Eating Habits as a Predictor of Performance on the Army Combat Fitness Test Total Score of ROTC Cadets

Original Research

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ABSTRACT

Introduction: The Army Combat Fitness Test (ACFT) is a newly developed combat readiness assessment test that may require nutritional interventions. The purpose of this cross-sectional study is to determine if diet quality can predict performance outcomes on the ACFT in ROTC cadets.

Methods: ROTC cadets (54 males, 17 females; aged 21.08 ± 3.8 years) reported to the laboratory to complete a comprehensive questionnaire (HEI-2015). The ability of the HEI-2015 to predict ACFT performance was determined with a linear regression model. Significance was set at $p < 0.05$.

Results: HEI-2015 total score was significantly and positively correlated to ACFT total score ($r = .287$, $p = .015$). Subcategories of the HEI-2015 were positively and significantly correlated with ACFT total scores, greens, and beans ($r = .276$, $p = .020$), total protein ($r = .249$, $p = .037$), seafood and plant protein ($r = .341$, $p = .004$), and fatty acid ratio ($r = .273$, $p = .004$). HEI-2015 total score significantly explained 8% ($p = .015$) of the variance on the ACFT total scores with a beta coefficient of 2.862.

Conclusion: The HEI-2015 total score is a predictor of success on the ACFT total score. HEI-2015 subcategories GB, TP, SPP, and FA are associated with the ACFT total score. This data shows that overall diet quality determines a soldier's combat readiness. For every 1-point increase in the HEI-2015 total score, the ACFT total score is predicted to increase by 3 points.

Keywords: Army, HEI-2015, Military

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Introduction

The Army has been testing physical readiness for the last 100 years by assessing physique and body composition, which are strongly influenced by diet quality[1]. It is widely established that diet and nutrition may optimize physical performance in athletic populations, but there is a limited amount of research examining the relationship between overall diet quality and performance in Military populations [2]. Dietary habits are becoming more of a focus for the U.S. Army, specifically, the quality of food consumed. Diet quality is an issue among Military recruits and special operators [3,4]. To get a better understanding of soldiers' diet quality, the Healthy Eating Index-2015 (HEI-2015) is a valid way to measure overall diet quality through balance, variety, and adequacy[5]. The HEI-2015 assesses diet quality on a scale from 0 to 100 with a higher score indicating greater adherence to the

2015 to 2020 federal Dietary Guidelines for Americans (DGA)[5]. The Army's current Nutrition and Menu Standards for Human Performance Optimization [6] establishes nutritional standards from the DGA.

Since 1980, the Army Physical Fitness Test (APFT) has been used as a method of assessing physical fitness to ensure soldiers are prepared to engage in combat operations[7]. The APFT consists of 2-minute push-ups and sit-ups and a timed 2-mile run, which only assesses muscular and aerobic endurance. The chief concern of the Army is to accurately assess and predict combat readiness, which leads to the development of the Army Combat Fitness Test (ACFT). The ACFT is designed to better assess strength, power, agility, and sustained anaerobic and aerobic capacities using six events three-repetition maximum trap bar deadlift (MDL), standing power throw (SPT), hand-release push-ups (HRPU), sprint-drag-carry (SDC), plank (PLK), 2-mile run (2MR) [8].

A high-quality diet is critical for optimal performance during the Army Physical Fitness Test (APFT) Farina et al. [9]. These findings corroborate previous research showing that those who passed their APFT in the top quartile reported a higher HEI-2005 score[10]. While there is not an ideal score established, HEI-2015 scores in the 3rd and 4th quartile (68.92 ± 2.65, 77.64 ± 4.57, respectively) performed better on the APFT. The average American (aged 19 – 30 years) obtains an HEI-2015 score of 53, while military soldiers have an average HEI-2015 score of 59.9 and Division I athletes of 59.2[11,12]. There is currently a gap in the literature establishing an ideal HEI-2015 score to pass the newly implemented ACFT.

The ultimate goal of the U.S. Army is to ensure the physical readiness of each soldier with food being best used as a tactical weapon[13]. Performance may be influenced by many mechanisms, but there is an ample amount of evidence showing the positive effects of nutritional adherence[10]. Due to the lack of understanding of how diet quality affects performance on the newly implemented ACFT, the purpose of this study is to examine HEI-2015 scores as a predictor of performance on the ACFT total score. Based on the influence of diet and nutrition on performance, the hypothesis is that diet quality will significantly predict ACFT total scores. Therefore, the primary aim of this study was to distribute a Diet Health Questionnaire III (DHQIII) and collect HEI-2015 scores to assess its ability as a predictor of ACFT total scores. A secondary aim was to assess protein intake as a predictor of performance on the ACFT total scores.

Scientific Methods
A cross-sectional study was conducted to determine if the HEI-2015 total score predicts ACFT performance. The 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 have any known chronic disease or injury that can affect performance. The study was approved by 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 test. 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 were asked to come into the laboratory for one visit to complete testing. All participating cadets signed informed consent forms and were provided adequate time to read through them and ask any questions. Following a signed consent form, ROTC cadets were sent a private link to access the DHQIII. The web-based questionnaire consists of 135 food and beverage line items and 26 dietary supplement questions. The cadets performed the ACFT test within 2 weeks of completing the questionnaire.
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Protocol
Anthropometric Assessments
Body weight was measured with minimal clothing and height was assessed without shoes worn. 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].

Healthy Eating Index-2015
Participants were directed to the web-based 161-item DHQIII where they received verbal instructions on how to complete the questionnaire (National Cancer Institute, NIH, Bethesda, Maryland)[14]. The daily consumption of foods and total energy intake were derived from the DHQIII. The DHQIII collected data and computed the HEI-2015 scores by identifying the set of foods under consideration, then determined the amount of each relevant dietary constituent by their respective densities computing a score. The HEI-2015 is a measure of diet quality used to assess how well eating habits align with the recommendations of the DGA[15]. The HEI-2015 is the latest version that includes DGA from 2015 to 2020. The HEI-2015 total score ranges from 0 to 100, with higher scores indicating greater compliance with the DGA. The total score is made up of 13 components [total vegetables (TV), greens and beans (GB), total fruit (TF), whole fruit (WF), whole grains (WG), dairy (D), total protein foods (TP), seafood and plant protein (SPP), fatty acid ratio (FA), sodium (S), refined grains (RG), added sugars (AS), and saturated fats (SF)], that reflect various food groups based on their density (amounts per 1,000 kcal). The nine components that assess compliance with adequate intakes have maximum scores ranging from 5 to 10 that correspond to the following standards: ≥1.1 cup equivalents per 1000 kcal for total vegetables, ≥0.2 cup equivalents per 1000 kcal for greens and beans, ≥0.8 cup equivalents per 1000 kcal for total fruit, ≥0.4 cup equivalents per 1000 kcal for whole fruit, ≥1.5 oz equivalents per 1000 kcal for whole grains, 1.3 cup equivalents per 1000 kcal for dairy, ≥2.5 oz equivalents per 1000 kcal for total protein foods, ≥0.8 oz equivalents per 1000 kcal for seafood and plant protein, and (polyunsaturated fatty acids + monounsaturated fatty acids)/saturated fatty acids ≥2.5 for fatty acid ratio. A 0 is given if a person does not intake food or has a fatty acid ratio of ≤1.2. The four components that assess compliance with moderation each have a maximum score of 10 that corresponds to the following standards: ≤1.1 g per 1000 kcal for sodium, ≤1.8 oz equivalents per 1000 kcal for refined grains, ≤6.5% of energy for added sugars, and ≤8% of energy for saturated fats. The minimum score of 0 corresponds to ≥2.0 g per 1000 kcal for sodium, ≥4.3 oz equivalents per 1000 kcal for refined grains, ≥26% of energy for added sugars, and ≥16% of energy for saturated fats [16].

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, body fat %, HEI-2015, and ACFT scores are presented as mean ± SD. Significance was set a priori at $p < .05$. Data normality was evaluated with scatter 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-samples t-test was run to determine if there were a difference between males and females. A one-way ANOVA was conducted to determine if HEI-2015 was different from ACFT total scores. Linear regression was run to understand the effect of HEI-2015 total scores (independent variables) on ACFT performance (dependent variable). A scatterplot was used to test the linearity between ACFT total scores against HEI-2015 values with a superimposed regression line plotted. Visual inspection of these two plots indicated a linear relationship between the variables. There was homoscedasticity and normality of the residuals. Correlation coefficients were interpreted in accordance with guidelines by Cohen[18] 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 = 0.30, α > 0.05, $p \geq 0.05$) 55 participants to achieve a power of .95.

Results
Seventy-one ROTC cadets (54 males, 17 females; aged 21.08 ± 3.8 years) volunteered to participate in the study. All participants took the ACFT within 14 days of completing the HEI-2015. There was a significant difference between sexes for age, height, weight, %BF, and FFM. No differences were found for BMI (Table 1).

Table 1. Cadet descriptive data.

	Total (*n* = 71)	Male (*n* = 54)	Female (*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**
HEI Scores				
Total Veggies	3.15 ± 1.36	3.04 ± 1.38	3.50 ± 1.28	.116
Green Beans	3.37 ± 1.76	3.37 ± 1.78	3.39 ± 1.75	.488
Total Fruits	3.59 ± 1.41	3.53 ± 1.40	3.79 ± 1.48	.258
Whole Fruits	4.13 ± 1.33	4.14 ± 1.34	4.10 ± 1.35	.459
Whole Grains	3.27 ± 1.91	3.05 ± 1.76	3.96 ± 2.22	.044*
Dairy	6.12 ± 2.49	6.31 ± 2.57	5.51 ± 2.17	.125
Total Proteins	4.63 ± 0.69	4.73 ± 0.56	4.34 ± 0.95	.065
Seafood-Plant Protein	3.93 ± 1.42	3.97 ± 1.37	3.81 ± 1.60	.347
Fatty Acids	4.95 ± 2.83	4.83 ± 2.75	5.30 ± 3.13	.277
Sodium	3.75 ± 2.64	3.73 ± 2.42	3.80 ± 3.32	.464
Refined Grains	8.20 ± 2.20	8.13 ± 2.22	8.41 ± 2.19	.322
Saturated Fats	6.60 ± 2.93	6.51 ± 2.94	6.87 ± 2.96	.329
Added Sugars	6.36 ± 2.97	6.41 ± 2.99	6.21 ± 2.98	.406
HEI Total	62.15 ± 8.19	61.88 ± 8.19	63.00 ± 8.38	.312
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. ACFT event scores ≥ 60 are passing. p-value signifies the significance between the sexes.

When looking at males and females together, HEI-2015 total score was significantly and positively correlated to ACFT total score (*r* = .287, *p* = .015) and subcategories MDL (*r* = .249, *p* = .037), PLK (*r* = .235, *p* = .049), but not the SDC (*r* = .215, *p* = .071), SPT (*r* = .196, *p* = .102), HRPU (*r* = .144, *p* = .231), 2MR (*r* = .205, *p* = .086). Subcategories of the HEI-2015 were positively and significantly correlated with ACFT total scores, GB (*r* = .276, *p* = .020), TP (*r* = .249, *p* = .037), SPP (*r* = .341, *p* = .004), and FA (*r* = .273, *p* = .004) except TV (*r* = .044, *p* = .715), TF (*r* = -.042, *p* = .725), WF (*r* = -.019, *p* = .725), WG (*r* = -.032, *p* = .789), D (*r* = -.111, *p* = .358), RG (*r* = -.010, *p* = .934), S (*r* = -.107, *p* = .374), AS (*r* = .152, *p* = .204), SF (*r* = .197, *p* = .100). The prediction equation was: ACFT total scores = 326.414 + (2.862 x HEI-2015 total). HEI-2015 total statistically significantly predicted ACFT total scores, $F_{(1, 69)}$ = 6.198, *p* < .015, accounting for 8% of the variation in ACFT total scores. For every 1-point increase in HEI-2015 total score, ACFT total scores increased by 3 points, 95% CI (.569, 5.155). HEI-2015 total score was significantly higher among those with higher ACFT total scores (quartile 4 vs quartile 1) (Table 2).

Table 2. Mean differences between HEI-2015 and ACFT total scores of ROTC cadets.

	ACFT Total Score		HEI-2015 Total Score		
	n=71	Mean ± SD	Mean ± SD	n=71	P
Quartile 1 (REF)	18	469 ± 107	56.19 ± 3.73	18	REF
Quartile 2	18	488 ± 80	63.92 ± 2.18	18	.474
Quartile 3	19	517 ± 69	67.92 ± 1.23	17	.066
Quartile 4	16	544 ± 35	79.49 ± 3.08	15	.007*

Notes: *p < .05, **p < .001
Abbreviations: Healthy Eating Index-2015, HEI-2015; Army Combat Fitness Test, ACFT
Data are mean ± SD, rounded to the nearest 0.1; P values are compared to Reference, (REF).

When looking at males only, HEI-2015 subcategories were positively and significantly correlated with ACFT total scores, GB (r = .274, p = .045) and SPP (r = .310, p = .023), but not the TV (r = .042, p = .763) TF (r = -.019, p = .892), WF (r = -.070, p = .617), WG (r = .065, p = .641), D (r = -.150, p = .281), TP (r = .192, p = .165), FA (r = .253, p = .065), S (r = -.079, p = .570), RG (r = -.082, p = .555), SF (r = .141, p = .311), AS (r = .186, p = .177). HEI-2015 total score was not significantly correlated to the ACFT. MDL (r = .255, p = .063), SPT (r = .206, p = .136), HRPU (r = .072, p = .607), SDC (r = .209, p = .130), PLK (r = .199, p = .150), 2MR (r = .116, p = .403), and ACFT total score (r = .252, p = .066). HEI-2015 total score in men was significantly higher among those with higher ACFT total scores (quartile 4 vs quartile 1) (Table 3). Based on linear regression analysis for men's HEI-2015 total score, a higher score did not predict a higher ACFT total score (Table 3).

Table 3 Linear regression results for males and females HEI-2015 total score on ACFT performance outcomes.

	Total ACFT Score	MDL	SPT	HRPU	SDC	PLK	2MR
HEI-2015 Total Score							
Male (n=54)							
R^2	.042	.065	.005	.044	.039	.014	.064
P	.136	.063	.607	.130	.150	.403	.066
Female (n=17)							
R^2	.027	.062	.211	.129	.278	.264	.275
P	.531	.336	.063	.157	.030*	.035*	.031*

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; HEI, HEI 2015 Total Score

When looking at Females only, HEI-2015 total scores were positively and significantly correlated with ACFT total scores (r = .524, p = .031), PLK (r = .527, p = .03), and 2MR (r = .514, p = .035), but not the MDL (r = .248, p = .336), SPT (r = .163, p = .531), HRPU (r = .460, p = .063), SDC (r = .359, p = .157). HEI-2015 subcategories were not correlated with ACFT total scores, TV (r = .267, p = .301) GB (r = .359, p = .157), TF (r = -.011, p = .966) WF (r = -.091, p = .729), WG (r = -.008, p = .977), D (r = -.243, p = .347), TP (r = .172, p = .509), SPP (r = .425, p = .089), FA (r = .466, p = .059), S (r = -.168, p = .519), RG (r = .249, p = .334), SF (r = .462, p = .062), AS (r = .066, p = .800). HEI-2015 total score was not significantly correlated to the ACFT. MDL (r = .255, p = .063), SPT (r = .206, p = .136), HRPU (r = .072, p = .607), SDC (r = .209, p = .130), PLK (r = .199, p = .150), 2MR (r = .116, p = .403), and ACFT total score (r = .252, p = .066). HEI-2015 total score in women was significantly higher among those with higher ACFT total scores (quartile 4 vs quartile 1) (Table 3). Based on linear regression analysis for women's HEI-2015 total score, a higher score did not predict a higher ACFT total score (Table 3).

Discussion

This study demonstrated that ROTC cadet performance on the ACFT is associated with diet quality. It was hypothesized that HEI-2015 total scores will be a significant predictor of performance on the ACFT total score, especially the subcategory total protein. In cadets, higher HEI-2015 total scores were associated with elevated performance during the ACFT, which was shown in previous research using the APFT[9,11,20]. A higher HEI-2015 score predicted better performance on the MDL, SDC, and PLK, but did not correlate with the SPT, HRPU, and the 2MR. The current findings do not align with previous research showing that a higher HEI-2015 score was associated with the 2MR[9]. It is plausible to assume that the more rigorous, strength-based, and longer-duration ACFT played a role.

There is much research to show that the strongest predictors of performance on combat-related tasks are related to strength, power, agility, and anaerobic and aerobic capacity[8,21]. ACFT total scores were associated with HEI-2015 subcategories GB, TP, SPP, and FA. Previous research showed that higher intakes of protein are associated with higher HEI-2015 scores, which can help give direction to practitioners when giving dietary recommendations[22]. The ACFT incorporates events that require a high level of strength and power, which are associated with muscle mass. Protein is a necessity for the development of muscle mass, which leads to a greater cross-sectional area and can create the ability to produce more force[23]. Bigman and Ryan[20] showed that adequate intake of protein, using an HEI-2015, was associated with 70 to 80% higher odds of having an elevated grip strength. A higher level of grip strength is a valid predictor of overall strength due to it being associated with a higher level of muscle mass[24]. The current study deduced that sufficient protein intake (total protein, seafood, and plant protein) would enhance the performance of the ACFT.

Our findings of an association between diet quality and performance corroborate with previous research. The average American (aged 19 – 30 years) obtains an HEI-2015 score of 53, while military soldiers have an average HEI-2015 score of 59.9 and Division I athletes of 59.2 with the current research showing a slightly higher HEI-2015 amongst cadets[11,12]. Previous research showed that scores in the third and fourth quartiles (68.92 ± 2.65 and 77.64 ± 4.57, respectively) would be the strongest predictor of performance success on the APFT and would have greater chances of selection to the special forces[9]. The current study shows that HEI-2015 scores in the third and fourth quartiles are strong predictors of higher ACFT total scores (67.92 ± 1.23 and 79.49 ± 3.08, respectively). The HEI-2015 has shown that it could be a valuable tool in assessing the relationship between diet quality and ACFT performance.

This is the first study to solely examine HEI-2015 as a predictor of performance on the ACFT. A strength of this study is the use of an extensive 161-item questionnaire, with a weakness being it can be answered with a lack of recall. The primary limitation of this preliminary research is the modest sample size due to the use of the ROTC cadets at one University. A limitation would be that ROTC cadets are mainly students and do not have the same role as active-duty soldiers or special operators. Physical activity data was not obtained, but it was understood that the cadets do try to follow a schedule of training 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 before completing the DHQIII. Sleep and dietary variables were not obtained, which could be a limitation due to their effects on performance[9].

Conclusion

These findings suggest that a higher HEI-2015 total score is a valid predictor of the ACFT total score. There is a limited amount of data to establish a minimum HEI-2015 score that can be associated with passing the ACFT. TP and SPP are key macronutrients to consume when wanting to receive a higher ACFT total score. This data shows that overall compliance with the DGA is an important factor in determining a soldier's combat readiness. For every 1-point increase in the HEI-2015 total score, the ACFT total score is predicted to increase by three points.

Conflict of Interest
No conflict of interest.

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