGMP**	**WGPP**	**WGXP**	**WGMP**
WBLM (kg)	0.93**	0.96**	0.82**	0.72**	0.83**	0.59**	0.69**	0.82**	0.59**
WBFM (kg)	-0.03	-0.02	-0.1	0.32	0.3	0.11	0.01	0.06	-0.1
WBFMP (%)	-0.68**	-0.68**	-0.64**	0.01	-0.05	-0.13	-0.26	-0.26	-0.3
TRLM (kg)	0.91**	0.94**	0.81**	0.69**	0.79**	0.54**	0.56**	0.74**	0.63**
TRFM (kg)	0.25	0.27	0.19	0.23	0.26	0.12	0.01	0.06	-0.08
TRFMP (%)	-0.34*	-0.35*	-0.35*	0.04	0.02	-0.1	-015	-0.16	-0.26
UELM (kg)	0.91**	0.94**	0.81**	0.57**	0.71**	0.52**	0.67**	0.80**	0.57**
UEFM (kg)	0.06	0.11	0.06	0.38	0.45*	0.23	-0.11	0.04	-0.01
UEFMP (%)	-0.73**	-0.72**	-0.64**	0.08	0.03	-0.04	-0.39	-0.29	-0.23
LELM (kg)	0.93**	0.95**	0.80**	0.77**	0.83**	0.59**	0.69**	0.74**	0.46*
LEFM (kg)	-0.47**	-0.48**	-0.50**	0.21	0.15	0.01	0.01	0.08	-0.05
LEFMP (%)	-0.79**	-0.79**	-0.71**	-0.09	-0.16	-0.21	-0.34	-0.33	-0.29

3.3. Multiple Regression Analysis

Table 3 presents the multiple regression models developed based on total and segmental BC using data from the entire group. The results demonstrate that the strongest predictor of total BC variables is WBLM, explaining 87% ($F(1,48) = 315.887$, $p < 0.001$), 93% ($F(1,48) = 614.223$, $p < 0.001$), and 61% ($F(1,48) = 78.229$, $p < 0.001$) of the variance in WGPP, WGXP, and WGMP values, respectively. Regarding segmental BC, a model for WGPP is generated through LELM, accounting for 86% ($F(1,48) = 298.923$, $p < 0.001$) of the variance. For WGXP, two different models are generated. Model 1, explained by LELM, with a predictive capacity of 90% ($F(1,48) = 464.973$, $p < 0.001$), while Model 2, which incorporates the UELM variable, increases the predictive capacity of model 1 by 2% ($F(2,47) = 284.645$, $p < 0.001$). Finally, a model for WGMP is developed using UELM, accounting for 60% of its variance ($F(1,48) = 75.621$, $p < 0.001$).

Table 4 presents regression models created for the dependent variables, classified by sex. Prediction models based on WBLM were developed from total body composition. These models

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explain 46% (F(1,23) = 21.575, $p < 0.001$) and 42% (F(1,23) = 18.456, $p < 0.001$) of the variance in WGPP, 67% (F(1,23) = 48.974, $p < 0.001$) and 65% (F(1,23) = 46.432, $p < 0.001$) of the variance in WGXP, and 28% (F(1,23) = 10.441, p = 0.004) and 19% (F(1,23) = 6.668, p = 0.017) of the variance in WGMP for males and females, respectively.

When considering segmental body composition, prediction models were developed for both sexes, revealing a significant contribution from LELM. In the case of WGPP, LELM accounts for 51% (F(1,23) = 25.593, $p < 0.001$) and 47% (F(1,23) = 22.219, $p < 0.001$) of the variance in males and females, respectively. Similarly, for WGXP, LELM contributes to 66% (F(1,23) = 46.961, $p < 0.001$) and 60% (F(1,23) = 37.615, $p < 0.001$) of the variance in males and females, respectively. For WGMP in males, LELM was also selected as an independent variable, explaining 31% (F(1,23) = 11.739, p = 0.002) of the variance. Conversely, in the case of females, the independent variable TRLM was chosen for model creation, explaining 23% (F(1,23) = 8.278, p = 0.009) of its variance.

Table 3. Multiple regression models of the whole group using whole and segmental body composition.

Dependent variable	Independent variable	Coefficient	Std. Error	P	VIF	R^2	R^2-ajusted
Whole Body Composition							
WGPP	Constant	-299.238				0.87	0.87
	WBLM	17.186	0.967	<0.001	1		
WGXP	Constant	-230.705				0.93	0.93
	WBLM	12.755	0.515	<0.001	1		
WGMP	Constant	-113.528				0.62	0.61
	WBLM	7.299	0.825	<0.001	1		
Segmental Body Composition							
WGPP	Constant	-293.449				0.86	0.86
	LELM	48.620	2.812	<0.001	1		
WGXP (model 1)	Constant	-220.695				0.91	0.90
	LELM	35.805	1.660	<0.001	1		
WGXP (model 2)	Constant	-120.366				0.92	0.92
	LELM	19.432	5.237	0.001			
	UELM	33.419	10.232	0.002	1		
WGMP	Constant	28.907				0.61	0.60
	UELM	40.236	4.627	<0.001	1		

WGPP: peak power in watts; WGXP: mean power in watts; WGMP: minimal power in watts; WBLM: whole body lean mass in kg; LELM: lower extremity lean mass in kg; UELM: upper extremity lean mass in kg; VIF: variance inflation factor.

3.4. Sex Differences

Table 1 displays the sex differences observed among male and female athletes. The t-test results indicated statistically significant differences between sexes for most of the variables examined ($p < 0.05$). Conversely, a few variables did not exhibit statistically significant differences ($p > 0.05$), namely age, WBFM, TRFM, and UEFM.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

The main purpose of this study was to determine the relationship between BC values and anaerobic performance in CF athletes. The results of our work reveal a significant positive correlation

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between WBLM, TRLM, UELM and LELM with all studied anaerobic performance variables (WGPP, WGXP, and WGMP). The percentages of total or segmental fat mass in all segments (WBFMP, TRFMP, UEFMP, and LEFMP), as well as LEFM, showed a significant negative correlation with WGPP, WGXP, and WGMP when the sample was considered as a single group.

Concerning LBM, these results are consistent with those published by other authors in studies conducted on different populations. Maciejczyk et al. [13] found a positive correlation between lean mass and peak and mean power in a 20-second maximal effort cycling test in a sample of physically active men. Similarly, Stephenson et al. [12] demonstrated a significant correlation between total and segmental lower limb lean mass values and performance in vertical jump, in 102 non-athlete adults. Furthermore, a study conducted on motorcycle racing riders found a significant positive correlation between lean mass and WGPP [25]. Other findings, such as those of Collins et al., [26] showed a significant positive correlation between lean mass and maximum power, vertical jump, and medicine ball throw in law enforcement officer recruits.

In CF athletes, Mangine et al. [27] found a significant negative correlation between lean mass and the completion time of a standard WOD called "Fran," which involves performing a specified task as fast as possible. Therefore, athletes with higher lean mass values completed the WOD in less time. Menargues-Ramírez et al. [24] found a relationship between muscle mass and the total weight lifted in another standard workout. These findings support the idea that lean mass is positively related to anaerobic performance in different populations and sporting contexts.

Regarding fat mass, our results show a negative effect on performance, agreeing with those shown in other works that report a significant positive correlation between the WBFMP and skating times in male and female hockey players indicating that lower fat percentage is associated with faster times [28] and a significant negative correlation between the values of total and segmental fat mass and performance variables in some physical tests in recruits for law enforcement [26]. Similarly, other studies conducted on CF athletes show similar results in which the percentage of fat mass negatively affects performance in different WODs [10,11,27,29]. Like lean mass, these results highlight the relevance of the role of fat mass in athletic performance, emphasizing its influence on athletes' ability to achieve optimal levels of power and endurance.

The results presented in our work show that the absolute values of lean mass accurately predict anaerobic performance among CF athletes. The goodness of fit of the prediction models developed in this study ranges from 61% to 93% (for WGMP and WGPP, respectively) by the WBLM values of the pooled sample.

For the development of the prediction models of the whole group based on the segmental BC, the absolute values of LELM are included for three of the four models elaborated. As the only predictor of the WGPP and WGXP (model 1), explaining 86% and 90% of their variances, respectively. Likewise, as a co-predictor of the WGXP in model 2 where the UELM is included and increases its prediction capacity to 92%. For the prediction of the WGMP, the model excludes the LELM and includes the UELM instead, providing a goodness of fit of 60%. When the sample is divided by sex, the prediction models substantially decrease their predictive capacities, varying between 21% in men and 19% in women of the prediction model created for the WGMP and 67% in men and 65% in women for the WGXP, both created through the WBLM. In the same way as for the whole group, using the segmental body composition values, almost all the models were created by the LELM, except for the prediction of the WGMP in women executed through the TRLM. The goodness of fit of these models ranges from 23% to 66%. An interesting aspect to consider is the improvement in the predictive capacity of the models made with the segmental BC variables compared to those of the total body when the sample is split by sex. This variation could be explained by differences between men and women in the amount and distribution of lean mass.

Finally, significant differences between sexes were found in all performance variables. These differences have been previously published by some authors such as Maud & Shultz [30], who found significant differences between sexes in the absolute power values in the WG test, or Collins et al. [26], who found significant differences between men and women in all performance variables except for maximum repetitions of push-up and the multi-station fitness test. In addition, statistically

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significant differences were found in all BC variables except for WBFM, TRFM, and UEFM. However, significant differences were found between sexes when expressing these same variables as a percentage (WBFMP, TRFMP and UEFMP). This discrepancy can be attributed to the percentage value since it provides a more individually standardized parameter than a simple absolute value in kg. Likewise, the significant difference observed in the LELM value between both sexes could be associated with a more significant amount of lean mass and a lower amount of segmental fat in the lower limbs of male athletes than their female counterparts. In addition, our results are consistent with those published by Collins et al. [26], who found significant differences in the WBLM, as well as TRLM, UELM, and LELM, but found no differences in the variables of total or segmental fat mass between male and female law enforcement recruits.

Several limitations should be acknowledged in the present study. Firstly, the menstrual cycle timing in female athletes and the use of contraceptive pills were not recorded, potentially affecting BC and performance results. Additionally, dietary habits during the study period were not documented, which could provide insights into the impact of nutrition on the results.

Moreover, it is important to note that laboratory tests conducted in a controlled environment may not fully replicate real competitive conditions in this sport. The absence of external factors and competitive pressure may limit the generalizability of the findings to actual scenarios.

Lastly, this study is cross-sectional and does not establish a causal relationship between BC values and anaerobic performance. Future intervention studies are required to elucidate the effects of changes in LBM and fat values on anaerobic performance and to identify other contributing factors for a more comprehensive understanding of these effect.

The research findings suggest that leaner CF athletes perform better, indicating that increasing LBM could significantly enhance their performance. These results offer valuable insights for CF coaches, encouraging them to focus on training programs that promote lean muscle growth and fat reduction to improve athlete performance. However, future research should aim to identify the ideal balance between lean and fat mass, avoiding excessive lean mass gains or extreme fat reductions that could be counterproductive or harmful to health.

Additionally, the study's developed prediction equations for BC demonstrate high accuracy. These equations could be utilized to estimate anaerobic power and capacity in CF athletes at specific times or for ongoing monitoring during the season. Therefore, BC assessment provides a valid tool for healthcare professionals, coaches, and fitness practitioners, offering an alternative means of evaluating anaerobic performance without subjecting athletes to maximal effort tests.

5. Conclusions

We can conclude that our findings show a moderate to nearly-perfect relationship between LBM and total and segmental body fat percentage with anaerobic performance in CF athletes. Furthermore, considering the high goodness of fit of the prediction models developed in this study, we can report that total and segmental lean mass values are strong predictors of peak and mean power determined in the WG. However, due to the multiple factors that can contribute to performance, the specific predictive value of the regression models developed in this study should be interpreted with caution. The mentioned parameters can be reliable and cost-effective tools to aid in identifying athletes' potential and monitoring their fitness levels throughout the season.

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