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Bioelectrical Impedance Analysis (BIA) in Male and Female Para-Archery Athletes: A Comparative Study

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Abstract

Study purpose. To determine the differences in bioelectrical impedance analysis (BIA) results in male and female para-archery athletes.

Materials and methods. A comparative study was used in this study with a sample of 5 para-archery athletes (male, n=3; female, n=2) aged 31.40±10.11 years, height 161.40±9.84 cm, weight 69.20±5.93 kg, BMI 26.60±1.66 kg/m2, and playing experience 7.20±1.79 years. Participants underwent body composition tests and measurements using the InBodyS10 device consisting of body water composition, segmental body water, muscle-fat and obesity analysis, and basal metabolic rate. Data were then analysed using independent t-test.

Results. The results showed no significant differences between male and female para-archery athletes in the results of bioelectrical impedance analysis (BIA) which includes body water composition, namely TBW (t=1.710; p=0.186), ICW (t=2.479; p=0.089), ECW (t=1.008; p=0.388), and ECW/TBW ratio (t=1.023; p=0.382); segmental body water, namely RA (t=0. 417; p=0.705), LA (t=0.888; p=0.440), TR (t=0.099; p=0.927), RL (t=2.432; p=0.093), and LL (t=1.099; p=0.352); muscle-fat and obesity analysis namely weight (t=0. 469; p=0.671), SMM (t=2.470; p=0.090), BFM (t=0.805; p=0.480), BMI (t=1.222; p=0.309), and PBF (t=0.898; p=0.436); and basal metabolic rate (t=1.637; p=0.200).

Conclusion. Males had greater total body water. Neither males nor females showed overhydration. For segmental body water, the trunk contributed the largest water distribution in both males and females. Male athletes have a heavier weight with a greater skeletal muscle mass composition, while females are fatter with BMI and Percent body fat above normal. Every day to lose fat or gain muscle mass, male athletes need a greater number of calories than women.

Keywords: BIA, Para-Archery, Body Composition

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Introduction

Para-archery is one of two very popular adaptive shooting disciplines that have earned a place as major official events at the Paralympic Games (Puce et al. 2024), with only minor modifications and adaptive equipment, people with disabilities can compete at a high level with able-bodied individuals. Adaptive archery is a sport that uses a bow to propel arrows, and emphasises accuracy, concentration and technique. Archers are assessed for accuracy by hitting a target with arrows from a specified distance (Chen and Mordus 2018). Athlete body composition is an important criterion in determining the optimal body profile required for optimal health and performance in various sports disciplines (Bandyopadhyay et al. 2018). Body composition represents the unity of the basic structural elements of the human body that cannot be separated and involves the relative representation of various constituent elements of the total human body weight. Currently, modern devices for body composition evaluation use computer technology to determine or estimate body components (Gligoroska et al. 2018). Bioelectrical impedance analysis (BIA) is one of them, having become a widely adopted method for body composition assessment using InBody devices.

Bioelectrical impedance analysis (BIA) using the InBody device is used to estimate total body water, segmental water, muscle mass and body fat, and basal metabolic rate. For archery athletes, they have to play outdoors with unpredictable environmental conditions that challenge the body's ability to control dehydration (Gligoroska et al. 2018). A study showed that there was psychological and physical stress on archery performance, athletes felt thirstier, more tired, and less able to concentrate during dehydration (Savvides et al. 2020). Therefore, the measurement of total body water is very important for archery or para-archery athletes, through the ratio of extracellular water to total body water, the level of dehydration experienced by athletes can be determined. In addition to total body water, the advantage of BIA and InBody devices methodology, compared to other field methods in sports anthropometry is segmental analysis (Gligoroska et al. 2018).So that it can be seen that the distribution of water is symmetrical and balanced between the left and right sides of the body.

In addition to hydration, increasing muscle mass and reducing body fat play an integral role in achieving optimal performance. An excess proportion of fat to total body mass (fat%) in the body leads to decreased performance. Fat% and FFM% (proportion of fat free mass to total body mass) are less important for relatively stationary sports, such as archery and shooting (Slater and Phillips 2011). Nutrient intake also plays an important role in elite sport recovery and performance. Estimating energy requirements is important for adequate nutrition management in athletes (T. et al. 2012). A study reported that daily energy intake ranged from 2563 to 3986 kcal per day, respectively. Thus, archers can practice elements of periodised nutrition so that energy intake is greater on high-volume competition days (i.e. days 1 and 3; more arrows, longer duration, and walking distance) compared to low-volume days (days 2 and 4) during tournaments (Esen, Walshe, and Goodall 2024).

However, the previously described studies were only limited to non-disabled samples, so it is not yet known how the results of bioelectrical impedance analysis (BIA) assessment if applied to para-archery athletes, moreover the needs between men and women are also different. In this study, the hypothesis proposed is how the results of bioelectrical impedance analysis (BIA) in male and female para-archery athletes and the differences. So the purpose of this study is to determine the differences in the results of bioelectrical impedance analysis (BIA) in male and female para-archery athletes. The importance of this study for athletes with disabilities, especially para-archery, considering that (Puce et al. 2024) have reported that there is still limited literature available regarding adaptive shooting disciplines, especially regarding para-archery.

Materials and Methods

Study participants.

The subjects were 5 para-archery athletes (male (n=3) and female (n=2) aged 31.40±10.11 years, height 161.40±9.84 cm, weight 69.20±5.93 kg, 26.60±1.66 kg/m2, and playing experience 7.20±1.79 years table 1. Ethical approval was obtained by the Ethics

Committee of Sebelas Maret University Surakarta prior to the study. The purpose of the study was explained and written consent was obtained from each sample before the study took place.

Table 1. Participant data

Gender	**Number of athletes**	**Age (years) (*Mean±SD*)**	**Height (cm) (*Mean±SD*)**	**Body weight (kg) (*Mean±SD*)**	***BMI* (kg/m^2) (*Mean±SD*)**	**Playing experience (years) (*Mean±SD*)**
Male	3	32.33±12.86	165.00±8.00	70.33±3.06	25.90±1.92	7.33±1.53
Female	2	30.00±8.49	156.00±12.73	67.50±10.61	27.65±0.21	7.00±2.83
Total participants	5	31.40±10.11	161.40±9.84	69.20±5.93	26.60±1.66	7.20±1.79

Study organization.

A comparative study was used in this study to examine the differences in bioelectrical impedance analysis (BIA) results in male and female para-archery athletes. To assess the bioelectrical impedance analysis (BIA) results of body composition, participants underwent tests and measurements using the InBodyS10 device (Model BPM040S12F07, BridgePower Corp. USA). Body composition consists of body water composition (total body water, intracellular water, extracellular water, ratio extracellular water/total body water, segmental body water (right arm, left arm, trunk, right leg, left leg), muscle-fat (weight, skeletal muscle mass, body fat mass), obesity analysis (body mass index, percent body fat), and basal metabolic rate. The test was conducted indoors with a temperature range of 10-400C and a relative humidity of 30-75%. The test uses AC input power 100-240V, 50/60Hz, 1.2A (12A-0.6A), DC output power 12V, 3.4A. This model uses eight electrodes positioned on each hand and foot and allows multifrequency impedance measurements on 5 segments (right arm, left arm, trunk, right leg, and left leg). The impedance measurements were made using 6 different frequencies (1kHz, 5kHz, 50kHz, 250kHz, 500kHz, 1000kHz). Measurements were made following the InBodyS10 standard testing manual. The device was calibrated every morning using the standard control circuit provided by the manufacturer, and ensured that the precision error was less than 2% (Choi et al. 2021). Before the test, participants were not allowed to exercise 6-12 hours before, eat 3-4 hours before, not allowed to consume alcohol or caffeine 24 hours before, not allowed to use a shower or sauna, not allowed to use lotions or ointments on hands or feet, and maintain good hydration. When the test is conducted, all socks, stockings, shoes, heavy clothing (jackets) and metal objects (jewellery, watches, belts) are removed.

Statistical analysis.

Data were analysed using SPSS version 17.0. For descriptive characterisation, means and standard deviations were calculated. All data were normally distributed through Kolmogorov-smirnov normality test so to evaluate the BIA results, independent t-test was analysed. Significance was accepted at the 5% level.

Results

Body Water Composition

No statistically significant differences were found between male and female para-archery athletes in all body water composition assessment results, namely TBW (t=1.710; p=0.186), ICW (t=2.479; p=0.089), ECW (t=1.008; p=0.388), and ECW/TBW ratio (t=1.023; p=0.382). Although no differences were found, male para-archery athletes had more body water composition than females in TBW, ICW, and ECW, with a low ratio between ECW and TBW table 2.

Tabel 2. *Mean, SD,* dan uji beda *body water composition*

Body water composition	Male (Mean±SD)	Female (Mean±SD)	t	p-value
Total body water (*TBW*) (L)	41.53±6.22	33.15±3.04	1.710	0.186
Intracellular water (*ICW*) (L)	25.10±3.01	19.40±0.99	2.479	0.089
Extracellular water (*ECW*) (L)	16.43±3.26	13.75±2.05	1.008	0.388
ECW/TBW rasio	0.39±0.02	0.41±0.03	1.023	0.382

Segmental Body Water Analysis

Although seen specifically, namely segmental body, the results also found no statistically significant differences between male and female para-archery athletes in all segmental body water, namely RA (t=0.417; p=0.705), LA (t=0.888; p=0.440), TR (t=0.099; p=0.927), RL (t=2.432; p=0.093), and LL (t=1.099; p=0.352). Male para-archery athletes were found to have the highest segmental water composition at the segmental trunk (18.47±3.55), female para-archery athletes were also found to have the highest water composition at the segmental trunk (18.80±3.96). However, the composition was more in female para-archery athletes. While the lowest segmental water was found in the segmental left arm for male para-archery athletes (2.01±0.21) and right arm for female para-archery athletes (2.44±0.76) table 3.

Table 3. Mean, SD, and difference test of segmental body water analysis

Segmental body water analysis	Male (Mean±SD)	Female (Mean±SD)	t	p-value
Right arm (*RA*) (L)	3.08±1.98	2.44±0.76	0.417	0.705
Left arm (*LA*) (L)	2.01±0.21	2.57±1.15	0.888	0.440
Trunk (*TR*) (L)	18.47±3.55	18.80±3.96	0.099	0.927
Right leg (*RL*) (L)	6.70±1.13	3.96±1.42	2.432	0.093
Left leg (*LL*) (L)	10.04±7.54	3.79±1.70	1.099	0.352

Muscle-Fat dan Obesity Analysis

No statistically significant differences were found between male and female para-archery athletes on all muscle-fat and obesity assessment results namely weight (t=0.469; p=0.671), SMM (t=2.470; p=0.090), BFM (t=0.805; p=0.480), BMI (t=1.222; p=0.309), and PBF (t=0.898; p=0.436). Male para-archery athletes had greater body mass (weight) (70.33±3.06) compared to female para-archery athletes (67.50±10.61). This may be due to male para-archery athletes having greater skeletal muscle mass (30.77±3.96) compared to female para-archery athletes (23.30±1.27). Whereas female para-archery athletes were found to be more obese with greater body fat mass (22.25±15.34), body mass index (27.65±0.21), and percent body fat (31.50±17.82) compared to the body fat mass (14.67±6.48), body mass index (25.90±1.92), and percent body fat (20.93±9.53) of male para-archery athletes table 4.

Table 4. Mean, SD, and difference test of muscle-fat & obesity analysis

Muscle-fat dan obesity analysis	Male (Mean±SD)	Female (Mean±SD)	t	p-value
Weight (kg)	70.33±3.06	67.50±10.61	0.469	0.671
Skeletal muscle mass (*SMM*) (kg)	30.77±3.96	23.30±1.27	2.470	0.090
Body fat mass (*BFM*) (kg)	14.67±6.48	22.25±15.34	0.805	0.480
Body mass index (*BMI*) (kg/m^2)	25.90±1.92	27.65±0.21	1.222	0.309
Percent body fat (*PBF*) (%)	20.93±9.53	31.50±17.82	0.898	0.436

Basal Metabolic Rate

Basal metabolic rate also showed no statistically significant difference between male and female para-archery athletes (t=1.637; p=0.200). Although there was no difference, male para-archery athletes required more calories (1572.67±169.05 kcal) to perform basic activities than female para-archery athletes (1348.00±103.24 kcal) table 5.

Table 5. Mean, SD, and independent t-test of basal metabolic rate

Basal Metabolic Rate	Male (Mean±SD)	Female (Mean±SD)	t	p-value
Basal metabolic rate (*BMR*) (*kcal*)	1572.67±169.05	1348.00±103.24	1.637	0.200

Discussion

This research study found no significant differences between male and female para-archery athletes on the results of bioelectrical impedance analysis (BIA) which includes body water composition namely TBW, ICW, ECW, and ECW/TBW ratio; segmental body water namely RA, LA, TR, RL, and LL; muscle-fat and obesity analysis namely weight, SMM, BFM, BMI, and PBF; and basal metabolic rate.

Fluid balance in the body based on the results of the body water composition assessment found no difference between male and female para-archery athletes. Male para-archery athletes were found to have more total body water than female para-archery athletes. Of the total body water, both showed the most fluid composition in intracellular water. This suggests that both male and female para-archery athletes have more lean body mass, increased nutrient retention/utilisation and health, and overall cellular integrity. Judging from the ratio of extracellular water to total body water, para-archery athletes have an ECW/TBW ratio that is still within normal limits but closer to 0.39, while para-archery athletes have an ECW/TBW ratio that exceeds normal limits based on Kim, Krivulina, & Prosekin (2020) (0.39 ECW/TBW ratio for male para-archery athletes; 0.41 ECW/TBW ratio for female para-archery athletes). In a healthy state, the ECW/TBW ratio should be within the range of 0.360-0.390 (Savvides et al. 2020). The ratio of extracellular water to total body water is an important indicator of whether the body water is balanced, evaluating the adequacy of the amount of water released through extracellular water secretion. However, a study showed that an ECW/TBW ratio of <0.47 had a higher probability of survival (Pérez-Morales et al. 2021). (Cornejo-Pareja et al. 2022) also reported that overhydration was indicated as high hydration with ECW/TBW >0.58 and was a significant predictor of mortality.

Fluid balance in body segments based on the results of segmental water assessment found no difference between male and female para-archery athletes. This study found that water distribution in the upper extremities (arms) showed a higher mean value on the left side in female para-archery athletes while male para-archery athletes were higher on the right side. However, water distribution in the lower extremities (legs) showed higher mean values on the right in female para-archery athletes while male para-archery athletes were higher on the left. The trunk, with a large volume of water distribution compared to the upper (arms) and lower (legs) extremities, contributed an average of 18.80 litres in female para-archery athletes and an average of 18.47 litres in male para-archery athletes.

The presence or absence of health risks based on muscle-fat and obesity assessment results found no difference between male and female para-archery athletes. This study found that male para-archery athletes had greater body mass but this was because they had greater skeletal muscle mass. Similar to a previous study that the muscle mass of male archery athletes was noted to be greater than female archery (Chen and Mordus 2018). Although not using a disability sample, the results were similar to this study. However, his skeletal muscle mass was reported at 27.56±4.82 kg, lower than the male para-archery athletes in this study at 30.77±3.96

kg. Female para-archery athletes tended to be more obese with a BMI of 27.65 kg/m2 and percent body fat of 31.50%. These results suggest that female para-archery athletes have increased health risks. (Shah et al. 2006) reported that BMI ≥23 kg/m2 was a determinant of overweight, 72.09% of overweight female subjects reported having diabetes. A study reported that women with high BMI were independently associated with the incidence of type 2 diabetes (Sui et al. 2008). Percent body fat of 28%-<33% is categorised as overweight (Chang 2010). A study reported that a decrease in percent body fat and BMI provided better blood pressure control (Chang 2010).

The daily requirement for calorific consumption, an indicator based on basal metabolic rate, was assessed with no difference between male and female para-archery athletes. Although no difference was found, this study found that the number of calories that male para-archery athletes need to consume is greater (1572.67±169.05 kcal) compared to female para-archery athletes (1348.00±103.24 kcal). This means that male para-archery athletes will burn 1572.67 kcal within 24 hours at rest whereas female para-archery athletes will burn 1348 kcal within 24 hours at rest. In addition, this also means that each day male para-archery athletes need to consume 1572.67 kcal of calories to lose fat or gain muscle mass. While every day female para-archery athletes need to consume 1348 kcal of calories to lose fat or gain muscle mass. The number of calories per day needed by both male and female athletes in this study is lower than that of male and female athletes in the (Wong et al. 2012) study. Using a sample of elite athletes in 15 sports including archery (the others were racquet sports, combat sports, aquatic sports, weightlifting, and team sports) the results reported the same thing that elite male athletes needed a greater number of calories than elite female athletes, namely 1715 kcal needed by male athletes per day and 1384 kcal needed by elite female athletes per day (Wong et al. 2012).

The results of this study can provide para-archery athletes with a good understanding and appropriate support regarding bioelectrical impedance analysis (BIA) to determine the body composition of para-archery athletes. Although the results did not show significant differences in male and female athletes, this study was conducted on a disability sample that has not been previously studied. As stated by (Puce et al. 2024) that there is still limited literature available regarding adaptive shooting disciplines, especially regarding para-archery. Therefore, this study may assist coaches in implementing quality nutrition and training regimes or rehabilitation procedures in para-archery athletes.

Conclusions

The conclusion of this study found that males had greater total body water. Neither males nor females showed overhydration. For segmental body water, the trunk contributed the largest water distribution in both males and females. Male athletes have a heavier weight with a greater skeletal muscle mass composition, while females are fatter with a BMI and Percent body fat above normal. Every day to lose fat or gain muscle mass, male athletes require a greater number of calories than women. This study reveals the body composition of para-archery athletes and the nutritional needs that need to be met, so these findings can be implemented in the sport of para-archery to formulate systematic training programmes following the nutritional needs of athletes.

This study used a limited sample of para-archery sports, so the results cannot be generalised. Due to the limitations of this study, future researchers can conduct research for different sports. It would be more useful if the study was conducted on a sample of disabilities in different sports, so as to enrich the research results as new findings for the future, especially for disabilities.

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Conflict of interest

This research does not contain any conflict of interest.

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