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Comparison of Methods to Evaluate Body Composition in Collegiate Women Ultimate Frisbee Athletes

Lauren E. Colston
University of North Georgia, lecols4099@ung.edu

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Body Composition in Ultimate Frisbee Athletes

I. Introduction

Ultimate frisbee is one of the fastest growing sports across the nation and in the world (Akinbola et al., 2015; Krustrup & Mohr, 2015). Ultimate frisbee is a physically demanding sport that is played at multiple levels of competition. It is a self-officiated game played with a total of fourteen players; two teams of seven. The field is generally a 70 by 40 yard playing field with endzones that are 25 yards deep. The purpose of the game is to catch the frisbee, also known as a disc, in the endzone to score one point. The players advance down the field by passing the disc from one player to another rather than running with the disc. One team tries to maintain possession of the disc until they reach the endzone while the other team attempts to gain possession of the disc by intercepting the disc or by causing the offensive team to turn the disc by dropping it. The defensive team becomes the offensive team by causing the offensive team to lose possession of the disc. During competition, the teams play until one team reaches the predetermined match point or until time runs out. One game can last anywhere from an hour to two hours depending on how many calls are made, how often teams are able to score, and how well the teams are matched-up. Most ultimate frisbee teams play year-round, but the main competitive season occurs in the spring and lasts around thirteen weeks (Akinbola et al., 2015). Teams usually practice three to four times a week and play in frequent weekend tournaments consisting of six to nine games.

Ultimate frisbee is a physically demanding sport even though it is considered a limited-contact sport. Common biomechanics in ultimate frisbee include running, cutting, guarding, jumping, catching, and diving/laying out for a disc. Ultimate frisbee meets the intensity guidelines laid out by the American College of Sports Medicine aimed to promote regular bouts of physical activity (Weatherwax et al., 2015). The sport incorporates intense running and high aerobic loading which allows athletes to reach the minimum vigorous aerobic intensity of 25 minutes for three days a week (Krustrup & Mohr, 2015; Weatherwax et al., 2015). All of these components of exercise affect body composition.

Body Composition is a useful tool for both the general population as well as the physically active such as ultimate frisbee athletes. Body composition looks at the components that make up the body, specifically fat mass and fat-free mass. Fat-free mass, also known as lean mass, refers to anything in the body that is not body fat. For example, muscle, bone, and organs are all considered components of fat-free mass. Fat mass, on the other hand, is body fat. Although body fat is necessary, excessive amounts of body fat can lead to multiple health risks including cardiovascular disease, stroke, metabolic syndrome, type 2 diabetes mellitus, hypertension, and dyslipidemia (Riebe et al., 2017). Body composition is an important measure to monitor in all populations because of the associated health risks. The recommendations for the healthy amount of body fat in men is 10-22% and in women it is 20-32% (Riebe et al., 2017). In women athletes, a low amount of body fat can also be a concern. Body fat percentages as low as 13% can lead to what is commonly known as “The Female Athlete Triad” (Nattiv et al., 2007). The female athlete triad is defined as the “interrelationships among energy availability, menstrual functions, and bone density, which may have clinical manifestations including eating disorders, functional hypothalamic amenorrhea, and osteoporosis” (Nattiv et al., 2007, p.1867). Therefore, body composition is not only important to monitor in the general population, but also among athletes, especially those that are females. Measuring body composition can lead to increases in performance especially in female athletes (Houska et al., 2018). Understanding what the ideal body composition looks like in specific athletic populations allows exercise protocols to be written for specific sport performance. Knowing a specific athlete's body composition leads to specific goals that aim to enhance performance.

For body composition to be a useful measure, the appropriate tool needs to be used for measurement. There are multiple tools used to assess body composition including underwater weighing, air displacement plethysmography (AP), duel-energy x-ray absorptiometry, anthropometric measurements, bioelectrical impedance analysis, and skinfold measurements. A recent study compared body composition measurements in cheerleaders (Houska, 2018). The measurements that were used included body mass index, bioelectrical impedance analysis, AP and underwater weighing. The results concluded that body fat percentage was estimated at a higher percentage when assessed using the body mass index, bioelectrical impedance analysis, and AP when compared to underwater weighing (Houska, 2018). However, strong correlations were seen between body fat percentages by bioelectrical impedance analysis, AP, and underwater weighing. There was no correlation seen between body mass index and any of the other methods used for assessing body composition. Therefore, in the cheerleading population, body mass index is not a valid measurement for assessing body composition (Houska, 2018). A study of male wrestlers saw very similar estimates for body fat percentage when comparing underwater weighing to AP (Houska, 2018). These studies are beneficial in adding to the literature on the topic of body composition in athletes. Furthermore, they demonstrate the similarities in accuracy between underwater weighing and AP.

This study aimed to evaluate multiple modalities of body composition in collegiate female ultimate frisbee athletes, a population that currently has no published peer-review body composition literature. For the purpose of this study, the tools that will be used to measure body composition will be AP, 3-site skinfold assessment, bioelectrical impedance analysis, four previously developed body mass index-based equations, and the body adiposity index. The purpose of this study was to determine if there is a significant mean difference between various tools for accessing body composition among women ultimate frisbee athletes when compared to the AP. My hypothesis is that a 3-site skinfold correlate well with AP which is considered the gold standard or true value for my experiment.

II. Methods

A. Experimental approach to the problem

In the current literature there is a lack of descriptive body composition data on ultimate frisbee athletes. Multiple body composition measures were assessed using AP, 3-site skinfold assessment, bioelectrical impedance analysis, four previously developed body mass index-based equations, and the body adiposity index in a small sample of collegiate women ultimate frisbee athletes. Athletes' body height, body weight, body mass, body fat percentage, fat mass, and fat free mass were all evaluated once on the scheduled test day. The study was completed across four days from the University of North Georgia's women's frisbee team.

B. Participants

The athletes that chose to participate in this study were recruited through the current players on the University of North Georgia's women's ultimate frisbee team which practiced at least three times a week for 2 hours each day. The practices were designed by the captains of the team and included components of aerobic conditioning, muscular endurance training, and sport specific drills. Nine (n=9) female collegiate ultimate frisbee athletes aged between 20-23 (height = 165.7 ± 4.5 cm, body mass = 64.1± 7.9 kg, and BMI = 23.3 ± 2.3 $kg \cdot m^{-}2$) completed this study. This study was approved by the Institutional Review Board at the University of North Georgia. Data was collected between 7:00am and 11:00am on one day at the University of North Georgia's Human Performance Lab. Participants were scheduled based on their availability. All subjects had the risks and benefits explained to them, signed an informed consent form approved by the institution, and completed a questionnaire regarding demographics, sleep, physical activity, and 24-hour history before being tested. Any athlete that was injured was not allowed to participate in this study.

C. Procedures

At minimum, participants were required to refrain from exercise, eating, and drinking for at least three hours before testing as it could affect the results of the tests (Fields, 2017). However, most of the testing was completed in the morning to ensure an overnight fast. Participants were sent an email reminder the day before testing on how to dress and what items to bring with them. Appropriate attire for test day required participants to wear loose fitting clothing and bring a formfitting sports bra and spandex shorts for the Bod Pod. All jewelry was removed, and a swim cap was worn for the Bod Pod (Fields, 2017). On test day, body weight and height were assessed with a stadiometer and a balance beam scale with subjects' bare feet. Anthropometric measurements of waist circumference and hip circumference were taken using a flexible measuring tape (Guilick II Tape Measure) with subjects standing and relaxed. The waist measurement was taken against the skin at the smallest location of the waist between the umbilicus and the xiphoid process. The hip measurement was taken, over spandex shorts, horizontally at the largest location of the gluteus maximus.

Body composition was first assessed via a handheld bioelectrical impedance analysis tool (OMRON, HBF-306CN, Bannockburn, Illinois). Then, subjects were assessed using the Bod Pod (COSMED, Concord, CA). Lastly, participants had a 3-site skinfold analysis done using skinfold calipers (Lange Caliper, Beta Technology Inc., Deer Park, NY). Body weight and height were used to calculate body mass index (BMI) which was used to estimate body fat percentage via four different BMI-based body fat percentage equations. Hip circumference and height were used to calculate body adiposity index (BAI) and estimation of body fat percentage using an equation and BAI. Data collection was only done once for each participant and collection time took between 20 to 30 minutes to complete. All data was collected in the University of North Georgia's Human Performance Lab.

Bioelectrical Impedance Analysis (BIA)

For this assessment, the subjects' height, weight, age, and gender were entered into the BIA handheld device (OMRON, HBF-306CN, Bannockburn, Illinois). The subject then stood upright with the device in hand at shoulder level. The assessment took 5-10 seconds to complete. The handheld device did not save any information and only produced a body fat percentage and body mass index score. Following assessment, the scores were recorded, and the device was turned off to erase any data shown on the screen of the device.

Air Displacement Plethysmography (AP)

Air displacement plethysmography was assessed via the Bod Pod (COSMED, Concord, California). The Bod Pod was calibrated according to the manufacturer. All manufacturer guidelines were followed for successful assessment. The participants were clothed in spandex shorts, a sports bra, and a swim cap. Then, the subject entered the chamber and sat down. The Bod Pod determined body volume using air displacement. The calculation used was

$$V_b = \text{Chamber Volume}_{\text{empty}} - \text{Chamber Volume}_{\text{subject inside}}$$

After completion of the test, the software predicted the following in all participants: thoracic gas volume, fat-free mass (FFM), fat mass (FM), and body fat percentage (BF%).

3-Site Skinfolds

The 3-site skinfold assessment was conducted by the same well-trained technician for each subject. The technician had over 15 years of skinfold analysis experience and followed all guidelines as indicated by the American College of Sports Medicine

(ACSM) (Riebe, 2017). The 3-sites were taken from the tricep, suprailiac, and thigh sites as instructed by the ACSM guidelines (Riebe, 2017). The corresponding equation was used to calculate body density.

Body Density = 1.089733 – 0.0009245 (sum of the three skinfolds) + 0.0000025 (sum of the three skinfolds)^2 – 0.0000979 (age).

Percent body fat was then calculated using the siri equation as indicated below:

BF% = (495/body density) – 450

Fat mass and fat-free mass were calculated using the known body fat percentage using the following equation.

Fat mass = weight * .BF

Fat-free mass = weight – fat mass

In accordance with the ACSM, guidelines for the 3-site skinfolds, subjects wore loose fitted clothing so that the sites were easily accessible. All measurements were taken on the right side of the body. The calipers were placed directly on the skin for the most accurate reading. The skinfold calipers were placed perpendicular to the skin fold, 1 cm away from the thumb and finger. The pinch was maintained throughout the entire reading. There was a 1-2 second wait time before a reading was recorded. Measurements were taken twice. If there was discrepancy greater than 1-2mm, a third reading was taken (Riebe, 2017).

Body Mass Index-Based BF% Equations

Table 1. BMI-based BF% equations utilized within the study.

Name	Equation
Jackson et al. (BMI_{JA})	(4.35 x BMI) – (0.05 x BMI^2) – 46.24
Deurenberg et al. (BMI_{DE})	(1.20 x BMI) + (0.23 x age) – 5.4
Womersley and Durin (BMI_{WO})	(1.37 x BMI) – 3.47
Gallagher et al. (BMI_{GA})	BF% = 76.0 – (1097.8X[1/BMI]) – (20.6Xsex) + (0.053Xage) + (95.0XAsianX[1/BMI]) – (0.044XAsainXage) + (154XsexX[1/BMI]) + (0.034XsexXage) Sex = 1 for male and 0 for female Asian = 1 for Asians and 0 for the other races

(Nickerson et al., 2016; Jackson et al., 1991; Gallagher et al., 2000, Womersley & Durnin, 1977).

Body Adiposity Index BF% Equation (BAI)

$$\text{BAI-BF\%} = (\text{hip circumference}/\text{height}^{1.5}) - 18$$

III. Statistical Analyses

Statistical analyses were completed using IBM SPSS Statistics Subscription. A repeated measures analysis of variance (ANOVA) was conducted to determine the difference between body fat percentages using bioelectrical impedance analysis, AP, 3-site skinfold, 4 body mass index-based body fat percentage equations (BMI_{JA}, BMI_{DE}, BMI_{GA}, BMI_{WO}), and a body adiposity index body fat percentage equation. An alpha level of 0.05 at a 95% confidence interval was used. Significance was determined by anything that had a p-value of less than 0.05 ($p<0.05$). Following the repeated measures ANOVA, a Bonferroni correction post hoc analysis was used to examine the group differences between the body fat percentage values. A Pearson Product-Moment Correlation was completed to find correlations between the different variables compared to the Bod Pod (Esco M., Williford H., Russell A, 2011).

IV. Results

Table 2 presents the mean body composition values for each method of assessment used in this study. There were no significant differences between any method of body composition and AP. This is important to note because AP is considered a more advanced laboratory method and evidence supports the use of AP as a valid estimation of body fat percentage in female athletes (Ballard, 2004). Additionally, an article was recently published using AP to establish descriptive body composition values for a large sample of collegiate female athletes (Fields, 2017). However, there were significance differences noted between BIA and BMI_{DE} (p=0.03), BMI_{WO} (p=0.01), BMI_{GA} (p=0.03), and BAI (p=0.006). No other statistically significant differences existed.

Table 2. Mean body composition values for each method of assessment (n = 9) (mean ± SD).

Method	Body Fat %
AP	28.4 ± 5.3
BIA	21.5 ± 4.0
SKF	28.4 ± 4.7
BMI_{JA}	27.7 ± 5.0
BMI_{DE}	27.4 ± 2.7
BMI_{WO}	28.4 ± 3.2
BMI_{GA}	29.5 ± 5.3
BAI	28.1 ± 2.5

The Pearson product-moment correlation is represented in Table 3. A strong, positive relationship is seen between body composition estimated by AP and skinfold assessment (r=0.83, p=0.0006). All other correlations had a weak to moderate positive relationship with AP and none were significantly significant.

Table 3. Relationship between each body composition method and AP (n = 9).

Method	r-value

BIA	r = 0.36, p=0.35
SKF	r=0.83, p=0.006
BMI_{JA}	r=0.49, p=0.18
BMI_{DE}	r=0.49, p=0.18
BMI_{WO}	r=0.49, p=0.19
BMI_{GA}	r=0.49, p=0.18
BAI	r=0.40, p=0.29

V. Discussion

The purpose of this study was to determine if there was a significant mean difference between various tools used to measure body composition among women ultimate frisbee athletes. However, my results indicated that there was no significance in the mean body fat percentages between AP and any of the other methods of body composition analysis among the women ultimate frisbee athletes. This is a promising outcome as AP is considered to be a more advanced laboratory method of body composition analysis that has been shown to provide valid results to gold standard methods in female athletes (Ballard, 2004). My hypothesis stated that a 3-site skinfold would be a comparable method for measuring body composition to AP. Based on the r-values from the Pearson product-moment correlation, a strong linear trend was seen between the Bod Pod and the skinfold assessment (r=0.83, p=0.0006). The method that seems to the most valid and reliable to use in the women ultimate frisbee population besides AP is the 3-site skinfold assessment.

Practitioners require body composition tools to be valid, accessible, and easy to use. While AP is a quality laboratory method, it is often not an accessible and feasible method of assessment for many practitioners due to the cost of the tool. Each method, other than AP, evaluated in this study is a cost effective and an easily accessible tool for body composition analysis. Thus, the lack of significant difference between these tools and AP provides promising opportunities to practitioners working with the collegiate female ultimate frisbee population.

There were a few limitations in this study that are of note. The most prominent limitation is the small sample size within this study. Three additional limitations that could have impacted the assessment of body composition were: hydration status was not actually measured in participants, phase of the menstrual cycle was not taken into consideration, and residual volume was estimated via AP as opposed to actually measuring the value. It is anticipated that any impact from hydration status and the menstrual cycle would have influenced each method in a similar manner due to all assessments being conducted on the same day within minutes of one another, making the impact on the results minimal.

VI. Conclusion

Understanding which tools for measuring body composition in collegiate female ultimate frisbee athletes are the most accurate and the most appropriate for the nature of the sport is necessary before body composition can be used to benefit the athletes. Furthermore, from this study, the athletes who participate, strength and conditioning coaches, and athletic trainers will have a benchmark value that can be used to improve the health of the individual athlete and overall performance in the specific sport.

While this study provides promising data, there were several limitations to the study. Due to the fact that this study was done on a sample at one point in time, causal inferences are unable to be made longitudinally. Longitudinal studies could be done as further research. Furthermore, this study looked at the mean differences from the data collected on the sample. Future research should look at the interpersonal relationships between the different measures for body composition on each individual participant. Lastly, future research should evaluate the benefits of using known body composition in collegiate women ultimate frisbee athletes and enhancement of performance. By knowing body composition, calculations can be done to improve fat mass vs fat-free mass to make an ultimate frisbee athlete more efficient.

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