BRIEF REVIEW

BODY COMPOSITION AND MILITARY PERFORMANCE—MANY THINGS TO MANY PEOPLE

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ABSTRACT

Friedl, KE. Body composition and military performance—Many things to many people. J Strength Cond Res 26(7): S87–S100, 2012—Soldiers are expected to maintain the highest possible level of physical readiness because they must be ready to mobilize and perform their duties anywhere in the world at any time. The objective of Army body composition standards is to motivate physical training and good nutrition habits to ensure a high state of readiness. Establishment of enforceable and rational standards to support this objective has been challenging even at extremes of body size. Morbidly obese individuals are clearly not suited to military service, but very large muscular individuals may be superbly qualified for soldier performance demands. For this reason, large individuals are measured for body fat using a waist circumference-based equation (female soldiers are also measured for hip circumference). The main challenge comes in setting appropriate fat standards to support the full range of Army requirements. Military appearance ideals dictate the most stringent body fat standards, whereas health risk thresholds anchor the most liberal standards, and physical performance associations fall on a spectrum between these 2 poles. Standards should not exclude or penalize specialized performance capabilities such as endurance running or power lifting across a spectrum of body sizes and fat. The full integration of women into the military further complicates the issue because of sexually dimorphic characteristics that make gender-appropriate standards essential and where inappropriately stringent standards can compromise both health and performance of this segment of the force. Other associations with body composition such as stress effects on intraabdominal fat distribution patterns and metabolic implications of a fat reserve for survival in extreme environments are also relevant considerations. This is a review of the science that underpins the U.S. Army body composition standards.

KEY WORDS body fat, physical activity, metabolism, chronic health, appearance

INTRODUCTION

Military and physical fitness trainers are keenly aware that specific types of physical performance are associated with specific body size and composition characteristics (24). An obvious example is the contrast between the massive musculature of a power lifter and the extreme thinness and leanness of a marathon runner. Body size, body composition, and military bearing (appearance) have always been important to the military because of real and perceived associations with physical performance capabilities (28). Despite associations, there is low specific predictive value of body size or composition to soldier performance within the wide range of healthy weights and adiposity (51). Nevertheless, it is reasonable to select against extremes of underweight and overweight where health and performance has a high probability of compromise, but this still bounds a large range of body size and composition, comprising a full spectrum of individuals that look like Vogue models, the fictional mesomorphic cartoon character “Sergeant Rock,” and fatter but extremely strong men. It is also reasonable to enforce body composition standards that drive fitness and nutrition habits, but these must be achievable by any motivated healthy soldier. These reasonably achievable standards of size and body composition must take into account factors such as genetics, developmental influences, selection, and the plasticity of the body to recent and habitual physical demands and other environmental factors (e.g., nutrition, health, neurobiology, and personal habits). The more recent inclusion of women in military services further complicates the issue because of sexually dimorphic characteristics that make “gender-appropriate” (rather than “gender-neutral”) standards essential to optimal health and performance of the force (29,120). This is a review of the basis for the U.S. Army body composition standards. The current U.S. Army screening weights and body fat standards are shown in Table 1.

The opinions and assertions in this article are those of the author and do not necessarily represent the official position or views of the Department of the Army or the Department of Defense.

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26(7)/S87-S100

Journal of Strength and Conditioning Research
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TABLE 1. Body mass index thresholds and percent body fat standards currently used by the U.S. Army (5,74).

<table>
<thead>
<tr>
<th>Age category (y)</th>
<th>Body mass index (kg m(^{-2}))†</th>
<th>Relative body fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;21</td>
<td>25.9</td>
<td>20</td>
</tr>
<tr>
<td>21–27</td>
<td>26.5</td>
<td>22</td>
</tr>
<tr>
<td>28–39</td>
<td>27.2</td>
<td>24</td>
</tr>
<tr>
<td>&gt;40†</td>
<td>27.5</td>
<td>26</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;21</td>
<td>25.0</td>
<td>30</td>
</tr>
<tr>
<td>21–27</td>
<td>25.3</td>
<td>32</td>
</tr>
<tr>
<td>28–39</td>
<td>25.6</td>
<td>34</td>
</tr>
<tr>
<td>&gt;40†</td>
<td>26.0</td>
<td>36</td>
</tr>
</tbody>
</table>

†The Army regulation uses tabled values rounded from these body mass index thresholds (AR 600-9).
‡The upper limits of body mass index permitted in the DoD instruction (DODI 1308.3, DoD Physical Fitness and Body Fat Programs Procedures, November 5, 2002) are 25–27.5 kg m\(^{-2}\) for both sexes. Permissible body fat standards are 26–36% for women and 18–26% for men. Other military services use different age categories and limits within the permissible ranges.

PURPOSE OF U.S. MILITARY OCCUPATIONAL WEIGHT AND BODY COMPOSITION STANDARDS

The purpose of military entry standards is to select recruits who will be able to meet soldier standards. In turn, soldier body composition standards are set according to the requirements of the Army, with general standards relevant to every individual regardless of their job assignment. These requirements include physical performance and military appearance and chronic health risk outcomes. Morbid obesity is negatively associated with each of these 3 broad categories (health, performance, military appearance), but more precise thresholds of risk at lower levels of obesity (overweight and overfat) require careful analysis and consideration of competing requirements (Figure 1). For example, the strongest Army women tend to carry more weight and fat and have a larger average waist circumference (WC) than do weaker women, increasing their risk for male-type health consequences such as cardiovascular disease (27,104). Thus, some superior performers may not have the lowest health risks. Imposing very strict body fat standards for an emphasis on military appearance is likely to compromise health and performance readiness by increasing disordered eating habits (80,81,96) and may eliminate individuals with other critical capabilities (e.g., some of the strongest soldiers). These are choices that have to be made, and it is important to clearly acknowledge the intent of the regulation that drives the standards. For the US military, the overall objective of enforced body composition standards is to promote regular fitness and nutrition habits that ensure a physically capable military force that is ready to deploy at any time.

ORIGIN OF THE DEPARTMENT OF DEFENSE BODY COMPOSITION STANDARDS

Height and weight and the combination, usually in the form of the Quetelet Index, or body mass index (BMI, kilograms per meter squared), has long been used in soldier selection criteria (26). Height-weight tables were already in use by the U.S. Army in the late 1800s, but the emphasis was on eliminating inadequately muscled sickly or chronically malnourished individuals. This focus on underweight shifted with improvements in nutrition and health over more than a century, as reflected in an average 30-lb lean mass increase in young soldiers compared between 1864 and 2000 (28). In the post-Vietnam era, overweight and obesity in career soldiers became the concern but height-weight table standards penalized large muscular individuals. As early as 1942, the military had recognized that muscular football players tested by underwater weighing would have failed to meet upper limits of Army height-weight tables that were in use at the time (123). Thus, weight tables were reduced to a screening tool and body composition assessment was adopted as the Army Weight Control Program standard for the US Army. This began in the 1980s, following a Department of Defense (DoD) Directive that all military services would set body fat-based weight control programs to promote fitness and prevent obesity in the military. The recommendations came from a symposium convened on June 17–19, 1980, by direction of the President because of a perception that the post-Vietnam era military was not maintaining adequate levels of physical fitness (114). Body composition standards became part of the discussion and recommendations for improving military physical readiness. To set rational standards, there was careful consideration of each of several outcomes related to body fat—physical strength, aerobic performance, military appearance, and chronic health. Several different types of data were used in the deliberations, with the ultimate conclusion in the supporting research article that average body fat of fit young men and women was around 15 and 25%, respectively (114,119). With consideration to a normal curve distribution in body composition, this suggested that desirable body fat limits for active young men and women should fall around 20 and 30%, for men and women. Individuals above this level would have to engage in remedial training and weight loss or be separated from the military. Body weight or BMI only started an individual into the process and body fat became the standard. The report recommended acknowledgment of an aging effect on body composition relationships to fitness, with additional leeway for older service members. These recommended thresholds ranged up to 37% body fat for the oldest age group of women (114).
Gender-appropriate, rather than gender-neutral, standards for body composition were established, recognizing fundamental endocrine physiology, and human sexual dimorphism. However, in the translation between the recommendations of the panel (114) and the DoD Instruction, there was an adjustment to tighten the women's standards. This was based on a prevailing misperception that, in terms of physical performance, women were basically men with too much body fat, and their performance might come closer to that of the male counterparts if they were held to leaner standards.

Screening weights and body fat standards were later amended in a revision of the Army Regulation and the DoD Directive to the original recommendations, based on data that showed how female soldier health and performance was impaired by inappropriately stringent body fat standards (5,34,38). There is clearly a weight penalty for additional sex-specific fat that affects running and marching performance (14). However, there is also a more enlightened understanding that female physiology has its own performance advantages, particularly in estrogen-regulated fat metabolism (59,111,112).

**Body Size and Strength Requirements**

In addition to the general body fat standards applicable to all soldiers, there are also physical standards specific to military occupational specialties (MOS). Previously, these were focused on strength requirements associated with specific tasks in the specialties such as ability to lift kettles of food and handle fire hoses (46). These MOS-specific standards have been revised over time and today include primarily height standards such as minimum heights for man portable field artillery system crewmembers (64") and maximum heights for armor crewmembers (73") based on human limitations of engineered systems. Earlier strength requirements were abandoned because it was recognized that specific thresholds for individual characteristics or capabilities were not defining limitations in military job specialties, especially considering the complexity of modern jobs and team efforts, and with changes in safety and efficiency offered by reengineering tasks and equipment.

This represents a significant shift in common perceptions that massive soldiers are the best soldiers and recognition that other soldier characteristics are at least equally important to mission success. Consistent with this thinking, the Army research investment has been in "skin-out" technologies such as exoskeletons and jet packs to provide Superman performance rather than attempts to produce an Army of massive soldiers through very narrow genetic selection or through genetic manipulation of myostatin or other musculotrophic regulators (30).

A large effort to classify job strength requirements and then classify eligible candidates by minimum strength capability with an upright lift test in the recruit processing centers failed because of testing safety concerns that reduced the rigor of the test and changed the results to job advisory guidance rather than requirements (67,113,121). The Assistant Secretary of the Army for Manpower and Reserve Affairs, Ms. Sara Lister, challenged Army researchers to find any conclusive evidence that physical strength had relevance to job selection criteria. This eventually led to a comprehensive study of one military job specialty (wheeled vehicle mechanics) to determine if body weight and strength measures were related to injury risk. Injuries provided a more quantifiable outcome measure than "job performance" and represented an aspect of military job performance. Wheeled vehicle mechanics were chosen because they have one of the highest injury rates for men and women. The results indicated that the leading cause of injuries was physical fitness training (notably, running), rather than job-specific mechanical work. Although the female soldiers were smaller and weaker on average than the males, men had the highest rates of traumatic injury and men with a higher BMI were at greater risk for sustaining an injury than the smaller men (66). The results of this study highlight the complexity...
of soldier physical demands and the difficulty in assigning specific physical strength or lean mass requirements for any MOS.

Nevertheless, many Army tasks involve a strength component, and minimum strength requirements are presumed to reduce injury rates (51,121). These strength requirements are addressed through semiannual physical fitness testing (push-ups and sit-ups) (115) and minimum weight recruitment standards. World War II data established the importance of body size, representing lean tissue, in work capacity and energy requirements (107). However, further precision in defining absolute strength (or related lean mass) requirements have not proven feasible. Current entry standards require a minimum BMI of 19 kg·m⁻², based on WHO classification of the lower limit of normal weight; severe thinness by WHO classification is 16 kg·m⁻², and 12 kg·m⁻² is approximately the lower limit for normal survival. Lower limits reflecting minimum muscle mass consistent with military performance are not a new topic. The 1919 evaluation of recruit standards by Love and Davenport noted that “Combatant forces have to move on their feet often great distances each day and carry a load of 40 pounds or more on the back. A man who weighs only 100 pounds (~BMI of 15 kg/m² for typical height of today’s soldier), however healthy and however strong he may be for his size, can rarely do this.” (76). Although strength performance (measured by incremental dynamic lift) has no association with percent body fat, many of the strongest soldiers are the largest soldiers and may carry considerable fat as well. The issue of applicability of body fat standards to a massively built soldier with extraordinary physical performance is raised with some regularity but the current Army body fat standards are not overly stringent, and they are the most liberal of the 4 military services. Using body fat standards rather than weight standards provides protection to the large but lean soldiers; for the oldest age group, body fat standards are pushed to the threshold associated with chronic health risks but not beyond this limit. These standards are more important to men than for women because of the greater variation in lean mass at the upper reaches of body size in men, and androgen-related function, whereas lean mass in young military women is not significantly associated with body size (Figure 2).

**DISTINCTIONS BETWEEN BODY SIZE, BODY FAT, AND ABDOMINAL FAT IN MILITARY STANDARDS: POT BELLIES ARE THE TARGET**

The method of assessment for body composition standards was dictated by the 1980 panel (“develop a circumference-based body fat assessment method”), based on the successful model of body fat enforcement in the U.S. Marine Corps using circumference equations (126–128). The wisdom of
this panel, which had to make recommendations with limited available data, has been borne out over the ensuing 3 decades. The move away from body size to a focus on abdominal circumference was ahead of its time (31,62,73,103). The insurance industry had long been predicting mortality risk from girth (44), but WC has since emerged as a key marker of many undesirable body composition-related outcomes. Abdominal circumference has also proven to be a practical method for widespread use by nontechnical users, and turning out to be superior to sophisticated state-of-the-art scientific methods of body fat assessment in regards to the outcomes of military interest. Specifically, a very accurate total body fat measurement is not nearly as important to the military standard as an abdominal circumference. The target of each of the outcomes of interest is intraabdominal fat. This is also one of the more labile fat depots under control of the service member through exercise and nutritional habits. Furthermore, the circumference-based method is blind to genetic variations in subcutaneous fat distribution elsewhere on the body making it fairer and not racially biased (28,71).

The U.S. military has a long investment in the area of body composition and performance. This includes early development of some of the body composition measurement technologies including underwater weighing, body water dilution, whole-body plethysmography, bioelectric impedance, caliper-measured skinfold thicknesses, and abdominal circumference (Table 2). It also includes a long history of initiatives and studies that were driven by national security issues. The criterion method against which the current military body fat equations were developed was underwater weighing (53,54), but this has since been revalidated in multiple studies using 3 and 4 compartment models using dual-energy x-ray absorptiometry (DXA) technology and methods of body water estimation (57,71,117). Each method of body fat estimation is based on factors and principals that make comparison between methods problematic. The most accurate assessments in living humans come from combining methods that measure specific chemical compartments such as body water, bone, fat, and everything else or additional elemental components (32,52). It must be reiterated that this greater accuracy in body fat estimation is not preferable to WC-based estimations for military body composition standards, for reasons discussed in the previous paragraph. The method is necessarily part of the standard and service members are not permitted to shop for a method that provides a lower estimate. Originally, each of the 4 military services had different circumference-based circumference methods that gave very different assessments because of the differences in measurement sites, especially for women where there are more choices for regional fat deposition (Figure 3) (42). Although the methods were applied consistently within each military service, the differences called into question the scientific basis of all of the standards and led to the adoption of a single best set of equations for men and women, the Hodgdon equations, developed by the Navy (43,53,54). The Defense Advisory Committee on Women in the Services demanded further investigation of the methodology with the goal of a single unisex equation for body fat prediction, but this yielded only poorer body fat prediction for both men and women (Hodgdon, J, unpublished results, 1996).

The performance of anthropometrically based equations in longitudinal studies has not been well established (64,130). The subcutaneous fat layer could be reasonably hypothesized to adjust to fat loss at a slower rate than the more labile intraabdominal fat stores; thus, skinfold thickness measurements could be less sensitive to change than an abdominal circumference. The WC-based military equations are relatively sensitive to changes in criterion-measured body fat for male and female soldiers during basic training and male soldiers during Ranger training (35,36,39,98). The Army regulation also takes into account the variability of the measurement error (±1% body fat), allowing for progress of overfat soldiers to be recognized by monthly changes in weight or fat changes of 1% body fat or more. This is different than the ±3% body fat error of the estimate compared with criterion methods, which is assumed not to be an additional error in monthly measurements of the same individual (27,37). Regardless of the actual reliability of fat changes assessed by WC (and hip circumference, for women), the standard is ultimately based on waist girth and not total body fat loss.

The circumference-based body fat standards have also been examined for their long-term effects on the population, but these effects are difficult to separate from national trends in weight gain. The average girth of male soldiers in their 20s increased by at approximately 2” (5 cm) between the start of the Army body composition standards enforcement in 1984 and a survey conducted in 2000; however, the impact of the existing weight control standards on limiting this increase could not be determined (28). For comparison, the WC of men aged 20–29 years in the U.S. population (measured at abdominal midpoint rather than the military standard of the umbilicus) also increased by approximately 2” between the 1988–1994 and 1999–2000 National Health and Nutrition Examination Survey survey (25). In U.S. and Finnish studies, there has been a trend for young soldiers to increase in BMI and body fat and for a decline in physical fitness levels (99,105). The older career soldiers remained unchanged and slightly below their upper limits of WC. Career soldiers were examined in a study at the U.S. Army Sergeants Major Academy (Fort Bliss, TX, USA) that compared circumference determined body fat and DXA measurements. Many older soldiers carried high total body fat as measured by DXA but maintained abdominal circumferences within standards for the Army body fat standards (28). This can be explained by some combination of the effect of exercise and nutrition habits on maintaining low abdominal girth relative to total body fat and earlier elimination of individuals.
Military Body Fat Standards

TABLE 2. Body composition technologies advanced by U.S. military research

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1864</td>
<td>Soldier Anthropometry and Physiology: Benjamin Apthorp Gould publishes soldier “health and vigor” statistics based on comprehensive measurements including anthropometry, lifting strength, and other physiological measures collected by field research teams from ~25,000 Union soldiers (47). Longitudinal health assessments of Civil War veterans are mandated by the Pension Bureau, producing data that are still mined today.</td>
</tr>
<tr>
<td>1918</td>
<td>Soldier Weight Balance and Caloric Requirements: LTC John Murlin defines the caloric needs of soldiers based on intake and weight balance studies of ~300 Army messes described a 9-lb average weight gain in recruits offered 4,600 Kcal·d⁻¹ and actually consuming &lt;4,000 Kcal·d⁻¹ (83,84).</td>
</tr>
<tr>
<td>1921</td>
<td>Anthropometric measurement methods: Davenport and Love analyze anthropometric and medical data on 2 million recruits (1917–1918) and 100,000 troops demobilized in 1919, establishing anthropometric methods and procedures still used in epidemiological surveys today (15).</td>
</tr>
<tr>
<td>1934</td>
<td>Biometric study of weight change and health risk: Reed and Love describe cardiovascular risk associated with long-term weight gain, based on study of 20-year annual medical exams of Army officers (95).</td>
</tr>
<tr>
<td>1942</td>
<td>Use of body density to estimate body fat:** LCDR Albert Behnke estimates body fat from body density, driven by the need to estimate body fat content for nitrogen calculations in diving medicine (proposed values for obesity corresponded to 17% body fat and waist circumference &gt;30” (7)).</td>
</tr>
<tr>
<td>1945</td>
<td>Use of body water to estimate lean mass:** In a 4-part publication, L.T. Nello Pace at the Naval Medical Research Institute, demonstrates the relationship of body water to fat and lean components and describes a tritium dilution method to predict fat and lean mass components (89).</td>
</tr>
<tr>
<td>1950</td>
<td>Correlates of Semistarvation and Refeeding in Healthy Men:* Landmark Minnesota Starvation Study commissioned by the Army Office of the Surgeon General characterized the nature and consequences of voluntary weight loss in healthy young men (loss of 24% of body weight in 24 weeks) and tested controlled refeeding regimens to optimize recovery of returning U.S. prisoners of war (83). This classic dataset is still being used to validate metabolic models.</td>
</tr>
<tr>
<td>1950s</td>
<td>Use of skinfold thickness as practical estimates of body fat: Multiple military studies in the 1950s investigate the use of skinfold thickness in estimating body composition; Army later adopts the Durnin and Womersley (18) equations as the interim body fat standard measurement method based on studies by Jim Vogel conducted with the UK military (33,118).</td>
</tr>
<tr>
<td>1954+</td>
<td>Use of x-ray to estimate soft tissue analysis: Stanley Garn funded by AFOSR to select optimal anthropometric measurement sites and compare skinfold to x-ray techniques for soft tissue analysis (40,41). Predecessor of dual-energy x-ray absorptiometry assessment of nonbone soft tissue components of body composition.</td>
</tr>
<tr>
<td>1959</td>
<td>Standardization of body composition methods:* National consensus conference hosted in 1959 at Natick Army Labs with the National Research Council established the basis and standardization of techniques for underwater weighing with correction of air-filled organs and assumptions about lean mass (8).</td>
</tr>
<tr>
<td>1960</td>
<td>Estimation of the density of tissues for multicompartment model estimates: Investigators at the Army Nutrition Laboratory compared methods of body composition analysis in soldier populations, including potassium 40 counting, water isotope dilution, and underwater weighing and were first to estimate the bone compartment for a 4-compartment model (2,70,122).</td>
</tr>
<tr>
<td>1963</td>
<td>Use of body plethysmography for dry assessment of density: Tom Allen, in research at Brooke Air Force Base, was the first to estimate body density using a plethysmographic system instead of underwater weighing, a predecessor to the “Bod Pod” (1).</td>
</tr>
<tr>
<td>1974</td>
<td>Body fat estimation from circumference-based equations in the DoD: Wright and Wilmore produce the first waist circumference–based equation for body fat estimation for the U.S. Marine Corps for practical estimation of body fat that improved on predictions from body weight or body mass index (128). The Navy develops equations that eventually become the DoD standard method (53,54); Army also conducts a major investigation of body composition (23).</td>
</tr>
<tr>
<td>1988</td>
<td>Use of bioelectrical impedance for estimation of body composition:** Jim Hodgdon and CPT Pat Fitzgerald are military participants in a team that explore the use of bioelectrical impedance in a major multicenter validation trial that resulted in one of the most frequently cited articles in body composition literature (101), with later studies in multicompartment models (13,55,117).</td>
</tr>
<tr>
<td>1990s</td>
<td>Studies of body composition change in military training: Dual x-ray absorptiometry and multicompartment model methods were employed to study semistarvation in Ranger students (35,36,59), in basic training and other special populations (39).</td>
</tr>
<tr>
<td>2005</td>
<td>Bone density and quality assessments with pQCT: LTC Rachel Evans organizes and leads a series of studies that extend bone mineral density measurements to measures of bone quality in soldiers using pQCT, including collaborative studies with the Israeli Defence Forces on stress fracture risk in physical training (22).</td>
</tr>
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*Studies cited with high frequency by other authors.
who are unable to meet body fat standards as measured by abdominal girth. Still to be determined is the impact of retirement and the large weight gain that appears to occur for a segment of soldiers in the first year of retirement from the military. This may be particularly important for restrained eaters who have carefully observed Army standards for 30 years of active duty and are suddenly relieved of these constraints (4).

Methods to cheat the tape measure have been observed and considered. Attempts to beat the technique range from deliberate misinterpretations of the regulation (e.g., measuring the abdominal circumference with tension tapes or with a regulation tape pulled as tightly as possible) to bizarre adaptations (e.g., targeted liposuction of a horizontal band at the level of the umbilicus). Requests for waivers have been just as varied and interesting, including neck surgery with consequent neck muscle atrophy, milk intolerance causing stomach distention, claims of bias based on unusual body types, etc. (LTC Judy Turcotte, personal communication, 1989). Neck strength training can provide a neck muscle hypertrophy averaging ½” within 12 weeks for men and this provides meaningful advantage in the equations to an individual ranging close to their upper limit of body fat (110). Arguments about this “loop hole” include consideration that individuals are being drawn to some form of regular exercise in a gymnasium and may gain other desired fitness benefits, meeting the intent of the regulation to promote fitness habits.

**Aerobic Performance Basis of the Army Body Fat Limits**

The 1980 panel made the important observation that standards set according to a consensus of ideal military appearance would be stricter than standards set by chronic health risk thresholds (114). Ultimately, the recommendations were anchored to body fat of fit young men, with an estimate of 15%, and a statistical allowance of up to 20%. This was checked by estimating body fat from a linear regression of aerobic capacity against percent body fat, with 20% body fat corresponding to a value of 50 mL·kg$^{-1}$·min$^{-1}$ as a good aerobic fitness level (Figure 4) (119). Clearly, body fat is associated with aerobic performance but cannot be...
used to select for aerobic performance within this large range of variability.

In the face of recruitment challenges in the previous decade, many entry standard waivers were given and motivated, but overfat recruits who entered Army training were still able to achieve their training standards in basic training (86). This entry waiver was based on success in performing the Harvard Step Test. The investigators inferred from their data that the test evaluated both aerobic performance and motivation, with motivation of the volunteers to succeed possibly being the more relevant factor to predicting success in basic training. Nevertheless, individuals in this waivered group are most likely to fail weight control standards later in their Army career. There may also be a gender difference in weight management success. A study conducted 2 decades ago demonstrated that men but not women could lose fat weight (up to 4% body fat units) during basic training and continue to meet their standards after the first 6 months in the Army (38). In other words, a young man with an upper limit of 20% body fat could enter basic training at 24% because he had a reasonable chance of success in meeting his standard by the end of eight weeks of basic training, and continue to be successful in meeting the standard 6 months later. Women promptly regained the weight lost in basic training. The reason for this difference was not further evaluated but may have included sex differences in postraining aerobic fitness habits, and the physicality of the MOS assignments available to young women 20 years ago. This issue has not been reexamined in the current generation of Army recruits, but medical standards for entry still reflect this gender dichotomy with a 4% allowance for men only.

**Military Appearance Rating Associations**

Military appearance is a stated consideration in military body composition standards. Part of an Army’s deterrent effect comes from having soldiers who at least look as if they are fit to fight; it would be even better if soldiers could all look like a seriously intimidating force of powerfully built individuals. Previously, the US Army actually had minimum height standards for military police set at 1” taller than the population average for men and women based on the rationale that this provided a psychological advantage in crowd control (46). The US review of fitness in the military services in 1980 was reputedly motivated by a nationally televised event in the capital where cameras panned across the pot bellies of members of a military honor guard and the reporters expressed their reservations about whether this looked like an Army that could defend our country (Col. David D. Schnakenberg, personal communication, 1992). The Army conducted a comprehensive study in 1984 to better understand military appearance associations with body composition (56). A command-experienced panel made visual ratings of military appearance from front, side, and rear view anthropometrically posed photographs of >1,075 male and 251 female soldiers in formal uniforms and in swimsuits. In uniform, the correlation between appearance ratings and body fat for men was 0.53, suggesting that uniforms worn well may partially conceal a pot belly. In swimsuits, the correlation was higher \( r = 0.69 \), and the panel could also visually estimate body fat with some accuracy \( r = 0.78 \). The results were similar for the female soldiers. In both men and women, a “poor” or “fair” military appearance rating was specifically associated with larger abdominal circumferences (28), although other factors besides percent body fat and abdominal girth also play into ratings of military appearance (56). Further analysis of this dataset demonstrated that median ratings of uniformed military appearance were “good” at the threshold percent body fat standard in each of the
Army age groups for men and women until the oldest group. The oldest soldiers had median appearance ratings of only “fair” as they approached the health-based upper limits of body fat allowance; thus, military appearance dictates a more stringent body fat standard than health risk thresholds (Col. Karl E. Friedl, unpublished results, 1990).

**Chronic Health Risk Associations**

For upper limits of body fat standards at the oldest age groups, thresholds of 26 and 36% body fat were set from a variety of comparisons to epidemiological studies (Table 1), with the strongest data from type 2 diabetes and overweight associations (31,90). The screening weights that trigger a body fat measurement in the Army regulation are BMI of 27.5 kg·m\(^{-2}\) (men) and 25.0 kg·m\(^{-2}\) (women) (Table 1). The body fat thresholds correspond to WCs of 38.5" and 35.0" for the typical male and female soldier, respectively (31). Thus, the most liberal Army body composition standards, those applied to soldiers over age 40, map to health risk thresholds including an approximation of the NHLBI guidelines for healthy body composition (BMI < 25 kg·m\(^{-2}\); WC < 40" [men] and <35" [women]). Screening weights that are higher than BMI 25 for Army men; soldiers are larger but leaner than the typical U.S. male because of selection and because of the emphasis on fitness and enforced fitness testing standards. If the male screening weight tables used an upper limit of BMI 25 kg·m\(^{-2}\), more than half of the Army would also have to be measured for body fat in every semiannual evaluation required by the regulation. Thus, screening weights extend up to BMI 27.5 kg·m\(^{-2}\) for male soldiers.

There is a general perception that massively large men must carry significant health risks no matter how their fat is distributed. Although this may be true for factors such as osteoarthritis that are suspected of an association with biomechanical stress from increasing mass regardless of whether it is from muscle or fat, it is not necessarily true for cardiovascular and metabolic risks. Matsuzawa et al. (77) highlighted this in a very interesting analysis of fat distribution and health risks in sumo wrestlers with BMI exceeding 35 kg·m\(^{-2}\). This study demonstrated large differences in CT-imaged intraabdominal fat distribution associated with marked differences in biochemical health risk profiles.

Although BMI might effectively identify overweight women where there is no statistically significant relationship between increasing BMI and lean mass, there is a highly significant increase in lean mass for men and greater variability in their adiposity with increasing BMI (Figure 2). In any case, WC-based body fat estimation is much better associated with male and female chronic health risks than total body fat, body weight, or body size (BMI) (28). Even for women, intraabdominal fat becomes an issue above a certain threshold of adiposity. Kvist et al. (72) demonstrated a linear increase in intraabdominal fat with increasing adiposity in men. In women, intraabdominal fat remained at a minimal level with increasing fatness until an accumulation of 30 L (−27 kg) of total body fat, at which point a steady increase in intraabdominal accumulation began. Fat deposition in other subcutaneous sites in women, including arms, legs, buttocks, and breast are not generally associated with health risks and in some cases may reflect an association with reduced cardiovascular and other health risks. Intraabdominal fat (detected by WC), on the other hand, is strongly associated with increasing health risks in women as it is with men (31).

At present, there is no plausible rationale for a more lenient WC or body fat standard than this current U.S. Army upper limit for men and women. A better understanding of the interaction between physical activity and adipose tissue physiology (i.e., “fit fat”) could change this. A proposal to link Army physical fitness test performance with body fat standards, allowing a sliding scale for body fat limits in the younger age categories (74), was carefully evaluated but ultimately deemed too complicated to implement (LTG Timothy J. Maude, personal communication, 2001). Stricter standards are conceivable for other populations characterized by slighter body builds. In 2008, Japan adopted WC limits for men and women between age 40 and 74 years with measurements that trigger weight management interventions at 33.5” (men) and 35.4” (women) (88). Arguments have been made for body composition standards to be adjusted to correspond to national weight gain trends as the Army should reflect the national population from which recruits are drawn. Such an adjustment, or the suspension of body fat standards, would signal a deliberate acceptance of lower fitness and health standards. Some armies, such as the People’s Republic of China, have been forced to ease weight standards, allowing a sliding scale for body fat limits that reflect recruit availability (91). The good news for recruiters in western Armies is that the increase in BMI in several other countries with weight and health monitoring statistics peaked around 2000 and appears to have leveled off. The reason for this plateau in obesity rate is unexplained (87).

**Other Health and Performance Associations and Impacts**

A central tenet behind the military body fat standards is the use of these standards to drive fitness and nutrition habits. The standards are only fair if healthy men and women can reasonably attain and maintain the standards through personal habits. This is a critically important point and one that again points to the relevance of the abdominal circumference as a key component of the military standards because this is one of the most labile sites of fat deposition. Intraabdominal fat as reflected by WC is sensitive to exercise and dietary control (16,17,36,50,97). Other sites of fat deposition such as thigh fat have a lower responsiveness to lipogenic factors and appear to be relatively stable and immovable (94).

Weight gain after smoking cessation has been a concern expressed by some soldiers considering giving up cigarettes. This represents a tradeoff between 2 different types of health risks; however, earlier data have also suggested that smokers...
have an altered distribution of fat storage, with a higher waist girth (106). For some individuals, nicotine suppression of lipoprotein lipase may result in a rebound expression of the enzyme when they quit smoking, leading to increased triglyceride storage in adipose tissue (11). An existing database of soldier data was used to test the effect of cigarette smoking on WC, skinfold thickness, overall fatness, aerobic performance, and lifting strength; aerobic fitness was significantly lower in smokers (COL Daniels, W, unpublished results, 1994), but it was also noted that smokers were leaner (~3% body fat) in each age group compared with nonsmokers (COL Friedl, KE, unpublished results, 2003).

Intraabdominal fat distribution is commonly cited as a physiological marker of chronic psychological stress, particularly the influence of a chronic activation of the hypothalamic-pituitary-adrenal axis (100). This is supported by experiments with animals where abdominal fat is specifically reduced by administration of RU486, a drug that blocks the effects of adrenal stress hormones on adipocytes (6). Trauma spectrum disorder related to current combat deployments may also be a critical factor in weight gain from disorder caused eating and other behavioral changes observed in some soldiers (61). Certain drugs such as protease inhibitors (e.g., indinavir) also have specific effects on increasing intraabdominal fat distribution (82). In men, the role of testosterone and dihydrotestosterone has been well investigated and aging-related reductions in testosterone in men are associated with an increased intraabdominal fat distribution (78,79). This effect has also been demonstrated in shorter term studies with artificial reduction of testosterone (125). Fat is mobilized from all stores (intraabdominal, subcutaneous, intermuscular), especially in intermuscular fat depots, in men with high dose testosterone administration, along with increases in lean mass (125). Androgen effects in women have been well studied for conditions such as polycystic ovary syndrome and associated overweight and upper body fat (“android”) distribution. Androgenicity increases male-type health risks and fat distribution and also increases male-type strength and training responses (3,68,69,21,102,116).

Important in utero effects were discovered through an observation that a cohort of overweight Dutch Army conscripts were sons of women who had been chronically malnourished in early pregnancy during the wartime blockade of northern Holland, referred to as the Dutch “Hungerwinter” (93). This effect of semistarvation during early pregnancy has since been further studied in animals, with a postpartum alteration in brain appetite centers that result in a chronic hyperphagia and excessive fat weight gain. It has since been confirmed in other human disasters such as the Biafran war (60). This points to another potential harm from overly stringent female body composition standards that may cause excessive dietary restriction during pregnancy. Ironically, proud young female soldiers seeking to minimize gestational weight gain are more likely to produce obese offspring.

Weight management and physical fitness habits are interrelated and, somewhere in this interrelationship, are benefits to the brain. This is seen repeatedly in epidemiological studies of general health such as illness rates and BMI associations (48) and aerobic exercise and pain perception and other symptom complaints (45). Other findings are highlighting the importance of weight management and fitness habits to long-term health associations with neurodegenerative diseases such as Alzheimer’s and Parkinson’s disease (12,65). Thus, as jobs become more technical and cognitively demanding but possibly less physically demanding, the value of fitness and nutrition habits continue to be important (75).

**Other Influences—How Much Fat Is Useful?**

Body size has been a factor in logistical considerations, with large soldiers having higher metabolic requirements than smaller soldiers do. This is the basis of the Military Dietary Reference Intakes for male and female soldiers (2,300 vs. 3,250 kcal). It has been impractical to produce a “pink ration” with adequate nutrients but lower energy content for women but there has been a better effort to educate and inform (e.g., with ration labeling) so that women can make more appropriate food choices from the nearly 4,000 Kcal d⁻¹ operational rations (29). Even in World War I, there was consideration to providing different rations for groups of male soldiers organized into units by different European ethnic origins, based on the perception that some groups required more calories than others (67).

Clearly, more fat is advantageous in a starvation situation. This gives female soldiers a survival advantage over male soldiers, both because of larger sex-specific fat stores and also because of more efficient fat metabolism. A greater proportion of Russian women survived the Siege of Stalingrad than did men (9). In high stress military training with no food for a week, women were more efficient in fat energy metabolism than were the men (59). In an extended semistarvation, soldiers nearing the limits of accessible fat reserves sacrifice increasing amounts of lean mass and sacrifice strength performance; the more extreme fat losses begin to affect fat pads on the soles of the feet making even walking painful (36).

The adaptive role of fat in sensitivity, performance, and survival in the cold has been well studied and modeled by thermal physiologists, with low body fat individuals at significantly disadvantage (10,92,129). Distance cold water swimmers have high insulative fat levels while Ama pearl divers, known for their extended endurance dives in cold water, appear to have metabolic adaptations rather than higher insulative fat (58). The role of brown adipose tissue in thermogenesis and lifetime weight maintenance and glucose disposal makes this a potential intervention target of interest to military medical research.

**Future Directions**

The important research to be done in military weight control programs is on how to provide effective assistance...
to soldiers who are motivated to meet and maintain standards. Training service members and their family members in how to choose and prepare satisfying but healthy meals is one piece of the intervention. Teaching soldiers sensible approaches to physical activity without incurring significant injuries, including overuse injuries, is another. Today’s soldiers use everyday technologies such as smartphones and expect to receive information and training through these technologies. Sophisticated metabolic models can now be brought to bear behind simple inputs and outputs for smart food and exercise choices (49). With the Pennington Biomedical Research Center, the Army has developed an internet-based program that provides such choices (108,109,124). This is part of the weight management intervention in a current statewide randomized control trial with the Louisiana Army National Guard (85). Smartphone technologies can provide biomonitoring feedback to individuals through measured activity patterns and other sensing. For example, the Nokia Activity Monitor in the Nokia S60 phone has an accelerometer that can capture daily voluntary activity displayed for the user for days and months of activity patterns. A wide array of technology opportunities exist as highlighted in a recent special workshop on this topic between TATRC and the National Science Foundation (19,20), with many of these currently being tested in related health and weight management applications.

**Conclusions**

The Army body fat standards and screening weights have not substantially changed since 1983. Constant reevaluation of the standards with new data has reaffirmed that these upper limits are about right in terms of key outcomes (physical performance, military appearance, and chronic health risk) and fairness. Military body composition standards are not intended to predict performance; they are intended to motivate fitness and nutrition habits that promote individual physical readiness. Regular physical activity, good nutrition, and weight management provide extensive health and performance benefits including physical and mental performance and resistance to disease. Excessive fat, particularly intraabdominal fat, is associated with increased health risk and poor military appearance (the “pot belly”). This distribution of body fat is particularly susceptible to environmental influences such as exercise and dietary control but is also affected by stress hormones and other metabolic factors. Fat-free mass is an important component associated with strength and work capacity. Minimum levels of fat-free mass, accurately reflected in body weight of very light weight individuals, are important to injury prevention, especially in tasks that require strength. The BMI and WC thresholds related to these standards approximate emerging data on health, performance, and appearance. Current research gaps center on effective weight management interventions to help soldiers achieve and sustain good nutrition and fitness habits throughout their lives.

**References**


Military Body Fat Standards


