Preparing for Combat Readiness for the Fight: Physical Performance Profile of Female US Marines

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Abstract

Kelly, KR and Jameson, JT. Preparing for combat readiness for the fight: physical performance profile of female US Marines. *J Strength Cond Res* 30(3): 595–604, 2016—Females have been restricted from serving in direct combat arms' positions for decades. One reason for the exclusion derives from the perceived physical demands of these positions. As a result, many current efforts are directed toward defining the physical demands of combat arms' positions. The purpose of this study was to develop a physical performance and body composition profile of females who could overcome the physical demands of combat tasks that rely primarily on upper body strength. This study is based on an analysis of archival data from 2 separate samples of active-duty female Marines ($n = 802$), who had been recruited to participate in heavy lifting tasks. These tasks included lifting a heavy machine gun (HMG) lift (cohort 1, $n = 423$) and Clean and Press lifts (29.5–52.3 kg) (cohort 2, $n = 379$). To develop the physical performance profile, data from annual physical fitness tests were collected, which included run times, ammunition can lift, 804. Seven-meter (880-yard) movement to contact, and the maneuver under fire. In cohort 1, 65 females (~15%; $n = 423$ females) successfully completed HMG; in cohort 2, 33 females (~9%; $n = 379$ females) successfully completed another strength task, a Clean and Press of 52.3 kg. In both samples, female Marines who were successful on these tasks also outperformed their unsuccessful counterparts on the annual physical fitness tests. In addition, larger females typically outperformed their smaller counterparts. Females seeking assignment to closed combat arms' positions would thus be well served by targeting upper body strength, while maintaining overall physical fitness.

Key Words gender, physical fitness, strength differences, body composition

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Introduction

Females have been restricted from serving in direct combat arms' positions for decades. These restrictions can limit the advancement of females through the ranks of military leadership and could also potentially deprive the military of a rich pool of talented and capable leaders in some of the more physically demanding military occupational specialties (MOSs). In Section 535 of the National Defense Authorization Act for Fiscal Year 2011, the Secretary of Defense has been directed to review the status of exclusion of women from combat arms' positions. Because the reason for the exclusion depends, to a considerable extent, on the perceived physical demands of combat arms positions, many current efforts are directed toward defining and quantifying the physical demands of combat arms' positions. A second, and equally important goal, is then to quantify the extent to which women meet these demands.

One important, and robust conclusion emerging from these efforts, is that combat requires a broad set of physical capabilities, from aerobic fitness to upper body and lower body strength. To what extent, then, do women meet these broad physical demands? If men's performance is used as an approximate indicator of required physical capability, then women perform at comparable levels on tests that require aerobic fitness, core strength, and lower body movements (8,10). However, many women exhibit decreased performance on tasks that rely primarily on upper body strength (8,10). Although it is possible that the importance of upper body strength for success in combat arms' positions has been overstated, what is clear at least is that some essential occupational tasks require lifting and moving heavy loads (7,9).

The need to quantify the extent to which women meet the physical demands of combat-related tasks that depend on upper body strength provides the motivation for this study. To date, there are limited published data describing the physicality, or the physical ability and anthropometrics, required of Marines in combat arm roles; and, to our knowledge, there are little data on female Marines' physical ability to perform in combat-related tasks. What is known is that the annual physical fitness tests (PFTs) are good predictors of success on ground combat physical tasks but that the majority of female Marines at the beginning of their career typically exhibit limited upper body strength (9).

The primary goal of this article was to describe the body composition and physical performance profile of women who have demonstrated that they can successfully overcome a key performance barrier–upper body strength tasks. Ultimately, by identifying and targeting key physical capabilities that would benefit from additional training, it is our hope that such a profile can provide guidance to women seeking entry into closed combat arms' positions.

Methods

Experimental Approach to the Problem

Active-duty female Marines (age 18–25) were recruited from 2 different sites within the US Marine Corps (USMC): Marine Corps Recruit Depot, Parris Island, South Carolina, and The Basic School, Quantico, VA, on 2 separate occasions as part of 2 separate previous efforts (8,10). Data from this larger effort were extracted for the current effort. Therefore, the results are presented separately for each group because the upper body–dependent combat proxy physical tasks differed between the 2 samples. However, for both test dates, a briefing on the events was conducted for all participants, and informed consent was provided to those who volunteered. The combat-related tasks were designated as the physical training for the day, which is a mandatory requirement for active-duty Marines. All participants were required to have completed a PFT and combat fitness test (CFT) within the last 6 months. The official PFT and CFT composite scores, and also individual component times, were acquired for each participant from their respective command so as not to rely on individual recall. The 13.6-kg ammunition can lift (AL) (maximum number of overhead lifts performed in 2 minutes), and pull-up components of these annual PFTs were extracted for use in this effort.

Subjects

Cohort 1 (C1) (10) and cohort 2 (C2) (8) consisted of 423 and 379 female Marines, respectively. Both cohorts were recruited from the same training locations. Data on age, height, and weight were recorded for both cohorts on the morning of testing. Physical fitness test and CFT scores were received from the respective commands for all participants in both cohorts. Despite differences in initial study design and purpose, all female Marines were recruited at approximately the same point, during boot camp, and group means across all anthropometric and physical testing tasks were similar, suggesting that there were no substantial differences between the 2 groups (Table 1). All participants completed each set of tasks in standard physical training gear. Subjects were informed of the benefits and risks of the investigation before signing an institutionally approved informed consent document to participate in the study. The study was approved by the US Marine Corps Combat Development Command Institutional Review Board, and all participants gave their free and informed written consent. The study conforms to the Code of Ethics of the World Medical Association (approved by the ethics advisory board of Swansea University) and required players to provide informed consent before participation.

Table 1. Comparison of cohort 1 to cohort 2.*†‡

	Cohort 1 ($N = 424$)	Cohort 2 ($N = 379$)	p	d
Age, y	20.7 ± 2.5	22.3 ± 4.6	<0.01	−0.43
Height, m	1.6 ± 0.1	1.6 ± 0.1	0.07	0.13
Weight, kg	61.1 ± 7.2	60.3 ± 7.0	0.12	0.11
BMI, $kg \cdot m^{-2}$	22.6 ± 1.9	22.6 ± 1.9	0.76	0.02
FFM, kg	45.5 ± 4.2	44.9 ± 4.3	0.05	0.14
3-mile run, min:sec	24:11 ± 1:58	24:30 ± 2:10	0.07	−0.15
Sit-ups, reps	98.5 ± 3.7	93.5 ± 11.1	<0.01	0.61
FAH, sec	66.8 ± 6.4	65.6 ± 8.6	0.19	0.16
AL, reps	62.0 ± 13.2	56.8 ± 14.8	<0.01	0.37
MANUF, min:sec	3:12 ± 0:21	3:20 ± 0:26	<0.01	−0.36
MTC, min:sec	3:28 ± 0:18	3:31 ± 0:22	0.04	−0.14

*BMI = body mass index; FFM = fat-free mass; FAH = flexed-arm hang; AL = ammunition can lift; MANUF = maneuver under fire; MTC = movement to contact.

†Values are presented as mean ± *SD*. In addition to the *p* values, effect sizes (Cohen's *d*, a standardized mean difference) are also reported to provide an indicator of how large the difference is between the 2 groups. Following Cohen's (1977) convention, 0.20 may be regarded as small, 0.50 as medium, and 0.80 or greater as large.

‡For variables exhibiting salient departures from normality (i.e., age, 3-mile run, sit-ups, FAH, and proxy pull-ups), the corresponding nonparametric version of the *t*-test (the independent 2-group, Mann-Whitney *U* test) was performed and reported in the table. All other comparisons are based on Welch's unequal variances *t*-test.

Upper Body Strength Tasks

In general, combat tasks were selected on the basis of informed judgment of subject matter experts who were Marine senior leaders (E6 and above, O5-O6) from US Marine Corp Training and Education Command (TECOM). Participants in C1 completed a heavy machine gun (HMG) lift. The HMG lift required lifting the machine gun (approximately 37.3 kg) from the ground to overhead 1 time, with elbows extended for the lift to be considered successful. Heavy machine gun was selected as it is a common task across infantry, artillery, and tank units in that all of those closed combat arm positions require lifting a heavy weapon up to a vehicle. It is important to note that the HMG is an awkward weapon with the bulk of the weight being in the stock and having a long barrel. The weight is not uniformly distributed. Data on pull-up performance were also obtained from records on the most recent PFTs. However, a small percentage of females from C1 (3.6%, 29 total) had opted to complete the pull-up task. All females in C2 completed a pull-up task as part of a larger test battery. Because C2 is likely a more representative group of female Marines, the analyses in this report will focus on their pull-up performance.

Participants in C2 completed a maximal set of pull-ups, and Clean and Press was performed in progression from 6 lifts of 29.5 kilograms to single lifts of 31.8, 36.4, 43.2, and 52.3 kg, as described previously (8). A typical barbell with the appropriate weight was used for this task and thus the weight was uniformly distributed. If a participant could not lift a weight with proper technique and/or lock out the weight above her head, the lower weight was considered the maximal lift. Two attempts were given per load. Success was defined as being able to achieve the maximal lift. Clean and Press was selected based on the fact that all closed combat arms' positions require some form of overhead lift (unpublished data from subject matter experts to include Marine Corp senior leadership and exercise physiologists, including Dr. Kelly, as a part of a current physical standards' validation effort). The progressive increase with fixed weights served to balance the practical limitations of testing a large sample with the need to test a broad range of occupationally relevant weights. The greatest weight, 52.3 kg, was selected based on subject matter expert judgment about the maximal weight a Marine would be expected to lift alone (unpublished data from subject matter experts as a part of a current physical standards' validation effort). Pull-ups were also included in this physical task battery, for 2 reasons. First, Marines must routinely pull themselves up and onto physical obstacles during training and combat (e.g., walls and vehicles). Second, at the time of the initial effort (i.e., when data from C1 were being gathered), TECOM was assessing whether female Marines should be required to perform pull-ups as opposed to flex-arm hang during their annual fitness testing. Pull-ups are a widely used field test for upper body strength in both military and civilian PFTs and were included to examine the relationship between pull-ups and the ground combat physical tasks.

Before testing, participants were provided with instructions and a demonstration of correct movement and posture for each task and were given the opportunity to practice the events with lighter weights. For the Clean and Press, incremental lifts were used to gradually warm up and advance the participant according to their own comfort level, which was measured by both individual self-report and observations made by study investigators overseeing data collection. Lifts were performed in succession and participants were allowed time to rest dependent on their own comfort level to account for individual differences in fatigue.

Anthropometrics

Height and weight were measured, and body mass index (BMI) was calculated as a function of height and weight. From this information, percent body fat was calculated using the Gallagher equation (5). Fat-free mass (FFM) was then calculated for each individual. Owing to the testing environment and sample size, direct measurement of body composition was not available.

Fitness Testing

To maintain physical readiness, all Marines, regardless of sex, are required to pass 2 standard physical fitness tests: the PFT and the CFT. These tests have been described in detail elsewhere (7–10); briefly, each test is composed of 3 component tasks. For the PFT, these tasks are pull-ups (males only, at the time of this effort), flexed-arm hang (females only, at the time of this effort), crunches, and a 4.8-km (3-mile) run. The CFT was developed in 2008 and consists of basic aerobic (805-m movement to contact (MTC), a timed sprint MTC) and strength testing (number of lifts of a 13.6-kg ammunition can to exhaustion in 2 minutes), and the maneuver under fire (MANUF), a 274-m shuttle run comprising several component combat-related tasks that require both strength and endurance.

Statistical Analyses

Descriptive statistics and independent sample *t*-tests between successful and unsuccessful females were performed in SPSS (IBM, Armonk, NY, USA) and R (R Foundation for Statistical Computing, Vienna, Austria), with an alpha level set at $p \leq 0.05$. When group proportions were analyzed, 2-sample tests for equality of proportions with continuity correction were performed in R. Data in the tables are presented as mean values, *SD*s, and statistical significance levels for specific comparisons. In addition, for Table 1, to highlight the similarity of the 2 cohorts, measures of effect size (standardized mean difference, unbiased Cohen's *d*) were computed. A standardized mean difference of 0.20 may be regarded as small, 0.50 as medium, and 0.80 or greater as large.

Table 2. Comparison between the heaviest females, in terms of FFM and defined as those in the upper quartile of females, and the lightest, defined as those in the lowest quartile.*†‡

	Heaviest FFM (61–101 kg, *N* = 199)	Lightest FFM (43–60 kg, *N* = 199)	*p*
3-mile run, min:sec	23:55 ± 2:06	24:30 ± 1:59	<0.01
Sit-ups, reps	96.9 ± 7.1	94.7 ± 10.6	0.05
FAH, sec	64.3 ± 9.1	67.6 ± 6.2	<0.01
AL, reps	64.6 ± 13.6	55.6 ± 14.2	<0.01
MANUF, min:sec	3:08 ± 0:22	3:22 ± 0:22	<0.01
MTC, min:sec	3:26 ± 0:20	3:33 ± 0:19	<0.01
Proxy pull-ups, reps	3.4 ± 5.1 (*N* = 87)	4.1 ± 4.0 (*N* = 113)	0.02

*FFM = fat-free mass; FAH = flexed-arm hang; AL = ammunition can lift; MANUF = maneuver under fire; MTC = movement to contact.

†The ranges of values defining each group are provided in kg. Values are presented as mean ± *SD*.

‡For variables exhibiting salient departures from normality (i.e., 3-mile run, sit-ups, FAH, and proxy pull-ups), the corresponding nonparametric version of the *t*-test (the independent 2-group, Mann-Whitney *U* test) was performed and reported in the table. All other comparisons are based on Welch's unequal variances *t*-test.

Results

Subjects

A comparison of cohort anthropometrics and physical performance is provided in Tables 1 and 2. Summaries of key demographic variables (e.g., age, height, and weight) and also body composition estimates between successful and unsuccessful female Marines are provided in Tables 3 and 4. "Successful" females were defined as those who could complete a lift of the HMG (in C1) or lifts of the heaviest Clean and Press weights (36.4 kg, 43.2 kg, and 52.3 kg in C2); otherwise, they were deemed "unsuccessful."

Table 3. Comparison of successful to unsuccessful females, on the HMG lift and the 52.3 kg Clean and Press (C&P).*†‡

	Successful HMG (*N* = 66)	Unsuccessful HMG (*N* = 358)	*p*	Successful 52.3-kg C&P (*N* = 33)	Unsuccessful 52.3-kg C&P (*N* = 346)	*p*
Age, y	21.8 ± 2.7	20.5 ± 2.5	<0.01	24.5 ± 4.3	22.1 ± 4.5	<0.01
Height, m	1.7 ± 0.06	1.6 ± 0.07	<0.01	1.7 ± 0.07	1.6 ± 0.07	<0.01
Weight, kg	65.9 ± 6.3	60.1 ± 6.9	<0.01	64.2 ± 6.9	59.9 ± 6.9	<0.01
BMI, $kg \cdot m^{-2}$	23.9 ± 1.6	22.4 ± 1.9	<0.01	23.0 ± 1.6	22.5 ± 1.9	0.18
FFM, kg	47.9 ± 3.8	45.1 ± 4.1	<0.01	47.4 ± 4.4	44.7 ± 4.2	<0.01
3-mile run, min:sec	23:13 ± 1:56	24:23 ± 1:56	<0.01	23:20 ± 2:17	24:37 ± 2:08	<0.01
Sit-ups, reps	99.1 ± 3.0	98.3 ± 3.9	0.14	95.6 ± 9.4	93.3 ± 11.2	0.29
FAH, sec	67.1 ± 6.5	66.7 ± 6.3	0.51	68.3 ± 4.3	65.4 ± 8.8	0.09
AL, reps	70.6 ± 11.9	60.3 ± 12.8	<0.01	67.8 ± 15.8	55.7 ± 14.3	<0.01
MANUF, min:sec	2:55 ± 0:23	3:15 ± 0:20	<0.01	2:54 ± 0:23	3:23 ± 0:25	<0.01
MTC, min:sec	3:16 ± 0:17	3:31 ± 0:17	<0.01	3:14 ± 0:19	3:33 ± 0:21	<0.01
Proxy pull-ups, reps				8.4 ± 6.1	3.1 ± 3.7	<0.01

*HMG = heavy machine gun; BMI = body mass index; FFM = fat-free mass; FAH = flexed-arm hang; AL = ammunition can lift; MANUF = maneuver under fire; MTC = movement to contact.

†Note that women who completed the HMG lift (cohort 1) were not tested on the proxy pull-ups task (cohort 2). Values are presented as mean ± *SD*.

‡For variables exhibiting salient departures from normality (i.e., age, 3-mile run, sit-ups, FAH, and proxy pull-ups), the corresponding nonparametric version of the *t*-test (the independent 2-group, Mann-Whitney *U* test) was performed and reported in the table. All other comparisons are based on Welch's unequal variances *t*-test.

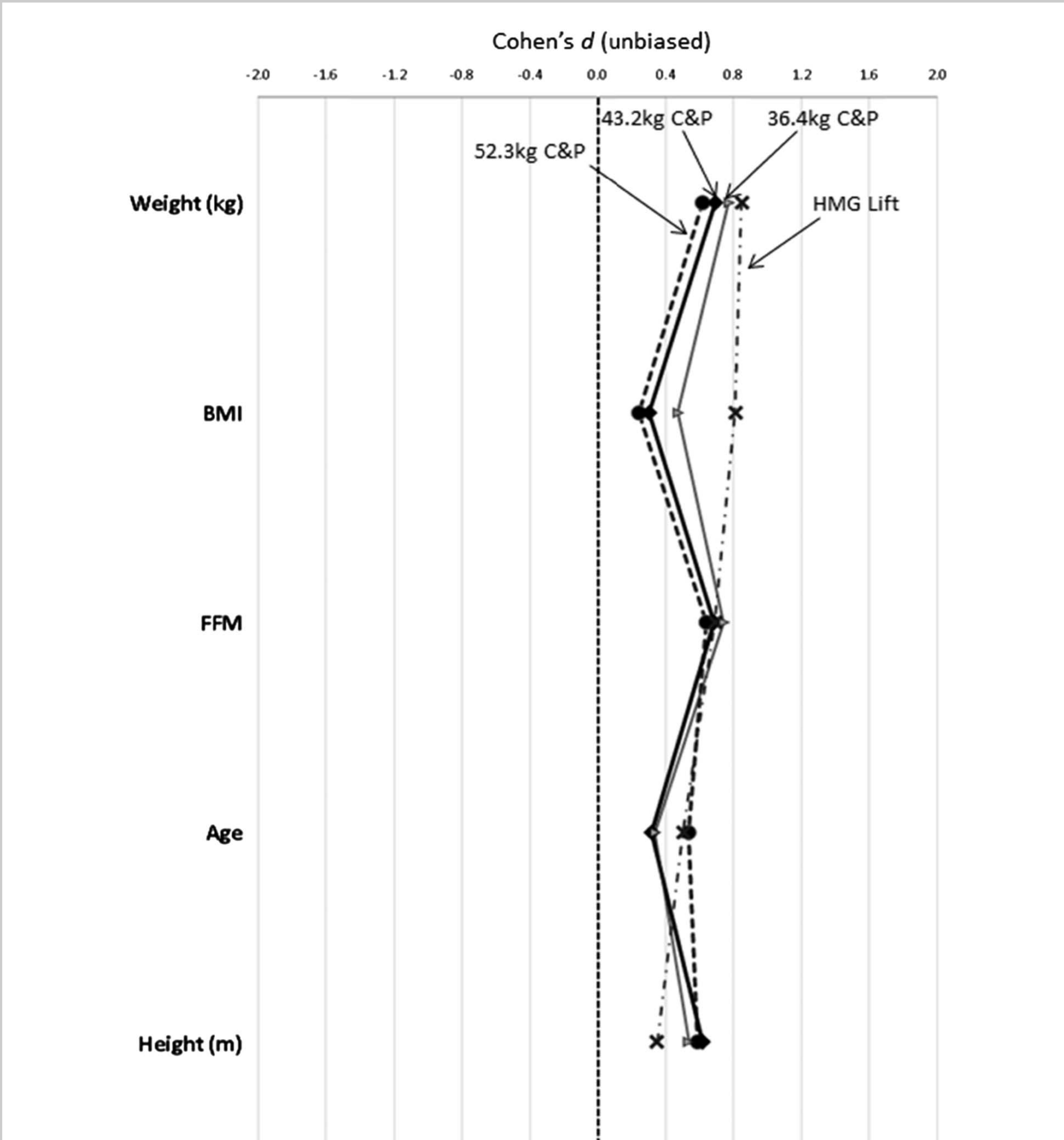

Figure 1. Comparison of group differences between the successful and unsuccessful candidates, on the Clean and Press tasks, and the HMG lift. The horizontal axis represents the standardized mean difference between the unsuccessful and successful groups (the effect size, unbiased Cohen's *d*); the vertical axis identifies the physical performance measures. Larger effect sizes (line to the right of vertical axis at zero) indicate that the females who were successful on the particular proxy task (e.g., those who could complete the heaviest Clean and Press task, 52.3 kg) outperformed those who were unsuccessful. HMG = heavy machine gun; BMI = body mass index; FFM = fat-free mass.

Upper Body Strength Tests

In C1, 15% of the women completed the HMG Lift; in C2, 8% of the women completed the 52.3 kg Clean and Press (Table 3).

In comparing successful females to unsuccessful females, successful females were larger (body weight differences, $p \leq 0.05$) and more fit (on both cardiovascular intensive tasks and strength-dependent tasks), as

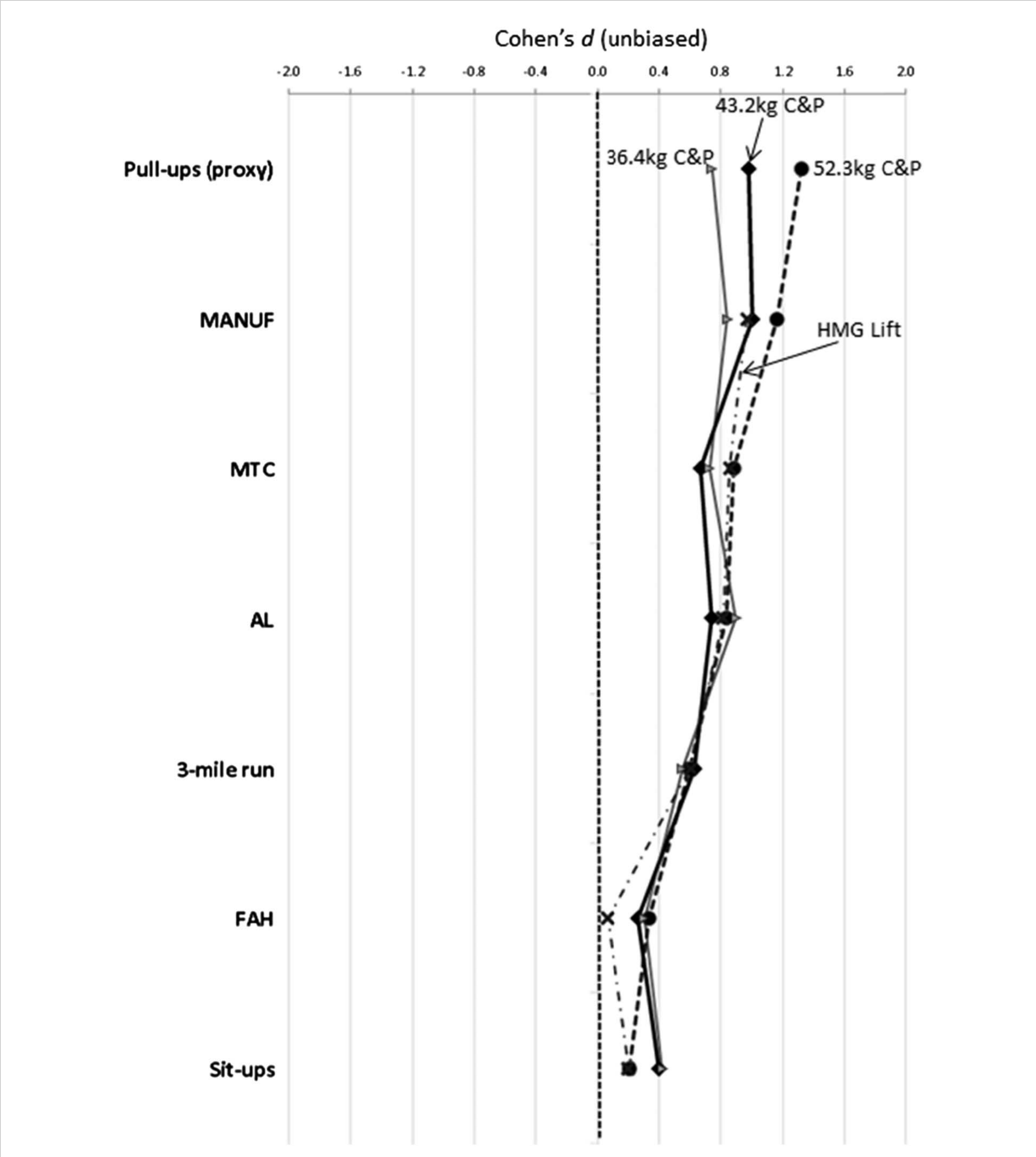

Figure 2. Comparison of group differences between the successful and unsuccessful candidates, on the Clean and Press tasks, and the HMG lift. The horizontal axis represents the standardized mean difference between the unsuccessful and successful groups (the effect size, unbiased Cohen's *d*); the vertical axis identifies the physical performance measures. Larger effect sizes (line to the right of vertical axis at zero) indicate that the females who were successful on the particular physical task outperformed those who were unsuccessful. HMG = heavy machine gun; MANUF = maneuver under fire; MTC = movement to contact; AL = ammunition can lift; FAH = flexed-arm hang.

measured by performance on the PFT and CFT components tasks ($p \leq 0.05$). The effect sizes (Cohen's d) were calculated on performance measures between successful and unsuccessful women and are depicted in Figures 1 and 2. Tables 3 and 4 provide more detailed summary data.

Figure 1 depicts the extent to which women who were successful on the upper body strength tasks can be

Table 4. Comparison of successful to unsuccessful females, on the 43.2-kg and 36.4-kg Clean and Press (C&P).*†‡

	Successful 43.2-kg C&P ($N = 90$)	Unsuccessful 43.2-kg C&P ($N = 289$)	p	Successful 36.4-kg C&P ($N = 175$)	Unsuccessful 36.4-kg C&P ($N = 204$)	p
Age, y	23.4 ± 4.4	21.9 ± 4.5	<0.01	23.1 ± 4.8	21.6 ± 4.2	<0.01
Height, m	1.7 ± 0.07	1.6 ± 0.07	<0.01	1.7 ± 0.07	1.6 ± 0.06	<0.01
Weight, kg	63.9 ± 7.1	59.2 ± 6.7	<0.01	63.0 ± 6.8	58.0 ± 6.4	<0.01
BMI, $kg \cdot m^{-2}$	23.0 ± 1.7	22.4 ± 1.9	<0.01	23.1 ± 1.5	22.2 ± 2.1	<0.01
FFM, kg	47.1 ± 4.3	44.3 ± 4.0	<0.01	46.5 ± 4.3	43.5 ± 3.8	<0.01
3-mile run, min:sec	23:30 ± 2:17	24:49 ± 2:03	<0.01	23:53 ± 2:11	25:02 ± 2:01	<0.01
Sit-ups, reps	96.8 ± 7.6	92.5 ± 11.7	<0.01	96.0 ± 8.5	91.4 ± 12.5	<0.01
FAH, sec	67.4 ± 6.5	65.1 ± 9.0	<0.01	67.1 ± 6.4	64.5 ± 9.8	<0.01
AL, reps	64.7 ± 13.5	54.3 ± 14.3	<0.01	63.3 ± 13.7	51.2 ± 13.4	<0.01
MANUF, min:sec	3:02 ± 0:25	3:26 ± 0:24	<0.01	3:09 ± 0:25	3:30 ± 0:24	<0.01
MTC, min:sec	3:21 ± 0:17	3:35 ± 0:22	<0.01	3:23 ± 0:20	3:38 ± 0:21	<0.01
Proxy Pull-ups, reps	6.5 ± 5.3	2.7 ± 3.4	<0.01	5.2 ± 4.9	2.2 ± 3.0	<0.01

*BMI = body mass index; FFM = fat-free mass; FAH = flexed-arm hang; AL = ammunition can lift; MANUF = maneuver under fire; MTC = movement to contact.
†Values are presented as mean ± *SD*.
‡For variables exhibiting salient departures from normality (i.e., age, 3-mile run, sit-ups, FAH, and proxy pull-ups), the corresponding nonparametric version of the *t*-test (the independent 2-group, Mann-Whitney *U* test) was performed and reported in the table. All other comparisons are based on Welch's unequal variances *t*-test.

distinguished from women who were unsuccessful on the basis of anthropometric characteristics. Women with larger mass (i.e., weight, FFM, and height) also exhibit greater upper body strength (Figure 1; Table 2).

Figure 2 depicts the extent to which successful women on the upper body strength tasks can be distinguished from unsuccessful women on the basis of physical performance on other tasks. There were larger magnitude effect sizes associated with the pull-ups and the AL (close to or greater than 0.80, i.e., farther to the right on the graph in Figure 1). In addition, the effect sizes for the upper body strength tests tend to cluster around the same value for a particular task, with the notable exception of pull-ups, with larger differences in pull-up performance associated with the increasing difficulty in the Clean and Press.

Discussion

Many activities involved in combat are intense and demand high levels of strength and endurance. Women have traditionally been excluded from participation in direct ground combat roles for many reasons (e.g., social norms), but one of the most important reasons is due to the intense and kinetic nature of combat. Previous work suggests that upper body strength may be the primary limiting factor for women; however, some of the women included in this study have demonstrated the ability to overcome those challenges, at least on some measures of upper body strength (e.g., pull-ups, HMG lift, and Clean and Press). Not surprisingly, the most fit female Marines (as determined by performance on the PFT and CFT) consistently outperformed their less fit counterparts on heavy lifting tasks. The more successful females were taller, heavier, and with greater estimated FFM.

The body composition results are consistent with early research on military personnel, which has tied performance to these characteristics (1,2,4,15). Body composition is a critical component of optimal physical performance in the military setting and has been shown to be related to operational readiness and performance (2,4,6). Typically, these standards are based on measures of BMI and estimates of percent body fat through circumference measurements. Although extremes on either side (morbid obesity or extreme underweight) are negatively associated with health and performance, previous work from our laboratory and others suggest that in a military population, BMI is related to combat readiness, as defined by proxy measures of combat tasks (1,4,9). That is, women with greater mass are typically more successful on combat tasks than women of lesser mass. Women have a higher rate of fat mass accumulation during puberty and, in addition to higher levels of essential fat (12%), women have approximately 20–25% body fat relative to their mass compared with 13–16% in men (3,13).

Additionally, women in their twenties have, on average, approximately 30% less lean body mass than their male peers (3,13). For successful females, the average age of enlisted personnel was 24 years; for unsuccessful females, the average age was 22 years. This finding suggests that older women in this effort were more successful and had larger estimated lean body mass than their younger counterparts. As further support for this claim, successful women were indeed older than their unsuccessful counterparts (for the HMG lift, M = 21.8, M = 20.5, $p < 0.0001$, $d = 0.53$; for the Clean Press, M = 24.5, M = 22.1, $p < 0.01$, d = 0.54).

The successful women were also both taller and heavier than the unsuccessful ones, suggesting that successful females may have more muscle mass. This suggestion is bolstered by the current effort and estimated FFM. These results suggest, not surprisingly, that larger individuals are at a disadvantage in events such as the flexed-arm hang and pull-ups, given that body weight is the key physical force that must be overcome during these tasks. However, in the combat proxy tasks, there were no such disadvantages: heavier females (as defined by the upper and lower quartiles for FFM) were more successful than lighter females at the HMG lift and the heaviest Clean and Press. For cohort 1 (heavier individuals, $N = 113$; lighter individuals, $N = 87$), a much larger percentage of heavier females could complete the HMG lift (27%) than lighter females (3%) ($p < 0.0001$). For cohort 2 (heavier individuals, $N = 87$; lighter individuals, $N = 113$), a larger percentage of heavier females could complete the heaviest Clean and Press as compared to the lightest female (16% vs. 3%, heaviest vs. lighter females; $p < 0.01$).

Performance differences on the PFT and CFT also correspond to performance differences on combat-related tasks. Currently, Marines are required to complete both the PFT and CFT semiannually. As expected, women who performed well on their semiannual PFTs were more successful on heavy lifting tasks. Successful female Marines performed on average 5 more pull-ups and 12 more ammo can lifts than unsuccessful females (successful women from both cohorts exhibited nearly identical scores on the PFT and CFT). Successful females also exhibited greater cardiovascular fitness and, potentially, muscular endurance, as demonstrated by faster run times on the 4.8-km (3-mile) run, the MTC, and MANUF, which is a combination of exercises. This finding is consistent with other studies demonstrating a strong relationship between cardiovascular endurance and overhead lifting (7,15). Thus, these data suggest that women seeking entry into closed combat arm positions should strive for whole body fitness, not limiting training efforts to single performance domains.

In addition, the best-performing female Marine in C2, in terms of pull-up performance and success on the Clean and Press, completed 23 pull-ups and 85 ammo can lifts and had a 4.8-km (3-mile) run time of 22:03 (minutes:seconds). These numbers, at least for pull-ups, exceeded the performance of 87% of men tested in C2 (9). Although not included in this analysis, male Marines were tested alongside the female Marines presented in this effort. To what extent is this woman an anomaly, an unachievable standard for the vast majority of women? Even if she is a rare case, previous studies have shown that women who are strength trained and/or endurance trained can increase their performance on combat-related tasks and upper body strength tasks (6,11,12,15,16), suggesting that, with proper training, the percentage of female Marines able to complete heavy lifting tasks may increase. Consistent with this claim are the results of a previous USMC study, which demonstrated that a 12-week training program increased by 30% the number of women who could perform more than 3 pull-ups (14). Although training was not a focus of this effort and was not controlled for, the results from C1 exhibited a suggestive trend in the restricted sample of females who were tested on pull-ups in both the annual PFT and again for the proxy tasks. In this smaller sample of 26 females, only 8 saw either no gain or a small decrement in pull-ups performance, whereas the remaining 18 Marines saw at least some increase in performance.

As expected, in general, those who were more physically fit performed better than those who were less fit. However, there were some unexpected findings when comparing heavy overhead lifting to light-to-moderate overhead lifting. For example, in C1, the HMG weighed approximately 37.3 kg, and successful women in that group completed 71 ammo can lifts. In comparison, in C2, for the most difficult Clean and Press of 52.3 kg, successful women completed 68 ammo can lifts. The difference in weight of almost 15 kg would seem to suggest larger expected differences in performance on the AL task, but this is not what was found. In what might be considered, ostensibly, the most comparable Clean and Press task to the HMG–the 36.4 kg Clean and Press–successful women completed, on average, 63 ammo can lifts. Although it might seem surprising, the women in C1 were not provided the opportunity to lift a heavier weight (e.g., 52.3 kg); thus, the similarity in number of ammo can lifts may indicate analogous upper body strength. However, whether ammo can lifts are related to maximal upper body lift strength would need to be tested and validated to confirm this assumption.

Another interesting fact is that effect sizes are similarly large for tasks that would seem to be less dependent on upper body strength. Also notable is the fact that for the most demanding upper body strength tasks (the HMG lift and 52.3 kg Clean and Press), the flexed-arm hang and sit-ups were less successful at distinguishing successful performers from unsuccessful performers. This is perhaps less important for sit-ups, as that test has been designed to measure a separate capability (e.g., core strength); however, if flexed-arm hang is taken as a proxy for measuring upper body strength, then issues related to the validity of the test become important. (Note, however, that the limitation may be due to differences in measurement procedure, of restricting the test to a 70-second maximum; the issues may potentially be resolved if the task was simply made harder, by introducing longer time limits, for instance, top performers on a harder version of the task might then exhibit the expected greater upper body strength pattern as in the other tasks).

There are several limitations to this study that need to be addressed. First, the physical capabilities of men were taken as an approximation of required physical ability for the job because men are currently serving in these combat roles. Ideally, a detailed and comprehensive job analysis of all components of relevant combat MOSs would serve as the standard against which to judge the required physical capabilities. This is a very high and potentially impossible standard to meet, however, given the kinetic and volatile nature of combat. Even so, the main conclusions of this report on the key physical capabilities needed for combat operations (e.g., whole body fitness, including upper body strength), and the most significant challenge areas for women would likely remain unchanged.

Second, training status was not controlled for or documented in this effort beyond the standard Marine Corps fitness tests; thus, many of the women tested might not have ever executed a Clean and Press–type movement before being asked to lift and press the HMG or a barbell. Proper lift techniques and opportunities to practice were given; however, if the participants do not come from a background of weight lifting or experience with pull-ups, they may have been limited by the execution of the movements. Third, the data used in this report were compiled from 2 separate efforts and as a result contained potentially important differences. For instance, the participants in the separate cohorts completed different upper body tasks: although the HMG lift involved a lighter weight than the heaviest Clean and Press, the technical difficulty of safely lifting a HMG may have led to the HMG lift being more difficult than the hardest Clean and Press task. Fourth, although the groups were recruited at the same time in training and seem to be similar with respect to physical fitness, there may be factors such as seasonal effects and experience that were not accounted for. Finally, measures of FFM were not based on direct body composition measurements but were estimated from a statistical model (i.e., the Gallagher equation) that was derived from a similar population.

In conclusion, this study aimed to describe female Marines, anthropometrically and physically, who were physically capable of heavy lifting at the onset of military training despite no known previous training. These data show that overall physical fitness, specifically aerobic capacity and upper body strength (as measured by ALs and pull-ups), translates to lifting capacity on military occupational tasks and that some active-duty female Marines can perform these tasks. However, performance on these tasks does not necessarily indicate operational readiness. Preparedness for combat is multifaceted, and physicality is just one, albeit important, component of a much broader set of capabilities and skills, such as land navigation, weapons handling, and shooting/moving/communicating as a unit. Furthermore, it is important to realize that annual fitness tests are designed not only to prepare active-duty Marines for battle but also to ensure that Marines maintain baseline fitness levels that can reduce the risk of injury and perhaps prevent illness or disease. Further work is needed to better understand how physical fitness and body composition are related to preparedness for combat and combat effectiveness.

Practical Applications

These findings could help direct requirements for individuals seeking assignment to physically demanding military occupations such as infantry, artillery, or tank positions, where heavy lifting is a common occupational task. The results from this effort could offer support in establishing mandatory minimum values for body composition, strength, and cardiovascular fitness for entry into physically demanding occupations. Additionally, these data could serve as guidelines–benchmarks that would increase the probability of success–for women as they seek entry into ground combat roles. Although upper body strength is an important challenge area for women, these challenges may not be an inherent limiting factor.

Finally, it is important to note that each of the tasks tested a single physical component, and was not combined into some overall aggregate task, to better capture the multicomponent nature of actual combat missions. Although the CFT attempts to do this, it is limited in that it is performed in physical training clothes and not actual combat gear. Whether women can sustain performance over the long term, or effectively execute multicomponent tasks, is thus an open question. In addition, although this and previous studies have focused on performance descriptions of women, the findings of this study suggest that women with greater overall fitness and upper body strength and also greater overall size (mass and height) perform better on combat-related tasks. In short, women seeking entry into closed combat arms' positions should train appropriately, combining strength training with aerobic conditioning to improve the physical capabilities required for lifting and moving heavy loads over varying distances.

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14. ABSTRACT
Females have been restricted from serving in direct combat arms' positions for decades. One reason for the exclusion derives from the perceived physical demands of these positions. As a result, many current efforts are directed toward defining the physical demands of combat arms' positions. The purpose of this study was to develop a physical performance and body composition profile of females who could overcome the physical demands of combat tasks that rely primarily on upper body strength. This study is based on an analysis of archival data from 2 separate samples of active-duty female Marines (n = 802), who had been recruited to participate in heavy lifting tasks. These tasks included lifting a heavy machine gun (HMG) lift (cohort 1, n = 423) and Clean and Press lifts (29.5–52.3 kg) (cohort 2, n = 379). To develop the physical performance profile, data from annual physical fitness tests were collected, which included run times, ammunition can lift, 804. Seven-meter (880-yard) movement to contact, and the maneuver under fire. In cohort 1, 65 females (~15%; n = 423 females) successfully completed HMG; in cohort 2, 33 females (~9%; n = 379 females) successfully completed another strength task, a Clean and Press of 52.3 kg. In both samples, female Marines who were successful on these tasks also outperformed their unsuccessful counterparts on the annual physical fitness tests. In addition, larger females typically outperformed their smaller counterparts. Females seeking assignment to closed combat arms' positions would thus be well served by targeting upper body strength, while maintaining overall physical fitness.

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