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A Comparative Analysis of Army Body Composition Standards for Women

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ABSTRACT

International Journal of Exercise Science 13(7): 1275-1282, 2020. The aim of this study was to compare body fat percentage (BF%) of women measured using the U.S. Army standard body composition assessment (ABC) and two common laboratory measures of body composition to evaluate the efficacy of ABC within this population. The BF% of 27 women (21.5 ± 1.8 years) was assessed using the 7-site skinfold, air plethysmography, and ABC measurements. The initial physical fitness test (IPFT) was used to determine if participants met the criteria required for admittance into basic combat training. A repeated measures ANOVA identified differences in BF% between the three assessment methods, (F (2, 52) = 22.83, p < .001, η^2_p = .47). Pairwise comparisons revealed that mean BF% obtained using the ABC (29.3 ± 7.7 %) was significantly higher (p = .042) than BF% measured using air plethysmography (26.9 ± 8.4 %). ABC and air plethysmography measured BF% was significantly higher (both p < .001) than BF% obtained from skinfold assessment (22.2 ± 5.9 %). Of the 27 total participants, 4 (14.8%) passed IPFT but failed to meet the Army body composition standards using the ABC method. The primary findings of this study suggest that the overestimation of BF% by the ABC method could lead to an unnecessary delay in enlistment for women approaching the upper threshold of the Army's acceptable body composition standards. Alternative methods of assessing body composition in this population should be explored. However, skinfold assessment does not appear to be a suitable alternative to the ABC.

KEY WORDS: Body fat percentage, assessment methods, military recruits

INTRODUCTION

New U.S. Army recruits are subject to comply with many physical, mental, and occupation-specific demands. For entrance into basic combat training, recruits must meet the required body composition and physical fitness standards of the U.S. Army (18, 9). Body composition is, by definition, the relative amount of muscle, fat, bone, and other vital tissues of the body (16).
Recruits with body fat levels within the acceptable range as defined by the U.S. Army display increased muscular strength and endurance (8,18). Additionally, recruits with BF% outside this range may be more likely to sustain injuries during strenuous military duties such as long-distance marches and high-impact movements under external load (8, 18, 10). As such, recruits within the required body composition range may be more likely to meet the fitness requirements

for basic combat training assessed using the initial physical fitness test (IPFT) (8, 9) and potentially the revised Army Combat Fitness Test that will be the force's test of record as of October, 2020 (5).

The only sanctioned method of estimating body fat percentage (BF%) of U.S. Army personnel is the Army body composition (ABC) method (18). The ABC procedures include measuring height along with circumference measures of the neck, hips, and waist using a non-stretchable tape (18). These data points are then entered into the ABC equation to estimate BF%. Acceptable BF% defined by the Army is age-dependent and ranges from 30% to 36% for female recruits and 20% to 26% for male recruits (18). Each recruit looking to enter basic training must also undertake the IPFT. The test consists of a 1-minute push-up, 1-minute sit-up, and a 1-mile run. If a recruit fails one of the three assessments, the recruit fails the IPFT and must enter a remediation program (18).

For Army recruits and warfighters, maintaining body composition and physical fitness levels within the acceptable range of Army guidelines is undeniably important. However, research investigating the accuracy of the ABC BF% assessment shows equivocal results. Several investigations have provided evidence that BF% obtained using the ABC exhibits moderate (2) or strong (1) correlation (r = .66 to .81) with other laboratory measured BF% values (1, 2, 6). Despite this correlation, studies have reported overestimation of BF% in lean individuals and underestimation of BF% in individuals with higher levels of fat using the ABC in comparison to skinfold and hydrostatic weighing measures (1, 2, 19). This apparent limitation of the ABC, particularly in cases of overestimation, has important implications for those approaching the threshold of unacceptable BF%. If the BF% standard is not met, such recruits may be required to enter the Army's weight control program (18) or be involuntarily separated from the U.S. Army. Considering the correlation of Army circumference measures to other BF% measures has been lower for women (r = .66 to .82) compared to men (r = .79 to .89) (1, 2, 18), the margin of error could be larger for female Army recruits.

The majority of research investigating the accuracy of the ABC assessment used male-only samples (1, 6). To date, little research has assessed the accuracy of the ABC in female recruits (2, 18). Considering the lack of research using female samples and the well-established differences in body composition between biological sexes, additional research focused on determining the efficacy of the ABC in female samples is needed. Therefore, the purpose of this study was to compare BF% of women using U.S. ABC standard means of measuring body composition to air plethysmography and skinfold measures.

METHODS

Participants

An a priori power analysis conducted using G*Power 3.1 (Universitat Kiel, Germany) indicated that 27 participants were needed for the current study to achieve a power of 0.80. Physically active women (N = 27) (age = 21.5 ± 1.8 years, height = 166.4 ± 6.4 cm, weight = 67.5 ± 13.9 kg) were recruited by word-of-mouth from a university setting for this investigation based on convenience sampling. Before this study, each participant was notified of all test procedures and completed a written informed consent form. After signing the informed consent form, participants completed a Physical Activity Readiness Questionnaire (PAR-Q) and an American College of Sports Medicine (ACSM) health risk questionnaire (3). All participants were free from any medical or musculoskeletal conditions. Physical activity levels were assessed using the International Physical Activity Questionnaire (IPAQ) (3). Participants' height and weight were then measured using a digital scale and a stadiometer (Detecto RS232; Detecto, Webb City, Missouri, USA). All procedures were approved by the University Institutional Review Board and followed the ethical standards of the Helsinki Declaration. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (11).

Protocol

The ABC estimates were based on procedures outlined in the Army Regulation 600-9 (18). Measurements of neck, waist (abdomen) and hip circumferences were taken with a tape measure made of non-stretchable material (Baseline Evaluation Instruments, White Plains, New York, USA). The tape was one-quarter to one-half inch wide and a minimum of 5 feet in length. All circumference measurements were taken 3 times and recorded to the nearest half-inch in compliance with ABC protocol. Neck circumference was measured at a point just below the larynx (perpendicular to the long axis of the neck). The participant looked straight ahead during the measurement, with shoulders down, perpendicular to the floor. Waist (abdominal) circumference was measured at the end of the participants' normal, relaxed exhalation. The measurement was taken against the skin between the navel and lower end of the sternum with the tape parallel to the floor with arms at the sides. Hip circumference was measured by placing the tape around the hips so that it passed over the greatest protrusion of the gluteal muscles ensuring tape was level and parallel to the floor.

After ABC measurements were conducted, a Bod Pod (Cosmed Inc, Concord, California, USA) device was used to obtain each participant's BF% using air plethysmography. Before each test, the Bod Pod was calibrated according to specific instructions from the manufacturer using a two-point volume and mass calibration. All participants fasted for 3 hours before the assessment based on recommendations from the Bod Pod manufacturer. For testing, participants wore compression shorts, a sports bra, and a swimming cap and removed jewelry. Each participant was weighed on a level and calibrated scale, prompted to enter the test chamber, and instructed to remain still and breathe normally throughout the test. Lung volumes were estimated using the BodPod software and BF% estimates were obtained after 2 successful attempts. Because the ABC equation applies to all ages and racial groups (18), the Siri equation (15) was chosen to calculate BF% as it is often considered a generalized equation (12) and allowed for a more equitable comparison.

Following air plethysmography testing, a 7-site skinfold assessment was used to estimate BF%. With the participant standing, the examiner directed the participant to move in the correct direction and expose the appropriate site for measurement. All measurements were taken on the right side of the body. The administrator then located the appropriate landmarks for each site at the chest, abdomen, thigh, midaxillary, subscapular, triceps, and suprailiac (12). The administrator grasped the skin fold between the thumb and index finger 2-cm above the measurement site, pulling the skin and the underlying subcutaneous tissue away from the muscle. With the free hand, the administrator held the calipers (Lange, Cambridge, MA, USA) dial side up, and placed the jaws of the calipers 1-cm below the thumb and finger and perpendicular to the skinfold. The administrator then released the caliper pressure and allowed the jaws to rest 1-2 seconds and then took the reading. Two measurements were taken at each site. Between measures of the same site, the administrator waited at least 15-30 seconds between repeating measurements at the same site to avoid assessment of compressed tissue that could potentially lead to underestimation of BF%. If the difference between the two measures was greater than 1 mm, additional measures were taken until there were two measures within 1-mm of each other. If more than 2 measurements were required, the two values within 1-mm are averaged for analysis. Body density was calculated using procedures from *ACSMs guidelines for exercise testing and prescription* (14). Again, the Siri equation (15) was used to standardize BF% equations between laboratory measures of body composition.

After all body composition assessments were completed, participants performed the U.S. Army's IPFT (10) to determine if participants possessed minimum physical fitness levels to enter the U.S. Army. Fitness tests consisted of determining the maximum number of repetitions of push-ups and sit-ups accomplished in 1-minute and a timed 1-mile run. All assessments were administered by the same investigator using a stopwatch (Accusplit, Pleasanton, California, USA) and following the Army's guidelines for the fitness test (9).

Statistical Analysis

All statistics were reported in means and standard deviations and analyses were conducted using SPSS software (Version 25, IBM, Chicago, IL). Statistical significance was accepted at $p < .05$. Repeated measures analysis of variance (ANOVA) was used to identify differences in mean scores between each method of measuring body composition. Mauchly's test of sphericity indicated the data met the assumption of equal variances. Least significant difference pairwise comparisons with false discovery rate correction (7) using the Benjamini-Hochberg method (4) were used for post-hoc analyses.

The BF% and performance variables of all participants are shown in Table 1. Information obtained from the IPAQ indicated that 15 participants exhibited "moderate" physical activity levels and the remaining 12 were classified as having "high" physical activity levels. The repeated-measures ANOVA indicated that BF% was significantly different in between assessment methods (F (2, 52) = 22.83, $p < .001$, $\eta^2_p = .47$). Post-hoc pairwise comparisons revealed significant differences between all three BF% assessment methods (see Table 2). The ABC BF% was significantly higher than BF% obtained via air plethysmography. The ABC and air plethysmography BF% measurements were significantly higher than BF% measured using the 7-site skinfold method. IPFT tests indicated that 15 participants (55.6%) did not pass both the IPFT and the ABC requirements. Out of the 27 total participants, 4 (14.8%) passed the IPFT but failed the ABC.

Table 1. Body composition and fitness test results for all participants.

Variable	Mean ± SD
ABC (BF%)	29.3 ± 7.7
AIR (BF%)	26.9 ± 8.4
SKF (BF%)	22.2 ± 5.9
1-mile run (min)	9.3 ± 1.7
Push-ups (reps/60s)	14.2 ± 11.5
Sit-ups (reps/60s)	24.6 ± 7.0

Note: ABC = Army Body Composition, AIR = Air Plethysmography, BF% = Body Fat Percentage, SKF = 7-site skinfold.

Table 2. Pairwise comparisons of body fat percentage between measurement methods.

Variable	Variable	Mean Difference (%)	Std. Error (%)	p	FDR-adjusted significance
ABC	AIR	2.37	1.09	.042	.042
	SKF	7.05	1.11	<.001	.003
AIR	ABC	-2.37	1.09	.042	.042
	SKF	4.72	0.99	<.001	.002

Note: ABC = Army Body Composition, AIR = Air Plethysmography, FDR = False Discovery Rate, SKF = 7-site skinfold.

DISCUSSION

The primary finding of this study was that the ABC method for measuring body composition of women with characteristics similar to those of U.S. Army recruits overestimated BF% by an average of 2.37% when air plethysmography was considered the criterion measure. This report of overestimated BF% is not surprising considering the results of existing literature. Bathalon and colleagues (2) reported a 2.2% underestimation of BF% using ABC compared to data obtained using hydrostatic weighing in middle age women. Furthermore, the correlation coefficient of .66 reported by Bathalon et al. (2) is noticeably weaker than the correlation coefficients reported by other studies using samples of male firefighters (3-site skinfold equations, r = .79) and male soldiers (dual-energy X-ray absorptiometry, r = .81) (1, 6). Although more data focusing on the accuracy of the ABC specifically in women is needed, the findings of the current investigation in addition to the existing literature suggests that the ABC exhibits a relatively large potential for error.

A major limitation associated with using circumference-based equations to predict BF% is that they only consider total girth and do not attempt to differentiate between fat mass and fat-free mass. This limitation could be problematic for women who participate in regular resistance training (such as bodybuilders) (17) or sport that could increase circumference (via increased muscle mass) without significant alterations in subcutaneous and visceral fat. In the current study, the frequency and type of training of participants were not assessed. However, many of the participants were students studying exercise science or related fields that were highly active and likely participated in a strength training. It is possible that this sample possessed higher levels of skeletal muscle mass that may have led to the overestimation of BF% using the ABC method.

The limited accuracy of the ABC for assessing body composition compliance of women in the U.S. Army has important implications for the Army directly, as well as the individual women seeking entrance into basic combat training. During the previous ~10 years, the U.S. Army has faced a difficult recruiting environment, with a significant challenge stemming from poor fitness levels and body composition (13). Health and fitness were responsible for 59% of the ineligible recruits becoming enlisted, which largely comes from America's obesity issue (13). Considering the recruitment challenges the Army faces that are in part attributable to high BF% and non-compliance with the body composition standards, the wide error range of the ABC may exacerbate these challenges. Those with overestimated BF% obtained via ABC could falsely fail to meet the body composition requirements, and instead, have to participate in the U.S. Army's weight control program (18). Those within the program are assessed every month until they meet the BF% requirement (18). If a recruit fails the program then the commander would request a medical evaluation, and if no underlying medical conditions are found, the commander will then initiate separation action, bar to reenlistment or involuntary transfer (18). These limitations and setbacks would slow down the influx of recruits into basic combat training or result in recruits being separated from the service.

The current study also highlights the limitation of using skinfold measurements to assess compliance with Army body composition regulations (18). In relation to air plethysmography, the mean difference of BF% obtained from skinfold assessment was 4.72% compared to 2.37% mean difference for ABC, suggesting that the ABC was a better method of BF% estimation compared to skinfold procedures. Although the researchers that administered the skinfold assessments in this study had ~1 year of experience performing and teaching skinfold measurements, these large mean differences between skinfold and plethysmography measured BF% could be due to the relatively high potential for human measurement error when obtaining the skinfold measurements. In addition to higher levels of human error, the skinfold may also be less practical than the ABC for use in military populations. Military use of skinfold assessments would require a large number of personnel with many hours of training.

In conclusion, it appears that a large discrepancy exists for BF% of women when assessed using the ABC and that use of this method could cause overestimation of BF%. In cases of overestimation, entrance into basic combat training may be delayed. It is our current opinion that a review of the procedures and methods for measuring body composition is needed by U.S. Army personnel, specifically the equation for women.

REFERENCES

1. Babcock CJ, Timothy KE, McCarroll ML, Devor ST. A comparison of military circumference equations to skinfold-based equations to estimate body composition. Mil Med 171(1): 60-3, 2006.

2. Bathalon GP, Hughes V, Campbell WW. Military body fat standards and equations applied to middle-aged women. Med Sci Sports Exerc 27(7): 1079-85, 1995.

3. Baumann AE, Craig CL, Marshall AL. International physical activity questionnaire: 250 12-country reliability and validity. Med Sci Sports Exerc 35(8): 1381-1395, 2000.

4. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Series B Stat Methodol 57(1): 289-300, 1995.

5. Brading, Thomas. "ACFT 2.0: Changes Sparked by COVID-19." www.army.mil, Army News Service, 15 June 2020, www.army.mil/article/236479.

6. Friedl KE, Vogel JA. The validity of percent body fat predicted from circumferences classification of men for weight control regulations. Mil Med 162(3): 194– 200, 1997.

7. Glickman ME, Rao SR, Schultz MR. False discovery rate control is a recommended alternative to Bonferroni-type adjustments in health studies. J Clin Epidemiol 67(8):850-857, 2014.

8. Jones BH, Bovee MW, Knapik JJ, Marriott BM, Grumstrup-Scott J. Associations among body composition, physical fitness, and injury in men and women army trainees. In Body Composition and Physical Performance: Applications for the Military Services, pp 141-173. Washington DC, National Academy Press, 1992.

9. Knapik JJ, Darakjy S, Hauret KG, Canada S, Scott S, Rieger W, Marin R, Jones BH. Increasing the physical fitness of low-fit recruits before basic combat training: An evaluation of fitness, injuries, and training outcomes. Mil Med 171(1), 45-54, 2006.

10. Knapik JJ, Sharp MA, & Montain SJ. Association between stress fracture incidence and predicted body fat in United States Army Basic Combat Training recruits. BMC Musculoskelet Disord 19(1): 161, 2018.

11. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1): 1-8, 2019.

12. Pollock ML, Jackson AS. Research progress invalidation of clinical methods of assessing body composition. Med Sci Sports Exerc 16(6): 606-613, 1984.

13. Read R. "Why the U.S. military is on the brink of a recruitment crisis." Sinclair Broadcast Group, WJLA. 16 February 2018. Retrieved from https://wjla.com/news/nation-world/why-the-us-military-is-on-the-brink-of-a-recruitment-crisis

14. Riebe D, Ehrman JK, Liguori G, Magal M. ACSMs guidelines for exercise testing and prescription. tenth edition. Philadelphia: Wolters Kluwer: 74-77, 2018.

15. Siri WE. The gross composition of the body. In C. A. Tobias & Lawrence J. H. Advances in biological and medical physics. New York Academic Press: 239-280, 1956.

16. Swain D, Brawner C. ACSM's resource manual for guidelines for exercise testing and prescription. tenth edition. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins: 36, 2014.

17. Tran ZV, Weltman A. Generalized equation for predicting body density of women from girth measurements. Med Sci Sports Exerc 21(1): 101-104, 1989.

18. U.S. Department of the Army. The army weight control program, AR 600-9. Washington DC, U.S. Department of the Army, 2013.

19. Vogel JA, Kirkpatrick JW, Fitzgerald PI. Derivation of anthropometry based body fat equations for the army's weight control program. Technical Report T17-88. Natick, MA, US Army Research Institute of Environmental Medicine, 1988.