Body Mass Index and Percentage Body Fat as Health Indicators for Young Adults

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***Objectives*: To investigate the validity of an axiom that body mass index (BMI) and percentage body fat (%BF), above an ideal, are health risk factors. *Methods*: Participants were 2615 volunteers who participated in a health-screening program conducted in college residence halls over a consecutive 8-year period. *Results*: Nearly half of all participants were misclassified when BMI and/or %BF were used to define better versus poorer health whether analyzing all variables together, by individual factor, or by type of variable. *Conclusions*: Results of this study indicate that BMI and %BF are poor indicators of health status among young adults.**

***Key words*: body mass index, percentage body fat, screening tests, health risk indicators, college students**

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Body mass index/Quetelet Index {BMI = weight (kg)/[height (m)]^2} is preferred to assess health status in comparison to other indices such as the Ponderal and Broca, because it has the best correlation with percentage body fat.[1] BMI is the most widely used procedure for assessing body weight in large populations[2] and for assessing overweight clinically.[3] BMI is used for classification of individuals into weight categories such as underweight, normal, overweight, obesity class I and II, and extreme obesity or obesity class III.[4] The thickness of multiple skinfolds also has been recommended and widely used to estimate adiposity.[5] Use of both BMI and multiple skinfold measurements are arguably 2 of the most practical estimates of overweight and obesity.[6]

Overweight and obesity are pandemic and increasing in the United States and many countries of the world including China.[7-11] The problems of overweight/obesity are apparent among the youth of America according to the National Collegiate Health Risk Survey that revealed 1 in 5 college students was overweight with BMI = $\geq$ 27.8 for men and 27.3 for women[12] {weight (kg)/[height (m)]^2}, and there was a threefold increase between 1990 and 2000 in obesity class III (BMI $\geq$ 40) among young people 18-29 years old.[13] Overweight (BMI = 25.0 – 29.9) and obesity (BMI = $\geq$ 30) were recently identified by the Surgeon General in *Healthy People 2010* as among the 10 leading health indicators that reflect the major public

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health issues in the nation.[14] Overweight/ obesity are described as one of the few national health problems in which progress has dramatically moved away from the desired target objective by as much as 150% and in which early intervention programs and prevention initiatives are indicated.[15]

A sizable body of scientific evidence links overweight/obesity to a number of chronic illnesses including type 2 diabetes, coronary heart disease, hypertension, stroke, musculoskeletal disorders, and some types of cancer.[8,16] Furthermore, BMI categories of obesity (30 and above) are associated with increases in morbidity, mortality, disability, hospitalizations, health care expenditures, higher absenteeism, earlier entry to nursing homes, earlier retirements, and poorer quality of life.[9,17,18] The NIH Consensus Development Conference as early as 1985 went so far as to conclude that "the evidence is now overwhelming that obesity, defined as the excessive storage of energy in the form of fat, has adverse effects on health and longevity."[19]

The conclusions above may be over simplified and inappropriately represent the association among indices of adiposity and health risk for genetically diverse individuals.[20-22] It is true that the majority of well-designed, large, epidemiologic studies have shown for the obese, as indicated by a BMI >30, an increased association with mortality and morbidity.[23] Overall, however, correlations are relatively low (~.20 - ~.30) between BMI and morbidity and mortality, and the coefficients of determination account for $\leq$ 10% of the total variance.[18,24-26] Percentage body fat (%BF) seems to fare no better than BMI and is in fact equivalent or worse as an indicator of health risk.[27,28]

There may be several plausible confounders that may negatively influence the relationship between adiposity estimates and health risk. First is distribution of adipose tissue. In overweight adults, abdominal and visceral fat has been significantly associated with increased health risks whereas lower body fat has not been significantly related to health risks.[29] Women with favorable waist/hip ratios had ideal health parameters, even though %BF was higher than recommended.[30] Sumo wrestlers who are obese by traditional BMI and %BF standards and have massive subcutaneous obesity with low visceral fat have a notable absence of metabolic disorders.[31,32]

A second confounder that may negatively influence the relationship between adiposity estimates and health risks is the level of physical fitness. Researchers have found physical activity and physical fitness to be more relevant to positive health outcomes than body weight parameters. Mortality rates were lowest among the fittest men regardless of body weight after an 8.5-year follow-up of 25,389 men who had undergone medical and fitness evaluations at the Cooper Clinic in Dallas.[33] A similar finding was noted in the Nurses' Health Study where fitness was found to be what really mattered and body weight again was less relevant.[34,35] An expert review panel also reported that there was strong evidence favoring an association between higher levels of physical activity and cardiorespiratory fitness with lower rates of morbidity and mortality and that active and fit overweight and obese individuals have lower morbidity and mortality risk than do their inactive normal weight counterparts.[36] In addition, another study of a small group of women who remained obese found that those who exercised 90 minutes/day for 14 months and continued to do so and to eat a low-fat diet during the next 15 months had cholesterol, blood sugar, blood pressure, and other metabolic factors within normal limits.[37] In another study, individuals with high risk for cardiovascular disease were prescribed an exercise program without weight loss to reduce their risk. This group showed significant improvement in their health parameters while maintaining their BMIs at higher than prescribed "ideal" standards.[38] Even those who were overweight and were prediabetic reversed their indicators of disease by improving diet and physical activity while maintaining or increasing body weight and still remaining "overweight."[39]

A third confounder that may negatively influence the relationship between adiposity estimates and health risks is the extremes of the BMI continuum. Mortality and morbidity may occur more often at the extremes of the BMI continuum. A meta-analysis of epidemiologic studies published over the past 40 years, each of which looked at the relationship between body weight and mortality rates, indicated that roughly 75% of these studies contradict the notion that the thinnest live the longest.[40] This notion is contradicted either by showing weight to be relatively neutral (except at the extremes) or by showing that in some cases, people who are heavier than recommended ideals by ~20% have the best prospects at longevity.[33,40-46] Additionally, research related to morbidity indicates that the lowest health care expenditures occur at BMIs of 27, which are 19% higher than the ideal BMI of 22,[18] and another study suggested BMIs <25 to be associated with fewer indicators of morbidity in young women.[46] The highest health care expenditures and morbidity indicators occurred at the extremes or both ends of the BMI continuum. In both studies, neither the heaviest nor the thinnest was the healthiest.

College students were chosen as the study population because of the presumption that screening tests ought to perform better in the sense of missing fewer people with the adverse heath conditions. In order to assess BMI and %BF as indicators of health, the study addressed 2 issues: (1) whether a substantial percentage of individuals would be identified with ideal or lower than ideal BMI and/or %BF, yet have health parameters poorer than ideal health and (2) whether a substantial percentage of individuals would be identified with higher than ideal BMI and/or %BF whose health parameters would be closer to ideal.

METHODS

Participants

Participants were 2615 (total sample) university students from a large Midwestern university. There were 1334 women (51%) and 1281 men (49%) between 17 and 48 years old (M = 20), and 95% were between 18 and 25 years old. Ethnic breakdown was white 79.3%, black 8.3%, and other 12.4%. Average weight for women was 138 lb and for men 173 lb. Average BMI for women was 22 and for men 24; %BF was 25% for women and 12% for men. Average total serum cholesterol was 161mg/dl for women and 153 mg/dl for men. Average systolic blood pressure was 109 mmHg for women and 122 mmHg for men. Average diastolic blood pressure was 71 mmHg for women and 75 mmHg for men. Average heart rate during the recovery phase of the 3-minute step test was 115 beats/min for women and 110 beats/min for men.

Procedures

Recruitment. Posters and cafeteria table tents were used to advertise a free health screening. Announcements were placed in highly visible locations in university residence halls 2 weeks before each screening. Announcements emphasized a free, voluntary health screening that would be conducted on site at the residence halls. A sign-up sheet with specific appointment times was located in the lobby of the residence hall. A poster located in the lobby of the residence halls specified the location and time, what to wear, and what would be measured and assessed: current health behaviors, blood pressure, cholesterol, body composition, cardiovascular fitness, flexibility, muscular strength and endurance, speech, and hearing. Health screenings were conducted every year for 8 years.

Health screening. In addition to the measures mentioned in the poster, students also completed a 38-item questionnaire. The questionnaire included self and family health history (11 items), hearing and communication (5 items), dietary and exercise habits (16 items), and tobacco and alcohol use (6 items). Blood pressure was measured with a stethoscope and sphygmomanometer according to the procedures set forth by the American Heart Association.[47] Cholesterol was screened by a finger-stick method and analyzed using the Kodak DT 60 cholesterol screener[48] and the Boehringer Mannheim Corporation ProAct System cholesterol screener.[49] Height was measured in inches with a valid standard metric ruler. Weight was measured with a Detecto Mechanical Physician's Eye Level Scale Model #339 (pivot and bearing).[50] Skinfold thickness was measured using Lange skinfold calipers (patent# 3,008,239).[51] Three sites were measured for men and women. Each site was measured 3 times and then averaged. For women, the triceps, suprailium, and thigh were used.[52] The sites used for men were the chest, abdomen, and thigh.[53] Cardiovascular fitness was assessed with the 3-minute step test using a 12-inch step adapted from *Y's Way to Physical Fitness.*[54] Muscular strength and endurance were screened using abdominal curl and push-up norms adapted from *Y's Way to Physical Fitness.*[54] Hip and hamstring flexibility was measured with the Sit-and-Reach test and the modified Sit-and-Reach test[55] using the Acuflex 1 Sit-and-Reach Flexibility Tester.[56] Speech and hearing screenings were performed courtesy of the Audiology and Speech Sciences Department in private rooms using a prepared speech screening passage and the Beltone 10D portable audiometer.[57]

Screeners. Screeners completed the subject's assessment sheet. All screeners were rigorously trained and tested as part of an upper division undergraduate course called Wellness Screening Programs. Screeners were trained to a strict criterion to achieve an interrater reliability of at least 90%, but training usually exceeded this minimum standard.

Data preparation and management. Data from the original questionnaire and assessment sheet were recorded onto computer Scantron© sheets. To verify data entries, one person read data aloud and the other recorded data as they were being read. The Scantron© sheets were scanned into the computer. The data were reformatted for common variable alignment because the questionnaire and assessment sheets varied slightly annually depending on emphasis of the screening. The SAS data analyses software program version 9.1.3 for Windows was used for all analyses.[58] The aligned data were converted in order to be read by SAS.

Variable selection. Sixty variables were available for analyses. Each variable, whether independent or dependent, was transformed so that the higher the value, the higher the health risk according to published recommendations of the appropriate national health organizations or federal guidelines. This put all 60 variables on a common dimension such that an increasing value implied increasing health risk. Then, the 60 variables were grouped by measurement scale: Likert-type ordinal scales or interval/ratio scale. Factor analyses were then applied to the collection of variables for each scale type. All variables retained for final analyses were those that (1) grouped with one or more other variables on the same factor (after varimax rotation), (2) had a commonality of at least .4, (3) contributed to a proportion of variance explained exceeding .5, and (4) the number of factors corresponded to the number of eigenvalues greater than 1.0. The process was iterative. On each iteration, if one or more variables did not satisfy criteria (1) - (4), the variable with the lowest commonality on the factor with lowest proportion of variance explained was dropped and the factor analysis repeated. The process terminated when all retained variables met all of criteria (1) - (4). This led to 22 variables grouping on 7 factors being retained for health analyses. This grouping remained consistent and satisfied criteria (1) - (4) when combined into a single factor analysis.

Independent variables. There were 2 independent variables, BMI and %BF. The Siri formula[59] was used to calculate %BF from skinfold measures: women = 1.0994921 - .0009929 x tf + .0000023 x tf x tf - .0001392 x age; men = 1.10938 - .0008267 x tf + .0000016 x tf x tf - .0002574 x age. tf = sum of 3 skinfold thicknesses in mm. BMI {weight (kg)/[height (m)]^2 }, developed by the National Center for Health Statistics, also was computed.[60]

Dependent variables. The 22 variables retained after variable selection were the following: chest pain; dizziness; diagnosis of high blood pressure; number servings of soft drinks, sweets, fatty meats, fast food, fish, poultry, legumes, fruit, and vegetables; systolic blood pressure; diastolic blood pressure; total serum cholesterol; cardiovascular fitness; tobacco use; alcoholic drinks/day, days/week of drinking alcohol; type of exercise, minutes/session of exercise, and exercise sessions/week.

Scoring. A "good/bad" scoring system was developed for each of the 22 variables in order to analyze the relationship between the 7 health factors and both BMI and %BF. The criteria used to determine a good/bad score for the 22 variables was based upon the published recommendations of the American Academy of Pediatrics,[61] American Cancer Society,[62] American Heart Association,[63] Centers for Disease Control and Prevention,[64,65] *Healthy People 2010*,[14] Institute of Medicine of the National Academies,[66] *Lifetime Physical Fitness and Wellness*,[55] National Heart Lung Blood Institute,[67] The President's Council on Physical Fitness and Sports,[68,69] United States Department of Agriculture Dietary Guidelines 2005,[70] United States Department of Health Human Services,[71,72] United States Environmental Protection Agency,[73] United States Food and Drug Administration,[74] and *Y's Way to Physical Fitness*.[54]

Finally, each of these 22 variables was dichotomously scored 0 or 1 to correspond with lower health risk or greater health risk, respectively. Then, these 0 or 1 scores were totaled over the collection of variables loading on each factor, and over all 22 variables combined. To produce a good/bad health classification, the total score for each factor was then split at its median. Cross-tabulations were constructed with 2 levels (high/low) for the BMI and %BF variables against the good/bad health classification for each of the 7 factors and all 22 variables as a single combined "desireable health" factor.

Analytic Plan

Research design and statistical analyses. A cross-sectional design was selected. The 7 scored health factors and overall combined "desirable health" factor were evaluated using odds ratios from logistic regression analyses with 95% confidence limits. Coefficients of determination, misclassification frequencies from 2 X 2 contingency tables, and epidemiologic statistics also were computed.

Screening test analyses. Epidemiologic analyses were conducted to evaluate the effectiveness of each test. These calculations included 9 interrelated analyses: (1) sensitivity (*Se*), (2) specificity (*Sp*), (3) false positives (*FP*), (4) false negatives (*FN*), (5) positive predictive value (*PPV*), (6) negative predictive value (*NPV*), (7) yield (*Ye*), (8) accuracy (*Ac*), and (9) validity (*Va*). *Se* is the ability of the screening test to correctly classify those with the disorder. *Sp* is the ability of the test to correctly classify those without the disorder. *FP* is the percentage of subjects without the disorder who test positive. *FN* is the percentage of subjects with the disorder who test negative. *PPV* is the probability that a person who tests positive does have the disorder. *NPV* is the probability that a person who tests negative does not have the disorder. *Ye* is the number of true positives correctly identified divided by the total sample size. *Ac* is the degree of agreement between the screening test and the gold standard for identifying *TP* and *TN*. *Va* is the ability of a test to give a true measure and how well it measures what it is supposed to measure, and *Va* comprises values that include *Se* and *Sp*.

Sample and population comparisons. These data were compared with the total sample, university population data, and national datasets collected by the federal government.[5,75-77]

RESULTS

Sample to Population and National Comparisons

Table 1 shows a set of comparisons based on race, BMI, %BF, cholesterol, and blood pressure. Values were essentially identical for the subset, the total sample, and the national samples. The indications for this finding are 2-fold: (1) the data subset of 738 (selected by factor analysis) is representative of the entire data set of 2615 and (2) the subset and the data set as a whole are representative of college-aged students nationwide. Based on statistical analyses, any differences between values fall within a standard error of measurement for that variable and are not statistically different.

Main Analyses

The 7 factors accounted for 49% of the variance and were labeled as follows: (1) licit drug use, (2) negative dietary habits, (3) blood pressure, (4) positive dietary habits, (5) exercise behaviors, (6) cardiovascular health, and (7) health history. Factor analysis was used iteratively with the item selection criteria (1) – (4) described in the Variable Selection section above primarily as a dimensionality reduction technique. For each iteration, the number of factors retained was determined by the selection criteria. Overall percent variance explained in the final model was acceptable at about half of the total variance. More importantly for the purposes of this study, the retained variables did group together on factors that could be meaningfully labeled as described above.

Frequency misclassification. The focus on frequency of misclassification is cells b + c/*FP* + *FN* and describes percentage of subjects who had either BMI and/or %BF above normally recommended levels yet had health parameters within optimal limits, or had BMI and/or %BF within normally recommended limits, yet had health parameters outside of optimal limits. About half (44%-56%) of all subjects were misclassified when BMI or %BF were used to define better health versus poorer health whether analyzing all variables together, by individual factor, or by type of variable.

Epidemiologic evaluation. The results of this evaluation, shown in Table 2, indicate that BMI and %BF were poor indicators of overall health. Average sensitivity and specificity of the 22 variables that compose "Desirable Health" were both 50% for BMI and were 56% and 50% for %BF, respectively. Sensitivity, specificity, and accuracy for all 7 factors investigated sepa-

Table 1
Sample Comparison for External Validity

Variable	Age	Subset	Total Sample	National
Race %				
White	n/a	80.0	79.0	79.0[a]
Black	n/a	8.0	8.0	8.0[a]
Other	n/a	12.0	13.0	13.0[a]
BMI				
Female	18	21.2	21.7	21.8[b]
	19	21.4	21.3	22.4[b]
	15-19	22.3	21.9	21.1[d]
	20-24	20.8	21.6	21.6[d]
Male	18	22.8	22.7	21.8[b]
	19	24.0	23.1	22.7[b]
	15-19	23.6	23.3	21.1[d]
	20-24	19.5	24.7	23.4[d]
% BF				
Female	16-30	24.0	24.0	25.0[c]
	18	24.0	24.3	22.8[b]
	19	23.8	23.8	22.5[b]
Male	16-31	12.0	11.0	13.0[c]
Cholesterol (mg/dL)				
Female	16-19	157	155	164[b]
	15-19	158	155	155[d]
	20-24	161	159	170[d]
Male	16-19	144	144	156[b]
	15-19	140	142	146[d]
	20-24	152	154	165[d]
Blood Pressure (mm Hg)				
Systolic				
Female	15-19	108	108	107[d]
	20-24	110	108	109[d]
Male	15-19	120	120	115[d]
	20-24	122	120	122[d]
Diastolic				
Female	15-19	70	70	68[d]
	20-24	70	70	68[d]
Male	15-19	76	72	70[d]
	20-24	76	76	76[d]

Note.
All values (except the variables listed within the race category) are medians
All 18-, 19-, 16-19-year-olds are *All Race*
All 15-19-, 20-24-year-olds are *White* only
BMI = body mass index. %BF = percentage body fat

a National Center of Education Statistics[75]
b National Health and Nutrition Examination Survey III[76]
c McArdle, Katch, and Katch[5]
d Lipid Research Clinic, National Heart Lung Blood Institute[77]

Table 2
Epidemiologic Data for Body Mass Index (BMI)/Percentage Body Fat (%BF)

Factor	Se	Sp	FP	FN	PPV	NPV	Ye	Ac	Va
"Desirable Health"	50/56	50/50	50/50	50/44	64/62	36/44	32/33	50/53	0/6
Licit Drug Use	51/56	51/50	49/50	49/44	58/61	44/44	29/33	51/53	2/5
Negative Dietary Habits	50/54	50/48	50/52	50/46	74/70	26/31	37/38	50/52	0/2
Blood Pressure	51/56	54/56	46/44	49/44	79/83	25/25	39/44	52/56	2/12
Positive Dietary Habits	49/53	48/45	53/55	51/47	69/65	28/33	35/35	49/50	-4/-2
Exercise Behaviors	43/55	45/48	55/52	57/45	34/44	55/63	17/21	44/51	-12/3
Cardiovascular Health	51/54	56/57	44/44	49/46	89/93	14/11	45/50	51/55	7/11
Health History	57/56	51/47	50/53	43/44	8/10	94/91	4/5	51/48	8/3

Note.
"Desirable health" is an average of the 22 variables.
Se = Sensitivity, Sp = Specificity, FP = False Positive, FN = False Negative, PPV = Positive Predictive Value, NPV = Negative Predictive Value, Ye = Yield, Ac = Accuracy, Va = Validity

rately were approximately 43-57%. Results for validity all fell below 12%.

Odds ratio. Two of the results in this evaluation shown in Table 3 yeilded statistical significance, but none of them were of practical significance. Values were from .59 to 1.54 with 14 of the 16 values nearly at the null hypothesis of 1.

Coefficient of determination. The squared correlations in Table 3 show that there is effectively no ordinal association between either BMI or %BF and the good/bad health assessments constructed from the scored factors. The coefficients of determination (r^2) were between 0.0001 and 0.0608 with 9 of the 16 values under 0.01 and the remaining 5 values between 0.01 and 0.1. These values suggest that both BMI and %BF would perform poorly as predictors of health status even in those instances where statistical significance was evident. According to Cohen,[78] r^2 values up to 0.01 constitute negligible effect sizes, and r^2 up to 0.1 are considered weak in terms of explained variance.

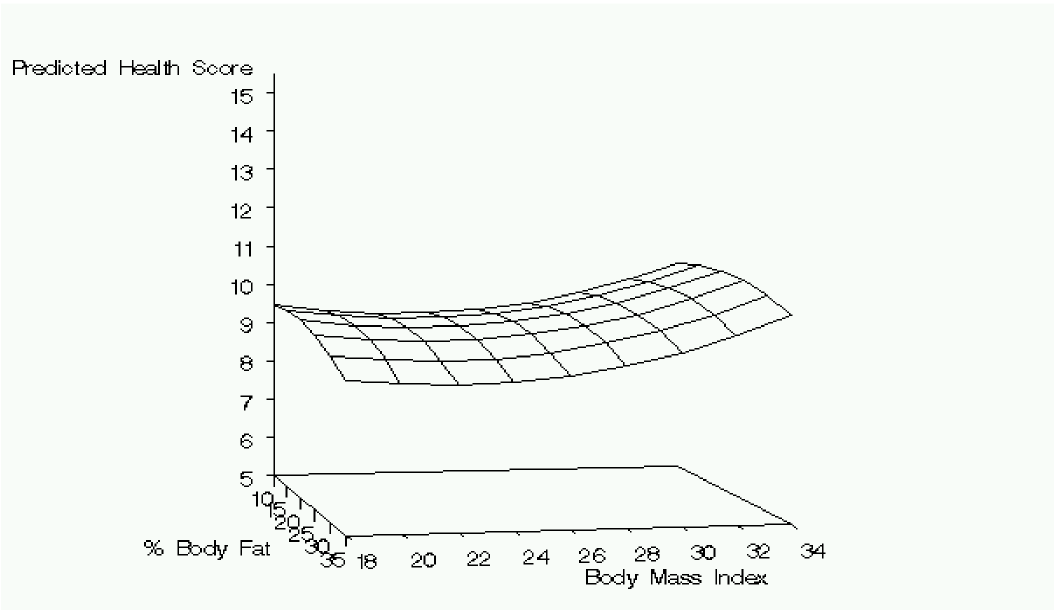
Figure analyses. Figure 1 was developed to show the relationship among variables in graphic form and when the variables are analyzed as continuous rather than discrete variables. This figure shows

Table 3
Odds Ratio (OR) and Coefficient of Determination (R^2) for Body Mass Index (BMI)/Percentage Body Fat (%BF)

Variable	OR	R^2
"Desirable Health"	1.04/1.32	0.0025/0.0013
Licit Drug Use	1.44/1.16	0.0042/0.0039
Negative Dietary Habits	0.68/0.75	0.0001/0.0246[b]
Blood Pressure	1.13/1.52[a]	0.0314[a]/0.0139[b]
Positive Dietary Habits	0.59/1.02	0.0105/0.0008
Exercise Behaviors	0.62/1.12	0.0159/0.0010
Cardiovascular Health	1.31/1.54[a]	0.0608[b]/0.0065[a]
Health History	1.36/1.13	0.0008/0.0104[b]

Note.
"Desirable health" is an average of the 22 variables.
a = $P < .05$. b = $P < .01$

Figure 1
Predicted Total Health Risk Score as a Function of BMI and %BF, Including Quadratic Effects of BMI and %BF and the Interaction of BMI and %BF



the predicted total health score as a function of BMI and %BF. In this multiple linear regression model, linear and quadratic BMI and %BF, plus the interaction of BMI and %BF, were used as independent variable effects. The quadratic and interaction effects were included with the linear effects to allow for the possibility that the association of each of BMI and %BF with mean health score might be nonlinear and perhaps U-shaped. However, this overall model was nonsignificant, $F(5,190) = 0.79$, $P = 0.5612$; and each of the 5 individual effects (2 linear, 2 quadratic, 1 interaction) was nonsignificant, $P > 0.20$ in all cases. Model R-square was a weak 2%. Thus, as with the dichotomized total health score and BMI or %BF relationship, total health was not associated with either BMI or %BF when each of these variables was analyzed continuously. The figure does depict the slight but nonsignificant increase in total health risk as BMI approaches either extreme.

DISCUSSION

The study was conducted to investigate whether BMI or %BF are valid indicators of health. Specifically, the study was designed to compare an individual's health parameters to BMI and %BF estimates and to ascertain (1) if a substantial percentage of individuals would be identified with ideal or lower than ideal BMI and/or %BF, yet poorer than ideal health parameters and (2) if a substantial percentage of individuals would be identified with higher than ideal BMI and/or %BF and be closer to ideal health parameters.

The findings of this study suggest that BMI and %BF estimates are poor indicators of health for this population. The nomogram shows the relationship was essentially constant, which means that neither BMI nor %BF was a good health indicator across the BMI or %BF spectrum. The slight curvatures of BMI and %BF values in the tails of their distributions are not statistically significant. The expected high positive linear association that is generally believed to exist was not observed. A positive linear trend, which would indicate that a lower BMI and/or %BF toward what has been defined as "ideal" equates with better health, was not found. The notion that BMI and/or %BF and health are represented by a positive linear trend seems to be an inappropriate extrapolation to this population and the broad spectrum of BMI and %BF observed in this population. The notion that "less is better" is not supported by these data.

It also was observed that approximately half of the study participants were misclassified. Approximately half with recommended BMI and/or %BF had poor health status, and approximately half with higher than recommended BMI and/or %BF had favorable health status. In other words, using BMI and %BF as indicators of health is no better than the results of a coin toss. In order to be certain that these findings were not the result of scoring criteria choices (based on published standards), empirically determined cutoff points (medians) also were applied. The same analyses were then recomputed with mediians as cutoff points. With the exception of dietary variables (not unexpected as explained in the paragraph below), there was no difference in associations of health status with BMI and/or %BF whether scoring decisions were made using published standards or an empirical approach of splitting on the median. Outcomes were not a function of analysis methods or computing bias.

In regard to dietary variables, although an association was seen when using the median value as a scoring cutoff point, the association was very weak. Furthermore, it was expected that an association would be revealed because as the number of servings of high-calorie food increases, it is logical that BMI and/or %BF would increase as well. Additionally, in regard to individuals who consume a higher number of servings of fruits, vegetables, lean meat, and legumes, yet have lower BMI and/or %BF, one possible explanation is that the BMI and/or %BF values are lower because they are choosing these foods in place of the high-calorie foods.

The results of this study support the following ideas: (1) there is little or no relationship between BMI or %BF and health status; (2) for many individuals, health is independent of BMI and/or %BF; (3) the definition of overweight may be distinctly different for different populations (ie, the definition of overweight as a BMI of 25 may be not be applicable to college-aged individuals); (4) health parameter recommendations for the college-aged population may need to be different from those for the general population; (5) it may be inappropriate to apply to individuals data that were originally intended for epidemiologic populations comparisons; (6) a person with higher than ideal BMI and/or %BF can still be considered healthy; (7) a person with ideal or lower than ideal BMI and/or %BF can be unhealthy; and (8) the popular philosophy that indicates "the lower the BMI and/or %BF, the better the health status"[55] may be invalid; many individuals with low or "ideal" BMI and/or %BF are unhealthy as defined by health parameters used in this study.

The results of this study highlight many practical problems in the area of health recommendations to the public. In spite of other research also indicating that higher than ideal levels of BMI and/or %BF above an ideal may not necessarily be unhealthy for all individuals,[18,79] recommendations are routinely made to reduce levels that are above the so-called ideal. These recommendations are often made regardless of an individual's current level of body fat or current health parameters ("normal" blood pressure, blood lipids, dietary habits, exercise heart recovery rate, etc).[80] Furthermore, recommending a reduction in body fat or body weight encourages focusing on a characteristic that could lead to the development of an unhealthy condition (eg, eating disorders, disordered eating, weight cycling, and depression) and potentially seriously harming health status.[81] Conversely, according to health behavior research, recommending specific changes in diet and exercise may promote positive changes in health parameters and improve morbidity and mortality, independent of weight status.[65,80]

Many health professionals have placed an unbalanced emphasis on absolute amounts of adipose tissue and weight. As a result, society appears to have developed an unhealthy preoccupation on weight, body fat, and aesthetics instead of healthy behaviors and lifestyle modifications.[80,81] For example, it is common during health screenings for recommendations to be made for the individual to reduce weight and/or body fat even if the measured values are already in the ideal range.[80] The popular "lower is better" belief is then mistakenly passed on to the population. When discussing dietary and activity level modifications with slender individuals and recommending a reduction in sugar or saturated fat intake along with regular physical activity, the typical response is "Why should I do that? I'm not fat." Being thin is thought of as being "healthy" as opposed to ways to make lifestyle changes that will improve health.

The message of health has been lost from losing fat for health's sake, to losing fat for aesthetics, which in extreme instances can result in the loss of life.[81] Individuals who are not obese, but have higher than what has been defined as ideal body fat percentages are going to great extremes to achieve a certain weight or %BF, which is the wrong focus. Individuals will literally risk their lives to lose weight or body fat that is not endangering their health. Extreme diets, excessive exercising, dangerous diet supplements, and weight cycling can lead to serious, sometimes irreversible health problems even before any significant amounts of weight are lost.[81-85]

To be clear, the authors of this study are not recommending obesity as a healthy state. The literature is becoming increasingly clear regarding the health consequences of obesity, as well as underweight.[9,72,79,86] Weight seems to play a role in a person's health status in the extremes in older adult populations. Furthermore, the authors are not suggesting that the reduction of body weight or body fat for obesity is contraindicated, but that changes to BMI and %BF must be thought of as results of healthy dietary and exercise practices, not as goals in and of themselves. BMI and/or %BF estimates may be used to monitor change, but adherence to behaviors that promote optimal overall health should be the ultimate focus.

The findings of this study provide further justification for future research that is focused on establishing normative health data for the college-aged population; examining whether or not the current health standards set forth for the public are appropriate for the college-aged population; establishing different health standards for the college-aged population if necessary; making extremes in body weight a health priority versus those who are a given an amount over the prescribed ideal level; examining and disputing the popular "lower is better" philosophy that has crept into the scientific arena; finding ways to educate the public regarding the false notion that "thin equals health" regardless of health behavior; establishing whether it is really appropriate to use epidemiologic data intended to compare populations as health recommendations for individuals; and using the location of excess adipose tissue, versus just the absolute amount, as a health risk indicator.

Inferences from the data in this study should help to establish the idea that the simple presence and amount of adipose tissue or excess body weight above a recommended ideal is not a health risk factor. Health practitioners might consider whether routinely recommending the reduction of body weight and body fat is always appropriate, reevaluate the validity of the current standards upon which these recommendations are made, and reassess the literature regarding BMI and %BF as health risks.

The findings of this study suggest that health professionals ought to consider doing away with the term *overweight* with its many definitions. Instead, it might be appropriate to advocate a more descriptive, functional, medically oriented term such as *metabolic fitness* that would take into account factors such as blood pressure, cholesterol levels and ratios, triglyceride levels, glucose levels, insulin resistance, postexercise heart rate recovery, resting heart rate, intra-abdominal/visceral fat, central fat, and bone density. This might be a better alternative than basing it on the current average weight or on someone's opinion of what it should be.

In summary, BMI and %BF are poor indicators of health status for young adults and should not be used by health professionals to appraise an individual's health risk. The supportive external validity comparisons suggest that this applies to the broader population of 18- to 24-year-olds. Individuals should not strive for a certain level of BMI and/or %BF, but should strive for improved health based on a variety of health assessments, some of which are described herein. Individuals should focus more on optimal health and the specific behavior changes that will help this occur. There needs to be an understanding that optimal levels of BMI and %BF will occur somewhere along a continuum due to an individual's unique physiology, and not within a tight window of acceptability. A shift in thinking is needed that will view ideal BMI and %BF levels as a result, not a goal. Once behavior changes occur, it is up to the individual's physiology to determine the appropriate weight and body composition for optimal health.

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