ORIGINAL RESEARCH

Fitness and Fatness: Body Mass Index versus Percent Body Fat

Jennifer Bunn, PhD, ACSM-EPC[1], Danielle Eustace, BS[1], Taylor Miskech, BS[1], John Manor, MA[2], Michael Jiroutek, DrPH[3]

ABSTRACT

Background: Body mass index (BMI) is frequently used to evaluate risk of disease, but can be misleading because it does not account for different types of tissue mass (e.g., bone, muscle, fat). The purpose of this study was to classify adults in the United States according to cardiovascular fitness (CVF), BMI, and body fat using the National Health and Nutrition Examination Survey (NHANES) data.
Methods: The three most current NHANES datasets (6,648 records) were included. Counts, means, and 95% confidence intervals (CI) determined the distribution of CVF across percent of body fat and BMI categories.
Results: According to BMI, approximately 42.3% of participants were classified as either underweight or normal weight, and 24.9% were classified as obese. According to percent of body fat, 13.5% of subjects were classified as lean, while 68.4% of subjects were in the high percent body fat group. In regard to BMI, 9.9% and 6.7% of the overweight and obese populations, respectively, were classified in the highest third of CVF. According to adiposity, 6.6% and 21.0% of the moderate and high percent body fat population fell into the same category, respectively.
Conclusion: Two-thirds of the population ranked below the 35th percentile for body fat (high percent body fat), with more of these individuals in the low CVF category than any other. The largest categorization for BMI was the normal-weight category. This supports that BMI may be misleading, and that utilizing percent body fat and CVF may provide a better indication of health. *Journal of Clinical Exercise Physiology*. 2019;8(4):131–137.

Keywords: cardiovascular health, obesity, physical activity, body composition, overweight

INTRODUCTION

Physical inactivity has an inverse relationship to overall mortality (1,2), cardiovascular disease (3,4), metabolic disease (5), and obesity (6,7). High levels of physical activity and/or cardiovascular fitness (CVF) are related to an attenuation of negative health risks associated with obesity and a lack of overall fitness (8,9). In previous research, the “fat but fit” concept has been presented to demonstrate that populations with body mass index (BMI) levels classified as overweight or obese are able to reach moderate to high levels of CVF (2,10). Obese or overweight individuals who remain fit and active tend to have morbidity and mortality rates lower than normal weight individuals who are not fit and active (11,12). Other factors—including genetics, hormonal activity, environment, and diet—contribute to the fitness and fatness continuum, but seemingly the two measures of fitness and fatness are significant determinants of overall health status (13–16). There are inconsistencies in how fitness is assessed (e.g., self-report survey, submaximal testing, or maximal testing) and in how fatness is assessed (e.g., duration, body composition, and distribution of adiposity) that would effect how health is evaluated (16).

A recent study used CVF and BMI, provided by the National Health and Nutrition Examination Survey (NHANES) data, to estimate the proportion of adults in the

[1]Department of Physical Therapy, Campbell University, Buies Creek, NC 27506 USA
[2]School of Osteopathic Medicine, Campbell University, Buies Creek, NC 27506 USA
[3]Department of Clinical Research, Campbell University, Buies Creek, NC 27506 USA

Address for correspondence: Jennifer Bunn, PhD, PO Box 1090, Buies Creek, NC 27506; (910) 893-1361; e-mail: bunnj@campbell.edu.

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United States who have high, moderate, and low fitness levels by BMI category (underweight, normal weight, overweight, and obese) (10). The methods used to categorize CVF were weighted to include more people in the moderate (21-60th percentile) and high-fitness (61-100th percentile) categories, instead of an even spread for all three categories. The highest risk for all-cause mortality and morbidity exists for those at or below the 20th percentile for CVF and, thus, this level of CVF is often selected as the "low" level category in other studies (2,10). In an effort to avoid potentially skewed data and to utilize more standardized guidelines for CVF-related cut-offs, we decided to use NHANES data and divide CVF into tertiles by percentile rank (i.e., ≥65th percentile, 35-64th percentile, and <35th percentile) (17). The purpose of this study was to classify and descriptively compare adults in the United States by CVF level and BMI and body fat percentage.

BMI is not a measure of body composition and is unable to distinguish between fat mass and lean mass. Those with high levels of lean mass may be suboptimally classified as overweight or obese based on BMI, while those who are thin but have a high amount of fat mass may be classified as normal weight. An advantage of classification of percent body fat was to assess adiposity-related disease risk. We hypothesized that due to the difference in methods used for classification (i.e., body composition versus BMI), fewer individuals with high levels of CVF would appear in the overweight and obese categories compared to that previously reported (10). We also hypothesized that by using percent body fat more individuals would be placed in the middle and lowest third (high body composition), indicating a higher amount of adiposity.

METHODS

This retrospective, cross-sectional, observational study analyzed data collected by NHANES during the years 1999–2004. These were the most up-to-date available NHANES data for the specific variables assessed. Briefly, NHANES includes studies designed to evaluate the nutritional and health status of children and adults in the United States (18). Jointly capturing information from survey participants through interviews and physical assessments, NHANES is designed, overseen, and conducted by the National Center for Health Statistics (NCHS), which is a part of the Centers for Disease Control and Prevention. Designed to form a nationally representative sample, NHANES includes approximately 5,000 to 6,000 participants per survey each year, selected from 15 counties across the United States.

NHANES data are collected annually and reported biannually. Three datasets covering 6 years (1999–2004) were included in this study (the only years for which the CVF data were collected and available). The only survey responses included in the final analysis were for those 20-49 years of age and for whom pregnancy status was definitively known to be negative. Across all 6 years included in this study, a total of 6,648 raw records met the inclusion/exclusion criteria.

The NHANES survey sample methodology is based on a sophisticated multistage probability design that includes sampling weights, clusters, and strata. The sampling weights are computed by the NCHS to compensate for unequal probabilities of selection, adjusted for participant nonresponse, and post-stratified to "match estimates of the US noninstitutionalized population available from the Census Bureau" (18). For the variables of interest, the survey was designed to allow the generation of national average annual estimates of the number of people in the United States, among those meeting the study inclusion/exclusion criteria, for the years 1999–2004 by extrapolation of the survey sample (n = 6,648). Because of the complex design, sampling errors were determined using the SAS SURVEYFREQ and SURVEYMEANS procedures, which take into account the clustered nature of the sample. The appropriate NOMCAR and DOMAIN statements/options were implemented in these procedures as recommended by the NCHS.

Two outcome variables were of interest: CVF and percent body fat. In each case, the denominator was the number of surveys meeting the inclusion/exclusion criteria. CVF level was defined as low, medium, or high and was based on sex, age, and maximal oxygen consumption (VO_2max), per the CVF dataset variable CVDESVO2. Body composition was defined as low, medium, or high and was based on sex, age group, and estimated percent body fat. VO_2max was estimated using a submaximal multi-stage treadmill test, and body composition was determined using dual-energy x-ray absorptiometry (DXA) (19–21). Breakdown of these groupings by level, as shown in Table 1, were determined from previously established normative data (22).

As appropriate, means/proportions and associated 95% confidence intervals (CI) were computed for participant characteristics. Counts, means/proportions, and associated CIs were reported by CVF level, percent body fat level, and BMI group (under-/normal weight, overweight, and obese). CVF level was cross-tabulated with both BMI and percent body fat level, creating a pair of matrices to determine the distribution of CVF and across BMI-determined categories and body fat-determined categories.

Statistical Analyses

All analyses were generated using SAS software, version 9.3 (SAS Institute, Cary, North Carolina), utilizing the SURVEYFREQ and SURVEYMEANS procedures. The tests available in these procedures are more limited than in their nonsurvey counterparts. Therefore, CIs were constructed and reported in lieu of such tests. While no formal comparisons were made, under the hypothesis-generating paradigm determined by this retrospective study design and data analysis, the means/proportions for any CIs that do not overlap can be considered suggestive of a statistically significant difference at the 0.05 alpha level. As such, no adjustments were made for multiple comparisons.

Per NCHS recommendations, the reliability of all variables of interest was assessed through the determination of the amount of missing data, the number of available records,

TABLE 1. Definitions of cardiovascular fitness for low, medium, and high level categories, stratified by age and by sex.

Sex	Age Range (y)	VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)			Body Composition (% Fat)		
		L	M	H	L	M	H
Male	20-29	≤ 40.9	>40.9-46.7	> 46.7	≥ 20.6	14.8-<20.6	< 14.8
	30-39	≤ 39.4	>39.4-45.2	> 45.2	≥ 23	18.2-<23.0	< 18.2
	40-49	≤ 37.5	>37.5-43.8	> 43.8	≥ 24.8	20.6-<24.8	< 20.6
Female	20-29	≤ 34.5	>34.5-40.5	> 40.5	≥ 24.5	19.4-<24.5	< 19.4
	30-39	≤ 32.3	>32.3-38.0	> 38.0	≥ 26.7	20.8-<26.7	< 20.8
	40-49	≤ 30.8	>30.8-35.5	> 35.51	≥ 29.6	23.8-<29.6	< 23.8

and the relative standard error. Body composition and fitness level categories both had high amounts of missing data, 35% and 52%, respectively. As noted in the analytic notes section of the CVF dataset documentation at the NHANES website, “a series of exclusion criteria were developed for the NHANES CV fitness component to preclude participants with conditions that might endanger them during the testing or affect the estimation of the VO_2max from the exam” (23). Further, it is known that the exclusion rate increases with age. While no obvious patterns in the missing data other than those already known were observed, these limitations suggest caution in the interpretation of the presented results. No other reliability issues were noted.

RESULTS

Of the 6,468 participants analyzed, 48% were female and 52% were male. Classified by ethnicity, 16% were Hispanic/Latino and 84% were not. By race, 67% identified as white, 12% identified as black, and 21% identified as other. The average age was 35.2 years (95% CI: 34.8, 35.5), the mean BMI was 27.8 $kg \cdot m^{-2}$ (95% CI: 27.5, 28.0), the mean percent body fat was 31.4% (95% CI: 31.1, 31.8), and the mean VO_2max was 40.0 $mL \cdot kg^{-1} \cdot min^{-1}$ (95% CI: 39.4, 50.6).

Table 2 presents the matrix classifying participants by lower (poor fitness), middle, and upper (high fitness) tertiles for VO_2max and by standard BMI classifications (e.g., normal weight, overweight, obese). Approximately 58% of all participants were classified as overweight or obese. Visual inspection of the computed CIs as a surrogate for formal hypothesis tests (24) is suggestive of a true difference between the obese and other groups. The participants were approximately evenly split by CVF classification—low CVF 36%, moderate CVF 31%, and high CVF 33%—with the highest percentage of participants falling into the low CVF category. Within the high fitness group, the highest percentage of participants were in the under-/normal weight BMI classification, 17%. Further, Figure 1a shows the weighted percentage of participants in each CVF level relative to their

TABLE 2. Comparison of cardiovascular fitness (CVF) level as defined by VO_2max by body mass index (BMI) classification.

	Under/Normal Weight	Overweight	Obese	Fitness Totals
Estimated VO_2max (ml/kg/min), mean (95% CI)	41.2 (40.5, 41.8)	40.1 (39.2, 41.0)	37.9 (37.2, 38.6)	--
% Low Fitness (weighted sample size)				
% of population (95% CI)	12.2 (10.8, 13.6)	12.7 (11.4, 14.0)	10.9 (9.7, 12.1)	35.8 (33.7, 37.9)
No.[a]	7,312,678	7,624,478	6,529,876	21,467,032
% Moderate Fitness (weighted sample size)				
% of population (95% CI)	13.2 (11.7, 14.8)	10.2 (9.1, 11.4)	7.3 (6.2, 8.4)	30.7 (28.9, 32.6)
No.	7,936,778	6,136,436	4,361,689	18,434,904
% High Fitness (weighted sample size)				
% of population (95% CI)	16.8 (14.9, 18.8)	9.9 (8.5, 11.3)	6.7 (5.7, 7.7)	33.5 (31.2, 35.7)
No.	10,090,134	5,940,742	4,026,236	20,057,112
BMI Totals				
% of population (95% CI)	42.3 (40.0, 44.6)	32.9 (30.8, 34.9)	24.9 (23.0, 26.7)	100.0
No.	25,339,590	19,701,657	14,917,801	59,959,048

[a]National average annual estimates of the number of people in the United States, amongst those meeting the study inclusion/exclusion criteria

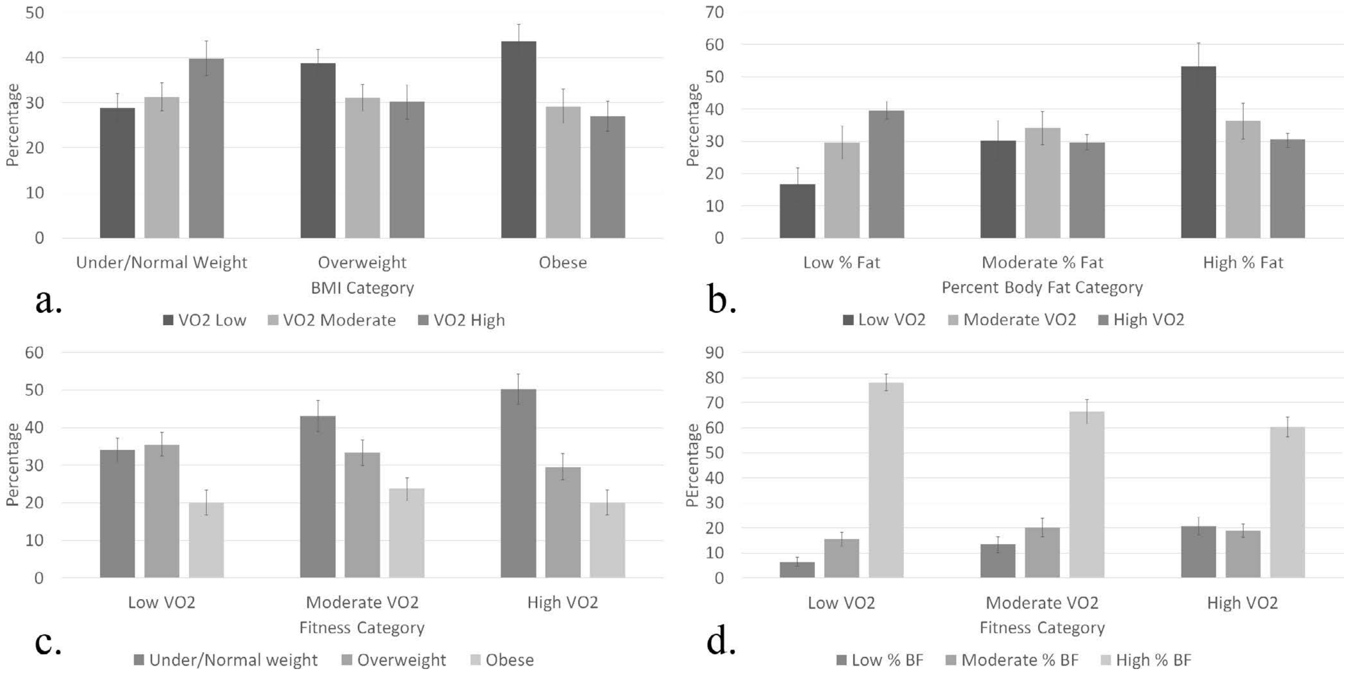

FIGURE 1. (a) Percentage (95% CI) in each cardiovascular fitness (CVF) level stratified by body mass index (BMI) category (Table 2 column percentages); (b) Percentage (95% CI) in each CVF level stratified by percent body fat classification (Table 3 column percentages); (c) Percentage (95% CI) in each BMI category stratified by CVF level (Table 2 row percentages); (d) Percentage (95% CI) in each % body fat classification stratified by CVF level (Table 3 row percentages).

BMI classification (the column percentages from Table 2). For the obese and overweight groups, the largest percentage of participants were classified low CVF. For the under-/normal weight BMI group, the largest percentage of participants were classified as high CVF. Figure 1c illustrates the percentage of participants in each BMI category stratified by CVF (the row percentages from Table 2). The majority of people with high and moderate CVF are under-/normal weight per BMI. The preponderance of participants with low CVF are overweight or obese. Most striking is the large disparity in high CVF between the BMI categories demonstrated in Figure 1c.

Table 3 shows the matrix classifying participants based upon their percent body fat and their CVF level. Similar to the BMI categories, visual inspection of the CI for VO_2max between the different body fat groups serves as a surrogate

TABLE 3. Comparisons of cardiovascular fitness (CVF) level as defined by VO_2max by body composition.

	Low % Body Fat	Moderate % Body Fat	High % Body Fat	Fitness Totals
Estimated VO_2max (ml/kg/min), mean (95% CI)	46.5 (45.4, 47.6)	43.6 (42.4, 44.8)	38.5 (37.8, 39.2)	--
% Low Fitness (weighted sample size)				
% of population (95% CI)	2.2 (1.5, 3.0)	5.4 (4.3, 6.4)	27.1 (25.1, 29.1)	34.7 (32.3, 37.1)
No.[a]	976,196	2,325,250	11,779,796	15,081,242
% Moderate Fitness (weighted sample size)				
% of population (95% CI)	4.1 (3.1, 5.1)	6.2 (4.9, 7.4)	20.3 (18.3, 22.4)	30.6 (28.4, 32.8)
No.	1,775,397	2,679,175	8,833,158	13,287,730
% High Fitness (weighted sample size)				
% of population (95% CI)	7.2 (5.9, 8.6)	6.6 (5.4, 7.7)	21.0 (19.0, 22.9)	34.7 (32.1, 37.4)
No.	3,131,588	2,852,569	9,109,333	15,093,489
Body Composition Totals				
% of population (95% CI)	13.5 (11.8, 15.3)	18.1 (16.1, 20.0)	68.4 (65.8, 70.9)	100.0
No.	5,883,182	7,856,993	29,722,287	43,462,462

[a]National average annual estimates of the number of people in the United States, among those meeting the study inclusion/exclusion criteria

for formal hypothesis tests and is suggestive of true differences between three groups. Approximately 87% of the population is classified in the middle and lowest third for percent body fat, indicating a relatively high amount of fat mass. This value is approximately 30% higher than the number of people classified into the overweight and obese categories as determined by BMI (Table 2). For percent body fat classification, the separation of participants across the CVF categories is fairly evenly split, with the lowest CVF group having the highest representation. For the lean group (those with the lowest percent body fat), 17% had low CVF, while the majority of this body fat group was in the high CVF category. Figure 1b shows the weighted percentage of participants in each CVF level stratified by percent body fat group (the column percentages from Table 3). Analogous to Figure 1a, the group with the highest percent body fat also had the highest number of people in the low CVF classification. Figure 1d illustrates the percentage of participants in each body fat category stratified by CVF level (the row percentages from Table 3). From this figure, the large percentage of individuals with a high percent body fat across the three different CVF categories is noted. Additionally, with low CVF, there is a significant disparity between those of high and low/moderate percent body fat as compared to those with moderate and high CVF.

DISCUSSION

These data are not aligned with the data presented by Duncan (10). The present study shows that individuals classified as obese based on BMI tend to have low CVF, and that roughly 27% of obese people can be classified as “fat but fit.” The percent body fat data also indicated that the majority of people in the worst category also had the lowest level of fitness, and approximately 31% of these individuals could be classified as “fat but fit.” These data may differ from the Duncan study because they are linked to different percentile ranks and classification for VO_2max (10). Duncan’s demarcations were skewed to be more inclusive of moderate and high CVF. Duncan classified VO_2max using the bottom 20^{th} percentile as low CVF, and then split the remaining 80% in half to classify moderate and high level of CVF. These classes were used because individuals with a VO_2max below the 20^{th} percentile have a significantly higher risk for all-cause mortality (6). While this demarcation is useful, it presents a false sense of fitness since moderate (21-60^{th} percentile) and high (>61^{st} percentile) level CVF carry a heavier weight because they cover 40% of the normative data rather than 30% to 35% separations used in the present study.

Data from our analysis provides a different perspective on the “fat but fit” paradox by comparing two assessments of “fatness”—percent body fat and BMI—and the NHANES data include submaximal assessment to determine VO_2max rather than a self-reported physical activity survey to address fitness. There was little distinction seen between the overweight and obese BMI groups for moderate and high fitness levels, but the lowest fitness level is distinctive between groups with 38% of the overweight participants classified as low CVF and 43% of the obese participants classified as low CVF (Figure 1a). This distribution of the population disagrees with the results from Duncan (10), who used the 20th percentile as the cut-off for low CVF. The data from our analysis suggests that there is a potentially large percent of the population from the overweight and obese that would be ranked in the 20th to the 35th percentile of CVF. The under-/normal weight BMI group shows clear differences in fitness categorization, where the highest percentage represents those of a high CVF, as anticipated. The distribution of BMI categories was similar in the moderate and high fitness groups, but distinctive in the low fitness group (Figure 1b). Thus, the population percentage of under-/normal weight in each fitness category is significantly higher as fitness levels improve. This is consistent with the current literature as a relative increase in physical fitness is associated with increased metabolic rate and energy expenditure that can contribute to lower overall body mass (25).

Data from our analysis suggests that approximately 25% of the population is classified as obese according to BMI, but 68% of the participants fell into the lowest third for percent body fat, meaning that 68% of the sample population is overfat. The differences in these percentages were unexpected. BMI is often criticized as a clinical tool because it does not consider muscle mass or body fat distribution. Many athletes have been inappropriately classified as overweight or obese because they have a higher BMI, but this is due to relatively higher proportions of lean mass for their height. The Behavioral Risk Factor Surveillance System (BRFSS) reported state-specific data regarding the percentage of people classified as obese, ranging from one-fifth to more than one-third of the total population (26). As suggested in our analysis, there is a potential mismatch between population estimates using BMI to assess overweight and obesity and the reality of the nation’s health based on the number considered overfat.

The differences in fitness and fatness as measured by BMI versus body composition are particularly powerful when comparing Figure 1a to Figure 1b, and Figure 1c to Figure 1d. The disparities in CVF are greater when analyzed using percent body fat (Figure 1b) as opposed to BMI (Figure 1a). In the low and high percent body fat categories, each CVF is easily delineated from the other, but this separation by CVF is not as clear with the obese and under-/normal weight BMI groupings. Using the body fat data, 30.6% of the highest percent body fat group would be deemed “fat but fit” compared to 27% of participants with the BMI data. However, these values are quite different because there is a much larger proportion of the population with high percent body fat than those who are classified as obese with BMI. This representation of the population with unfavorable percent body fat is illustrated in Figure 1d, whereas the differences between BMI groups and fitness categories are not as distinguishable in Figure 1c. Those with high body composition have a more even distribution across the three fitness categories as compared to the obese BMI group. By BMI, it appears that the majority of people with high CVF are classified as under-/normal weight, but via body fat, a large portion of those with high CVF fall into the high percent body fat category. Essentially, these data suggest that many people are carrying excess body fat, which potentially contributes to the risk of poor health (7,27). Excess body fat, especially when centrally located, is linked with metabolic disease, cardiovascular disease, and cancer (4–6,28). Further, these data indicate that just over one-third of the population have CVF below the 35th percentile of normative data, which is a predictor of increased all-cause mortality in both men and women (29,30).

The data from the present study indicate that the population studied was divided almost evenly into thirds by CVF category. This reinforces that there are some portions of the population that are "fat but fit" and "unfit and thin," and suggests that improving one's CVF may be more impactful on health than adiposity alone (28,31). This is supported in the literature, where it is noted that physical activity and improvement in CVF are linked to a reduction in fat mass and increase in lean mass, as well as reduced risk for metabolic diseases (e.g., diabetes), cardiovascular disease, and cancer (14,28,32,33). The presence of excess fat mass increases risk for many of these diseases (7). Further complicating the issue, improving fitness has been shown repeatedly to improve central nervous and immune system function (34–36), an idea that requires exploring in its relation to the "fat but fit" relationship.

The relative lack of difference in VO_2max across the BMI categories is masked because BMI does not differentiate between lean and fat mass. The healthcare community has used BMI as quick and simple assessment for risk of several diseases. However, there is the potential that BMI assessment may be misleading to the public. Though not assessed in this analysis, a classification of normal or underweight may contribute to low amounts of daily physical activity among persons who consider themselves "healthy." Thus, this may contribute to the proportion of the population that falls into the category of "unfit and thin." Additionally, an incorrect classification of overweight or obese via BMI may not adequately describe a patient who is "fat but fit" and potentially lead to increased health insurance premiums (depending on what method is used to set premium amounts) or a negative effect on mental health. Furthermore, previous literature indicates that individual perceptions of CVF and percent body fat are not accurate (37). Coupling individual misperceptions with an inaccurate assessment through BMI may result in substantial misinformation and poor health advice among a population. Most likely the healthcare community and the individual would benefit greatly from normative comparisons of CVF and percent body fat. CVF and measures of adiposity may be more indicative of morbidity and mortality risk than what standard care currently provides with BMI.

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