Body Composition as a Predictor of Performance on Army Combat Fitness Test Total Score of ROTC Cadets

Original Research

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ABSTRACT

Introduction: Body composition characteristics vary between soldiers and could affect performance outcomes. This study aimed to determine whether %body fat (%BF) and fat-free mass (FFM) could predict performance outcomes of the Army Combat Fitness Test (ACFT) in ROTC cadets.
Methods: ROTC cadets (54 males, 17 females; aged 21.40 ± 3.79 years) completed the 6-event ACFT (3-repetition maximum trap-bar deadlift [MDL], standing power toss [SPT], hand-release pushups [HRPU], sprint-drag-carry shuttle run [SDC], plank [PLK], and 2-mile run [2MR]). The ability of body composition to predict ACFT performance was determined with a linear regression model. Significance was set at $p < 0.05$.
Results: Percent BF was significantly and negatively correlated to HRPU ($r = -.467$, $p < .001$) SDC ($r = -.367$, $p = .002$), PLK ($r = -.453$, $p < .001$), 2MR ($r = -.384$, $p < .001$), and overall ACFT score ($r = -.483$, $p < .001$). FFM was significantly correlated to MDL ($r = .310$, $p = .008$), SPT ($r = .424$, $p < .001$) SDC ($r = .388$, $p < .001$), PLK ($r = .363$, $p = .002$), and overall ACFT score ($r = .423$, $p < .001$).
Conclusion: It is shown that evaluating body composition is a reliable predictor of performance in the ACFT. Consequently, there is a need to reevaluate the Army's body composition standards to align them with the significance of FFM in determining ACFT outcomes. Recognizing that body composition can be modified, soldiers can utilize this information to develop tailored strategies for enhancing their ACFT performance.

Keywords: Army, Body Fat, Fat-Free Mass

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Introduction

The physical characteristics of a U.S. Army soldier have long proven to be a significant factor in establishing a strong military force[1]. The U.S. Army requires a set of body composition standards set by the Army Weight Control Program that ensure a soldier has a high level of physical readiness to complete associated military tasks[2]. In 2020, the U.S. Army introduced a new physical fitness assessment, the Army Combat Fitness Test (ACFT), that includes tasks related to combat readiness. Soldiers must complete all six tasks in order within 70 minutes or less. The ACFT will be tested bi-annually for active-duty soldiers and annually for reservists and National Guard soldiers. Each task is scored from 0 to 100, with a score of 60 required to pass the event.

When compared to the previous physical fitness assessment, the Army Physical Fitness Test (APFT), the ACFT includes a higher need for strength, muscular endurance, and aerobic endurance[3]. Although body composition does not show to affect performance on the APFT, a few studies suggest it may correlate with ACFT performance[4,5]. The ACFT is still in its infancy, and the increased physical demand creates the need to understand better how body composition characteristics are related to the ACFT.

Body composition characteristics are widely associated with many aspects of performance and are primarily set to select the soldier best suited to the physical demands of military combat tasks[5]. This concept was initially developed as a screening tool for those who might be malnourished, underweight, overweight, and obese[6]. Heileson et. al.[7] tested 52 ROTC cadets and found a lower % body fat (%BF) predicted better performance in all ACFT events, except the plank (PLK). The 2-mile run (2MR) showed the best benefit from having a lower %BF[7]. Due to the limited amount of research, more studies are needed to examine if body composition is a predictor of performance on the ACFT. The understanding of ACFT metrics is of immense importance due to promotion points being awarded based on ACFT scores.

Historically, the Army is focused on %BF, however, recent research suggests that FFM is a significant performance factor[4,7]. This new understanding of the need for FFM should motivate a higher level of physical training. The ability of a soldier to be strong, powerful, agile, and sustain a high level of anaerobic capacity is a strong predictor of performance[8,9]. Roberts et al[4] found that FFM was significantly correlated with ACFT total scores, but these results do not reflect the updated ACFT that includes the PLK. Heileson et. al.[7] showed that FFM was strongly and positively correlated with MDL, SPT, HRPU, SDC, and overall ACFT performance but did not correlate with the 2MR. Aanstad[10] showed that an increased FFM enhanced performance in strength-demanding military tasks, which encompass the need for muscular strength and endurance.

The recently introduced ACFT creates a need to understand better factors that may impact the successful completion of this assessment. Additionally, female military personnel are a growing population that is inadequately studied. Only a single study of 52 ROTC cadets (43 males, 17 females) examined body composition's impact on ACFT scores[7]. Thus, the purpose of this study was to determine whether %BF and FFM can predict performance outcomes of the ACFT in ROTC male and female cadets. It is hypothesized that a higher FFM and a lower %BF will predict better performance on the ACFT. The primary aim was to determine the extent to which %BF and FFM predict the total ACFT score in ROTC cadets.

Scientific Methods

A cross-sectional study was conducted to determine if body composition measures predict ACFT performance. Participants were recruited from the 'Army's Reserve 'Officers' Training Corp (ROTC) program located at Grand Canyon University. The ROTC cadets were required to be actively enrolled in Grand Canyon University and the ROTC program. Participants were excluded if they were currently on light duty, pregnant, and/or had any known chronic disease or injury that could affect performance. The study was approved by the Grand Canyon University Institutional Review Board and was performed in accordance with the ethical standards of the Declaration of Helsinki.

Participants

The participating ROTC cadets were recruited by the commanding officer, who worked with lab staff to organize the scheduling of the tests. The commanding officer made it clear that participation in this research study was voluntary and that a decision not to participate would not impact the 'cadet's role in the ROTC program with the university. The ROTC cadets came into the laboratory for one visit to complete testing. Participants were advised to avoid physical activity for 12 hours, and caffeine for 4 hours before testing. All participating cadets received an informed consent form and were provided adequate time to read through it and ask questions. Following a signed informed consent, ROTC cadets underwent anthropometric and body composition testing. The ACFT tests were completed within 2-weeks of the body composition tests.

Protocol

Anthropometric Assessments

Body weight was measured with minimal clothing and height was assessed without shoes. Participant body mass was measured to the nearest 0.01 kg and height to the nearest 0.1 cm using a stadiometer with a calibrated digital scale attached (Tree LS-PS 500). Waist circumference (WC) and hip circumference (HC) were captured using a Gulick II 150 cm anthropometric tape (model 67020) and reported to the nearest 0.1 cm. WC was captured immediately above the iliac crest, parallel to the floor, with readings taken at the end of exhalation[11]. HC was captured at the most substantial protrusion of the buttocks[12]. Measurements are described in the Anthropometric Standardization Reference Manual[12].

Body Composition
Body composition was determined using whole-body air displacement plethysmography (BOD POD, Cosmed). The BOD POD has been shown to be valid when compared to dual-energy x-ray absorptiometry[13]. The BOD POD was warmed up and calibrated prior to the daily testing. The BOD POD captured weight using the scale associated and derived a % body fat, body fat % (%BF), and fat-free mass (FFM) reading. Before the testing, participating cadets were asked to wear bathing suits or tight-fitting clothing, place a cap on their heads to cover all hair, and remove all jewelry. The test captured two measurements of 50 seconds each. A third measurement was done if there was an inconsistency with the first two measurements.

Army Combat Fitness Test (ACFT)
The ROTC cadets took the ACFT with their training unit in accordance with the procedures and standards outlined by the U.S. Army Field Testing Manual[14]. Official scores were collected and documented using Microsoft Excel and provided to the researchers. The ACFT consists of six events to be completed within 70 minutes or less: 3 repetition maximum deadlifts (MDL), standing power throw (SPT), hand-release push-ups (HRPU), sprint-drag-carry (SDC), plank (PLK), and a 2-mile run (2MR). The total work time is 34 to 37 minutes with a minimum of 17 minutes of rest time. Each event is scored from 0 to 100 with a 60 required to pass each event[14]. The current ACFT (3.0) has removed the leg tuck and replaced it with the plank, as well as, adding scoring for differences in sex and age[14].

Statistical Analysis
SPSS for Windows version 28 software (IBM, Armonk, NY) was used to analyze the data from this study. Descriptive data of age, height, weight, BMI, %BF, FFM, and ACFT scores are presented as mean ± SD. Data normality was evaluated with histograms and P-P plots, and the independence of observations was confirmed via the Durbin-Watson statistic. No outliers were identified. All participants with missing data were removed from the analysis.

An independent-sample t-test was run to determine if there was a difference between males and females. Pearson correlations were used to determine the strength and direction of relationships of males and females separately, %BF, FFM (independent variables), and ACFT performance (dependent variable). Assumptions were met with variables being continuous, paired, without outliers, and with bivariate normality. For significant Pearson correlations, a linear regression was used to provide an equation that predicts the ACFT score based on %BF and FFM. Correlation coefficients were interpreted in accordance with guidelines by Cohen[15] as small (f^2 = 0.2-0.14), medium/moderate (f^2 = 0.15-0.34), or large ($f^2 \geq 0.35$). The targeted sample size used a priori power *G power analysis (effect size = 0.3, $\alpha = 0.05$, $p \geq 0.05$) 55 participants to achieve a power of .95.

Results
The seventy-one ROTC cadets (54 males, 17 females, aged 21.08 ± 3.79 years) volunteered to participate in the study. All participants took the ACFT within 14 days of completing the body composition measurements. There was a significant difference between sexes for age, height, weight, %BF, and FFM. No differences were found for BMI (Table 1).

When looking at males and females combined (n = 71), BMI did not significantly correlate with total ACFT scores, or any component of the ACFT test (all $p > .05$). %BF, however, was significantly and negatively correlated to HRPU (r = -.467, $p < .001$) SDC (r = -.367, p = .002), PLK (r = -.453, $p < .001$), 2MR (r = -.384, $p < .001$), and overall ACFT score (r = -.483, $p < .001$) but not for the MDL (r = -.222, p = .063), or SPT (r = -.228, p = .056). Based on linear regression analysis for body composition, lower %BF was significantly predictive of higher HRPU, SDC, PLK, 2MR, and overall ACFT scores (Table 2). The prediction equation was: ACFT total scores = 587.062 + (-3.998 x %BF). %BF statistically significantly predicted ACFT total scores, $F(1, 69) = 20.96$, $p < .001$, accounting for 23% of the variation in ACFT total scores. For every 1 % increase in %BF, ACFT total scores decreased by 3 points, 95% CI (-5.740, -2.256).

Tables 1 Cadet descriptive data .

	Total (*n* = 71)	Men (*n* = 54)	Women (*n* = 17)	*P*
Age (years)	21.08 ± 3.79	21.80 ± 4.07	18.82 ± 0.95	<.001**
Height (cm)	172.85 ± 9.00	175.74 ± 7.47	163.69 ± 7.19	<.001**
Weight (kg)	77.73 ± 16.63	80.34 ± 16.11	69.46 ± 15.95	.018*
BMI (kg·m²)	24.76 ± 5.03	25.29 ± 5.12	23.08 ± 4.43	.114
%BF (%)	20.71 ± 9.86	18.00 ± 8.77	29.33 ± 8.18	<.001**
FFM (kg)	59.84 ± 11.18	63.64 ± 9.55	47.77 ± 6.39	<.001**
ACFT Scores				
3 Rep Maximum Dead Lift	86.58 ± 15.13	87.00 ± 15.85	85.24 ± 12.91	.323
Standing Power Toss	83.52 ± 15.23	83.57 ± 16.03	83.35 ± 12.75	.477
Hand-Release Pushup	88.08 ± 9.94	89.31 ± 9.82	84.18 ± 9.56	.031*
Sprint-Drag-Carry	89.73 ± 13.08	92.20 ± 11.45	81.88 ± 15.13	.002*
Plank	76.65 ± 26.39	83.98 ± 18.46	53.35 ± 34.06	<.001**
2 Mile Run	79.60 ± 25.05	83.66 ± 21.98	66.71 ± 30.22	.007*
Total ACFT Score	504.25 ± 81.66	519.85 ± 71.96	454.71 ± 92.67	.007*

Notes: *$p < .05$, **$p < .001$
Abbreviations: BMI, Body mass index; %BF, % body fat %; FFM, Fat-Free Mass; ACFT, Army Combat Fitness Test
Data are mean ± SD, rounded to the nearest 0.1. The p-value signifies significant differences between sexes. ACFT event scores ≥ 60 are passing.

Table 2 Linear regression results for body fat percentage (%BF) and fat-free mass (LBM) on ACFT performance outcomes.

	Total ACFT	MDL	SPT	HRPU	SDC	PLK	2MR
%BF (%)							
R^2	.233	.049	.052	.218	.135	.205	.147
P	< .001**	0.12*	0.104	< .001**	< .001**	< .001**	< .001**
FFM (kg)							
R^2	.179	.096	.180	.027	.216	.131	.029
p	0.003*	0.029*	< .001**	0.347	< .001**	0.047*	0.219

Notes: *$p < .05$, **$p < .001$
Abbreviations: ACFT, Army Combat Fitness Test; MDL, 3-repetition maximum deadlift; SPT, standing power throw; HRPU, hand-release pushup; SDC, 300 m sprint-drag-carry shuttle run; PLK, plank; 2MR, 2-mile run; %BF, % body fat %, FFM, fat-free mass

FFM was significantly correlated to MDL ($r = .310$, $p = .008$), SPT ($r = .424$, $p < .001$) SDC ($r = .388$, $p < .001$), PLK ($r = .363$, $p = .002$), and overall ACFT score ($r = .423$, $p < .001$) but not the HRPU ($r = .164$, $p = .171$), or 2MR ($r =$

.169, p = .159). Based on linear regression analysis for body composition, higher FFM was significantly predictive of higher MDL, SPT, SDC, PLK, and overall ACFT scores (Table 2). ACFT total scores = 319.385 + (3.090 x FFM). FFM statistically significantly predicted ACFT total scores, $F(1, 69) = 15.029$, $p < .001$, accounting for 17% of the variation in ACFT total scores. For every 1 kg increase in FFM, ACFT total scores increased by 2 points, 95% CI (1.500, 4.679).

When looking at males and females separately, Male (n = 54) %BF was significantly and negatively correlated to SPT (r = -.306, p < .024) HRPU (r = -.348, p = .010), and overall ACFT score (r = -.325, p < .016) but not for the MDL (r = -.201, p = .145), SDC (r = -.227, p < .098), PLK (r = -.196, p < .001), and 2MR (r = -.153, p = .269). Female %BF (n = 17) was significantly and negatively correlated to HRPU (r = -.690, p < .002) and 2MR (r = -.653, p = .004), and overall ACFT score (r = -.559, p < .020) but not for the MDL (r = -.341, p = .180), SPT (r = -.048, p < .854), SDC (r = -.299, p < .243), and PLK (r = -.468, p = .058). Based on linear regression reanalysis for male body composition, lower %BF was significantly predictive of higher SPT, HRPU, and overall ACFT scores (Table 3). Based on linear regression reanalysis for female body composition, lower %BF was significantly predictive of higher HRPU, 2MR, and overall ACFT scores (Table 3). Male %BF accounted for 10% of the variation in ACFT total scores, while female %BF accounted for 31%.

Table 3 Linear regression results for male and female body fat percentage (%BF) and fat-free mass (LBM) on ACFT performance outcomes.

	Total ACFT	MDL	SPT	HRPU	SDC	PLK	2MR
%BF (%)							
Men (n=54)							
R^2	.106	.040	.094	.121	.052	.038	.023
P	0.016*	0 .145	0.024*	0.010*	.098	0.156	.269
Women (n=17)							
R^2	.313	.117	.002	.475	.090	.219	.426
P	0 .020*	0.180	0.854	0.002*	0.243	0.058	.004*
FFM (kg)							
Men (n=54)							
R^2	.153	.143	.265	.004	.188	.028	.012
p	0.003*	0.005*	< .001**	0.653	< .001**	0.230*	0.427
Women (n-17)							
R^2	.004	.044	.405	.008	.007	.010	.203
p	0.810	0.421	0.006*	0.736	0.747	0.697	0.069

Notes: *p < .05, **p < .001

Abbreviations: ACFT, Army Combat Fitness Test; MDL, 3-repetition maximum deadlift; SPT, standing power throw; HRPU, hand-release pushup; SDC, 300 m sprint-drag-carry shuttle run; PLK, plank; 2MR, 2-mile run; %BF, % body fat %, FFM, fat-free mass

Male FFM was significantly correlated to MDL (r = .378, p = .005), SPT (r = .515, p < .001) SDC (r = .434, p < .001), , and overall ACFT score (r = .391, p < .003) but not the HRPU (r = .063, p = .653), PLK (r = .166, p = .230), and 2MR (r = .110, p = .427). Female FFM was significantly correlated to SPT (r = .636, p = .006), but not the MDL (r = .209, p = .421), HRPU (r = -.089, p = .736), SDC (r = .084, p = .747), PLK (r = -.102, p < .697) 2MR (r = -.451, p < .069), and overall ACFT score (r = -.063, p < .810). Based on linear regression reanalysis for male body composition, higher FFM was significantly predictive of higher MDL, SPT, SDC, and overall ACFT scores (Table 3). Based on linear regression reanalysis for female body composition, higher FFM was significantly predictive of higher SPT (Table 3). Male FFM accounted for 15% of the variation in ACFT total scores, while female FFM did not.

Discussion

The purpose of this study was to determine the extent to which %BF and FFM predict the total ACFT scores. It was hypothesized that a higher FFM and a lower %BF would be associated with better performance on the ACFT. This study demonstrated that body composition plays a significant role in predicting physical performance on the ACFT. This study found that %BF and FFM are significant predictors of the ACFT total score. For every 1 % increase in body fat, ACFT scores decreased by 3 points. For every 1 kg increase in FFM, the ACFT score increased by 2 points. The current study found that %BF did not correlate with the individual events MDL and SPT, and FFM did not correlate with HRPU and 2MR. This does not align with previous findings as Heileson et al[7] found that %BF predicted better performance on all ACFT events except the PLK, and FFM predicted better performance on all events except the PLK and 2MR. The variations in findings could be due to different baseline characteristics, as well as different methods used to determine body composition. Additionally, the current sample was selected from a private Christian school in Arizona while 'Heileson's sample was from a private school in Texas. The differences between schools may attract a different demographic into their respective ROTC programs. Importantly, Heileson et al[7] used dual-energy X-ray, while the current study used air displacement plethysmography to determine body composition. Heileson et al[7] showed higher correlations between body composition and tasks, which could be due to the population being more fit and familiar with the testing.

Our results may have direct implications as body composition plays a significant role in the performance of U.S. Army soldiers. Our findings are consistent with previous military research that reports a lower %BF is associated with better 2MR[6,7,16]. This is important due to previous research showing that >40% of those who failed did not receive passing scores on the 2MR[17]. The current findings show that >80% of those who failed did not pass the 2MR. While %BF is an essential contributor in predicting performance outcomes, the ACFT incorporates tasks that require higher levels of strength, power, speed, and agility, which are associated with muscle mass. FFM is a surrogate for muscle mass that leads to a greater cross-sectional area, which can create the ability to produce more force[18]. Although FFM did not correlate with the HRPU and 2MR it was associated with MDL, SPT, SDC, and PLK. Similarly, Farina et al[16] found that FFM did not predict better performance on the push-up event.

When comparing sexes, both males' and females' %BF significantly correlated with ACFT total scores. The current study showed that %BF predicted 43% of the variance in the 2MR in female cadets. This finding could be useful for practitioners as our data aligns with previous research that shows the 2MR has a high failure rate in women[17]. The SPT was the only event that correlated with FFM in females. This study is the first to report that body composition plays a role in men's and women's ROTC cadet ACFT performance.

The current body composition standards of the Army only account for %BF. The research shows a high level of importance in understanding a soldier's FFM, as it plays a critical role in ACFT performance. The Army has recognized its outdated body composition analysis method and started planning to explore more accurate options. A new adaptation that was recently introduced showed that if a solider scored at least 540 out of 600 on the ACFT total score, they will not need to undergo the tape test[19]. The current study supports this directive such that when analyzing only participants who scored > 540 (n = 25), body composition measures do not correlate with the ACFT total score. Thus, considering body composition with ACFT total score may only be necessary for low performers. Once cadets achieve an acceptable performance standard, additional variables outside of body composition should be the training focus for continual performance. Determining what these variables are is outside the scope of this study and should be a focus for future research.

The primary limitation of this preliminary research is that the physical activity data were not obtained, but it was understood that the cadets do try to follow a training schedule that consists of three days of aerobic training and two days of resistance training. To mitigate this limitation, we asked the cadets to conduct the ACFT within 14 days of completing the body composition testing. Sleep and dietary variables were not obtained, which could be a limitation due to their effects on performance [20]. The current study's examination of the new ACFT assessment was a strength. The ACFT is still in its infancy, and little is known about predictors of high-performance outcomes. Additionally, a strength of the study was the inclusion of female ROTC cadets. The study used n = 17 female cadets (23%), which is higher than the U.S. Army female officers' average of 19%[21]. Limited data is available on the female soldier. Thus, future research is needed to better understand predictors of ACFT scores and battlefield readiness in female soldiers. Additionally, future research is needed to investigate active-duty soldiers and the effect %BF and FFM have on older active-duty soldiers.

Conclusions

Percent BF and FFM are valid tools to use as predictors of the ACFT total score. BMI did not predict any event in the ACFT. Thus, body composition is a metric that the Army should reevaluate as a universal method to assess 'soldiers' physical readiness. The current methods (height and circumference measurements) of body composition assessment and current standards do not align with a soldier having elevated lean muscle tissue due to the formula not accounting for FFM. Due to the significance of FFM on the performance metrics of the ACFT, the 'Army's body composition standards may need to be re-examined. Since body composition is modifiable, soldiers can use this information to create plans to improve ACFT performance. Our data suggests that body composition should be a routine measurement of a 'soldier's readiness for duty. Accurate and affordable body composition methods have become increasingly available, such that military training installations should invest in body composition measurement devices.

Acknowledgments

Grand Canyon University ROTC Cadets

Conflict of Interest

No conflict of interest

References

1. Knapik JJ, East WB. History of United States Army physical fitness and physical readiness training. *US Army Med Dep J*. 2014 Apr-Jun 2014:5-19.
2. Army Dot. The Army Body Composition Program, Army Regulation 600-9. Washington, DC: Department of the Army; 2013.
3. Bigelman KA, East WB, Thomas DM, Turner D, Hertling M. The New Army Combat Fitness Test: An Opportunity to Improve Recruitment and Retainment. *Obesity (Silver Spring)*. 11 2019;27(11):1772-1775. doi:10.1002/oby.22619
4. Roberts BM, Rushing KA, Plaisance EP. Sex Differences in Body Composition and Fitness Scores in Military Reserve Officers' Training Corps Cadets. *Mil Med*. Jan 15 2021; doi:10.1093/milmed/usaa496
5. Friedl KE. Body composition and military performance--many things to many people. *J Strength Cond Res*. Jul 2012;26 Suppl 2: S87-100. doi:10.1519/JSC.0b013e31825ced6c
6. Steed CL, Krull BR, Morgan AL, Tucker RM, Ludy MJ. Relationship Between Body Fat and Physical Fitness in Army ROTC Cadets. *Mil Med*. 09 2016;181(9):1007-12. doi:10.7205/MILMED-D-15-00425
7. Heileson JL, McGowen JM, Moris JM, et al. Body Composition, Eicosapentaenoic Acid, and Vitamin D are Associated with Army Combat Fitness Test Performance. *J Int Soc Sports Nutr*. 2022;19(1):349-365. doi:10.1080/15502783.2022.2094717
8. Barringer ND, McKinnon CJ, O'Brien NC, Kardouni JR. Relationship of Strength and Conditioning Metrics to Success on the Army Ranger Physical Assessment Test. *J Strength Cond Res*. Apr 2019;33(4):958-964. doi:10.1519/JSC.0000000000003044
9. Pihlainen K, Santtila M, Häkkinen K, Kyröläinen H. Associations of Physical Fitness and Body Composition Characteristics with Simulated Military Task Performance. *J Strength Cond Res*. Apr 2018;32(4):1089-1098. doi:10.1519/JSC.0000000000001921
10. Aandstad A. Association Between Performance in Muscle Fitness Field Tests and Skeletal Muscle Mass in Soldiers. *Mil Med*. 06 08 2020;185(5-6):e839-e846. doi:10.1093/milmed/usz437
11. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res*. Sep 1998;6 Suppl 2:51S-209S.
12. Lohman TG, Roche, A.F. and Martorell, R. Anthropometric standardization reference manual.: Human Kinetics Books, Chicago.; 1988.
13. Maddalozzo GF, Cardinal BJ, Snow CA. Concurrent validity of the BOD POD and dual energy x-ray absorptiometry techniques for assessing body composition in young women. *J Am Diet Assoc*. Nov 2002;102(11):1677-9. doi:10.1016/s0002-8223(02)90358-5
14. US Army ACFT Field Testing Manual. U.S. Army Center for Initial Military Training, TRADOC, Fort Eustis, VA2022.
15. Cohen J. Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.1988.
16. Farina EK, Thompson LA, Knapik JJ, Pasiakos SM, McClung JP, Lieberman HR. Anthropometrics and Body Composition Predict Physical Performance and Selection to Attend Special Forces Training in United States Army Soldiers. *Mil Med*. 2021; doi:10.1093/milmed/usab315

17. Hardison C, Paul W. Mayberry, Krull, Messan Setojdi CP, Madison, R, Simpson MA, TOTTEN, M, WONG, W. Independent Review of the Army Combat Fitness Test. e RAND Corporation, Santa Monica, Calif.; 2022.
18. Fitts RH, McDonald KS, Schluter JM. The determinants of skeletal muscle force and power: their adaptability with changes in activity pattern. *J Biomech*. 1991;24 Suppl 1:111-22. doi:10.1016/0021-9290(91)90382-w
19. Beynon S. No More Tape Test, But Only For Soldiers That Crush the Fitness Test. 2022.
20. Farina EK, Thompson LA, Knapik JJ, Pasiakos SM, Lieberman HR, McClung JP. Diet Quality Is Associated with Physical Performance and Special Forces Selection. *Med Sci Sports Exerc*. 01 2020;52(1):178-186. doi:10.1249/MSS.0000000000002111
21. U.S. Army Demographics. 2022.