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Original research

Sex and age differences in physical performance: A comparison of Army basic training and operational populations

Esther O. Dada*, Morgan K. Anderson, Tyson Grier, Joseph A. Alemany, Bruce H. Jones

Army Public Health Center, Injury Prevention Division, Clinical Public Health and Epidemiology Directorate, United States

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ABSTRACT

Objectives: To determine the age- and sex-specific differences of physical fitness performances and Body Mass Index (BMI) in basic training and the operational Army.

Design: Cross-sectional Study.

Methods: This secondary analysis utilizes retrospective surveys of U.S. Army Soldiers in Basic Combat Training (BCT) and operational units to compare physical performances between men and women as measured by the Army Physical Readiness Test (APFT). An ANOVA was used to compare mean differences in APFT results and BMI within sex-specific populations. A post hoc Tukey test identified specific mean differences. Adjusting for age, an ANCOVA was used to compare sex and occupation (infantry and non-infantry) differences in APFT results.

Results: Surveyed populations consisted of 2216 BCT Soldiers (1573 men and 643 women) and 5515 Operational Soldiers (4987 men and 528 women). Male and female operational Soldiers had greater muscular performance (79%–125% higher APFT push-ups, 66%–85% higher APFT sit-ups) and cardiorespiratory performance (22%–24% faster APFT 2-mile run times) than BCT Soldiers. Male BCT and operational Soldiers outperform their female counterparts on tests of muscular and cardiorespiratory endurance. Sex differences in physical performances attenuated among female Soldiers in operational units compared to BCT. Among male operational Soldiers, infantry Soldiers exhibited greater cardiorespiratory and muscular performance than non-infantry Soldiers. Higher BMI was associated with higher age groups, except for female BCT Soldiers.

Conclusions: Gaps in cardiorespiratory and muscular performances between men and women should be addressed through targeted physical training programs that aim to minimize physiological differences.

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1. Introduction

Military physical readiness largely depends on Soldiers maintaining the level of general health and physical fitness to perform their requisite occupational duties in garrison and deployment environments. Every Service Member in the U.S. Army Forces is required to maintain body composition standards and a minimal level of physical fitness in terms of cardiorespiratory endurance, muscular strength, and muscular endurance that is specific to their military specialty and mission.¹ Physical fitness assessments are an essential component in measuring the physical capacities of all Service Members.

The Army Physical Fitness Test (APFT) is designed to assess the cardiorespiratory endurance, and muscular strength and endurance of U.S. Army Soldiers. The physical performance test is administered biannually and consists of three fitness events: a 2-min maximal effort push-up (PU)³ event, a 2-min maximal effort sit-up (SU) event, and a 2-mile run performed for time. Although Army physical fitness testing is age and sex adjusted, female Soldiers must also meet the minimum physical capabilities in order to successfully perform their military duties.

As female Soldiers begin to enter infantry and other combat positions, questions about their physical capabilities compared to male Soldiers have been raised.^{2,3} When comparing absolute muscular strength, on average, women are 50% lower in upper body strength and 30% lower in leg strength.⁴ Cardiovascular endurance is also 15%–30% lower in untrained and trained women compared to men of similar age.^{5–7} Given the higher physical demands of infantry Soldiers compared to non-infantry Soldiers,⁸ sex differences in several components of physical fitness is concerning.

* Corresponding author.

E-mail address: usarmy.apg.medcom-aphc.mbx.injuryprevention@mail.mil (E.O. Dada).

Although the APFT does not assess female and male Soldiers' abilities to meet the physical demands of their military occupational specialties (MOSs),^{9–11} understanding sex and age-specific differences in measures of cardiorespiratory endurance, muscular strength and endurance in BCT and operational units can provide insights into the gaps in physical performances and potential targets for specific physical fitness and body composition programs.

The purpose of this investigation is to examine sex- and age-specific differences of physical fitness performances in BCT and operational units. Because BMI is an important indicator of physical fitness and general health, differences in Body Mass Index (BMI) will also be assessed.

2. Methods

This investigation was a secondary analysis utilizing retrospective cross-sectional surveys of U.S. Army Soldiers in Basic Combat Training (BCT) and operational units. Voluntary surveys were administered as part of ongoing public health studies examining the interrelationships of demographic characteristics, military occupational specialties (MOS), physical performance/APFT results, and injury. The studies were approved by the institutional review board at the Army Medical Research and Materiel Command and the institutional Public Health Review Board at the U.S. Army Public Health Center. Informed consent was obtained from all volunteer participants.

Participants in BCT were U.S. Army recruits who were followed during the nine-week BCT. Data on Army physical fitness was collected within the first three weeks of BCT and personal characteristics were captured through self-reported survey upon arrival at BCT reception station. Operational Soldiers were assigned from Infantry Regiments, Combat Aviation Brigade, and support brigades. Data was collected in operational units through an electronic self-reported survey using Verint Enterprise Feedback Management™ software (Verint® Systems Inc., Melville, NY) in 2016.

Body mass index (BMI, kg/m²) was calculated from self-reported height and weight data. The APFT consists of a 2-min maximal effort PU event, a 2-min maximal effort SU, and a 2 mile run performed for best time.¹² These events were completed in accordance with Army Field Manual 7–22.¹² Age was categorized by the APFT-designated age groups.¹² Male operational Soldiers were classified as infantry or non-infantry Soldiers based on MOS categories as established by the Department of the Army Pamphlet ((DA PAM) 611-2).⁸ Even though current doctrine has permitted female Soldiers to serve in infantry positions, no female Soldiers were assigned to infantry positions at the time of data collection.

Statistical analyses were performed with Statistical Package for the Social Sciences (SPSS®), Version 19.0 (IBM Corp, Armonk, NY). Descriptive statistics and results were presented as frequencies, means, and standard deviations. An ANOVA was used to compare mean differences in APFT results and BMIs across age groups between and within Soldier populations. A post hoc Tukey test was used to determine specific mean differences. An ANCOVA was used to adjust for differences in age when comparing sex differences in APFT results within BCT and non-infantry operational units, as well as differences in APFT results between male infantry and non-infantry Soldiers. All findings were statistically significant at $p < 0.05$.

3. Results

The surveyed populations consisted of 2216 BCT Soldiers (1573 men and 643 women) and 5515 operational Soldiers (4987 men and 528 women). No significant difference in mean age was noted

between male (23.0 ± 5.2 years) and female (23.0 ± 4.7 years) BCT Soldiers ($p = 0.083$). Male and female non-infantry Soldiers had similar mean ages (26.7 ± 6.7 years and 25.8 ± 6.8 years, respectively, $p = 0.208$), but had significantly higher mean ages ($p < 0.001$) compared to male infantry Soldiers (23.9 ± 4.9 years). Mean differences in BMI were observed between male (25.5 ± 4.3 kg/m²) and female (23.8 ± 3.2 kg/m²) BCT Soldiers ($p < 0.001$). Mean BMI values differed among male and female non-infantry Soldiers (26.3 ± 3.5 kg/m² and 24.7 ± 3.3 kg/m², respectively, $p < 0.001$) and male infantry Soldiers (25.8 ± 3.1 kg/m²).

Fig. 1 depicts sex- and age-specific APFT results for PU, SU, and 2-mile run time (2MRT) in BCT and operational units. Overall, male and female operational Soldiers assigned to infantry and non-infantry units consistently had higher APFT performances for all events than BCT Soldiers across age groups (79%–125% and 66%–85% higher APFT PU and SU repetitions, respectively, and 22%–24% faster APFT 2MRT). On average, female BCT Soldiers exhibited slower 2MRT and fewer PU and SU compared to their male counterpart (PU: 16.6 ± 11.7 reps vs. 35.4 ± 14.7 reps, $p < 0.001$; SU: 34.3 ± 16.5 reps vs. 40.8 ± 14.1 reps, $p < 0.001$; 2MRT: 21.8 ± 3.2 min vs. 18.3 ± 2.9 min, $p = 0.001$). Similarly, the gap in APFT performance was observed in female and male non-infantry Soldiers (PU: 37.4 ± 12.4 reps vs. 61.8 ± 12.7 reps, $p = 0.023$; SU: 63.4 ± 11.5 reps vs. 66.4 ± 10.9 reps, $p = 0.220$; 2MRT: 17.8 ± 1.8 min vs. 15.1 ± 1.4 min, $p < 0.001$). Although compared to BCT Soldiers, sex differences in APFT performance narrowed among non-infantry Soldiers: 53.1%–39.5% fewer PU; 15.9%–4.7% fewer SU; and 19.1%–17.9% slower 2MRT.

Among male Soldiers, infantry Soldiers had the highest PU and SU performances (65.2 ± 12.2 and 69.5 ± 10.2 reps) followed by non-infantry (61.8 ± 12.7 and 66.4 ± 10.9 reps) and BCT (35.4 ± 14.7 and 40.8 ± 14.1 reps) Soldiers. Similarly, female non-infantry Soldiers performed more PU (37.4 ± 12.4 reps, $p < 0.001$) and SU (63.4 ± 11.5 reps, $p < 0.001$) than female BCT Soldiers (16.6 ± 11.7 and 34.3 ± 16.5 reps). Non-infantry female Soldiers' PU performance was statistically similar compared to male BCT Soldiers across age groups. Within age groups, SU performances were similar between male infantry and non-infantry Soldiers aged 17–21 years; male and female non-infantry Soldiers aged 22–26, 27–31, and 37 years and older; and male and female BCT Soldiers 32–36 and 37 years and older. Across age groups, the fastest to slowest 2MRT were infantry men (14.5 ± 1.4 min), non-infantry men (15.1 ± 1.4 min), non-infantry women (17.8 ± 1.8 min), BCT men (18.3 ± 2.9 min), and BCT women (21.8 ± 3.2 min). Within age groups, 2MRT were similar between non-infantry women and BCT men for age groups 27 years and older, and between infantry and non-infantry men for age groups 32 and older.

Table 1 displays the age-sex-specific APFT performances of BCT Soldiers. For male BCT Soldiers, PU and 2MRT performances did not significantly differ across age groups while the 17–21 age group performed significantly more SU repetitions than age groups 27–31 and older ($p = 0.005$). Among female BCT Soldiers, there were no significant differences in PU, SU, and 2MRT performances across age groups. APFT performances of male BCT Soldiers were significantly greater than female BCT Soldiers across age groups, except for statistically similar SU performances in the 27–31 and 37 years and older age groups. Supplemental Table 1 presents sex- and age-specific BMIs by APFT event among BCT Soldiers. The mean BMI of male BCT Soldiers aged 17–21 years was significantly lower than the older age groups, while the mean BMI of female BCT Soldiers was statistically similar across age groups.

Table 2 presents the age-sex specific APFT performances of non-infantry and infantry Soldiers. Among male non-infantry Soldiers, the 27–31 age group performed the most PU repetitions on average and was significantly different than the two lowest performing age groups (17–21 and >37 years). For the SU performance, the oldest

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