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ORIGINAL SCIENTIFIC PAPER

Comparison of Body Compositions among Endurance, Strength, and Team Sports Athletes

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Abstract

Regular monitoring and evaluation of body composition determine an athlete's output, such as their probability of winning competitions. The purpose of this study was to analyze the differences in athletes' body composition among several sports categories. The data collected were on 251 athletes aged 20 to 30 years during the pre-competition period. The subjects were divided into three groups: endurance, power, and team sports. SECA 515mBCA was used to analyze the athletes' body composition, which included their body fat percentage (BFP), fat mass (FM), fat-free mass (FFM), skeletal muscle mass (SMM), total body water (TBW), and extracellular water (ECW). The results showed that all body composition parameters were lowest in the endurance category. Fat composition was lowest in the endurance category but did not differ significantly between categories in male athletes. Meanwhile, in female athletes, there was a significant difference in FM between sports categories ($p=0.009$). FFM, SMM, TBW, and ECW differed significantly between categories ($p<0.05$). In female athletes, these variables were higher in the team sports category, as opposed to the power category among male athletes. This study concluded that there were differences in lean body mass composition between sport categories, while fat mass did not differ between sport categories in male athletes. This can be attributed to the differences in training programs and needs of each sport category in maximizing performance. These findings can provide advice to sports professionals that each sport category has its own body composition specifications.

Keywords: *healthy lifestyle, athlete, sports category*

Introduction

Assessing athletes' body composition is an important step in optimizing their performance (Toselli, 2021). The parameters used to evaluate body composition in sports include fat mass at the molecular level and cellular levels (such as body cell mass), intracellular or extracellular fluids, and muscle mass from the tissue level (Campa et al., 2021). Body composition can change according to training and physical activity. Each sport requires a certain type of exercise and activity, which can affect the athlete's body composition. As a result, body composition standards depend on the type of sport (Thomas et al., 2016). Based on differences in athletes' phase angles within a sport among different game roles, sport modalities are divided into three categories: endurance, power/velocity, and team sports (Campa et al., 2022). Study results by Campa et al. (2019) found differences in the body composition of endurance and power sport athletes in a healthy population.

Body composition is associated with increased cardiorespiratory fitness and strength. Athletes have a lower fat mass percentage than non-athletes of the same age. Monitoring fat mass (FM) in athletes is important because excess fat mass in the body reduces performance and decreases the athletes' level of achievement in sports (Chathuranga & Perera, 2022).

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Several studies have analysed the effects of body composition, especially body fat percentage (BFP) and fat-free mass (FFM), on athlete performance. A study by Esco et al. (2018) revealed that high BFP and low FFM are associated with decreased performance and becoming easily fatigued. High lean soft tissue mass and skeletal muscle mass (SMM) composition in the power category can be advantageous to meet the strength and power requirements in achieving maximum performance (Lukaski & Raymond-Pope, 2021). Other studies have also shown that total body water (TBW) and extracellular water (ECW) composition are associated with strength and power in the power and team sport categories (Silva et al., 2014). These findings support the importance of monitoring athletes' body composition. Monitoring an athlete's body composition is important to support regional and national sporting achievements. However, the different BFP, FM, FFM, SMM, TBW, and ECW compositions among the endurance, power, and team sports categories are unknown. The purpose of this study was to analyze the differences in athletes' body composition between the categories of endurance, power, and team sport athletes. This study is expected to be a reference of body composition for sports clubs, institutions, and regional and national agencies in each sport category. This study's results can help the athletes in these organizations achieve higher productivity, and it can provide recommendations for dietary and nutrient intake for each sport category.

Methods

Study participants

This cross-sectional study was conducted on 251 highly trained athletes (132 males and 119 females). Data were taken during the pre-competition period for the largest national competition. Subjects were selected based on the following inclusion criteria: (i) aged between 20-30 years old; (ii) athletes who trained and quarantined in East Java; (iii) had no medical conditions or injuries; (iv) were willing to sign informed consent forms. The subjects were divided into three groups based on their sport modality: endurance, power, and team sports. The endurance sports category consisted of 16 athletes (marathon, open water swimming, and windsurfing athletes), and the power sports category consisted of 142 athletes (athletic, badminton, judo, karate, martial arts, roller skating, sprint, swimming, taekwondo, weight lifting, and wushu athletes), and the team sports category consisted of 93 athletes (basketball, football, futsal, handball, hockey, indoor volleyball, and kick volleyball athletes). This study obtained permission from the Indonesian National Sports Committee (KONI) of East Java (426/153/601.5/2022) and was approved by the Health Research Ethics Committee, Faculty of Public Health, Universitas Airlangga (181/EA/KEPK/2022).

Body composition measurements

Data were collected directly from the subjects before breakfast in the morning. The data collected for this study included age, gender, type of sport, weight (kg), height (cm), body fat percentage (BFP; %), fat mass (FM; kg), fat free mass (FFM; kg), skeletal muscle mass (SMM; kg), total body water (TBW; l), and extracellular water (ECW; l). Body height was measured using a portable stadiometer (SECA 213, SECA, Hamburg, Germany) with an accuracy level of 0.1 cm. Waist circumference was measured using measuring tape (SECA 208, SECA, Hamburg, Germany) with a 0.1 cm accuracy level at the mid-point between the lower costal margin and the anterior superior iliac crest. The measurements were repeated three times and the two measurements with the closest values were averaged as the result. Body mass index was also calculated by dividing the body weight in kilograms by the body height in square centimeters. Body composition was measured using BIA (SECA 515 mBCA, SECA, Hamburg, Germany). Body composition is the measurement that describes each compartment's components in the body, consisting of fat mass and non-fat mass. Fat mass refers to all the fat components' weight in the body, while non-fat mass includes bones, body fluids, muscles, and the non-fat parts of the human body.

Statistical analysis

The statistical analysis was computerized using the Software Statistical Packet for Social Science (SPSS) IBM SPS 21. All data are expressed as means and standard deviation (SD) after normality data distribution was calculated using the Kolmogorov-Smirnov test. Since the data distribution was not normal, the non-parametric statistic was applied. The Kruskal-Wallis test was used to compare the characteristics and body composition data between groups. The Mann-Whitney test was used to differentiate between groups for the post-hoc test, with a 95% significance level.

Results

Based on Table 1, there were significant differences in height, weight, and body composition components (FM, FFM, SMM, TBW, and ECW) between the groups of female athlete ($p < 0.01$). Female endurance athletes had lower body fat than females in other categories. Their FM composition showed no difference between the endurance and power categories, though there were significant differences between female endurance and team athletes, as well as between female power and team athletes. Furthermore, female athletes' FFM, SMM, TBW, and ECW compositions were higher in the team sports category compared to the other sport categories (FFM vs endurance: $p=0.007$; FFM vs power: $p=0.001$; SMM vs endurance: $p=0.006$; SMM vs power: $p=0.001$; TBW vs endurance: $p=0.008$; TBW vs power: $p=0.002$; ECW vs endurance: $p=0.012$; ECW vs power: $p=0.004$).

Table 2 presents the characteristics and body composition of male athletes. There were significant differences in weight, BMI, FFM, SMM, and TBW between groups ($p<0.01$). There were no significant differences in height, BFP, or FM in male athletes with different sports categories ($p>0.05$). Just like the female athletes, BFP and FM were lower in the male endurance athletes compared to the male athletes in the other categories. The FFM, SMM, TBW, and ECW compositions were highest in the power category but not significantly different from the team sport category ($p>0.05$). Meanwhile, those same compositions were significantly different between the endurance and power athletes, as well as the endurance and team sport athletes ($p<0.05$). In addition, the endurance and team sport athletes' BMIs were significantly different when compared to the power athletes compared to endurance ($p=0.011$) and to team sport ($p=0.040$). Female and male athletes' body composition mass in general are shown in Figure 1.

Table 1. Characteristics and body composition of female athletes

Variable	Endurance (n = 6)	Power (n = 69)	Team Sport (n = 44)	p-value (Kruskal-Wallis)
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	23.67±1.75	24.94±2.70	23.82±2.12†	0.049^
Weight (kg)	48.74±5.23	54.04±7.73	59.38±9.31*†	0.000^
Height (m)	1.57±0.06	1.58±0.05	1.66±0.08*†	0.000^
BMI (kg/m2)	19.64±1.74	21.52±2.55	21.18±1.86	0.172
BFP (%)	19.72±3.99	21.06±4.85	22.43±4.30	0.166
FM (kg)	9.68±2.66	11.63±4.38	13.54±4.30*†	0.009^
FFM (kg)	39.05±3.85	42.41±4.38	45.83±5.98*†	0.001^
SMM (kg)	17.44±2.41	19.46±2.64	21.39±3.32*†	0.000^
TBW (l)	28.43±2.93	31.07±3.35	33.57±4.67*†	0.003^
ECW (l)	11.70±1.13	12.75±1.49	13.83±2.17*†	0.000^

Note. BMI: body mass index); BFP: body fat percentage; FM: fat mass; FFM: free fat mass; SMM: skeletal muscle mass); TWB: total body water; ECW: extracellular water; SD: standard deviation; ^ Significantly different between groups ($p < 0.05$); * Significantly different from the endurance group ($p < 0.05$); † Significantly different from the power group ($p < 0.05$)

Table 2. Characteristics and body composition of male athletes

Variable	Endurance (n = 10)	Power (n = 73)	Team Sport (n = 49)	p-value (Kruskal-Wallis)
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	25.20±2.89	25.44±2.41	24.45±1.45†	0.063
Weight (kg)	61.88±7.92	69.89±12.90*	68.39±8.61*	0.080
Height (m)	1.70±0.05	1.70±0.06	1.73±0.08†	0.135
BMI (kg/m2)	21.29±2.34	24.07±3.76*	22.61±1.71†	0.010^
BFP (%)	12.01±5.66	13.05±6.49	12.71±3.83	0.733
FM (kg)	7.76±4.58	9.81±6.94	8.91±3.72	0.457
FFM (kg)	54.12±4.52	60.08±6.78*	59.47±5.97*	0.018^
SMM (kg)	25.85±2.79	29.35±3.81*	28.87±3.22*	0.020^
TBW (l)	38.99±3.55	43.60±5.18*	42.95±4.51*	0.019^
ECW (l)	15.22±1.37	16.93±2.26*	16.70±2.05*	0.056

Note. BMI: body mass index); BFP: body fat percentage; FM: fat mass; FFM: free fat mass; SMM: skeletal muscle mass); TWB: total body water; ECW: extracellular water; SD: standard deviation; ^Significantly different between groups ($p < 0.05$); *Significantly different from the endurance group ($p < 0.05$); †Significantly different from the power group ($p < 0.05$)

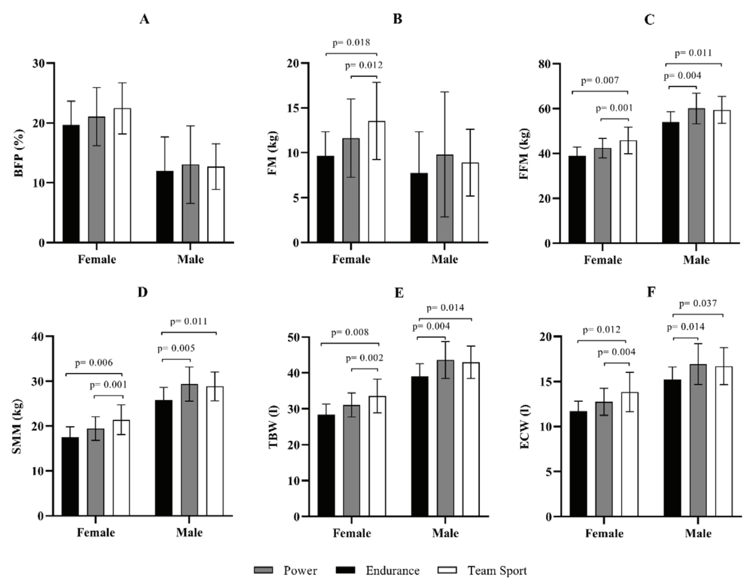

FIGURE 1. a. Body fat percentage (BFP); b. Fat mass (FM); c. Fat free mass (FFM); d. Skeletal muscle mass; e. Total body water (TBW); f. Extracellular water (ECW) in endurance (black symbols), power (grey symbols), and team sport (white symbols) on female and male athletes

Discussion

The main finding of this study is that all body composition parameters were lowest in the endurance category in female and male athletes. FM composition in female athletes was highest in the team sport category and differed from the other categories. FFM, SMM, TBW, and ECW compositions differed between categories. In female athletes, they were higher in the team sports category. Meanwhile, in male athletes, they were higher in the power category. In male athletes, the high FFM and SMM composition in the power category may correlate with the high BMI in this category compared to other sport categories. Body mass index cannot distinguish between FM and FFM, where athletes tend to have lower BFP and higher FFM, making it possible that high BMI is not due to high fat mass, but high FFM (Esco, et al. 2018). Body composition parameters are an essential part of sports performance and a prerequisite for reaching elite performance levels (Kutáč & Sigmund, 2017).

Previous studies have shown comparative results of body fat composition between different sports categories. This study showed no difference in BFP and FM in male athletes between categories, but it found lower BFP and FM in male and female endurance athletes. This is in line with a previous study that found a similar BF between the power and endurance categories (Trinschek et al., 2020). Studies have shown that minimal BFP is desirable in runners because excess adipose tissue causes increased muscle effort during accelerating strides, leading to higher energy expenditure at the same speed (Mooses & Hackney, 2016). This result is in line with other studies that also measured the body composition of male basketball athletes, where the average BFP was 11.69% (Gerodimos et al., 2005). Based on a previous study in male soccer athletes, low BFP (<12%) and high FFM can improve sprint performance (Ishida et al., 2021). Physiologically, moderate exercise (60-65% VO2max) increases fat oxidation. There is some research evidence to suggest that adaptations to endurance training, such as increased capillary angiogenesis and mitochondrial biogenesis, can increase fat oxidation (Holloszy & Coyle, 2016). This is one of the factors that contribute to fat mass being lower in the endurance category than in the other categories, though it is still not significantly different.

As expected, this study found higher FFM and SMM in the power and team sport categories. This is in line with a previous study that found female and male athletes in the power and team sport categories had a higher FFM and SMM composition than endurance athletes (Campa et al., 2022). Even for male athletes, there were significant differences in BMI, FFM, and SMM between sport categories, with the highest FFM and SMM found in the power category. Increasing FFM and SMM can be advantageous in sports that require strength and power (Lukaski & Raymond-Pope, 2021). Those in the power category had higher SMM than those in the endurance category during all training periods. However, in the power category, SMM increased from general to specific during the pre-competition phase (Trinschek et al., 2020). Good performance in the power category is achieved when an athlete has greater muscle mass (Hasan et al., 2021). Athletes with high-performance levels have high FFM values and low BFP (Nikolaidis, et al., 2015). In the team sport category, the FFM enhancement can help to improve jumps and sprints because excessive body mass can negatively impact these skills (Ishida et al., 2021). Previous studies have shown a relationship between BFP, FFM, and SMM with athletes' sprint performance (Dopsaj et al., 2020). Controlling body composition is important in sprinting. It must be done to maintain the body's efficiency in adapting during the training process to optimize competitive performance. Increased muscle mass helps athletes maximize strength, speed, acceleration, and agility (Shaw & Mujika, 2017).

High FFM in power and team sports is necessary because these sports are typically anaerobic. Power and team sport athletes have higher anaerobic power than endurance athletes, which is related to training adaptation and greater body strength (Degens et al., 2019; Campa et al., 2022). High-intensity intermittent sports predominantly use anaerobic resources because decisive actions rely on powerful movements (Glaister, 2005). Power athletes perform resistance and strength training with the main focus on muscle hypertrophy (Slater & Phillips, 2011). Muscle mass is an essential factor in sports that requires muscle strength or power (Garthe et al., 2013). Power is used to perform attacks or explosive movements that are integrated with reactions, intramuscular or intermuscular coordination, and timing to be effective in the application of certain techniques (Slimani et al., 2017). During the power athletes' performance, anaerobic contributions appear to be particularly important although other sources also contribute significantly to the overall work performed (Degoutte et al., 2003).

A previous study showed that those in the endurance category had the lowest muscle mass compared to other categories. The results of a study conducted by Campa, et al. (2019) also show that endurance athletes had less body fluids (TBW and ECW) than other athletes, which also plays a role in their lower body weight. This is in line with the increase in fluid quantity associated with heavier body mass, especially in power and team sport athletes.

Differences in body composition are influenced by several factors, such as the type of exercise and body activity during training and competition (Nepocatych et al., 2017). Previous research by Rejeki et al. (2023) also showed that the type of exercise had a positive effect on improving body composition. Previous studies have shown a relationship between body composition parameters and aerobic and anaerobic capacity (Akinoğlu & Kocahan, 2019). The mechanisms that are commonly found in sports are body morphological adaptations triggered by training components (training intensity or load) adjusted according to specific sports (Dopsaj et al., 2018). In addition, genetics, age, training status, competitive career stage, season, and sporting demands should be analyzed to interpret athletes' body composition. A previous study showed that body composition is influenced by age, sex, genetics, and ethnicity (Winkler et al., 2015). A study by Srhoj et al. (2002) predicted muscle mass was higher in East Asian athletes than in West Asian athletes. Based on those statements, this study may have different results from other countries due to the specific genetic and ethnic factors of Southeast Asia, especially Indonesia. Body composition is also influenced by external factors, one of which is the training season. During training season, increased FFM and SMM and decreased BFP have been reported (Gonzales-Rave et al., 2011). During training season, an increase in muscle strength and power has also been observed, as measured by squat, bench press, and countermovement jump tests (Marques, et al., 2008). The body composition profile for athletes from various sports categories during pre-season training can be referenced when monitoring and interpreting their body (Cullen et al., 2020). Other studies have also found that the body composition of elite athletes is different from that of amateur athletes (Slimani et al., 2017). Additionally, an athlete's body composition is influenced by the athlete's nutritional intake and position. The quality of an athlete's performance will be effective if they receive a good combination of proper training and nutritional intake (Hasan et al., 2021).

This study's strength is that it is the first study to compare athletes' body composition based on the three categories of endurance, strength, and team sports in the pre-competition period. A limitation of this study is the uneven distribution of samples, especially in the endurance category. Further research still needs to be done with a larger sample size, and by comparing trends in body composition changes in each periodization based on sports categories and in correlation with athlete performance.

Conclusion

In conclusion, BFP did not differ between sport categories, but FM differed between sport categories in female athletes. FFM, SMM, TBW, and ECW composition differed between categories. In female athletes, these variables were higher in the team sports category, while they were highest in the power category for male athletes. The results showed that all body composition parameters were lowest in the endurance category in female and male athletes. These differences can be influenced by differences in the training programs and needs of each category in maximizing performance. These findings can serve as advice to sports professionals that each sport category has its own body composition specifications.

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Conflict of Interest

The authors declare no conflicts of interest related to this manuscript.

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