Comparison of the physical fitness of men and women entering the U.S. Army: 1978–1998

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ABSTRACT


Purpose: To compare the physical fitness levels of recruits entering the U.S. Army in 1998 to those entering in 1978 and 1983.

Methods: In 1998, 182 men and 168 women were tested before beginning basic training at Fort Jackson, SC. The measurements were 1) skin-fold estimation of percent body fat (%BF); 2) maximum oxygen uptake by treadmill running ($\text{VO}_{2\max }$); and 3) upper-body (UB), lower-body (LB), and upright pulling (UP) isometric strength. These data were compared to data from basic trainees at Fort Jackson in 1978 (skin folds, $\text{VO}_{2\max }$, UB, and LB) and 1983 (skin folds and UP). Results: Body weight (BW) of 1998 recruits was greater ($P < 0.05$) than 1978 recruits (men, 12%; women, 6%) and 1983 recruits (men, 8%; women, 7%). %BF of 1998 recruits was greater ($P < 0.05$) than 1978 recruits (men, 15%; women, 5%) and 1983 recruits (men, 15%; women, 17%). The 1998 men had more fat-free mass (FFM) ($P < 0.05$) than men in 1978 (8%) or 1983 (5%), whereas 1998 women were only different from those measured in 1978 (4%, $P < 0.05$). The $\text{VO}_{2\max }$ of men (50.6 ± 6.2 mL·kg$^{-1}$·min$^{-1}$) was equivalent to men in 1978, whereas that of women (39.7 ± 5.2 mL·kg$^{-1}$·min$^{-1}$) was 6% greater ($P < 0.05$). The 1998 recruits were stronger ($P < 0.05$) on all measures of muscle strength than recruits measured in 1978 (men, UB = 16%, LB = 12%; women, UB = 18%, LB = 6%) and 1983 (men, UP = 7%; women, UP = 6%). Conclusion: The aerobic capacity, muscle strength, and FFM of 1998 recruits is comparable to or greater than that of 1978 and 1983 recruits; however, 1998 recruits tended to have more BW and a greater %BF. Key Words: EXERCISE, $\text{VO}_{2\max }$, STRENGTH, MUSCLE CONTRACTION, BODY COMPOSITION, PHYSICAL FITNESS

There is a public perception that the youth of today are less physically fit and fatter than in previous years (3). Although there is evidence that the prevalence of obesity has increased across all age and demographic groups during the last 20 yr (16), there is less evidence concerning physical fitness levels. Data from youth physical fitness tests have been interpreted to show a decline in youth physical fitness, particularly aerobic fitness, as measured by running performance (17). Others argue that youth physical fitness tests have changed over time from skill-oriented tests to health-related tests, making long-term comparisons difficult (5). The comparisons that can be made between skill-oriented test items do not strongly support a decrease in youth physical fitness (5). Although not a retrospective study, the Surgeon General’s report on physical activity and youth physical fitness (5) stated that only about 50% of today’s youth participate in regular vigorous physical activity and 14% are completely inactive (27). If the youth today are less active, have greater percentages of body fat, and have lower aerobic fitness than those of previous decades, they present a national health concern.

Basic training drill sergeants are also of the opinion that the physical fitness of today’s youth is significantly lower than in previous years. This opinion is supported by Knapik et al. (12), who reported 5% slower 2-mile run times for basic trainees over a 10-yr period (1988–1997), indicating a decline in the aerobic fitness of recruits. In a time of low unemployment, a decrease in youth physical fitness makes the Army’s task of recruiting and training physically capable people even more challenging. Lower levels of physical fitness have been shown to reduce the likelihood for successful completion of basic training and increase the likelihood of training-related musculoskeletal injury (14). Because many entry-level Army jobs are physically demanding, soldiers who are not physically fit may be unable to perform critical aspects of their jobs even if they are able to complete basic training.

Soldiers are required to take the Army Physical Fitness Test (APFT) semiannually, which consists of timed sit-ups, push-ups, and a 2-mile run (7). The extent to which the test results represent an individual’s maximum ability can be questioned. Soldiers know the minimum score needed to pass and may not put forth a maximum effort on any of the events. In a sample of more than 6000 soldiers asked to give a best effort APFT to be recorded in their personnel files,
10% clearly gave a submaximal effort (20). Although the APFT is useful as a field-expedient measure of physical fitness for large numbers of soldiers, measures of physical fitness with greater precision are needed to objectively evaluate population changes over time.

Researchers from the U.S. Army Research Institute of Environmental Medicine have measured the physical fitness of recruits entering basic training at Fort Jackson, SC, periodically over the past 20 yr. Maximal oxygen uptake during treadmill running (21) and upper- and lower-body isometric strength (15) of male and female recruits were measured before basic training in 1978. In 1983, a test of isometric lifting strength (upright pull strength) was measured on men and women before basic training (26). Skinfold estimates of percent body fat (%BF) were made on male and female recruits during the 1978 (15) and 1983 (26) studies and in female recruits before basic training in 1993 (28). These studies provide historical data to compare the pre–basic training physical fitness of 1998 U.S. Army recruits to those measured during the period 1978–1993. The purpose of this article is to compare the physical fitness of men and women entering the U.S. Army in 1998 to original data collected from similar samples at the same basic training site during the previous 20 yr to determine if the physical fitness of young people entering the U.S. Army has changed during this time period.

**MATERIALS AND METHODS**

**Subjects.** Volunteers were recruited from men and women about to enter basic training at Fort Jackson, SC, in May 1998. Recruits were briefed on the procedures and voluntary nature of the study. Of those who were briefed, the overall volunteer rate was 57% (53% of men and 63% of women). Volunteers read and signed an informed consent document and were medically cleared by a physician. The study was approved by a human-use review committee and by the Human Subjects Research Review Board. Recruits entering basic training in 1998 were required to pass a physical fitness screening test before they began training. The test included a 1-mile run for time, sit-ups, and push-ups. Recruits who failed the test were sent for remedial physical training and did not participate in the study. Of those who volunteered to participate in this study, it is estimated that five men and six women failed the run, five men and nine women failed the push-ups, and two men and five women failed the sit-up screening test. Testing of 350 recruits (182 men and 168 women) was conducted May 1–13, 1998.

**Comparison data sets.** The data sets used for comparison with the 1998 data were 1) body weight and %BF measured in 1978 by Knapik et al. (15), in 1983 by Teves et al. (26) and in 1993 by Westphal et al. (28); 2) VO\(_{2}\text{max}\) measured in 1978 by Patton et al. (21); 3) upper- and lower-body isometric strength measured in 1978 by Knapik et al. (15); and 4) isometric upright pull strength measured in 1983 by Teves et al. (26). As with the 1998 study, all of these studies were conducted before basic training at Fort Jackson. All volunteers were briefed on the procedures and risks of the respective study, signed an informed consent document, and were medically cleared before participation.

The racial distributions of the previous samples are not available; however, the racial distribution of the total Army for 1980, 1983, 1993, and 1998 is provided in Table 1 (data extracted from the Total Army Injury and Health Outcomes Database (2)). These data are listed by gender for the age group 17–25, which includes the majority of soldiers entering basic training. The racial distribution of the recruit sample reported here is also shown and is representative of the Army in 1998. From 1980–1998, the percentage of black males has dropped from 29% to 20%, whereas that of black females has remained fairly constant. The percentage of white males has remained stable, whereas that of white females has decreased from 59% to 49%. The percentage of soldiers classified as other (Hispanic, Asian/Pacific Islander, and Native American/Alaskan Indian) has increased nearly fivefold in men and nearly threefold in women, primarily because of an increase in the percentage of Hispanics (from approximately 4% to 8% of the total population).

**Measurements.** A four-site skin-fold estimate of %BF was made (8) using procedures and equipment identical to those of previous studies (15,26,28). Three measurements were made at each site (biceps, triceps, subscapular, and suprailiac) by a trained technician using Harpenden calipers (Country Technology, Inc., Gays Mills, WI). Subjects were asked their age (years). Height (centimeters) was measured using a stadiometer (Model GPM, Seritech, Inc., Carlstadt, NJ). Body weight (kilograms) was measured using a digital scale (Model 770, Seca Corp., Columbia, MD) with subjects in T-shirts, shorts, underclothes, and socks, which was the same as in previous studies (15,26,28).

Maximum oxygen uptake was measured using open-circuit, indirect calorimetry during a continuous uphill treadmill running protocol. An initial 5-min warm-up was performed at 0% grade and 2.68 m·s\(^{-1}\) (6 mph) for men and 2.24 m·s\(^{-1}\) (5 mph) for women. If the heart rate was less than 150 beats·min\(^{-1}\) by minute 5 of the warm-up, treadmill


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speed was increased 0.45 m$^{-1}$ (0.5 mph) for the remainder of the test. After the warm-up, the treadmill grade was increased by 2% every 3 min until voluntary exhaustion. If a plateau in oxygen uptake ($\Delta < 0.15 \text{ L min}^{-1}$ increase with an increase in treadmill grade) was not achieved, criteria for assessing maximal oxygen uptake were 1) heart rate in excess of 90% age-predicted maximum heart rate, and 2) respiratory exchange ratio in excess of 1.0. The protocol was similar to the interrupted protocol previously used in 1978 at Fort Jackson (21). The differences between the 1998 protocol and that used previously were that the earlier protocol was discontinuous and used treadmill grade increments of 2.5% instead of the 2% increase used here. The warm-up loads were identical, as were the speed adjustment and frequency of load adjustments. Differences between continuous and discontinuous treadmill running tests tend to be small (1.2%), with a discontinuous protocol producing a slightly higher VO$_2$max (18).

Volunteers wore a nose clip and were connected to an on-line oxygen uptake system via a low-resistance, two-way, nonrebreathing valve (Hans Rudolf, Inc., Kansas City, MO) and a mouthpiece. The on-line oxygen uptake system was developed in our laboratory and consisted of an Applied Electrochemistry S-3A oxygen analyzer (AEI Technologies, Pittsburgh, PA), a Beckman LB-2 carbon dioxide analyzer (SensorMedics, Inc., Yorba Linda, CA), a K.L. Engineering turbine flowmeter (K.L. Engineering Turbine Company, Northridge, CA), and a Yellow Springs Instrument Company Thermister (YSI, Yellow Springs, OH), interfaced with a Hewlett-Packard computer (model 9122, Hewlett-Packard, Palo Alto, CA). The gas analyzers were calibrated with certified gas cylinders (4% CO$_2$, 17% O$_2$) from SensorMedics. The turbine was calibrated with a Harvard Apparatus Dual-Phase Respiration Pump (Harvard Apparatus Corp., Holliston, MA). In the laboratory, the pump flow rate is routinely checked with a Collins 120 L Chain-Compensated Gasometer (Warren E. Collins Inc., Braintree, MA). During the field study, the turbine flow rate was checked daily with a 3-L calibration syringe (SensorMedics). The output of the 3-L syringe has been verified in our laboratory with both the Harvard Respiration Pump and the Collins 120 L Chain-Compensated Gasometer (Tissot).

There were differences in the equipment used to measure oxygen uptake in the 1978 study (21) and in this study. In 1978, volunteers breathed through a mouthpiece attached to a Koegel valve, and expired volume was collected into Douglas bags (30 s collection) during the final 60 s of each 3-min bout of exercise. The same O$_2$ and CO$_2$ gas analyzers (AEI S-3A and Beckman LB-2) used in the above-described on-line system were used to analyze aliquots of air extracted from the Douglas bags. A Collins Tissot was used to measure expired gas volume and temperature. This same Douglas bag system is routinely used to validate the on-line system that was used in this experiment. Exercise heart rate was monitored using a Hewlett-Packard model 1511B Electrocardiograph during the 1978 and 1998 tests.

Three measures of maximum voluntary isometric strength were made. Upper-body (UB) strength and lower-body (LB) strength were measured on the same triple-strength device used in 1978 (15). The volunteer was seated with a seat belt securely tightened over the pelvic area to prevent body movement. For UB, a handle was positioned such that the upper arms of the volunteer were parallel to the floor and the elbows were flexed to 90°. The volunteer grasped the suspended handle (45.7 cm long × 3.2 cm diameter aluminum tubing) using an underhand grip. On verbal command, the volunteer pulled maximally downward. For LB strength (isometric leg press), the volunteer remained seated with the back against the seat back and the pelvis tightly secured with a seat belt. A footrest was adjusted to obtain a knee angle of 90°. The volunteer grasped handles parallel to the seat bottom and pushed maximally against the stationary footrest on verbal command from the experimenter. The test-retest reliability of UB and LB measures were $r = 0.97$ and $r = 0.92$, respectively (15).

The third measure of isometric strength, the upright pull (UP), was designed to assess isometric lifting strength at a low point in a lift from the floor (26). The volunteer stood on a wooden platform with feet shoulder width apart, straddling the pulling handle. The volunteer bent over to grasp the aluminum handle 38 cm above the level of the platform and assumed a semisquat position with knees bent, head up, and back straight. The handle was identical to that used for the UB test and was attached via aircraft cable to a load cell mounted on the wooden platform. On command, the volunteer pulled maximally upward. This measure has a test-retest reliability coefficient of $r = 0.97$ for three trials (26). For all three measurements (UB, LB, and UP), force was applied smoothly, without jerking, reaching maximum within a 2-s period and was held for 4 s. The maximum force was measured by a BLH load cell and displayed on a BLH model 450A transducer indicator (BLH, Waltham, MA). The mean of two of the highest of three trials within 10% of one another was recorded as the score for each test. Additional trials (to a maximum of five) were performed if the greatest trial was more than 10% different than the second greatest trial. A minimum 1-min rest period was provided between trials. To examine differences in strength relative to fat-free mass (FFM), each individual’s strength score was divided by their FFM.

The third testing stations were 1) VO$_2$max test, 2) skin folds, and 3) muscle strength. When groups of 15–20 volunteers arrived, their age, height, and weight were recorded before they were evenly divided among the stations. Volunteers proceeded from station to station until all stations were completed. A minimum of 20 min of rest was provided between each station.

Sample size estimation and data analysis. Statistical Power: A Computer Program by M. Borenstein and J. Cohen was used to estimate the necessary sample size for the physical fitness measures with an alpha level of $P < 0.05$ and a beta of 0.85. The sample size estimates for most variables ranged from 20 to 70 men and women. Additional men and women were recruited to provide adequate power to assess the relationship between physical fitness and basic
training-related injuries, which has been reported elsewhere (13).

Descriptive statistics were calculated for each gender. Statistica software was used (‘99 edition, StatSoft, Inc., Tulsa, OK) to compare samples within gender using t-tests
(when there were only two samples for a given variable) or one-way ANOVAs (when there were more than two samples). Tukey’s HSD post hoc tests for unequal sample sizes were used to examine the significance of differences between more than two means.

RESULTS

Table 2 lists the age, height, and weight of volunteers from the 1998 study and from studies conducted in 1978 (15), 1983 (26), and 1993 (28). The 1998 men tended to be older than men measured in 1978 and 1983 and taller than those measured in 1978 (P < 0.05). The 1998 female recruits measured in 1978 (P < 0.05), but not different from the other samples of women. There were no differences in the height among the four samples of women. Men and women in 1998 had a greater body weight than those measured in 1978 or 1983. In 1998, the men averaged 8% greater body weight than 1983 males and 12% greater than 1978 males. The 1998 female recruits had 6% more body weight than those measured in 1978 and 7% more than those in 1983. The body weight of 1998 women did not differ from those measured in 1993.

Although the 1998 group of male recruits was significantly taller, the greater body weight cannot be solely attributed to greater height. Table 3 presents the %BF and FFM data for male and female recruits from each of the available samples.

Table 3. Comparison of percent body fat (%BF) and fat-free mass (FFM) of 1998 recruits with those from 1978 (15), 1983 (26), and 1993 (28).

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a Different letters represent a significant difference between year groups within each variable and gender (P < 0.05). For example, the 1978 males a are older than the 1983 males b, and younger than the 1998 males c (P < 0.05). The 1983 a males are younger than the 1998 males c and younger than the 1978 males a (P < 0.05).

* No men were tested.
1998 than in 1978 in men and women, respectively, but no statistical analysis was conducted, since the 1978 individual ventilation data were not available.

Table 5 compares the strength values in 1998 to those in 1978 (15) and 1983 (26). Compared with recruits in 1978, the mean UB strength of men and women tested in 1998 was 17% and 18% greater ($P < 0.05$), respectively. A frequency distribution of the UB strength measured in 1978 and 1998 for male recruits is shown in Figure 1A and for female recruits in Figure 1B. Because the sample sizes were not equal, the bars represent the percentage of each sample that scored within each interval. It can be seen that the entire curve is shifted to the right of the distribution in 1998, so the greater average score is not because of a few strong individuals. Compared to recruits tested in 1978, the mean LB strength of men and women in 1998 was greater by 6% and 11%, respectively ($P < 0.05$). As with UB and LB strength, the UP strength of 1998 recruits was significantly greater ($P < 0.05$) than that of 1983 recruits.

As noted above, the men tested in 1998 had more FFM than those tested in 1978 and 1983, and the women tested in 1998 had more FFM than those tested in 1978. For this reason, each individual’s strength scores were divided by FFM, to examine the differences in strength relative to FFM (Table 5). The differences in UB isometric strength remain even when normalized for FFM. This suggests the superior UB strength of 1998 recruits was not simply a result of greater quantities of FFM. Unlike UB strength, the differences in LB strength disappeared when normalized for FFM, which would suggest that group differences in LB strength were primarily attributable to differences in FFM.

The magnitude of sample differences in absolute isometric strength was smaller for LB than for UB. The 1998 men had a greater absolute UP strength than the 1983 men (26) but, when normalized for FFM, the difference was no longer significant. This suggests the difference in UP strength was because of group differences in FFM. The 1998 women had a greater UP, but were not different from 1983 women in terms of FFM. Therefore, when examined relative to FFM, UP was still greater in the 1998 sample ($P < 0.05$).

**DISCUSSION**

Recruits in 1998 entered basic training with levels of aerobic fitness, muscle strength, and FFM that were similar to, or greater than, those entering the Army 15–20 yr earlier. However, they also had more body weight and a greater %BF. The greater body weight and %BF reflects a national trend of an increased incidence of obesity (16). The ACSM guidelines place the male recruits in the 30th to 35th percentile or between the “fair” and “poor” categories for %BF, whereas the women are in the 15th percentile and rated “poor” (1).

Although the body weight and %BF of 1998 recruits were greater than in previous years, 1998 recruits also had more FFM than recruits 20 yr earlier (15). FFM is correlated with better performance on strength-demanding tasks, particularly military tasks requiring movement of an external load such as heavy lifting, or lifting and carrying (10). Box lifting performance, both repetitive and maximal lifting, does not appear to be negatively affected by an increase in %BF (10).
Muscle strength is a physically limiting component in 80% of entry-level Army jobs (23); therefore, greater levels of FFM and upper-body strength should benefit the 1998 recruits when performing strength-demanding tasks. Tasks such as loaded marching, which have both strength and aerobic components, may be negatively affected by greater quantities of body fat, but the relationship is not as strong as that between performance and FFM (10).

On the basis of the aerobic fitness categories of Shvartz and Reibold (24), the values for \( \dot{V}O_2 \text{max} \) of the 1998 male recruits place them between the “average” and “good” categories, whereas the women were in the “average” category for their age. Whereas 1978 men are in the same aerobic fitness category as the 1998 men, the 1978 women recruits would only be rated “fair.” Figure 2 displays the distribution of scores within each of the aerobic fitness categories for men (Fig. 2A) and women (Fig. 2B). Because the sample sizes differed, each bar represents the percentage of the sample within the category, rather than a count. The 1998 men ranged from poor to excellent, whereas 1978 men were more tightly clustered in the average and good categories. The 1998 women ranged from poor to excellent, whereas the 1978 women ranged from the poor to good categories. The ACSM guidelines for 20- to 29-yr-olds rate the aerobic power of the men “excellent” or 85th percentile, and the women “good” or 75th percentile (1). The differences between the ACSM guideline rating and the rating of Shvartz and Reibold are probably attributable to the populations from which they were developed. The ACSM guidelines are derived from data from the U.S. population (1), whereas the categories of Shvartz and Reibold are derived from western European as well as North American samples (24).

Knapik et al.’s (12) finding of slower 2-mile run times in 1997 recruits compared with 1988 recruits suggests that the aerobic power of recruits was lower in 1997 than 10 yr earlier. The 2-mile run times of the 1998 recruits were not different than those reported for 1997 recruits, confirming Knapik et al.’s (12) findings. The fact that the maximal aerobic power of the 1998 recruits was equal to or greater than the 1978 recruits is somewhat surprising, as \( \dot{V}O_2 \text{max} \) and 2-mile run times are reported to be highly correlated \((r = -0.76 \text{ to } -0.91)\) (11,19). In the 1998 sample, the correlation was \( r = -0.71 \) \((P < 0.01)\).

The 2-mile run test is a field performance test. It is less reproducible than a \( \dot{V}O_2 \text{max} \) test and can be influenced by environmental conditions, the method and location of test administration, course conditions, and the personnel conducting the test. Although aerobic power is an important component of the test, individual differences such as motivation and running experience can play a significant role in run times (20). Some recruits are not experienced runners and may not be able to pace themselves or tolerate exercise-induced discomfort. The \( \dot{V}O_2 \text{max} \) tests in 1978 and 1998 were conducted under controlled laboratory conditions, are reliable (test-retest reliability is \( r > 0.95 \) (J. F. Patton, personal communication)), and provide a superior method.
for examining differences in aerobic fitness across samples than does the 2-mile run test.

Unlike previous samples of recruits, those entering basic training in 1998 were required to pass a physical fitness screening test before they began training. Since this was not the case for the previous samples, the least fit recruits may have been underrepresented in the 1998 sample. Although the push-up and sit-up tests measure upper-body and abdominal muscular endurance, they may be considered tests of muscle strength for individuals who are too weak to perform one repetition. The maximum muscular strength measures reported here were not correlated with sit-ups (range: men, $r = 0.04 - 0.14$, women; $r = -0.06 - 0.06$) and only mildly correlated with push-ups (range: men, $r = 0.21 - 0.35$; women, $r = 0.05 - 0.19$ [214 required for significance at the $P < 0.05$ level]). The measure most likely to have been affected by the loss of volunteers is aerobic capacity. Of those who volunteered to participate in the 1998 study, it is estimated that six women and five men did not participate because they failed the physical fitness screening test run. It is felt that this small number is not likely to have significantly affected the means.

Other variables that may have affected group comparisons are smoking history, racial distribution, and differences in test methodology and equipment. In the 1998 sample, 52% were nonsmokers, 23% had quit smoking (most within the previous 6 months), and 23% were smokers. The prevalence of smoking for the previous groups was not recorded; however, the prevalence of smoking has decreased substantially Army-wide from 51% in 1980 to 30% in 1998 (4). Smoking has been banned in basic training since 1987, so none of the 1998 sample were smoking within $48$ h of testing. During 1978, soldiers were required to refrain from smoking for $2$ h before testing. Therefore, the acute effects of smoking, which last about $25$ min (18), would not have affected the results of either the 1978 or 1998 $\dot{V}_{O_2\text{max}}$ test. The chronic effects of smoking are not likely to have affected the outcome of the $\dot{V}_{O_2\text{max}}$ test either, as this is a young population (mean age, $21.6$ yr). Using the same treadmill protocol as Patton et al. (21), it has been shown that $\dot{V}_{O_2\text{max}}$ in young soldiers (mean age, $22$ yr) was not affected by smoking status (6). This was also true in the 1998 sample, as there was no significant difference in the $\dot{V}_{O_2\text{max}}$ of smokers and nonsmokers.

The data in Table 1 suggest there may have been racial differences among the samples measured in 1978, 1983, 1993, and 1998. The percentage of black men and white women ages $17-25$ in the Army appears lower, whereas the percentage of soldiers classified as “other” appears higher in 1998 versus 1978. There are reports that black adults (25) and adolescent girls (22) have a lower capacity for aerobic exercise than their white counterparts. In a large sample of soldiers (964 males, 238 females) tested using the same continuous treadmill protocol as the 1998 study, the effect of race on $\dot{V}_{O_2\text{max}}$ was not significant (9). In the 1998 sample, there was no significant difference in relative $\dot{V}_{O_2\text{max}}$ attributable to race in men. It is possible that the lack of change in aerobic fitness in men from 1978 to 1998 was affected by a decrease in the distribution of black men, but the lack of a significant race effect in both a previous sample (9) and in the 1998 sample of men would tend to refute this. The $\dot{V}_{O_2\text{max}}$ of black women ($36.4$ mL·kg$^{-1}$·min$^{-1}$) was $9.5\%$ less than that of white women ($40.2$ mL·kg$^{-1}$·min$^{-1}$, $P < 0.05$) and $14\%$ less than that of Hispanic women ($42.5$ mL·kg$^{-1}$·min$^{-1}$, $P < 0.05$) in the 1998 cohort, but the percentage of black women in the Army has not changed appreciably since 1980. There was no significant difference in $\dot{V}_{O_2\text{max}}$ between white and Hispanic women, so an increase in Hispanic women and decrease in white women in the 1998 sample should not have greatly affected the sample comparison.

Changes in the racial distribution of the Army may also have affected the body composition comparisons. The data of Fitzgerald et al. (9) seem to indicate that white males (%BF, 17.4%) and Hispanic males (%BF, 18.2%) have a greater %BF than black males (%BF, 15.4% as estimated using skin folds), but the statistical significance of these differences was not reported. As the percentage of Hispanic males has increased and the percentage of black males has decreased over time, this may account for some of the increase in %BF seen from 1978 to 1998. The Fitzgerald et al. (9) data also show the same relationship among women, with white (%BF, 26.2%) and Hispanic (%BF, 26.1%) women tending to have greater %BF than black women (%BF, 24.0%; statistical significance of difference not reported). Because the percentage of black females has not changed greatly over time, changes in racial distribution are not likely to have affected the outcome of the body composition comparison in women. In the 1998 data, there were no significant differences in %BF attributable to race in men or women.

As mentioned in the Methods section, there were some differences in the $\dot{V}_{O_2\text{max}}$ testing methodology and equipment used for the 1978 study and the 1998 study. An interrupted protocol with $2.5\%$ grade increments was used in 1978, whereas a continuous protocol with $2\%$ grade increments was used in 1998. The differences between similar treadmill running protocols have been shown to be small, with an interrupted test producing slightly greater results (18). In 1978, a Douglas bag system was used, as opposed to the on-line system used in 1998. To compare these systems, a small group of subjects ($N = 9$) running at various intensities (warm-up through maximal) were switched back and forth between the Douglas bag and on-line systems. There were significant correlations between the two systems for $\dot{V}_O_2$ ($r = 0.99$, $P < 0.01$) and $V_{\text{E}}$ ($r = 0.99$, $P < 0.01$), and the mean differences were small ($\dot{V}_O_2$, $0.05$ L·min$^{-1}$, $0.83$ mL·kg·min$^{-1}$; $V_{\text{E}}$, $0.83$ L·min$^{-1}$). These data suggest that the differences in protocol and equipment would have only a minimal effect on the differences in maximal oxygen uptake between 1978 and 1998.

There were several positive findings. These data show that recruits entering basic training in 1998 were as aerobically fit as those entering $20$ yr previously, and women had a greater aerobic capacity. The muscle strength of recruits was as good or better than it was $15-20$ yr previously.
Although the body weight, %BF, and FFM of 1998 recruits was greater than recruits measured 15–20 yr earlier, the benefit of enhanced occupational task performance attributable to increased FFM may overcome the drawback of having a greater body weight and %BF.

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