International Journal of Aquatic Research and Education

Volume 13 | Number 3 Article 5

10-15-2021

Body Composition Assessment in Masters Level Swimmers

Megan E. Larson
Bowling Green State University - Main Campus, larsmeg@bgsu.edu

Amy Morgan
Bowling Green State University - Main Campus, amorgan@bgsu.edu

Jessica Kiss
jekiss@bgsu.edu

Mary-Jon Ludy
Bowling Green State University - Main Campus, mludy@bgsu.edu

Recommended Citation

Larson, Megan E.; Morgan, Amy; Kiss, Jessica; and Ludy, Mary-Jon (2021) "Body Composition Assessment in Masters Level Swimmers," *International Journal of Aquatic Research and Education*: Vol. 13: No. 3, Article 5.
DOI: https://doi.org/10.25035/ijare.13.03.05
Available at: https://scholarworks.bgsu.edu/ijare/vol13/iss3/5

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Cover Page Footnote

This research was supported with funding from the Academy of Nutrition and Dietetics Research Dietetic Practice Group's Mead Johnson Nutrition Student Pilot Grant Award and Bowling Green State University's Center for Undergraduate Research and Scholarship. The authors would like to thank Anna L. Griesbach, Marissa L. Swindell, Maria Galic, Lauren M. Amirhamzeh, Elizabeth M. Rogers, Lindsey B. Pollock, and Emily M. Kollar for their assistance with data collection.

Abstract

Body composition of collegiate swimmers has been extensively studied; however, there are limited reports of body composition among Masters swimmers. This study compared the accuracy of air displacement plethysmography (ADP) and bioelectrical impedance (BIA) to the gold standard method of underwater weighing (UWW) in Masters level swimmers. The relationship between percent body fat (%BF) and body mass index (BMI) was also assessed. Recruitment (n = 6 females, 11 males) occurred at two Masters swim clubs. Pearson correlation coefficients revealed no significant differences between ADP, BIA, and UWW ($p > 0.05$). For both female and male Masters swimmers, the mean %BF was in the healthy range (30.4 ± 11.7% female, 21.3 ± 8.0% male); however, BMI was in the overweight range (27.0 ± 7.2 kg/m^2 female, 26.4 ± 4.8 kg/m^2 male). These findings suggest that while ADP, BIA, and UWW were comparable methods for assessing %BF in Masters swimmers, BMI did not adequately represent body composition and health risk for Masters swimmers.

Keywords: Masters swimming, body composition, aquatic sports, air displacement plethysmography, bioelectrical impedance, underwater weighing

While body composition of elite collegiate swimmers has been examined (Carbuhn et al., 2010; Johnson et al., 1982; Lukaski et al., 1990; Meleski et al., 1985; Noland et al., 2001; Petersen et al., 2006; Roelofs et al., 2017; Stanforth et al., 2014), reports of body composition among Masters swimmers are limited (Vaccaro et al., 1984). Although Masters athletes often have access to coaches and competitions, most do not have readily available access to high quality body composition assessment equipment. This study compared the gold-standard body composition assessment method, underwater weighing (UWW), to other body composition assessment techniques in Masters swimmers. This included air displacement plethysmography (ADP), characterized as the "practical" gold standard, and bioelectrical impedance analysis (BIA), a more routinely accessible technique.

Body composition is a common informational tool for athletes and their support providers (e.g., coaches, trainers, dietitians) (Moon, 2013). This information can contribute to the design of the training regimen with goals of optimizing performance and minimizing injury (Roelofs et al., 2017). Research across sports teams indicates that body composition in highly trained female and male athletes differs according to sport-specific training and can contribute to athletic performance (Andreoli et al., 2003; Carbuhn et al., 2010). Determining body composition in competitive Masters swimmers may provide beneficial insight for optimal performance and well-being.

The comparison of body composition assessment methods has been examined previously (Frisard et al., 2005; Hansen et al., 1993; Houska et al., 2018; Mazess et al., 1993). Houska et al. (2018) found a high correlation between ADP, BIA, and UWW in female collegiate level cheerleaders (n = 28; 20.1 ± 1.1 years), and Frisard et al. (2005) observed no differences between ADP, BIA, and dual-energy X-ray absorptiometry (DXA) in a population of healthy overweight adults (n = 34 female, 22 male; 52 ± 8.6 years). Hansen et al. (1993) reported that DXA is a precise method for estimating %BF that is correlated highly with %BF estimates from UWW in a population of premenopausal females (n = 100; 34.1 ± 3.0 years). Given the agreement between methods for other athletes and adult populations, ADP, BIA, and UWW were expected to yield comparable results for Masters swimmers as well.

While the body composition assessment techniques measure %BF, body mass index (BMI), based on an individual's height and weight, is an indicator of weight category, and is widely used to screen for health (CDC). There is evidence that BMI is not an accurate estimator of body fatness for athletes (Fitzgerald, 2014; Ode et al., 2007). This is because BMI is calculated only from weight and height and does not account for lean muscle mass (Witt et al., 2005). Athletes are expected to have a higher ratio of muscle mass to fat mass, which may lead to their BMI falling in the overweight or obese range despite having a lower %BF. Thus, BMI is expected to be an inaccurate estimator of body fatness for the Masters swimmer population.

The purpose of the study was to determine if ADP and BIA provided comparable estimates of %BF to UWW in Masters swimmers. The hypotheses were that ADP and BIA would provide comparable results to UWW in assessing %BF in Masters level swimmers, and BMI would not provide comparable results for body fat status.

Method

Participants

Participants were recruited from two Masters swim clubs in Northwest Ohio. Coaches for both groups were contacted and provided written permission for recruitment. The study was explained to the swimmers and coaches at a practice using an IRB-approved recruitment script. A brief form was distributed for athletes to self-determine their eligibility. Potential participants read a series of true and false statements related to eligibility criteria (i.e., ≥ 18 years of age, weigh ≤ 500 lbs, not pregnant or planning a pregnancy, not claustrophobic, no implanted medical devices, no chronic lung or pulmonary disorders, and willing to participate in study activities). Those answering "true" to all statements were identified as eligible to schedule a test visit.

Potential participants were asked to sign up for an individual test visit using an online scheduling system. The sign-up was password protected and only the research team had access to participant names. Participants were asked to reschedule their testing session if they were not feeling well on the day of the appointment.

Procedure

Data collection took place in the Bowling Green State University Exercise Physiology Laboratory. Participants were instructed to abstain from exercise and fast for at least two hours prior to their visit since ADP and BIA results are highly influenced by prior exercise, body temperature, food consumption, and fluid intake (Heiss et al., 2009). All participants signed an informed consent document prior to participation.

Anthropometric Measures

For all measures, participants dressed in a swimsuit or compression shorts and a sports bra (if applicable). Participants had their height measured to the nearest tenth of an inch using a stadiometer (Seca 213; Hamburg, Germany) and weight measured to the nearest tenth of a pound using the digital scale integrated into the BOD POD system (COSMED, Concord, CA). Weight and height were used to determine BMI (kg/m^2). Following the height measure, participants had %BF assessed using three different techniques in the following order: ADP, BIA, UWW.

Body Composition Methods.

Air Displacement Plethysmography (ADP/BOD POD). ADP measurements were conducted using the BOD POD, a dual-chambered body composition assessment unit (McCrory et al., 1998). Prior to testing, calibration was completed according to the manufacturer's recommendations. Each subject entered the airtight chamber for 2-3 measurements lasting approximately 45 seconds each. If the first two measurements were not within 0.2%, a third measurement was taken. Once all measurements were completed, the average of the volume measurements was calculated after correction for measured residual volume in the lungs (Fields et al., 2002). Weight and volume measurements were used to calculate body density; %BF was determined via the Brozek equation (Brozek et al., 1963).

Bioelectrical Impedance (BIA). BIA is conducted using a specialized electronic scale that functions based on the notion that electrical currents pass readily through muscle and other tissues which contain high levels of water, and the currents are impeded by bone and fat mass. %BF was estimated using an InBody 230 (Biospace, Seoul, Korea). After at least five minutes of standing, participants stood on the scale and firmly grasped the hand electrodes. The measurement (less than one minute) involved standing still while a small, undetectable electrical signal passed through their body.

Underwater Weighing (UWW). Hydrostatic weighing, or UWW, is a technique that utilizes a scale to measure a stable net underwater weight, which is used to calculate %BF. Participants entered a stainless-steel weighing tank where they were instructed to sit on a swing attached to a scale and submerge their entire body underwater while expelling as much air as possible. The test was repeated multiple times (≤ 5) to ensure accuracy. The measurements (3-5 seconds each) were taken when the participant was fully submerged, supported by the swing, and a stable reading was indicated. The average of the measurements was used to calculate body density, from which %BF was calculated (Brozek et al., 1963). Residual volume (RV) was estimated based on sex (i.e., 0.24 L for females, 0.28 L for males) per Wilmore (1969). It was necessary to use these estimates as some participants struggled with the measure of RV through the ADP system.

When testing was completed, participants received a snack (granola bar and milk). The entire test visit took 45 minutes per participant. Individual results were distributed in sealed envelopes approximately one week after the test date.

Health Categories.

The results from each of the techniques were compared against research-based health categories for the general population. The American College of Sports Medicine (ACSM) health categories are guidelines, derived from Cooper Institute data, that are based on sex and %BF (Cooper Institute, 2013). According to the guidelines, the required level of essential fat is 10-13% for females and 2-5% for males. The cutoff for being overfat, also defined as obese, is ≥ 32% for females and ≥ 25% for males. Thus, body composition standards for this study were: risky-low (< 13% for females; < 5% for males), normal (13 to < 32% for females; 5 to < 25% for males), and overfat (≥ 32% for females; ≥ 25% for females). The BMI categories defined by the Centers for Disease Control and Prevention (CDC) for both females and males are: underweight (≤ 18.5 kg/m^2), healthy weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥ 30 kg/m^2). These CDC categories provided standardized cutoffs for estimation of body fatness using BMI.

Statistical Analysis

IBM SPSS Statistics Version 25 (Armonk, NY) was used to analyze the data. Associations between ADP, BIA, and UWW were determined using Pearson correlation coefficients. Differences between techniques were identified with repeated measures analysis of variance. The Bonferroni adjustment was used to correct for multiple comparisons. Sex was a between participant variable (female

Masters swimmer, male Masters swimmer). $P < 0.05$ was used as the cut-point for statistical significance.

Results

Table 1 demonstrates the mean and standard deviations for anthropometric and body composition measures for the female and male Masters swimmers, as well as the average and standard deviations for comparisons of swimmers found to be overfat per %BF (≥ 32% for females; ≥ 25% for males) and overweight/obese per BMI (≥ 25 kg/m^2). Given that no significant differences were found between the body composition methods, the overall average of the three methods is also presented.

Discussion

Body Composition for Masters Swimmers

This study reports novel data regarding body composition and methods for estimating body fatness in a sample of Masters swimmers. The findings exhibited that, on average, female Masters swimmers were not overfat (30.4 ± 11.7%) despite being classified as overweight according to BMI (27.0 ± 7.2 kg/m^2). Similarly, male Masters swimmers were not found to be overfat (21.3 ± 8.0%) despite being overweight per BMI (26.4 ± 4.8 kg/m^2). When compared to the findings by Siders et al. (1993) on %BF in collegiate swimmers (female 24.4 ± 3.9%, male 14.6 ± 3.4%), the female and male Masters swimmers in the current study had higher %BF. Both the collegiate swimmers in the Siders et al. (1993) study and the Masters swimmers in this study fell within the healthy %BF range indicated by ACSM.

Differences in %BF between the Masters swimmers in this study and collegiate swimmers in the published literature (Siders et al., 1993) were expected. Athletes across a variety of sports, even those who are competitive, train less vigorously as they age (Kavanaugh et al., 1990). Although Masters athletes maintain more lean body mass and aerobic fitness relative to their age-matched counterparts, their body composition is not comparable to elite collegiate athletes who exercise with greater intensity and frequency (Kavanagh et al., 1990; Wroblewski et al., 2011). Siders et al. (1993) found that while %BF in collegiate swimmers may decrease throughout the season as a result of training, their average pre- and post- season %BF lies within a healthy range (ACSM). Given the disparity between age, training frequency, and intensity, it was expected that Masters swimmers would have greater %BF when compared to published data for collegiate swimmers, but still fall within a healthy range for their sex and age. This information implies that swimming is an effective sport for Masters-level athletes to maintain a healthy level of body fat.

Table 1
Anthropometric measures and body composition measures by population

		Female (n = 6) (46.2 ± 7.6 years)[a]	Male (n = 11) (54.5 ± 11.3 years)[b]
Anthropometric Measures	Weight (lbs)	159.4 ± 39.5	183.3 ± 34.7
	Height (in)	64.6 ± 1.4	69.9 ± 2.8
	BMI (kg/m^2)	27.0 ± 7.2	26.4 ± 4.8
	% overweight/obese (n)	50.0% (3)	54.5% (6)
dy Composition Measures (%BF)	ADP	29.5 ± 11.1	21.2 ± 9.5
	% overfat (n)	50.0% (3)	36.3% (4)
	BIA	30.9 ± 12.1	20.0 ± 7.1
	% overfat (n)	50.0% (3)	27.3% (3)
	UWW	30.8 ± 12.1	23.8 ± 8.0
	% overfat (n)	50.0% (3)	45.5% (5)
	Average	30.4 ± 11.7	21.3 ± 8.0
	% overfat (n)	50.0% (3)	36.3% (4)

Note. No significant differences were noted between air-displacement plethysmography (ADP), bioelectrical impedance analysis (BIA), and underwater weighing (UWW) ($p > 0.05$).
[a] Female age range = 39-60 years. [b] Male age range = 36-75 years.

DOI: https://doi.org/10.25035/ijare.13.03.05

Body Composition Assessment Methods

No significant differences were noted between ADP, BIA, and UWW ($p > 0.05$) which was hypothesized. Consequently, we concluded that for these Masters swimmers, ADP, BIA, and UWW provided similar results. Therefore, it is possible to rely on any of these methods as an accurate estimate of %BF. For example, time, effort, and costs of conducting the assessment may be decreased by using BIA when available.

BMI for Masters Swimmers

The data also provided evidence that BMI may not be an accurate estimator of body fatness for Masters level swimmers. Half (50%) of the Masters women were found to be both overweight/obese via BMI and overfat via their measured %BF. More than half (54.5%) of Masters men were found to be overweight/obese by BMI; however, only 36.3% were found to be overfat. These data, as well as results previously published by others (Fitzgerald, 2014; Ode et al., 2007; Power et al., 2020; Witt et al., 2005), support that BMI should be used with caution when estimating body fatness. Furthermore, BMI is often used to predict disease risk and determine insurance premiums (Riewald, 2008). For Masters swimmers, this could result in paying higher premiums despite the fact that their activity actually places them at a lower risk for chronic disease. This finding upported the value of holistic assessment, rather than the reliance on a single value or indicator when predicting health outcomes.

Limitations

Some limitations of this study should be considered. The small sample of participants was a convenience sample rather than a random sample. Participants were recruited based on the incentive of receiving their body composition information, which creates the potential for selection bias of individuals who are more interested in their personal health status. Furthermore, UWW measurements are often challenging, as some participants are unable to expel the maximal amount of air from their lungs. It was, however, expected that the study population of swimmers was more likely than the general population to complete this task successfully. Despite the discussed limitations of possible small sample, sample bias, and testing bias, the study featured body composition measurements of Masters swimmers using three different methods and did not present a statistically significant difference between them. The comparable data indicated that the methods for estimating %BF in Masters swimmers were effective and could be utilized with confidence.

Future Implications

While there is some existing literature focusing on body composition for Masters athletes participating in other sports (Sallinen et al., 2008; Piasecki et al., 2019), reports on assessment techniques for these athletes are lacking. Further research comparing the three methods (ADP, BIA, UWW) across a variety of Masters athletes would be beneficial. This could provide insight as to whether the conclusions of this study were limited to Masters swimmers, or if they can be applied to the Masters athlete population in general. It may also present data comparing the preservation of a healthy level of fat across different sports, information that would be valuable to aging athletes.

Conclusion

We demonstrated that Masters swimmers may benefit from access to accurate body composition measures through a variety of methods. Furthermore, it can be concluded that Masters swimmers effectively preserved a healthy level of body fat. Masters level athletes should consider this information and future research may be conducted on other Masters athletes to determine if the conclusions are comparable across different sports. In conclusion, the results indicated that, for Masters swimmers, ADP and BIA were comparable to UWW for assessing body fatness, and BMI was not an accurate predictor of body fatness.

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