Cost-Effectiveness Analysis of the U.S. Army Assessment of Recruit Motivation and Strength (ARMS) Program

COL David W. Niebuhr, MC USA; William F. Page, PhD†‡; David N. Cowan, PhD†‡; Nadia Urban, MHS†‡; MAJ Marlene E. Gubata, MC USA‡; Patrick Richard, PhD**

ABSTRACT The Assessment of Recruit Motivation and Strength (ARMS) Study was conducted at six Military Entrance Processing Sites during 2005–2006. The objectives were to compare morbidity and attrition of Army accessions who exceeded body fat (EBF) accession standards compared to weight for height or body fat qualified (WQ) and to compare among the WQ subset, those who were physically fit as measured by a 5-minute step test compared to unfit. We performed a cost-effectiveness analysis to address both objectives. Analysis was performed by gender with the primary outcomes of musculoskeletal injury and attrition. Results were expressed in terms of cost per year of military service. Sensitivity analysis was performed on probability cost estimates. We found WQ female recruits were $5,141 less expensive per year than EBF female recruits. WQ males were $2,785 less expensive per year of military service than EBF male recruits. Among WQ recruits, fit females were $3,638 and fit males were $10,381 less expensive per year of service than their unfit counterparts. The ARMS step test is a cost-effective method to identify physically fit EBF applicants for accession in weak recruiting environments. It also offers a cost-effective method to reduce poor physical fitness associated morbidity and attrition.

INTRODUCTION

Obesity is an epidemic in the U.S. population that crosses gender, age, race/ethnicity, geographic, and socioeconomic categories.[1–6] The U.S. military is dependent on the U.S. young adult population, primarily 18 to 30 years of age, to meet its recruiting mission and maintain the force structure. These factors are influenced by the operational tempo of each branch of service as well as the economic climate in our nation. Studies show that the prevalence of obesity in U.S. young adults limits the percent that are qualified for military service.[7] At the same time the U.S. military has seen a trend toward increasing prevalence of obesity in recruits and the overall force.[8] Military accession standards for body mass index (BMI) and body fat percentage exist to maximize readiness and protect the health of the force.[9,10]

Studies have shown that high BMI is associated with an increased risk of musculoskeletal injuries (MSIs), mostly overuse injuries (i.e., sprains and strains) of the lower extremity in recruits, in terms of both incidence and health care utilization.[11] An additional risk associated with high accession BMI is premature attrition. Obese recruits have an increased risk of discharge for all causes (i.e., failure to meet weight for height or body fat standards or physical fitness standards, conduct, and behavior) and specifically medical.[12] Increased morbidity and premature attrition potentially threaten readiness by limiting the services' ability to man the force and divert fiscal resources from force sustainment to recruiting and military health care.[13]

The Assessment of Recruit Motivation and Strength (ARMS) Study was conducted at six Military Entrance Processing Stations (MEPS) during February 2005–September 2006, a period when the Army was having difficulties meeting its recruiting needs due largely to the high operational tempo and relatively strong economy. The ARMS program was then expanded to an Army program at all 65 MEPS from February 2006 to August 2010. The primary goal of the ARMS Study was to ascertain if trainees who exceeded weight for height and body fat (EBF) accession standards (up to a maximum of 30% for males and 36% for females) but who could show a degree of physical fitness would have attrition no worse than those who were not EBF.[14,15] The principal component of the ARMS test was a 5-minute step test at a cadence of 120 steps per minute. There were secondary goals including evaluating morbidity, such as heat illness[16] and MSIs,[11] among EBF recruits compared to those who were weight for height or body fat qualified (WQ). In addition to examining these two outcomes by comparing EBF and fit to WQ, other analyses evaluated the impact of fitness among the WQ study subjects, MSIs,[17] stress fractures,[18] heat illness,[16] the Army weight control program,[19] and levels of pre-accession physical activity.[20]

These studies ascertained that while EBF and fit trainees did not have increased attrition,[15] they did have increased risk of morbidity.[11,16] WQ applicants who were less fit, defined as failing the step test portion of the ARMS fitness test, were at increased risk of attrition,[14] as well as MSIs and stress fractures.[17,18] In addition, other risk factors for

*Department of Preventive Medicine and Biometrics, Uniformed Services University of Health Sciences, 4301 Jones Bridge Road, Bethesda, MD 20814.

†Allied Technology Group, Inc., 1803 Research Boulevard, Suite 601, Rockville, MD 20850.

‡Preventive Medicine Branch, Walter Reed Army Institute of Research, 503 Robert Grant Road, Silver Spring, MD 20910.

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morbidity were identified, including age and smoking.[3,4,11,16–18] However, these studies did not evaluate the cost effectiveness (CE) of the ARMS test in selecting Army recruits.

Closely related to our study, the Assistant Secretary for the Army for Manpower and Reserve Affairs sponsored the RAND Corporation (RAND) to study the CE of ARMS as a tool to identify recruits who could be accessed into the Army and complete Initial Entry Training and service obligation.[21] The RAND report found that ARMS recruits did not differ significantly from non-ARMS recruits in 6-month and 18-month attrition and that the fiscal year 2007 cost of ARMS was $163 per additional accession. RAND concluded, "In both weak and strong recruiting environments, the ARMS test offers a simple, cost-effective way to separate the fit from the unfit." However, the RAND report was not a formal cost-effectiveness analysis (CEA) of ARMS and did not include sensitivity analysis. In addition, the RAND report did not consider the increased cost impact of morbidity, including MSIs, on training and retaining soldiers.

The goal of this work is to ascertain the potential CE in both strong and weak recruiting environments of adding the ARMS step test to MEPS in-processing. In the weak recruiting environment, it may be necessary to consider EBF recruits. Here, we will use data from the ARMS study to compare male and female WQ with male and female EBF recruits. Specifically, we will be looking at the CE of an in-processing program that allows physically fit EBF individuals to enter the Army, accounting for the risk of MSI and attrition. In the strong recruiting environment, presumably all potential recruits would be WQ. Here, we will use the data from the ARMS study to compare male and female WQ recruits who passed versus those who failed the ARMS step test. These are critical considerations for Army accession policy makers.

METHODS

This study included secondary data analysis from a prospective cohort study including male and female recruits who applied for Army active duty service for the first time at six MEPS and completed the ARMS step test between February 2005 and September 2006. Subjects were at least 18 years of age and followed for 3 years after entry or until separation from active duty service. Excluded individuals were those with no valid weight, height, or date of birth recorded (n = 13) and those who surpass EBF standards and failed the step test but were granted an ARMS waiver and accessed (n = 9). Service members without either an ambulatory health care record or a matching accession date within 30 days of the ARMS study entry date were also excluded (n = 81). Twelve subjects whose recorded separation date preceded the first deployment date were excluded. This study was approved by the Walter Reed Army Institute of Research Institutional Review Board, and informed consent was obtained from all participants.

Data sources included the Center for Accession Research (CAR), U.S. Army Accession Command (enlistment and attrition data), Defense Manpower Data Center (DMDC) (enlistment and attrition data), and Patient Administration Systems and Biostatistics Activity from the Standard Ambulatory Data Record (ambulatory encounter data do not include in-theater data).

Recruits were categorized as EBF or WQ based on whether they met weight/height or body fat standards.[10] Subjects who failed to meet weight/height or body fat standards pre-enlistment were considered EBF. All others were considered WQ including subjects who previously did not meet standard but lost weight and/or body fat and accessed later without an ARMS waiver. Physical fitness was determined by performance on the step-test portion of the ARMS fitness test, and classified as pass/fail. EBF recruits who passed the ARMS fitness test were given an ARMS waiver and allowed to access into service. EBF recruits who failed the ARMS test and were not accessed were treated as though they had served only a single day of service. Figure 1 shows a flowchart of ARMS subjects processing through MEPS.

Attrition was defined as early (i.e., less than three years of service) loss from the military for an adverse cause. The CAR provided military separation data identifying the type of separation. For subjects missing a CAR record, DMDC data was used to identify attrition. Subjects assigned separation codes not considered attrition, such as attending officer candidate school, were censored. We defined MSI using International Classification of Diseases, 9th Revision (ICD-9) codes (715–733), plus sprains and strains (codes 843–847), as previously described.[11] All ambulatory visits on separate days resulting in an MSI diagnosis were captured for the first 6 months of service.

The duration of Army basic combat training (BCT) and advanced individual (military occupational specialty) training varies, but can last between 13 weeks and 2 years. For the purpose of these analyses, we defined the "training" period as the first 180 days of Army service; "operational" service was defined as all days served after 180 days. A completed tour of service was established at 36 months (1,095 days).

Cost and Event Probability Estimates

We estimated the cost of administering the step test to be $25 (range $12–$50) per applicant based on historical study costs for the step test including stop watches, metronomes, and personnel time to administer the test and the number tested. Limited data are available on the costs of recruiting and medically screening an Army applicant, or on the cost to train a soldier. U.S. Army Training and Doctrine Command estimated cost to recruit and screen an applicant to be $22,000 (range $11,000–$44,000), and the cost to train a soldier to his/her first operational assignment to be $36,000, i.e., $200 (range $100–$400) per day for 180 days

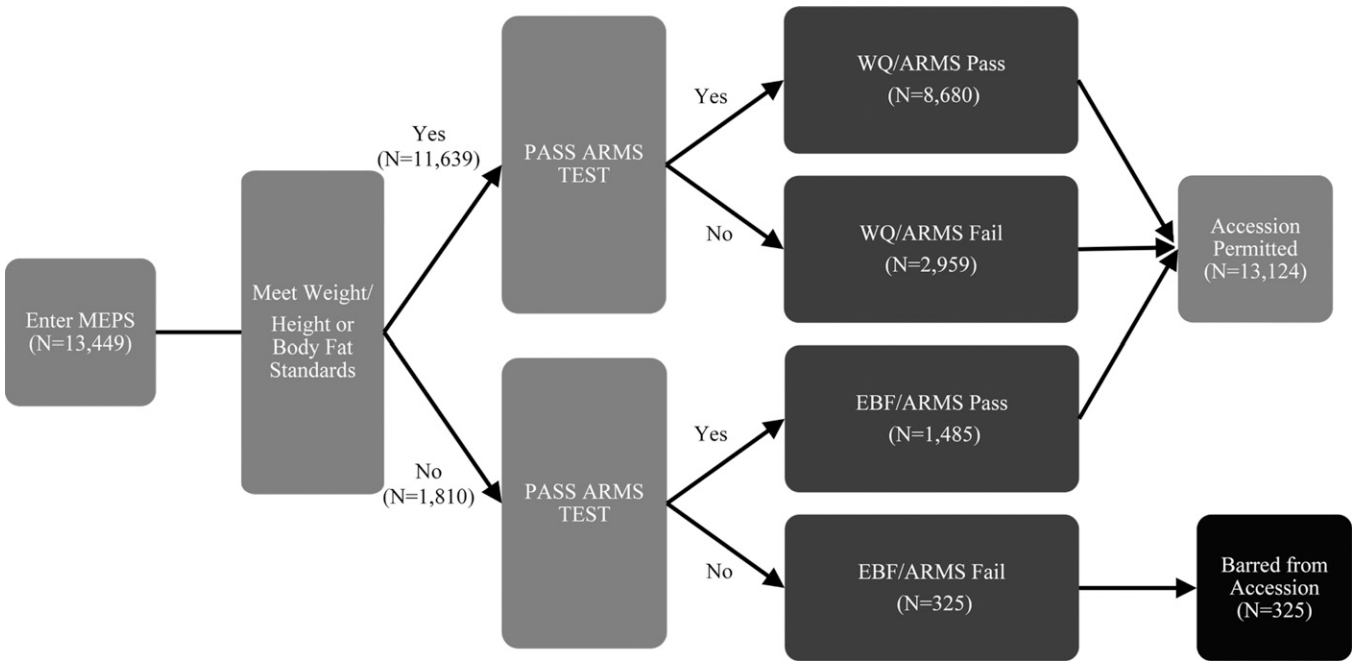

FIGURE 1. Flowchart of U.S. Army applicants who went through selected MEPS including ARMS Step Testing. ARMS, Assessment of Recruit Motivation and Strength; EBF, exceed body fat; WQ, weight for height or body fat accession standard qualified.

of training. TRICARE Outpatient Prospective Payment System estimated the cost of an ambulatory visit for an MSI to be $100 (range $50–$200).[22] The probability of each event (being EBF, failing the step test, accessing, occurrence of an MSI, and attrition) was based on actual ARMS study data. Figure 2 shows the ARMS decision tree including each stage from completion of MEPS processing to attrition.

Analytic methods

TreeAge Software Incorporated Pro Suite 2008[23] was used for CEA from the U.S. Army perspective. The TreeAge diagrams have been generated in such a way as both probabilities and costs are represented by variables, all shown at the "starts node." There are separate probability values for male and female recruits. Detailed, supplemental data listing each cost and probability value, along with the decision trees used for analyses are available from the authors upon request. Table I shows mean, standard deviation, and median values for the number of MSIs for various branches on the decision tree; for example, the value 2.9 for WQ, step test passed, accessed, and MSI represents the mean number of MSIs for male recruits who were WQ, passed the step test, were accessed, and who had an MSI. Table II shows corresponding mean, standard deviation, and median values for days to attrition. Calculations of descriptive statistics were performed using SAS 9.3., SAS Institute, Cary, North Carolina.

Our primary outcome was the absolute difference in CE, expressed as the net cost per year of military service, which was calculated by dividing the average group cost by the average group length of service; each group was defined on the decision tree by its gender, EBF, MSI, and attrition status. We chose to focus on the absolute difference in CE between EBF and WQ and WQ step test passed versus WQ failed rather than the incremental CE ratio because the average cost per year of military service is an absolute incremental cost that has a straightforward, useful interpretation for Army leadership who makes accession policy.

Sensitivity Analyses

We performed a number of 1-way sensitivity analyses using the TreeAge software. For each cost variable in our decision tree (e.g., cost of step test, daily cost of training), we analyzed a wide range of potential costs from one-half the estimated cost to double the estimated cost. For probability variables (e.g., the probability of a WQ male recruit passing the ARMS test), we similarly analyzed a range of values from one half to double the estimated probability, except the values were rounded to the nearest 0.05 and capped at a maximum value of 95%.

In our sensitivity analyses, we compared the relative cost effectiveness of the baseline group to the comparison group (e.g., EBF male recruits versus WQ male recruits) by subtracting the average cost of a year of military service for the baseline group from the average cost of a year of military service for the comparison group (i.e., average annual WQ male recruit cost minus average annual EBF male recruit cost). A positive difference indicated that the

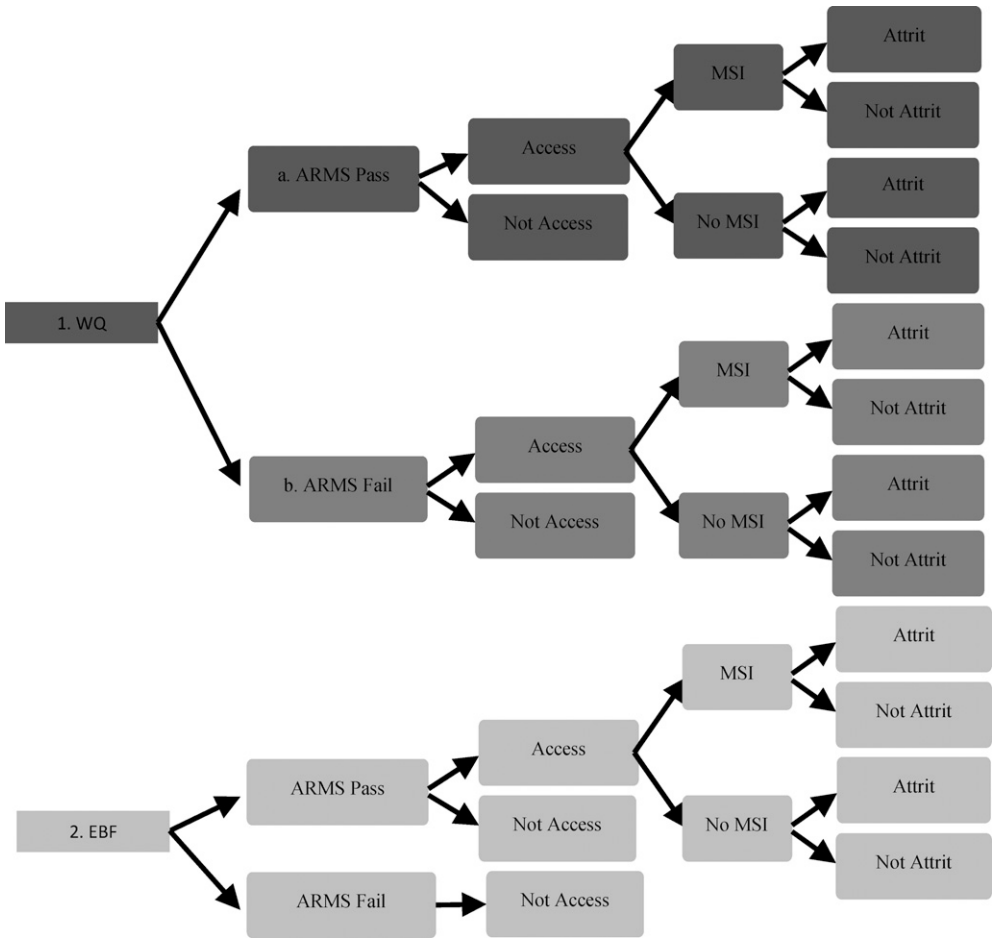

FIGURE 2. ARMS decision tree for U.S. Army applicants and whether they were accessed, experienced musculoskeletal injury and/or attrited. Comparisons are made between (1) WQ and (2) EBF and (a) between those who passed the ARMS test and (b) those who failed the ARMS step test, among the subset of subjects who were WQ. EBF, exceed body fat standard; MSI, musculoskeletal injury; WQ, weight for height or body fat accession standard qualified.

TABLE I. Mean and Median Number of Ambulatory Visits for MSI, by Weight for Height and Body Fat Status (WQ vs. EBF), Step Test Result (Pass vs. Fail), and Gender, for Subjects Who Accessed and Incurred an MSI in the First 6 Months of Service

	Number of Ambulatory Visits for MSI	
	Mean (SD)	Median
Males		
WQ, MSI	3.1 (3.6)	2
WQ, Step Test Passed and MSI	2.9 (3.1)	2
WQ, Step Test Failed and MSI	3.6 (4.6)	2
EBF, Step Test Passed and MSI	3.5 (4.1)	2
Females		
WQ, MSI	5.5 (6.0)	3
WQ, Step Test Passed and MSI	5.1 (5.9)	3
WQ, Step Test Failed and MSI	6.1 (6.0)	4
EBF, Step Test Passed and MSI	5.5 (6.7)	3

WQ, weight for height or body fat accession standard qualified; EBF, exceeded body fat standard; MSI, musculoskeletal injury.

baseline group was less costly (more efficient), whereas a negative cost indicated that the comparison group was less costly (more efficient).

RESULTS

WQ Recruits versus EBF

There were 11,639 WQ and 1,810 EBF study participants (Table III). Table IV shows the results of the CEA comparing WQ recruits to EBF recruits in the ARMS program, again stratified by gender. We see that the average costs for the WQ group are higher than those for the EBF group, again attributable to more nonaccessed recruits in the EBF groups. More importantly, cost per year of service is higher for EBF for both male and female recruits. For male recruits, the cost per year of service is $25,159 for WQ and $27,944 for EBF. The corresponding figures for female recruits are $27,488 per year of service for WQ and $32,629

TABLE II. Mean and Median Days to Attrition, by Weight for Height and Body Fat Status (WQ vs. EBF), Step Test Result (Pass vs. Fail), MSI, and Gender, for Subjects Who Were Accessed and Who Attrited in the First 3 Years of Service

	Number of Days to Attrition	
	Mean (SD)	Median
Males		
WQ and MSI	378 (252)	329
WQ, Step Test Passed and MSI	384 (253)	343
WQ, Step Test Failed and MSI	366 (251)	312
WQ, and No MSI	366 (280)	327
WQ, Step Test Passed and No MSI	369 (283)	337
WQ, Step Test Failed and No MSI	356 (274)	295
EBF, Step Test Passed and MSI	405 (304)	318
EBF, Step Test Passed and No MSI	325 (320)	174
Females		
WQ, and MSI	426 (273)	386
WQ, step test passed and MSI	416 (253)	411
WQ, step test failed and MSI	438 (296)	361
WQ, and No MSI	338 (284)	300
WQ, step test passed and No MSI	385 (296)	365
WQ, step test failed and No MSI	255 (240)	137
EBF, step test passed and MSI	376 (231)	350
EBF, step test passed and No MSI	283 (299)	138

WQ, weight for height or body fat accession standard qualified; EBF, exceed body fat standard; MSI, Musculoskeletal Injury.

for EBF. Thus, WQ recruits cost less per year of service, resulting in cost savings of $2,785 for males and $5,141 for females.

WQ Recruits Who Passed the Step Test Versus WQ Who Failed

Among all study participants, 10,165 subjects passed and 3,284 failed the ARMS test (Table III). Table V shows separately for males and females the results of the CEA comparing WQ recruits who passed the ARMS step test versus those who failed. We see that the average costs for the "step test pass" group are slightly higher, for both male and female recruits, than those for the "step test fail" group. We attribute this to the fact that a greater percentage of "step test fail" recruits are not accessed and assessed as having served only 1 day to avoid assigning zero cost, thus cost saving but also providing minimal benefit. Thus, the CE of recruits who passed WQ and step test, represented as cost in dollars per year of military service, is higher than that of recruits who failed WQ and step test. Specifically, WQ male recruits who passed the step test cost an average of $23,342 per year of military service, compared with $33,723 for WQ male recruits who failed the step test; the resulting difference being $10,381, a cost savings of

TABLE III. Characteristics of Study Participants by ARMS Waiver and ARMS Test Status in Males and Females, N = 13,449

	Males (N = 11,163)							
	ARMS Waiver Status				ARMS Test Status			
	WQ		EBF		Pass		Fail	
	N	%	*N*	%	*N*	%	*N*	%
	9,842		1,321		8,550		2,613	
Age (Years)								
<20	4,406	44.8	566	42.8	3,923	45.9	1,049	40.1
20–24	4,074	41.4	594	45.0	3,538	41.4	1,130	43.2
≥25	1,362	13.8	161	12.2	1,089	12.7	434	16.6
Race								
White	7,175	72.9	996	75.4	6,329	74.0	1,842	70.5
Black	1,251	12.7	94	7.1	990	11.6	355	13.6
Other	1,416	14.4	231	17.5	1,231	14.4	416	15.9
	Females (N = 2,286)							
	ARMS Waiver Status				ARMS Test Status			
	WQ		EBF		Pass		Fail	
	N	%	*N*	%	*N*	%	*N*	%
	1,797		489		1,615		671	
Age (Years)								
<20	881	49.0	241	49.3	825	51.1	297	44.3
20–24	643	35.8	189	38.7	583	36.1	249	37.1
≥25	273	15.2	59	12.1	207	12.8	125	18.6
Race								
White	1,082	60.2	311	63.6	1,014	62.8	379	56.5
Black	438	24.4	114	23.3	364	22.5	188	28.0
Other	277	15.4	64	13.1	237	14.7	104	15.5

TABLE IV. ARMS Cost-Effectiveness Analysis Results: Comparison of Excess Weight for Height and Body Fat (EBF) Army Applicants Versus Weight for Height or Body Fat Qualified (WQ), by Gender

Male Recruits						
Strategy	Cost	Incremental Cost	Effectiveness (Years of Service)	Incremental Effectiveness	Cost–Effectiveness	Net Cost-Effectiveness
EBF	$44,000		1.58		$27,944	
WQ	$52,000	$8,000	2.06	0.48	$25,159	–$2,785
Female Recruits						
Strategy	Cost	Incremental Cost	Effectiveness (Years of Service)	Incremental Effectiveness	Cost-Effectiveness	Net Cost-Effectiveness
EBF	$44,700		1.37		$32,629	
WQ	$51,900	$7,200	1.89	0.52	$27,488	–$5,141

ARMS, assessment of recruit strength and motivation; WQ, weight for height or body fat qualified.

TABLE V. ARMS Cost-Effectiveness Analysis Results: Comparison of Step Test Pass Versus Fail for Weight for Height or Body Fat Qualified (WQ) Army applicants, by Sex

Strategy	Cost	Incremental Cost	Effectiveness (Years of Service)	Incremental Effectiveness	Cost-Effectiveness	Net Cost Effectiveness
Male Recruits						
WQ and Step Test Failed	$50,600	—	1.5	—	$33,723	—
WQ and Step Test Passed	$52,100	$1,500	2.23	0.73	$23,342	–$10,381
Female Recruits						
WQ and Step Test Failed	$51,700	—	1.72	—	$30,018	—
WQ and Step Test Passed	$52,000	$400	1.97	0.25	$26,380	–$3,638

ARMS, Assessment of recruit motivation and strength; WQ, weight for height or body fat qualified.

$10,381 per year of service for male recruits who passed the step test. WQ female recruits who passed the step test cost an average of $26,380 per year of service, compared to $30,018 for WQ female recruits who failed the step test, resulting in a cost savings of $3,638 per year of military service for WQ female recruits who passed the step test.

Sensitivity Analysis

Figures 3A and 3B show results from selected sensitivity analyses showing net CE for up to four comparisons: WQ male recruits versus EBF male recruits; WQ female recruits versus EBF female recruits; WQ male recruits, ARMS test pass versus fail; and WQ female recruits, ARMS test pass versus fail. Figure 3A shows the sensitivity analysis for the daily cost of training. All four comparisons of the cost advantage per year of military service favor the WQ step test versus EBF and the WQ step test passed versus step test failed. However, the male WQ passed versus failed comparisons show a greater negative slope, indicating that increasing the daily cost of training has more effect on the net cost effectiveness.

Figure 3B shows the sensitivity analysis for the probability of passing the ARMS test and accessing. When this probability is less than 40% the cost advantage per year of military service favors WQ step test passed over failed and WQ over EBF. Three additional sensitivity analysis figures for the cost of MEPS evaluation, probability of WQ recruits passing the ARMS test, and the probability of attrition of WQ recruits, given that they sustained an MSI, are not shown but had similar results and are available as supplemental data upon request.

DISCUSSION

We found substantial CE benefits associated with the ARMS program in all our analyses. For example, comparing WQ versus EBF (recall that EBF recruits who did not pass the ARMS step test were not accessed), showed that female WQ recruits were $5,141 less expensive per year of military service than female EBF recruits; the corresponding cost per year of service for WQ male recruits was $2,785. Even when limiting comparisons to WQ recruits, female WQ recruits who passed the step test were $3,638 less expensive per year of service than those who failed the step test; the corresponding value for male recruits was $10,381. These substantial differences were all in favor of recruits who passed the ARMS step test, whether female or male recruits. Sensitivity analysis of the cost and probability estimates used did not materially alter these general findings.

This is the first report in the literature to our knowledge that showed the CE of using a pre-accession physical fitness test to select recruits who exceed weight for height and body fat standards in a weak recruiting environment.

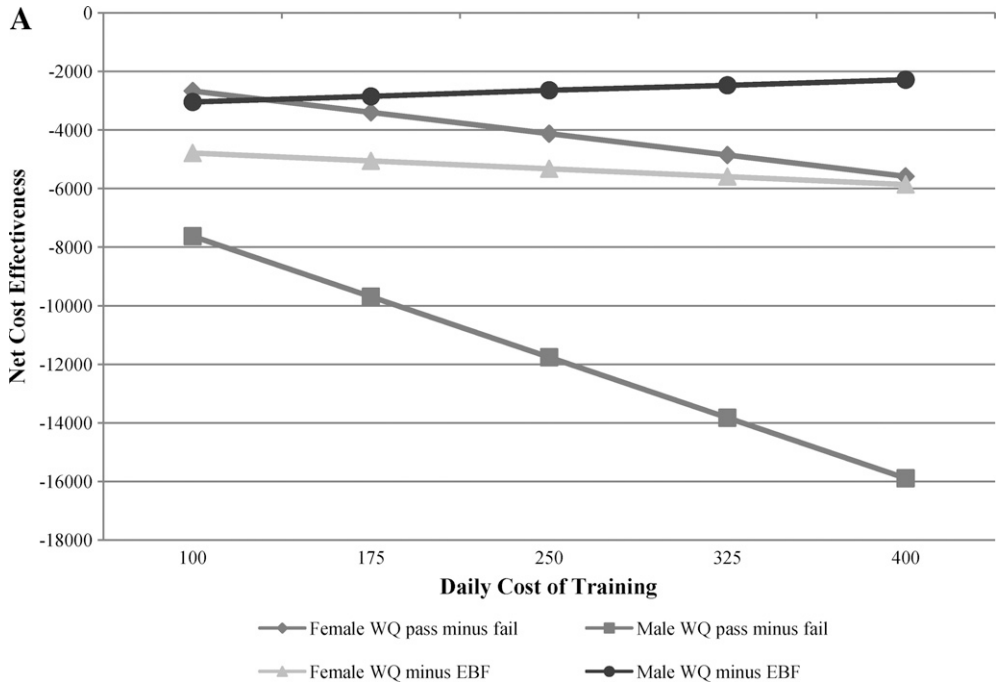

FIGURE 3A. Daily cost of basic combat and advanced individual training. Sensitivity analysis for selected cost and probability variables: net cost effectiveness per year of military service in WQ step test pass minus WQ step test fail and WQ pass minus EBF pass values represent differential cost. EBF, exceed body fat standard; WQ, weight for height or body fat accession standard qualified.

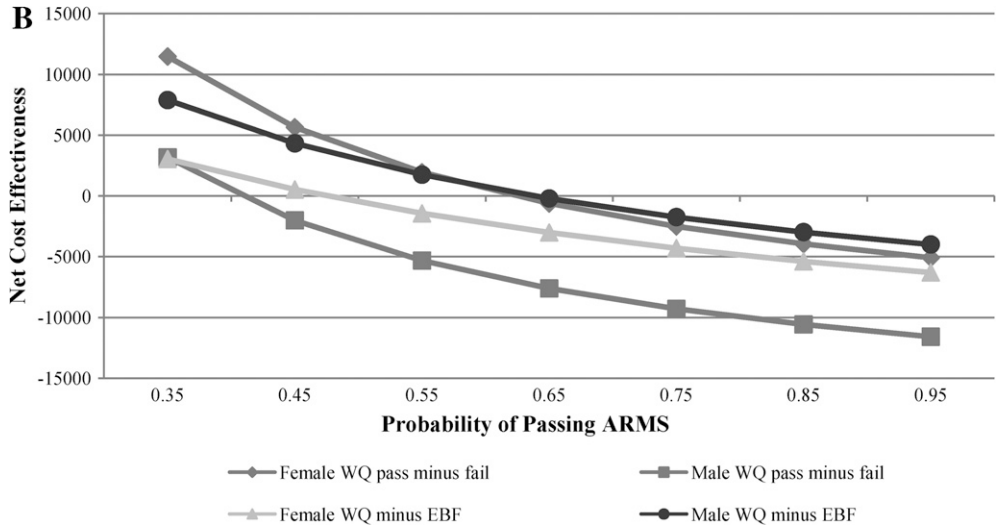

FIGURE 3B. Probability of WQ recruit passing the ARMS test and accessing. Sensitivity analysis for selected cost and probability variables: net cost effectiveness per year of military service in WQ step test pass minus WQ step test fail and WQ pass minus EBF pass values represent differential cost.-EBF, exceed body fat; WQ, weight for height or body fat accession standard qualified.

A 2004 report based on data from Fort Jackson, South Carolina showed the CE of the Fitness Assessment Program that assessed the entry-level physical fitness of new recruits at the Reception Station.[24] A special physical training unit was established where those who failed the test exercised until they could pass the test and then enter BCT. The authors estimated an annual cost savings from the program of $14 million per year based on a reduction in attrition. The analysis did not include the impact on CE of high body mass index nor MSI relative to physical fitness. A 2012 review article summarized the literature on physical fitness and BMI and other demographic, anatomical, behavioral and medical risk factors for MSIs in military recruits.[25]

This study has both strengths and limitations. Among the strengths is the use of data collected from a large, longitudinal cohort study of more than 10,000 Army recruits.

Routinely collected items from administrative data systems, e.g., MSIs, length of military service, are thought to be very complete and quite accurate.[14,15] In addition, both BCT and advanced individual training are well standardized across Army training sites.

Study limitations include the exclusion of other military relevant adverse ARMS program outcomes such as non-MSI morbidity (such as heat illness, which is rare and usually mild),[16] missed duty days due to MSI, Army Weight Control Program enrollment (increased risk of EBF enrollment but not attrition),[19] and adverse personnel actions and nondeployment. The U.S. Army Training and Doctrine Command estimated cost of recruit training did not consider the specific location and length of advanced individual training of ARMS study subjects. The TRICARE estimated cost of MSI ambulatory visits used did not consider regional differences. Broad sensitivity analyses of these estimates were used to compensate for these variations.

CONCLUSIONS AND POLICY IMPLICATIONS

This analysis shows that the ARMS step test is a cost-effective screen to reduce injury and attrition in the first year of service, both in female and male WQ and EBF and physically fit recruits. Presumably, ARMS is acting as a measure of both physical fitness test and motivation to serve in the military. Army policy makers can cost effectively use the ARMS step test to screen in selective overweight and over-body-fat applicants who are physically fit when demand for recruits exceeds supply (i.e., strong economy and high operational tempo) at an incremental cost incurred of less than $5,000 per male and $2,800 per female. The ARMS step test can also potentially screen out physically unfit applicants when supply exceeds recruit demand (i.e., weak economy and low operational tempo) at an incremental cost savings of approximately $10,000 per male and $4,000 per female. The effectiveness of the ARMS screening program should be replicated in other services and in a recruiting environment with a low demand and high supply of military applicants. The step test should be validated against aerobic capacity and compared to physical fitness testing in recruits. The body of published research including this CEA based on the ARMS step test program in U.S. Army applicants argue for a new accession physical fitness standard policy that would reduce MSIs and premature attrition in weight for height or body fat qualified recruits as well as identify overweight for height and body fat but physically fit and cost-effective recruits.

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