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Body Fat Standards and Individual Physical Readiness in a Randomized Army Sample: Screening Weights, Methods of Fat Assessment, and Linkage to Physical Fitness

Guarantor: LTC Karl E. Friedl, MS USA
Contributors: LTC John R. Leu, MS USA*; LTC Karl E. Friedl, MS USA†

Body fat standards have been used by the military services since the early 1980s to prevent obesity and motivate good fitness habits. The Army Weight Control Program has continued to undergo evaluation and incorporate improvements based on emerging scientific findings. Recently drafted revisions of Department of Defense-wide procedures address issues of consistency and validity raised by external oversight groups. This study evaluated the impact of three proposed refinements of the Army Weight Control Program. Anthropometric measurements and fitness test performance were obtained in a randomized sample of 1,038 male and 347 nonpregnant female soldiers at three Army posts. Of this sample, 11% of men and 17% of women were overweight and overfat; 6.3 and 9.8%, respectively, were currently on the Army Weight Control Program. Screening weight tables that ensure women are not inappropriately striving to meet weights more stringent than "healthy" weight (i.e., body mass index < 25 kg/m^2) still correctly identified all women for evaluation for the age-specific body fat standards. Body fat estimation using more valid DoD body fat equations that include an abdominal circumference for women reduced the number of female soldiers currently classified as exceeding fat standards, coincidentally resulting in a comparable prevalence of male and female soldiers over the fat standards (12%). A body fat allowance for young soldiers who scored very well on the physical fitness test could have benefited one-fourth of the soldiers exceeding fat standards and acknowledges biological variability in body fat thresholds. Whereas this linkage may motivate fitness habits, it complicates enforcement of reasonably achievable body fat standards. The proposed changes in fat screening and measurement methods are appropriate, but the impact to health and physical readiness of the Force cannot be accurately predicted or measured because of the absence of comprehensive baseline data and tracking mechanisms.

Introduction

Body fat standards have been used by the military services since the early 1980s to prevent obesity and motivate good fitness habits.[1-3] The specific objectives of the Army Weight Control Program (AWCP) are to ensure combat readiness and good military appearance. Long-term health has never been a major objective of this regulation; however, health endpoints have been heavily relied on to set body fat standards because these criteria are better defined than physical performance or appearance outcomes.[1] The military services moved ahead of the civilian community when they adopted a body fat standard to replace previous body weight standards. While body weight (preferably expressed as a body mass index (BMI), reflecting proportional body size) and body fat are correlated, this change allowed the military to protect big lean individuals and specifically target big fat individuals. National health goals now also include consideration of regional body fat placement, in the form of an abdominal girth.[4] Abdominal girth is central to the body fat estimation procedures that are in place or currently being considered for all the military services. The AWCP has continued to undergo evaluation and improvements to ensure that the procedures best serve readiness objectives. The purpose of this study was to evaluate the impact of three modest adjustments that have been proposed to further improve the Army regulation.

Body fat standards were revised with an increase of 2% body fat for women in 1995 because the existing standards were overly stringent for women and may have contributed to inappropriate weight loss attempts.[5] Weight-for-height screening tables were to be adjusted as well but have so far only been implemented for Army standards for accession of new recruits.[6] The purpose of the Army screening weight tables is solely to identify individuals who may be overfat; overweight individuals are then measured for body fat to determine whether or not they are in compliance with the AWCP. Although body fat standards are intended to protect large muscular individuals from inappropriate weight loss, many soldiers strive to meet screening weights to avoid a perceived stigma associated with having to be assessed for body fat. This is especially true in the Army where height and weight is recorded directly on annual evaluation reports and noted by promotion boards. Thus, screening weights have an impact on weight loss attempts. If set too low, these weight goals may encourage disordered eating and other health habits that impair rather than promote physical and medical readiness.

Public health and scientific advances support upward revision of the Army female screening weights. New national guidelines based on review of health epidemiological studies have adopted more stringent healthy weight thresholds of 25 kg/m^2 as the desirable goal for all U.S. citizens (thresholds for underweight were set at 18.5 kg/m^2).[7] This goal for a healthy weight is currently achieved by fewer than one-half of adult men and women in the United States.[8] These values (25 kg/m^2) are the screening weights currently in place for only the oldest age category of women in the AWCP; all younger women are screened as overweight at more stringent weight limits (there are

*Fort Bragg Office, U.S. Army Research Institute of Environmental Medicine, Natick, MA 01760-5007.
†Military Operational Medicine Research Program, U.S. Army Medical Research & Materiel Command, Frederick, MD 21702-5012.
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Reprints: LTC Karl Friedl, P.O. Box 1779, Frederick, MD 21702; e-mail: karl.friedl@det.amedd.army.mil.
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four age categories in the AWCP weight screen and fat standards). The weights for the youngest age category of Army women are currently the most stringent of all the military services, including the Marine Corps.

The same weight screening standards recommended for women are not appropriate to male soldiers who are substantially larger relative to male body fat standards than female soldiers are relative to female fat standards. Furthermore, soldiers participating in regular physical training are more likely to maintain a higher lean mass than the average U.S. population, and this would be expected even more in male than female soldiers because of normal androgen potentiation of muscle hypertrophy. The regular exercise habits of soldiers can also be reasonably expected to reduce disease risks for a given weight, compared with the populations upon which the healthy weight thresholds have been based.[9] The Department of Defense (DoD)-recommended age-independent screening weight-for-height threshold of 27.5 kg/m^2 is based on the highest reasonable limit that still falls within previous medical risk thresholds for men (this was based on the 85th percentile of BMI for young adults in a previous National Health and Nutrition Examination Survey). Although this limit falls in the range now defined as "overweight" by national medical standards, it is well below the limit that defines "obese" (30 kg/m^2). Most importantly, a BMI of 27.5 kg/m^2 misses relatively few male soldiers who are overfat, as indicated by the data in this current study and supported by the findings of a Navy study conducted nearly 20 years ago.[10]

At the request of the DoD, the Institute of Medicine conducted a review of individual readiness regulations concerning women and arrived at several important conclusions that triggered the current discussion.[11] First, there was relatively little scientific data on which to base any age-related weight limits. They recommended that all women be screened for the healthy weight threshold of 25 kg/m^2. Second, they proposed a novel approach to the issue of a sliding scale for body fat standards, recommending a linkage to performance on fitness testing. This addressed several concerns about the absence of a warning zone when soldiers suddenly exceed their body fat limit, the variability of body fat measurements (biological and procedural), and the misperception that health and performance thresholds can be attached to a precise level of body fat.

The DoD has recently drafted revised procedures to improve consistency across services and address issues of validity raised by external oversight groups and agencies, including the Defense Advisory Committee on Women in the Services,[12] the Government Accounting Office,[13] and the Institute of Medicine.[11] Three recommendations from discussions related to improvements of the current procedures have significant impact on current Army procedures and required closer examination for: (a) the suitability of a screening weight at 25 kg/m^2 for all women and a higher threshold of 27.5 kg/m^2 for all men; (b) the effect of adopting one set of equations across the DoD, replacing current Army equations to assess body fat in men and women; and (c) the impact of linking good performance on fitness testing to a sliding body fat standard for currently overfat young men and women. This study was conducted to evaluate the impact of these proposed changes for the AWCP.

Methods

Human Subject Protection and Sample Characterization

This study was conducted in accordance with AR 70-25 (Use of Human Subjects in Research) and approved by the Human Use Research Committee at the U.S. Army Research Institute of Environmental Medicine, Natick, Massachusetts.

Subjects were 1,043 male and 347 nonpregnant female subjects obtained in October and November 2000 from three Army posts: Fort Bragg, North Carolina; Fort Leonard Wood, Missouri; and Fort Jackson, South Carolina. New recruits were excluded from the sampling. The sample consisted of a representative combination of soldiers from the combat arms, combat support, and combat service support branches. Most of the subjects were recruited from soldiers reporting for random drug testing. Additional subjects were randomly selected from unit rosters with an over-sampling of women to obtain greater representation of female soldiers (25% of the sample instead of the current 15% Army-wide).

Soldiers were asked for age, gender, current and prior enrollment in the AWCP, and current medical profile. Female soldiers were asked about current and prior pregnancy status. Female soldiers currently identified as pregnant were excluded from the study.

Anthropometric and Physical Fitness Data Collection

Measurements were obtained for height and weight using stadiometers and electronic scales that were calibrated daily using standard weights. For men, neck and abdominal (at the level of the navel) circumferences were measured in accordance with directions in the Army regulation.[14] For women, neck, forearm, wrist, and hips were measured also in accordance with the Army regulation; in addition, the waist (thinnest portion between ribs and hips) was measured as prescribed in the Navy instruction.[14] Measurements were made with ¼-inch nylon tapes.

Army Physical Fitness Test (APFT) test component raw measures, and scores were obtained for each subject from unit records of the most recent APFT taken within the last 6 months, or they were recorded as on medical profile as appropriate. These scores were presented at the time of data collection.

Data Analysis

Percent body fat for the current Army methods[14] and proposed methods[15] was calculated using these formulas (using inches and pounds):

Men (Current)

$$\%\ \text{body fat} = 76.46 \times \log(\text{abdominal circ} - \text{neck circ}) - 68.68 \times \log(\text{height}) + 46.89$$

Men (Proposed)

$$\%\ \text{body fat} = 86.01 \times \log(\text{abdominal circ} - \text{neck circ}) - 70.04 \times \log(\text{height}) + 36.76$$

Women (Current)

$$\%\ \text{body fat} = (0.44 \times \text{hip circ}) + (105.33 \times \log(\text{weight})) - (1.31 \times \text{height}) - (3.99 \times \text{forearm circ}) - (1.35 \times \text{neck circ}) - (0.51 \times \text{wrist circ}) - 71.76$$

Women (Proposed)

$$\% \text{ body fat} = 163.21 \times \log(\text{waist circ} + \text{hip circ} - \text{neck circ}) - 97.68 \times \log(\text{height}) - 78.39$$

Data were analyzed using a commercially available statistical software (SPSS 8.0, SPSS, Chicago, Illinois). Unless specified, analyses involving percentage body fat in this report are based on the proposed rather than the current Army body fat equations. The proposed equations are those currently used by the Navy and Air Force. The same measurement sites are used in the Marine Corps equations but with slightly different coefficients.

Results

Current Soldier Weight and Fat Status

Of 1,043 male soldiers, 400 (38%) were overweight and 112 (11%) also exceeded current fat standards. Of 347 female soldiers, 194 (56%) were overweight and 58 (17%) also exceeded current fat standards. Only 13 (1%) men and 2 women were below the weight screening tables and exceeded fat standards; therefore, the current screening weight tables missed very few individuals that would have been identified if all soldiers were measured for body fat.

Of the total sample, 66 (6.3%) of the men and 34 (9.8%) of the women reported that they were currently on the AWCP. However, only 35 of these men and 24 of the women were measured as both overweight and overfat in this study, suggesting that some had met their standards. Others exceeded fat standards but were not on the AWCP; less than one-half of the men (31%) and women (41%) actually measured as overweight and overfat were currently enrolled in the AWCP. Many of these individuals were only a few pounds over the screening weight tables and probably ensure that they do not exceed weight limits at the regularly scheduled semiannual weigh ins.

Of all female soldiers assessed, 191 (55%) had been pregnant. These women were older on average (29.0 ± 6.3 years) than never-pregnant soldiers (25.2 ± 7.0 years; t test; $p < 0.01$) but were not different in terms of their current body fat (29.0 ± 4.8% versus 28.1 ± 4.7% for never-pregnant women).

Relationship between BMI and Percent Body Fat

Men had a higher average BMI than women (Table I) even though they were less likely to exceed their body fat standards. Only 40% of men, compared with 60% of women, were under 25 kg/m^2; nearly one-third (31.5%) of men exceeded 27.5 kg/m^2 compared with 16% of women. Few male and no female soldiers who were below a threshold weight screen of 25 kg/m^2 exceeded the most stringent body fat standards of 20% (men) and 30% (women) that are applied to the youngest soldiers (Fig. 1). This indicates that the current screening weights for all female soldiers could be adjusted to this limit without overlooking any significant proportion of overfat women (Fig. 1). Above this limit, the proportion of female soldiers exceeding their fat standards (using the proposed DoD equation) rose rapidly with 12% of women between 25 and 27.5 kg/m^2 overfat. For men, the relationship between BMI and adiposity (percent body fat) is less clear cut because of a greater range and variability of muscle mass. A significant proportion of men (28%) fell into the BMI range between 25 and 27.5 kg/m^2 but only 4% of men in this range were overfat (Fig. 1).

TABLE I

AVERAGE BMI, PERCENT BODY FAT BASED ON CURRENT ARMY EQUATIONS AND PROPOSED DOD EQUATIONS, AND ABDOMINAL CIRCUMFERENCES BY AGE CATEGORIES AND GENDER

	Male Soldiers			Female Soldiers		
Age Category	Limit	Mean (SD)	Range	Limit	Mean (SD)	Range
BMI (kg/m^2)						
<21 years	25.9	24.25 (2.77)	(18.66–33.20)	22.9	23.24 (2.71)	(18.24–32.15)
21–27 years	26.5	25.88 (3.46)	(17.62–36.17)	23.5	24.25 (3.25)	(18.76–39.89)
28–39 years	27.2	26.94 (3.11)	(19.01–36.03)	24.3	25.22 (3.15)	(18.50–35.60)
40+ years	27.5	26.86 (3.04)	(19.83–34.70)	25.0	25.46 (2.55)	(20.17–29.49)
Relative body fat based on current Army equations (%)						
<21 years	20	14.2 (4.7)	(3–27)	30	26.9 (4.7)	(19–36)
21–27 years	22	16.6 (5.3)	(2–32)	32	28.2 (4.5)	(18–47)
28–39 years	24	18.8 (4.6)	(5–31)	34	29.5 (4.9)	(18–41)
40+ years	26	19.7 (4.2)	(10–26)	36	31.1 (3.6)	(24–36)
Relative body fat based on proposed DoD equations (%)						
<21 years	20	13.3 (5.3)	(1–28)	30	21.6 (6.8)	(8–35)
21–27 years	22	16.0 (5.9)	(0–33)	32	24.0 (7.0)	(10–46)
28–39 years	24	18.5 (5.1)	(2–32)	34	27.0 (7.4)	(6–46)
40+ years	26	19.5 (4.7)	(8–26)	36	29.5 (6.2)	(19–40)
Abdominal circumference (cm)[a]						
<21 years	—	80.6 (7.0)	(62.9–100.3)	—	70.6 (6.2)	(59.7–89.8)
21–27 years	—	85.1 (8.8)	(66.0–115.6)	—	72.6 (7.7)	(57.8–97.8)
28–39 years	—	88.6 (7.9)	(65.4–110.5)	—	75.9 (7.7)	(58.4–101.6)
40+ years	—	89.4 (7.8)	(72.8–104.1)	—	76.8 (7.8)	(63.5–94.6)

[a] Measured at navel for men and narrowest portion of the waist for women; National health limit guidelines for abdominal girths are 102 (men) and 89 cm (women).

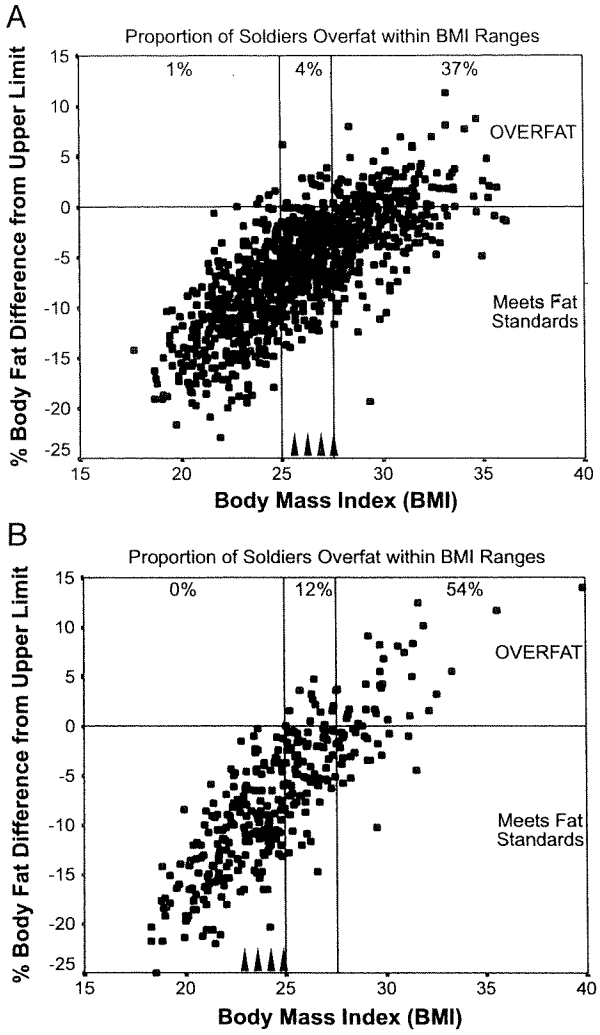

Fig. 1. Distribution of male (a, top) and female (b, bottom) soldiers for BMI and proximity to age-specific body fat standards; 60% of men and 40% of women exceeded a BMI of 25 kg/m². Markers on the BMI axis indicate current screening weight ranges as shown in Table I.

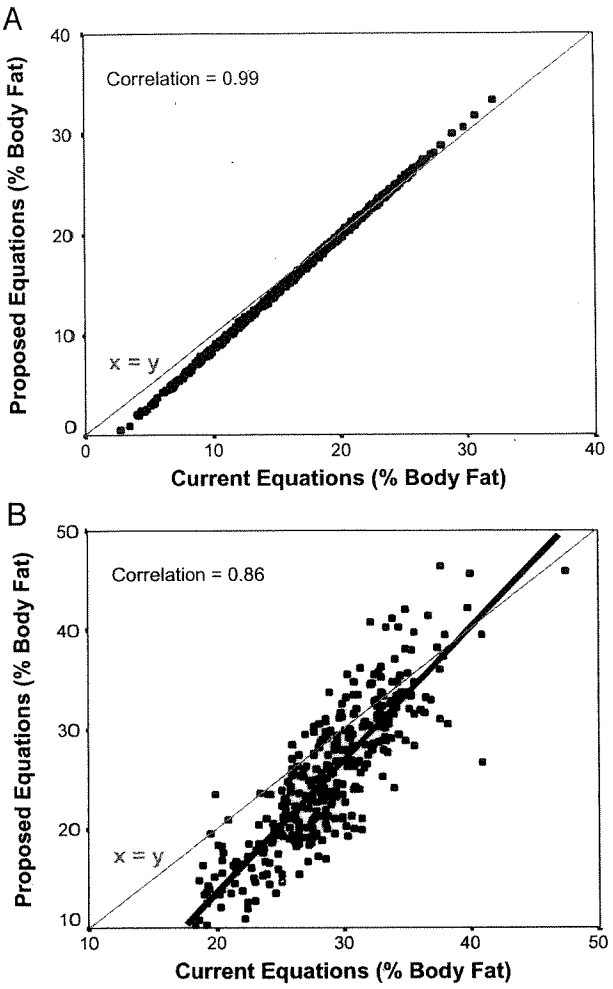

Fig. 2. Relationship between current Army equations and proposed DoD equations used to predict percent body fat for men (a, top) and women (b, bottom). The male equations are very similar, relying on the same measurement sites, whereas the female equations use different sites and coefficients.

Relationship between Current Army and Proposed DoD Equations

The current and proposed male equations had a high correlation ($r = 0.99$) with slightly lower values produced by the DoD equation, as reflected by mean values in Figure 2. The female equations, which involve different measurement sites, produced a good correlation ($r = 0.86$) but had large differences for some individuals (Fig. 2). For soldiers near and below the body fat limits, the mean values produced by the proposed DoD female equation tended to be lower than those of the current Army equation. Using the proposed DoD equation for women reduced the percentage of women classified as overweight and overfat from 17.0% to 12.1%. Thus, the DoD equations, which have the greater scientific validity, yield overfat prevalences that are comparable between male (11.0%) and female (12.1%) soldiers. The new equation for men, which has only minor differences in coefficients, produced no significant change in classification of male soldiers.

Abdominal circumferences averaged 84.0 ± 7.4 cm ($N = 900$) and 98.4 ± 4.7 cm ($N = 138$) for men within their fat standards and overfat men, respectively; for women, waist circumferences averaged 71.9 ± 5.9 cm ($N = 305$) and 86.9 ± 6.5 cm ($N = 42$). No women and very few men who were within current body fat standards exceeded health threshold abdominal measures of 35 inches (89 cm) for women and 40 inches (102 cm) for men. This provides further evidence that the methods of estimating body fat and the current body fat standards are appropriately calibrated to health goals.

Relationship between APFT Scores and Percent Body Fat

Female soldiers were more likely to have current medical profiles that excused them from participating in physical training (5%) than male soldiers (1.3%). Scores obtained from the portion of the sample that did have a current APFT were analyzed to determine performance at higher levels of adiposity. These data demonstrated that some male and female soldiers in the range of 20 to 26% and 30 to 36% body fat, respectively, scored well on the APFT (Fig. 3). One-fourth of male soldiers exceeding fat standards scored at least 270 points on the APFT (Fig. 4). This represented 2.6% of all men in the sample, which

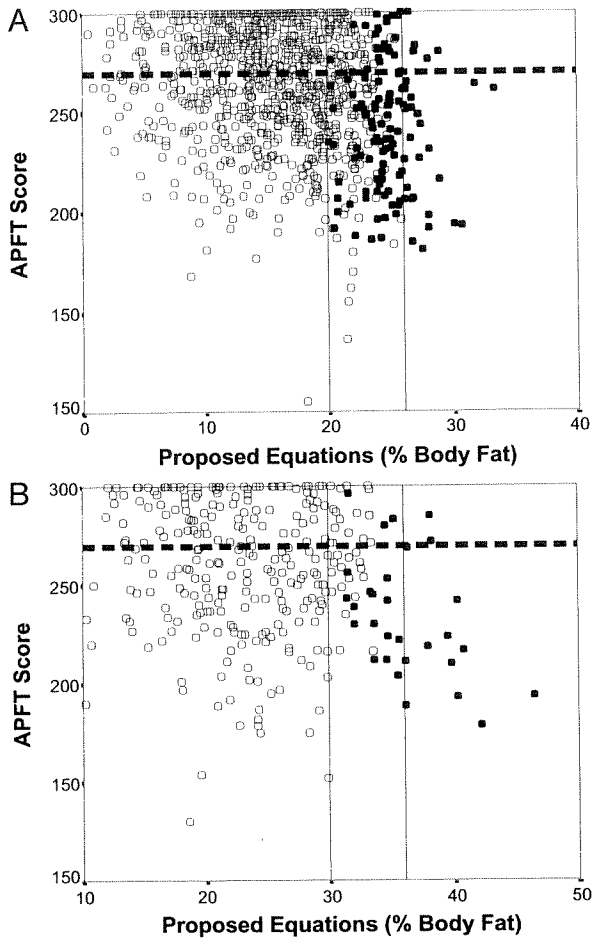

Fig. 3. Distribution of male (a, top) and female (b, bottom) soldiers for percent body fat (predicted by DoD equations) and score on the APFT. Filled circles denote soldiers exceeding their age-specific fat standards.

would translate to an estimated 10,500 active duty male soldiers. The smaller sample of women indicated the same trend with 12 of 51 women exceeding body fat standards also having recent APFT scores exceeding 270 points. There was no attempt to study the relationship between body fat and performance on individual APFT components, as this has been well studied and was not the objective of this study. The overall APFT score is the Army's current indicator of physical fitness status.

Discussion

Soldiers are only slightly lighter than the general U.S. population; however, they are held to percent body fat standards that are approximately the mean body fat of the U.S. population compared by age.[16] The data in this study indicate that the AWCP is successfully holding the line against the growing prevalence of obesity in the general population while protecting those large soldiers who carry greater lean mass. Military fitness requirements, however minimal these appear to well-conditioned individuals, motivate every soldier to some level of physical activity that is not required of the average U.S. citizen. It is reasonable to expect that soldiers possess a measurably higher average lean mass (i.e., higher BMI relative to body fat) than the U.S. population, of which a large proportion is entirely sedentary.

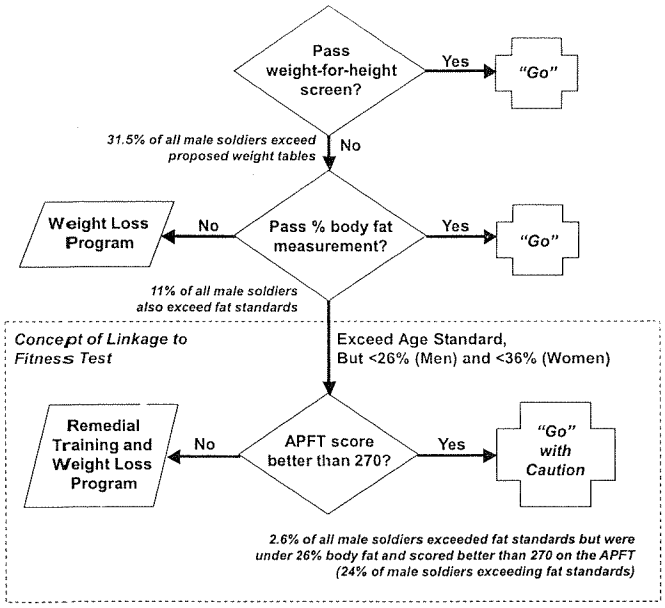

Fig. 4. Flow chart of current AWCP evaluation and proposed linkage to the APFT. Prevalence data for male soldiers from this study are shown on the chart.

These data confirmed that the proposed changes to the AWCP could improve identification of the individuals who most need to modify nutrition and exercise habits and ensure protection of good performers. Current weight standards for female soldiers that are far more stringent than the recognized threshold goal for healthy weight (i.e., BMI of 25 kg/m^2) should provoke concerns about impairment of readiness with inappropriate weight loss requirements. There is no basis for more stringent weight tables for women. The original intent of the tables was to identify those who are likely to exceed body fat. This study demonstrates that an age-independent weight screen set at a BMI of 25 kg/m^2 may serve the intended purpose of identifying female soldiers who are likely to exceed their body fat standards. Easing the current weight tables for all soldiers to the least stringent weight limits (currently applied to age $\geq$ 40 years) may lead to some increase in the average weight of female soldiers. However, the important benefit will be to relieve the stress of an inappropriately stringent limit that leads to frustration in weight management and may promote unhealthy attempts to lose weight.

An alternative to elimination of age-specific weight categories would be to retain current age categories for women and provide increases starting at 25.0 kg/m^2. Based on the data in this sample, age category increments of approximately 0.3 kg/m^2, with the oldest age category screened at ~26 kg/m^2, would permit detection of nearly all female soldiers who exceed the fat standards. This would maintain consistency in weight screening procedures for men and women (retaining current male weight screening tables) and further reduce the number of female soldiers unnecessarily measured. This should be further tested.

The advantages of the DoD equations for male and female body fat measurement have been extensively explored in previous studies.[15,17-19] In general, these equations developed by James Hodgdon at the Naval Health Research Center, have the greatest scientific validity, and they are best suited to military objectives because of their emphasis on the abdominal girth. The greatest differences have been in the measurement of fe-

male body fat, and Defense Advisory Committee on Women in the Services has previously questioned the justification for service differences requiring four very different approaches to the estimation of body fat.[12] The Army is the only service now at variance with the method adopted by the other services.

The purpose of the comparison here was to determine the impact of the adoption of the Hodgdon equations on the AWCP. The data demonstrate that fat estimates for individuals could change in either direction, but overall, there would be a trend to lower body fat estimations, and some individuals would be moved off the AWCP. Thus, application of a slightly better equation would tend to benefit soldiers currently at or over their standard.

The most difficult aspect of the AWCP has been to produce an enforceable standard that takes into account the soft relationship between adiposity and health and performance outcomes. Precise thresholds are necessarily arbitrary in the face of methodological error, day-to-day biological variability, and the imprecise and graded relationship to health and performance outcomes. The wider range of body fat limits currently applied to different age groups (20–26% for men and 30–36% for women) is defensible. The upper limit of body fat that approximately bounds 95% of the normal range for healthy and fit young men and women is 20 and 30%, respectively. For young male soldiers, 20% body fat also equates to a desirable level of aerobic capacity, averaging 50 mL of oxygen uptake per killigram of body weight per minute with a sharp decline occurring with increasing adiposity.[20] The best current estimates of body fat thresholds for increased health risks are approximately 26 and 36% for men and women, based on various extrapolations from BMI data.[17,21] Similar threshold values can be derived using average soldier height, neck, and hips (for women) values in the Hodgdon equations, and health threshold guidelines for abdominal circumferences (35 and 40 inches for men and women, respectively).[4,6]

The Institute of Medicine recommended a caution zone encompassing this range of body fat that could be linked to fitness test performance. The concept of a warning zone was incorporated into a distinctly separate concept of trying to accommodate fit soldiers who exceed body fat standards. This latter concept is justified in terms of health risk outcomes, which may be mitigated at higher adiposity by the physical activity required to maintain physical fitness. Nevertheless, health is not a primary objective of the AWCP, and body fat standards are not good predictors of aerobic capacity or muscular strength; they only help to motivate fitness habits and prevent obesity (where aerobic fitness would be clearly handicapped). While aerobic fitness is inversely correlated with body fat, strength is even more important to soldier task performance and is not associated with body fat.[17,20,22]

One-quarter of male soldiers exceeding their fat standards had excellent fitness test performance (270 points or better). These data indicate that providing a caution zone within the range of age-related body fat limits with linkage to performance on the APFT could benefit many fit but higher fat soldiers. An expected fringe benefit of this approach would be to increase motivation of overweight soldiers to exercise to try to gain the benefit of a higher body fat allowance instead of engaging in inappropriate weight loss behaviors that impair readiness.[23,24] However, this additional classification combining fitness habits (as indicated by body fat) and capabilities (as indicated by the three-event APFT) makes a good theoretical concept but an exceedingly complicated administrative challenge. It will also be perceived by some of the force as just another loophole to excuse some soldiers from maintaining reasonably achievable body fat standards. Performance in most Army jobs requires strength more than aerobic fitness; providing a break to some fit fat soldiers does nothing to help some of the best performers of critical Army tasks, strong fat soldiers. Fat standards and fitness standards have different purposes and cannot be easily combined, even though they are both ultimately intended to ensure individual soldier readiness.

In summary, this study provides data that help to evaluate each of three changes suggested by the proposed DoD directive and other recent external reviews. The actual effect of a change in measurement or screening methods on soldier health and readiness cannot be readily predicted because of uncertainty in behavior, acceptance, and enforcement. This is likely to remain unknown in the absence of comprehensive baseline data and weight management and fitness surveillance. Separate research efforts to improve guidance and assistance to soldiers on weight loss and weight maintenance are being planned with the assistance of the Institute of Medicine and with the Pennington Biomedical Research Center (Baton Rouge, Louisiana).

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