



Original article

Associations of body adiposity index, waist circumference, and body mass index in young adults

Michael V. Fedewa^{a,*}, Brett S. Nickerson^{a,b}, Michael R. Esco^a^a Department of Kinesiology, The University of Alabama, Tuscaloosa, AL, USA^b Department of Professional Programs, Texas A&M International University, Laredo TX, USA

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SUMMARY

Background & aims: The Body Adiposity Index (BAI) is an anthropometric measure developed to estimate body composition in field settings. Although this novel measure has been validated against clinical measures of adiposity (%Fat), the relative accuracy of other anthropometric measures, such as Body Mass Index (BMI), and waist circumference (WC), have not been assessed in comparison to the BAI using a 4-compartment (4C) model.

Purpose: The primary aim of this study was to examine the association between BMI, WC, BAI, and %Fat in young adults, and determine the relative accuracy of each anthropometric measure when predicting % Fat.

Methods: BMI, WC, and BAI were assessed in a sample of young adults ($n = 188$, 48.4% female, 21.8 ± 4.8 years). %Fat assessed using the 4C model was derived from underwater weighing for body density, dual-energy X-ray absorptiometry for bone mineral content, and bioimpedance spectroscopy for total body water. Bivariate associations were assessed using Pearson's r , with the relative accuracy of each measure assessed using multivariate linear regression and compared using Akaike's information criterion, R^2 and ΔR^2 statistics.

Results: BMI, WC, and BAI were associated with %Fat ($r = 0.192, 0.194,$ and 0.668 , respectively, all $p < .01$). WC and BAI collectively explained 46.3% of the variation in %Fat, and removing BAI significantly reduced model fit ($p < .001$). When stratified by sex, BAI provided greater accuracy when predicting %Fat beyond WC in men ($\Delta R^2 = 2.6\%$, $p = .022$), but not women ($\Delta R^2 = 2.1\%$, $p = .078$).

Conclusion: WC and BAI are more strongly associated with %Fat as measured by the 4C model than BMI in young adults.

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1. Introduction

Body Mass Index (BMI) has become one of the most commonly used anthropometric field measures used to determine overweight and obesity [1]. The use of this simple and convenient anthropometric measure has broad appeal, as higher BMI is often associated with a number of unfavorable health consequences due to excessive adiposity, and the increased prevalence of obesity has created tremendous concern [2–4]. Anthropometric measurements are used in field settings and in the absence of clinical and laboratory assessment tools to estimate body composition. However, the

utility of BMI in predicting body composition (i.e. %Fat) is somewhat limited due to the inability of this measure to distinguish between fat and fat-free mass. As a result, the limitations of BMI as a measure of body composition in various populations have been well documented [5–9]. The accurate estimation of body composition is important in research and clinical practice, and additional indices have been proposed as possible alternative body composition estimates when more costly or time consuming methods requiring additional equipment are unavailable [10–12].

The Body Adiposity Index (BAI) was first developed as a surrogate measure of adiposity and can be calculated as $BAI = \frac{Hip\ Circumference}{Height^{1.5}} - 18$ [13]. The BAI correlates well with BMI and waist circumference (WC), and has been validated using DXA as the criterion measure of %Fat in a number of studies [14]. However few studies have validated the BAI against a 4-compartment (4C) model [15]. Furthermore, the relative accuracy of BAI has not been

* Corresponding author. The University of Alabama, Department of Kinesiology, 2003 Moore Hall, Box 870312, Tuscaloosa, AL 35487-0231, USA. Fax: +1 205 348 0867.

E-mail address: mvmfedewa@ua.edu (M.V. Fedewa).

compared to BMI and WC when predicting %Fat as measured by the 4C model.

The 4C model has emerged as the preferred criterion for body composition testing since 2-compartment models such as DXA make assumptions of fat-free mass (e.g., muscle mass, total body water and bone mineral content) [16]. For instance, DXA can introduce error when analyzing populations whom vary from the assumption that hydration of FFM differs from a constant 73.72% [17]. Due to these factors, it becomes necessary to determine whether BAI or WC serve as better predictor of %Fat than BMI when using a preferred criterion. Previous research from Nickerson et al. found that BMI-based body fat equations produce large individual error when compared to a 4C model [18]. However, the evaluation of BAI and WC were not reported making comparisons to BMI impossible.

Identifying a more accurate estimate of body composition in field settings with limited access to advanced assessment methods is of particular interest to practitioners when determining the health risk associated with adiposity. As such, the primary aim of this study is to examine the relative accuracy of BMI, WC, BAI when predicting %Fat assessed using the 4C model, and determine whether BAI serves as a better predictor of %Fat than BMI or WC. As previous research has argued that the sex-related differences in height and %Fat may partially explain the improved precision of BAI when compared to BMI [19], a secondary aim of this study is to examine these associations when stratified by sex.

2. Methods

Participants were recruited via print advertising and by word of mouth. Inclusion in this study was limited to apparently healthy individuals 18–40 years with no known cardiovascular, pulmonary, or metabolic disease. Pregnant women, or women reporting pregnancy within the previous 12 months were excluded from participation. The university Institutional Review Board approved this study protocol and informed consent document, with written informed consent obtained from each participant prior to enrollment.

Participants were instructed to abstain from food and drink, except water, for a minimum of 3 h prior to data collection. Hydration was assessed via urine specific gravity (USG) by a refractometer (Atago SUR-NE, Atago Corp Ltd., Tokyo, Japan). Minimum USG values of <1.020 were required for participation. When USG values were ≥ 1.020 , participants were given 30 min to ingest water *ad libitum*. If values remained ≥ 1.020 after this time period, participants were rescheduled ($n = 0$). Standing height was measured without shoes to the nearest 0.1 cm with a stadiometer (SECA 213, Seca Ltd., Hamburg, Germany). Body mass (BM) (to the nearest 0.1 kg) with a digital weighing scale (Tanita BWB-800, Tanita Corporation, Tokyo, Japan). Waist and hip circumference measurements were measured with a flexible, tension-sensitive, non-elastic vinyl tape measure (Gulick, Lafayette Instrument Co, Lafayette, IN) to the nearest 0.1 cm at the narrowest point above the iliac crest and below the xyphoid process, and at the apex of the gluteal fold, respectively. The Body Adiposity Index (BAI) was calculated as $BAI = \frac{Hip\ Circumference}{Height^{1.5}} - 18$.

2.1. Bioimpedance spectroscopy (BIS)

BIS was used to determine total body water (TBW) (ImpTM SFB7, ImpediMed Limited, Queensland, Australia) for the 4C model. TBW values derived from BIS have been previously used in multi-compartment equations for validation studies [21–23], and provide a valid estimate of TBW when compared to criterion measures

(i.e., deuterium oxide) [24–27]. (12, 17–19). TBW was measured with electrodes placed on the right hand and right foot with participants in a supine position with the arms $\geq 30^\circ$ away from the body with legs separated.

2.2. Dual energy X-Ray absorptiometry

Dual energy x-ray absorptiometry (DXA) was used to measure bone mineral content (BMC) for the 4C model. The total body BMC was converted to total body bone mineral (Mo). Prior to each whole-body scan, DXA was calibrated according to the manufacturer's instructions via a standard calibration block (Lunar Prodigy, v 14.10.022, GE Healthcare, Madison, WI). Whole body scans were performed with participants in a supine on the scanning bed with hands in a neutral position at their side. Velcro straps at the ankles and knees were used to limit limb movement during testing. Mo was calculated as follows: $Mo_total\ body\ BMC\ (kg) \times 1.0436$ [28].

2.3. Underwater weighing

UWW was performed in an apparatus specifically designed for taking densitometry measurements (Vacu-Med, Ventura, CA). Prior to the UWW measurement, subjects changed into compression type clothing or a bathing suit. Subjects sat on a sling seat during testing. The subjects were instructed to perform a maximum expiration and submerge completely underwater. Simultaneous determination of lung volume was completed with the oxygen dilution technique via a nitrogen analyzer (Vacu-Med, Ventura, CA). Body volume (BV) derived from UWW was used to calculate %Fat for the 4C model.

2.4. Four-compartment model calculations

The 4C model calculation is described by Wang et al. [29]. The equation for fat mass (FM) and BF% are as follows:

$$FM\ (kg) = 2.748(BV) - 0.699(TBW) + 1.129(Mo) - 2.051(BM).$$

$$BF\% = (FM/BM) \times 100$$

3. Statistical analyses

Statistical analyses were performed using SPSS for Windows (SPSS 20.0, Chicago, IL). Bivariate correlations between variables of interest were estimated using Pearson's r . A secondary analysis was used to determine if the BAI provided greater accuracy in predicting %Fat when compared to the BMI or WC methods. Separate models were fitted to the raw data with the use of a maximum likelihood approach with accompanying Akaike's information criterion (AIC). A full model containing the BAI and either the BMI or WC methods was compared to reduced models containing only the BMI or WC methods using the AIC. The reduced univariate models including the dependent variable %Fat and one independent variable (BMI, WC, or BAI) are expressed in Equations (1)–(3). Equation (1) was used to determine amount of variation in %Fat that could be explained by BMI alone. Equation (2) and Equation (3) were used to determine the amount of variation in %Fat that could be explained by WC or BAI alone, respectively.

$$\%Fat = (b_1)\ BMI \quad (1)$$

$$\%Fat = (b_2)\ WC \quad (2)$$

$$\%Fat = (b_3)\ BAI \quad (3)$$

The full models including the dependent variable %Fat and the independent variables of BMI, WC, and BAI are expressed in Equations (4)–(6), where the coefficient for one variable represents the effect of a change in this anthropometric measure while holding other anthropometric measures constant. Equation (4) was used to assess whether the model containing BMI and WC provided better fit than the model containing BMI alone. Equation (5) was used to assess whether the model containing BMI and BAI provided better fit than the model containing BMI alone. Equation (6) was used to assess whether the model containing WC and BAI provided better fit than the model containing WC alone.

$$\%Fat = (b_1) BMI + (b_2) WC \quad (4)$$

$$\%Fat = (b_1) BMI + (b_3) BAI \quad (5)$$

$$\%Fat = (b_2) WC + (b_3) BAI \quad (6)$$

The statistical model with the lowest AIC reflects the best fitting and most parsimonious model explained by as few variables as possible. In addition, model fit was assessed using the R^2 and ΔR^2 statistics, beginning by comparing the full model with the reduced models. Data are presented for the total sample, and stratified by sex. Power analyses were performed *a priori* using G*power (Version 3.1.9.3), and indicated a minimum of 55 participants were needed in order to detect a moderate effect (power = 0.80, alpha level = 0.05) with two independent variables in a multivariate linear regression analysis [30,31]. Statistical significance was indicated using an α level of $p < .05$. All data are expressed as mean \pm standard deviation ($M \pm SD$), unless otherwise indicated.

4. Results

The sample of young adults ($n = 188$, 48.4% female) was racially/ethnically diverse (83.0% Caucasian, 8.0% African American, 2.7% Hispanic). BMI ranged from 15.7 to 49.5 (24.4 ± 4.6), with 11.7% and 23.9% of the sample classified as obese and overweight, respectively. Although there was no sex-related difference in age, male participants presented higher height, weight, BMI, and WC, whereas female participants presented higher BAI and %Fat (all $p < .001$). Demographic information is presented in Table 1. BMI, WC, and BAI were associated with %Fat in the total sample ($r = 0.192, 0.194$, and 0.668 , respectively, all $p < .01$). A correlation matrix is provided in Table 2, stratified by sex with male participants below, and female participants above the diagonal. Results of the univariate linear regression analysis indicated that BAI explained the largest amount of variation in %Fat in the total sample. When stratified by sex, BMI (Equation (1)), WC (Equation (2)), and BAI (Equation (3)) all yielded similar R^2 . Results of the univariate regression analysis are presented in Table 3.

Multivariate linear regression was used to determine if the association between WC or BAI and %Fat was larger than the

Table 1
Descriptive characteristics of the study sample ($n = 188$).

	Total	Female	Male	p value
Age	21.8 \pm 4.8	21.4 \pm 4.2	22.3 \pm 5.3	0.188
Height (cm)	171.7 \pm 9.6	164.7 \pm 6.5	178.4 \pm 7.1	<.001
Weight (kg)	72.5 \pm 16.3	62.3 \pm 12.8	82.0 \pm 13.0	<.001
BMI (kg/m ²)	24.4 \pm 4.6	22.9 \pm 4.4	25.9 \pm 4.4	<.001
WC (cm)	80.0 \pm 11.2	75.3 \pm 10.6	84.3 \pm 10.0	<.001
BAI	26.1 \pm 4.6	27.9 \pm 4.5	24.4 \pm 4.1	<.001
%Fat	21.9 \pm 8.1	27.5 \pm 6.0	16.6 \pm 6.1	<.001

Notes: Data are presented as $M \pm SD$. BAI, Body Adiposity Index. BMI, Body Mass Index. WC, waist circumference. SE, standard error. SEE, standard error of the estimate.

Table 2

Correlation matrix of body composition, body mass index, waist circumference, and body adiposity index in male ($n = 97$) and female ($n = 91$) young adults.

	%Fat	BMI	WC	BAI
%Fat	1.00	0.54**	0.64**	0.56**
BMI	0.60**	1.00	0.89**	0.86**
WC	0.72**	0.88**	1.00	0.73**
BAI	0.64**	0.79**	0.73**	1.00

Notes: Data are stratified by sex with male participants below, and female participants above the diagonal. BAI, Body Adiposity Index. BMI, Body Mass Index. WC, waist circumference. %Fat, body composition. ** $p < .001$.

Table 3

Univariate linear regression results predicting body composition from body mass index, waist circumference, and body adiposity index ($n = 188$).

	Standardized β (SE)	Unstandardized β (SE)	SEE	R^2	p value
Total			8.00	0.04	.008
Intercept		13.57 (3.16)			.000
BMI	0.19	0.34 (0.13)			.008
Male			4.87	0.37	.000
Intercept		-5.21 (2.99)			.085
BMI	0.60	0.84 (0.11)			.000
Female			5.08	0.30	.000
Intercept		10.54 (2.83)			.000
BMI	0.54	0.74 (0.12)			.000
Total			8.00	0.04	.008
Intercept		10.54 (4.23)			.014
WC	0.19	0.14 (0.05)			.008
Male			4.21	0.53	.000
Intercept		-20.64 (3.66)			.000
WC	0.72	0.44 (0.04)			.000
Female			4.64	0.41	.000
Intercept		-0.04 (3.53)			.991
WC	0.64	0.37 (0.05)			.000
Total			6.07	0.45	.000
Intercept		-8.69 (2.54)			.001
BAI	0.67	1.17 (0.10)			.000
Male			4.70	0.41	.000
Intercept		-6.39 (2.86)			.028
BAI	0.64	0.94 (0.12)			.000
Female			5.00	0.32	.000
Intercept		6.34 (3.33)			.060
BAI	0.56	0.76 (0.12)			.000

Notes: Data are stratified by sex with male ($n = 97$) and female ($n = 91$) participants. β coefficients are presented as unstandardized values. BAI, Body Adiposity Index. BMI, Body Mass Index. WC, waist circumference. SE, standard error. SEE, standard error of the estimate.

association between BMI and %Fat. In the total sample, the full model including BMI and WC (Equation (4)) explained 3.9% of the variation in %Fat (AIC = 785.6). Removing WC did not significantly reduce the proportion of variation explained by the model (AIC = 784.1, $\Delta R^2 = -0.2\%$, $p = .495$), indicating that WC method did not provide greater accuracy when predicting %Fat beyond what could be explained by BMI alone. However, the full model including BMI and WC explained 51.8% of the variation in %Fat (AIC = 282.1) in men. Removing WC significantly reduced the proportion of variation explained by the model (AIC = 309.0, $\Delta R^2 = -16.4\%$, $p < .001$). Similar results were also found in women; with the full model including BMI and WC explained 41.6% of the variation in %Fat (AIC = 282.6). Removing WC significantly reduced the proportion of variation explained by the model (AIC = 297.7, $\Delta R^2 = -12.1\%$, $p < .001$). These results indicated that WC method provided greater accuracy when predicting %Fat beyond what could be explained by BMI alone when stratified by sex.

In the total sample, the full model including BMI and BAI (Equation (5)) explained 50.8% of the variation in %Fat (AIC = 657.6). Removing BAI significantly reduced the proportion of variation

explained by the model ($AIC = 784.1$, $\Delta R^2 = -47.7\%$, $p < .001$), indicating that BAI method provided greater accuracy when predicting %Fat beyond what could be explained by BMI alone. Similar results were found in the sex-specific analyses. The full model including BMI and BAI explained 43.7% of the variation in %Fat ($AIC = 299.3$) in men. Removing BAI significantly reduced the proportion of variation explained by the model ($AIC = 309.0$, $\Delta R^2 = -7.2\%$, $p = .001$). Similar results were also found in women; with the full model including BMI and BAI explained 31.7% of the variation in %Fat ($AIC = 294.9$). Removing BAI significantly reduced the proportion of variation explained by the model ($AIC = 297.7$, $\Delta R^2 = -3.6\%$, $p = .031$). These results indicated that BAI method provided greater accuracy when predicting %Fat beyond what could be explained by BMI alone when stratified by sex.

When directly comparing WC and BAI, the full model including WC and BAI (Equation (6)) explained 46.3% of the variation in %Fat ($AIC = 676.1$) in the total sample. Removing BAI significantly reduced the proportion of variation explained by the model ($AIC = 783.9$, $\Delta R^2 = -42.6\%$, $p < .001$), indicating that BAI method provided greater accuracy when predicting %Fat beyond what could be explained by WC alone. In men, the full model including WC and BAI explained 55.1% of the variation in %Fat ($AIC = 277.5$). Removing BAI slightly reduced the proportion of variation explained by the model ($AIC = 280.9$, $\Delta R^2 = -2.6\%$, $p = .022$). The full model including WC and BAI explained 43.1% of the variation in %Fat ($AIC = 280.2$). Removing BAI did not significantly reduce the proportion of variation explained by the model ($AIC = 281.47$, $\Delta R^2 = -2.1\%$, $p = .078$). These results indicated that BAI method provided greater accuracy when predicting %Fat beyond what could be explained by WC in men, but not in women.

5. Discussion

The primary aim of this study was to examine the relative accuracy of BMI, WC, BAI when predicting %Fat, and determine whether BAI served as a better predictor of %Fat than BMI or WC. The results of this analysis indicate that WC and BAI are more strongly associated with %Fat as measured by the 4C model when compared to BMI in young adults within the age range of our analysis. In addition, BAI was a stronger predictor of %Fat in the total sample and among men, however not among women. Based on these results, WC and BAI can be used interchangeably as anthropometric measures when predicting %Fat. The differences in the relative accuracy of WC and BAI when predicting %Fat may be due to sex-related differences in body composition, as women exhibit greater adiposity throughout the lifespan when compared to men [32]. More specifically, sex-related differences in hip and waist adiposity are observed early in childhood and become more apparent through puberty and young adulthood [33]. As result, it stands to reason that using two regional anthropometric measures (hip and waist circumference) to predict total body %Fat may vary by sex.

Previous research examining the relative accuracy of BMI and WC in relation to %Fat has yielded somewhat inconsistent results. For example, previous research in 341 participants (39.6% female) aged 18–88 years, indicated that BMI presented a slightly stronger association with total fat mass assessed via magnetic resonance imaging in men ($r = 0.78$ vs. 0.68) and women (0.92 vs. 0.87) when compared to WC [34]. In contrast, based on data from a sample of 12,901 participants (51.1% female) in NHANES 1999–2004, WC was significantly more highly correlated with %Fat than was BMI among male participants across all age categories (except >80 years); however not among women [35]. Although BAI was not assessed in these studies; the results comparing BMI and BAI are equally inconsistent.

In a sample of 424 middle-age adults, BAI was more strongly correlated with total abdominal fat in the total sample participants, as well as when stratified by sex [36]. However, in a cross-sectional analysis of 1151 participants (66.7% female) aged 18 to 110, BAI yielded a stronger relationship with %Fat when compared to BMI ($r = 0.86$ vs. 0.74 , respectively) in the total sample, but not when stratified by sex [37]. BAI provided greater precision when predicting %Fat when compared to BMI in a sample of 623 healthy European-American adults (53.3% female) aged 20–50 years, however BMI and BAI presented similar correlations with %Fat in separate analyses of female and male participants [38]. Similar results were found in a cohort of 2601 participants (74.5% female), which observed a stronger correlation between BAI and DXA when compared to BMI in the total sample, and among normal weight and overweight participants, but not when the results were stratified by sex, or in obese participants [39]. Furthermore, BMI presented stronger associations with %Fat than did BAI in athletic populations, which lead previous researchers to believe the association between BAI and %Fat may be influenced by physical activity level, and indicated it should be used with caution when estimating adiposity in athletic populations [15,40].

Determining the correct time and place to use various anthropometric indices has become difficult, as there appear to be no consistent advantage of one measure over the other. Many have argued there is clinical utility in including BMI and other anthropometric indices when predicting mortality and disease risk [41]. However, there exists some concern about the use of BMI as it relates to threshold values and cut-points chosen for individuals in need of clinical action [42]. As adiposity can vary by age, race/ethnicity, activity level, and across individuals with similar BMI (e.g., resistance trained vs. sedentary individual), adopting a “one-size-fits all” approach may not be prudent [5,6,43]. Furthermore, accounting for WC may eliminate the increased health risk associated with higher BMI, indicating that WC, and not BMI, may explain the majority of observed obesity-related health risks [44].

A large body of literature has established consistent relationships between BMI and disease outcomes. Rather than throw the baby out with the epidemiological bathwater, perhaps it is time to designate BMI as a measure used to track population trends, and utilize alternative anthropometric indices to identify individuals with greater adiposity [45]. In the absence of clinical or laboratory equipment used to measure body composition, a battery of anthropometric indices could be used in field settings to identify individuals at greater risk of obesity-related health complications with BMI and WC, as well provide a reasonable estimate of body composition using BAI [46,47].

This study is bolstered by the use of the 4C model, which is considered one of the most accurate measures of body composition and often serves as the criterion reference for validation studies of new body composition assessment techniques [48]. Previous studies comparing the accuracy BAI in estimating %Fat have most commonly utilized DXA as the criterion reference, which may introduce potential error it assumes constant hydration of FFM [17,49]. Comparing the relative accuracy of these anthropometric measures against a multi-component model, rather than DXA alone, reduces the potential error by limiting number of assumptions and constants used in the body composition estimate [11]. Although there are a number of strengths of the current study, it is not without potential limitations. First, this study examined apparently healthy men and women between the ages of 18 and 35 years. Therefore, our results are limited to the age range of our analysis, and perhaps may not be consistent with clinical populations, or individuals outside of the age-range of our analysis. Furthermore, although the distribution of male and female participants was relatively equal, the limited number of African-American, Hispanic,

and Asian participants may pose a second potential limitation. Racial/ethnic differences in fat distribution patterns and bone mineral content may confound the relationship between anthropometric measures and body composition estimates, as African populations seem to have a lower %fat for a given BMI compared to European populations [50], which are further influenced by age and sex [51]. The current study was underpowered to assess the complex independent and interactive influence of age, race, and sex on the relationship between anthropometric measures and body composition estimates. In the current study, no differences in %Fat were found between racial/ethnic groups when analyzed for the entire sample, when stratified by sex, or when controlling for BMI (data not shown). Given that the current sample was predominantly Caucasian (>80%), it is possible that the results of our analysis may not be generalized to other racial/ethnic groups outside of the age range of our analysis. Third, our study sample is relatively small compared to other studies examining the accuracy of BAI in large epidemiological samples because of the time required to perform the criterion measure of the 4C model. BAI was a stronger predictor of %Fat than WC in the total sample and among men, however not among women. BAI explained an additional 2.6% and 2.1% of the variation in %Fat beyond WC alone among men and women, respectively. However, these results were only statistically significant among men despite improvements in model fit of relatively similar magnitude. As such, this study should be replicated in a larger sample with similar body composition assessment methods. Fourth, the population recruited for this study was relatively healthy, making the sample non-representative of the population of all young adults. Selection and participation bias occur when relationships are assessed in a sample of participants who are different than the population they are thought to represent. Furthermore, studies that require enrollment of participants may be inherently affected by participation bias [52]. It is unclear to what extent participation bias in body composition studies could have potentially influenced the results of this study, however it is possible that selection and participation bias may have impacted our findings. Participants were recruited for this project via print advertisement, which sought individuals for an unpaid study that examined “the relationship between body composition, muscular strength, and endurance variables in men and women.” Because this was advertised as a health and fitness study, it is possible that the current sample was relatively healthier and more fit than the general population. In addition, age, sex, race/ethnicity, education, and the use of incentives have all been shown to affect participation [52]. As such, participants in the current study may not represent the population across the entire spectrums of age, fitness levels, and race/ethnicity. Finally, because of the cross-sectional nature of the current study, it is unclear whether BAI and WC may provide more precision when tracking changes in %Fat. A prospective analysis of the relative accuracy of these anthropometric measurements was beyond the scope of the current analysis, but may offer an opportunity for future research. Furthermore, the associations between increased BMI and elevated cardiovascular disease risk is believed to be largely driven by the greater %Fat observed in individuals with higher BMI. WC and BAI may serve as a surrogate estimate of %Fat in field settings with limited access to more advanced body composition assessment methods, however the causal relation of elevated %Fat as estimated by WC or BAI and increased cardiovascular disease risk cannot be assessed using this cross-sectional design and should also be examined in future research.

6. Conclusion

The results of this analysis indicate that WC and BAI serve as better predictors of %Fat as measured by the 4C model when

compared to BMI in young adults. WC and BAI can be used interchangeably, and should be used to track individual changes in body size and composition; whereas BMI may best serve as an anthropometric measure to assess population trends over time. The use of WC and BAI may provide useful estimates of body composition and disease risk in field settings where more costly equipment is unavailable.

Conflicts of interest

The authors have no potential, perceived, or real conflicts of interest to disclose.

Disclosures

Michael V. Fedewa has no financial disclosures.
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