

Relation of body size and composition to clinical biochemical and hematologic indices in US men and women¹⁻³

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ABSTRACT Small but significant variations in clinical biochemical indices may be of great biological significance. Earlier studies conducted on small, chronically ill, hospitalized, anemic, and/or malnourished population samples suggested associations between body size and composition and indices of iron metabolism, serum protein, and plasma cholesterol. We studied a large, nonhospitalized probability sample of women and men in the First US Health and Nutrition Examination Survey (NHANES I) to characterize these associations. Greater weight, stature, body mass index (BMI), skinfold thickness, and lean body mass (LBM) are associated with higher hemoglobin, hematocrit, and total iron-binding capacity. LBM and body fat are weakly related to serum albumin concentrations in men and to serum total protein concentrations in women. Total cholesterol concentrations are directly associated with weight, body fat, and LBM and are more strongly associated with central than peripheral obesity. Constitutional factors may be important for clinical assessment and for interpretation of epidemiologic studies. *Am J Clin Nutr* 1989;50:1276-81.

KEY WORDS Albumin, body composition, body mass index, cholesterol, homeostasis, iron, lean body mass, obesity, protein

Introduction

Clinical biochemical and hematologic indices are closely maintained within narrow ranges by homeostatic physiologic mechanisms. Small but significant variations in biochemical indices may be of great biological significance. In earlier studies, some of which were conducted on small numbers of ill individuals, various constitutional factors were associated with systematic variations in blood, plasma, and serum biochemical values. Specifically, body fat and lean body mass were associated with biochemical and hematologic indices of systemic iron metabolism (1), lean body mass was weakly associated with serum protein concentrations (2, 3), and body fatness and fat distribution were associated with plasma cholesterol, lipid, and glucose concentrations (4).

Anthropometric indices were used to monitor the nutritional status of chronically ill and the elderly people (5), wherein associations between anthropometric dimensions and biochemical variables were observed (3, 6). Some of these studies may have been subject to variations because of small sample size and the effects of malnutrition and hospitalization (eg, multiple blood drawings and mild anemia) on ill individuals (2, 7).

Anthropometric variables and constitutional factors have also come under increased scrutiny as potential risk factors for chronic diseases (8, 9), whereas biochemical indices such as cholesterol concentrations (10-13) and

indices of iron metabolism (14) are also being investigated for their potential role in disease etiology. When associations between hematocrit and/or hemoglobin concentration and mortality were studied, for example, a number of risk factors such as age, sex, menopausal status in women, and cigarette smoking were taken into account (15, 16), but body size or body composition were not routinely considered in the analyses.

The association of body size and body composition with clinical biochemical indices may be of significance in designing and interpreting chronic-disease studies that collect anthropometric and biochemical variables. Establishing these associations may also be useful in the physical assessment of individuals of known constitution who manifest variations in biochemical indices. To more precisely establish systematic relations between physical constitution and biochemical indices, we studied a large,

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nonhospitalized, probability sample of US men and women in the First National Health and Nutrition Examination Survey (NHANES I).

Subjects and methods

Population sample

NHANES I was carried out on a probability sample of the US noninstitutionalized population from 1971 to 1974 by the US National Center for Health Statistics. There were 5808 men and 8592 women aged 25–74 y included in the survey who had requisite anthropometric data collected. Of these, 5600 men and 8234 women also had data on serum biochemical measurements collected. Individuals selected were generally healthy, ambulatory, and not clinically anemic or malnourished.

Anthropometric data

Stature, weight, arm circumference, triceps and subscapular skinfold thicknesses, elbow breadth, bitrochanteric breadth, and sitting height were measured by standardized techniques in NHANES I (17, 18). Of 14 407 adults aged 25–74 y, 14 400 (5808 men and 8592 women) had stature and weight data available for this study. A total of 14 371 (5802 men and 8569 women) had skinfold measurement data available also.

We calculated body mass index (BMI) for each member of the sample: W/S^2 for men and $W/S^{1.5}$ for women. These BMIs were selected on the basis of high correlations to weight and independence from stature across age and fatness groups in NHANES I population sample (19). Arm fat area and arm muscle area (AMA) were also calculated from arm circumference and triceps skinfold thickness measurements by the method of Jelliffe (20) for each individual with the modifications of Heymsfield et al (21) for men and women. Total muscle mass was calculated from AMA and stature with equations reported by Heymsfield et al (21). Frame size was estimated from elbow breadth (22). A sum of triceps and subscapular skinfold measurements (unilateral) was also calculated for each individual. Individual and summed skinfold measurements as well as arm fat area provide measures of fatness, with subscapular skinfold thickness representing central body fat and triceps skinfold thickness representing peripheral fat. The AMA and total muscle mass provide estimates of lean body mass. Arm circumference reflects both fatness and lean body mass.

Laboratory determinations

Blood samples were obtained by venipuncture (23). Hemoglobin concentration and hematocrit were determined on blood samples in the NHANES I mobile examination centers by using a Coulter Hemoglobinometer (Hialeah, FL). Serum samples were frozen and sent to the Nutrition Biochemistry Laboratory at the Centers for Disease Control. Serum iron and total iron-binding capacity (TIBC) were determined spectrophotometrically by a modification of the automated Technicon (Rockford, IL) AAI 25 method. Percent transferrin saturation was then calculated as $100 \times (\text{serum iron}/\text{TIBC})$. Serum total protein, albumin, and cholesterol concentrations were determined by use of standard laboratory techniques.

Statistical analyses

Both Pearson and Spearman correlations were calculated between each of the anthropometric variables and indices reported here and hemoglobin, hematocrit, iron, TIBC, percent transferrin saturation, total protein, albumin, and total chole-

sterol by sex controlled for age for the entire population (24). These variables were approximately normally distributed among men and women in the population. Men and women were then divided into quartiles of stature, weight, BMI, subscapular and triceps skinfold thickness, and arm muscle area on the basis of normal distributions of these variables in the population. Stratification was not performed by ethnic group because of small sample size in the nonwhite categories. Means were calculated for hemoglobin, hematocrit, TIBC, percent transferrin saturation, iron, total protein, albumin, and total cholesterol for each quartile of men and women controlled for age. Tests for trends were performed for each variable across quartiles.

Results

The correlation analyses across the population by sex controlled for age reveal significant associations for most of the individual relations examined. Correlation coefficients were generally in the range $r = 0.1-0.2$, $p < 0.0001$, for the associations between various anthropometric variables and the biochemical and hematologic indices reported here. Anthropometric variables were all significantly related to the biochemical and hematologic indices studied, and trend tests across the quartiles were significant with the following exceptions: Serum iron concentrations were not significantly related to stature in women or to weight or skinfold thickness in men. TIBC in men and hemoglobin and hematocrit in both sexes were not significantly related to stature. Lean body mass AMA was not significantly related to total protein amounts in men or to serum albumin concentrations in women.

These relations are evident in the calculation of mean biochemical values controlled for age across quartiles of men and women ranked by anthropometric variables. Greater weight, stature, BMI, subscapular skinfold thickness, and AMA are generally associated with significantly higher mean hemoglobin concentrations and hematocrits in men and women across quartiles (Table 1). Conversely, greater weight, BMI, skinfold thickness, and AMA area are generally associated with significantly lower mean serum iron concentrations in women but not men. Increasing anthropometric dimensions are generally associated with increased TIBC and decreased percent transferrin saturation in men and women.

In general, mean serum protein concentrations do not vary greatly (Table 2). However, mean serum albumin concentrations are significantly greater in higher weight, BMI, skinfold thickness, and AMA quartiles of men whereas serum total protein concentrations are significantly greater in higher weight, stature, BMI, skinfold thickness, and AMA quartiles of women. Serum albumin in men and serum protein in women serve as significant indicators of lean body mass (AMA). Serum albumin concentrations are significantly lower in the heaviest, most overweight, fattest quartiles of women, whereas they are significantly higher in heavier, more overweight (greater BMI), fatter quartiles of men.

Mean serum cholesterol concentrations are signifi-

TABLE 1
Iron metabolic indices by anthropometric quartiles in men and women*

Quartiles	Hemoglobin g/L	Hematocrit	Iron μmol/L	TIBC μmol/L	Percent transferrin saturation†
Women					
Weight (kg)					
<55.8	136 ± 0.3	0.407 ± 0.1	18.4 ± 0.2	65.6 ± 0.3	28.6 ± 0.3
55.8–62.5	137 ± 0.3‡	0.409 ± 0.1	18.0 ± 0.2	65.8 ± 0.3	28.1 ± 0.3
62.6–72.5	137 ± 0.3‡	0.409 ± 0.1	17.7 ± 0.2‡	67.0 ± 0.3‡	27.1 ± 0.3‡
>72.5	138 ± 0.3‡	0.413 ± 0.1‡	15.9 ± 0.2‡	67.5 ± 0.3‡	24.3 ± 0.3‡
Stature (cm)					
<157	137 ± 0.3	0.409 ± 0.1	17.4 ± 0.2	67.0 ± 0.3	26.6 ± 0.3
157–161	137 ± 0.3	0.409 ± 0.1	17.5 ± 0.2	66.8 ± 0.3	26.9 ± 0.3
162–165	137 ± 0.3	0.409 ± 0.1	17.5 ± 0.2	65.6 ± 0.3‡	27.4 ± 0.3‡
>165	137 ± 0.3	0.410 ± 0.1	17.6 ± 0.2	66.4 ± 0.3	27.2 ± 0.3
BMI (kg/m^{1.5})					
<27.4	136 ± 0.3	0.407 ± 0.1	18.6 ± 0.2	65.2 ± 0.3	29.0 ± 0.3
27.4–31.0	136 ± 0.3	0.408 ± 0.1	18.1 ± 0.2‡	65.7 ± 0.3	28.2 ± 0.3‡
31.1–36.1	137 ± 0.3	0.409 ± 0.1‡	17.5 ± 0.2‡	67.1 ± 0.3‡	26.9 ± 0.3‡
>36.1	138 ± 0.3‡	0.413 ± 0.1‡	15.9 ± 0.2‡	67.8 ± 0.3‡	24.1 ± 0.3‡
SSF (mm)					
<11.0	136 ± 0.3	0.407 ± 0.1	18.1 ± 0.2	65.1 ± 0.3	28.5 ± 0.3
11.0–17.0	136 ± 0.3	0.408 ± 0.1	18.3 ± 0.2	66.2 ± 0.3‡	28.3 ± 0.3
17.1–25.3	137 ± 0.3‡	0.410 ± 0.1‡	17.4 ± 0.2	66.9 ± 0.3‡	26.8 ± 0.3‡
>25.3	138 ± 0.3‡	0.413 ± 0.1‡	16.2 ± 0.2‡	67.6 ± 0.3‡	24.6 ± 0.3‡
AMA (cm²)					
<26.6	136 ± 0.3	0.407 ± 0.1	17.9 ± 0.2	65.3 ± 0.3	28.1 ± 0.3
26.6–31.6	137 ± 0.3‡	0.408 ± 0.1	18.0 ± 0.2	66.2 ± 0.3	27.8 ± 0.3
31.7–38.2	137 ± 0.3‡	0.410 ± 0.1‡	17.8 ± 0.2	66.3 ± 0.3‡	27.5 ± 0.3
>38.2	137 ± 0.3‡	0.412 ± 0.1‡	16.4 ± 0.2‡	68.0 ± 0.3‡	24.8 ± 0.3‡
Men					
Weight (kg)					
<69.2	151 ± 0.3	0.448 ± 0.1	19.2 ± 0.2	61.5 ± 0.3	31.7 ± 0.3
69.2–77.1	154 ± 0.3‡	0.453 ± 0.1‡	19.0 ± 0.2	62.1 ± 0.3	31.0 ± 0.3
77.2–85.7	155 ± 0.3‡	0.456 ± 0.1‡	19.0 ± 0.2	62.9 ± 0.3‡	30.8 ± 0.3
>85.7	156 ± 0.3‡	0.459 ± 0.1‡	18.8 ± 0.2	63.4 ± 0.3‡	30.1 ± 0.3‡
Stature (cm)					
<169	153 ± 0.3	0.453 ± 0.1	18.6 ± 0.2	62.8 ± 0.3	30.2 ± 0.3
169–174	154 ± 0.3	0.455 ± 0.1	18.9 ± 0.2	62.5 ± 0.3	30.8 ± 0.3
175–179	154 ± 0.3	0.454 ± 0.1	19.3 ± 0.2‡	62.6 ± 0.3	31.3 ± 0.3‡
>179	154 ± 0.3	0.454 ± 0.1	19.2 ± 0.2‡	62.3 ± 0.3	31.3 ± 0.3‡
BMI (kg/m²)					
<22.9	150 ± 0.3	0.448 ± 0.1	19.4 ± 0.2	61.1 ± 0.3	32.3 ± 0.3
22.9–25.5	154 ± 0.3‡	0.454 ± 0.1‡	19.0 ± 0.2	62.0 ± 0.3‡	31.1 ± 0.3‡
25.6–27.9	155 ± 0.3‡	0.455 ± 0.1‡	18.6 ± 0.2‡	63.1 ± 0.3‡	30.0 ± 0.3‡
>27.9	157 ± 0.3‡	0.460 ± 0.1‡	18.9 ± 0.2	64.1 ± 0.3‡	30.1 ± 0.3‡
SSF (mm)					
<10.3	150 ± 0.3	0.447 ± 0.1	19.2 ± 0.2	61.2 ± 0.3	31.9 ± 0.3
10.3–14.5	154 ± 0.3‡	0.455 ± 0.1‡	19.2 ± 0.2	62.0 ± 0.3‡	31.5 ± 0.3
14.6–20.8	155 ± 0.3‡	0.455 ± 0.1‡	18.8 ± 0.2	62.8 ± 0.3‡	30.6 ± 0.3‡
>20.8	156 ± 0.3‡	0.459 ± 0.1‡	18.7 ± 0.2	64.3 ± 0.3‡	29.7 ± 0.3‡
AMA (cm²)					
<44.0	152 ± 0.3	0.451 ± 0.1	19.1 ± 0.2	61.3 ± 0.3	31.5 ± 0.3
44.0–51.4	154 ± 0.3‡	0.453 ± 0.1‡	19.1 ± 0.2	62.4 ± 0.3	31.1 ± 0.3
51.5–59.9	155 ± 0.3‡	0.455 ± 0.1‡	18.9 ± 0.2	62.7 ± 0.3‡	30.6 ± 0.3
>59.9	155 ± 0.3‡	0.457 ± 0.1‡	18.9 ± 0.2	63.5 ± 0.3‡	30.3 ± 0.3‡

* $\bar{x} \pm \text{SEM}$. BMI, body mass index; SSF, subscapular skinfold thickness; and AMA, arm muscle area.

† $100 \times [\text{iron}/\text{TIBC}]$.

‡ Significantly different from reference (first) quartile at $p < 0.05$.

TABLE 2
Protein, albumin
in men and women

Quartile
Women
Weight (kg)
<55.8
55.8–62.5
62.6–72.5
>72.5
Stature (cm)
<157
157–161
162–165
>165
BMI (kg/m^{1.5})
<27.4
27.4–31.0
31.1–36.1
>36.1
SSF (mm)
<11.0
11.0–17.0
17.1–25.3
>25.3
AMA (cm²)
<26.6
26.6–31.6
31.7–38.2
>38.2
Men
Weight (kg)
<69.2
69.2–77.1
77.2–85.7
>85.7
Stature (cm)
<169
169–174
175–179
>179
BMI (kg/m²)
<22.9
22.9–25.5
25.6–27.9
>27.9
AMA (cm²)
<44.0
44.0–51.4
51.5–59.9
>59.9

* $\bar{x} \pm \text{SEM}$

† Significant

‡ TSF, triceps

TABLE 2
Protein, albumin, and cholesterol values by anthropometric quantiles in men and women*

Quantile	Protein g/L	Albumin g/L	Cholesterol mmol/L
Women			
Weight (kg)			
<55.8	70.6 ± 0.1	43.5 ± 0.1	5.56 ± 0.02
55.8-62.5	70.7 ± 0.1	43.4 ± 0.1	5.68 ± 0.02†
62.6-72.5	71.0 ± 0.1†	43.3 ± 0.1	5.79 ± 0.02†
>72.5	72.0 ± 0.1†	42.9 ± 0.1†	5.84 ± 0.02†
Stature (cm)			
<157	71.4 ± 0.1	43.3 ± 0.1	5.76 ± 0.02
157-161	71.1 ± 0.1	43.2 ± 0.1	5.75 ± 0.02
162-165	70.9 ± 0.1†	43.2 ± 0.1	5.71 ± 0.02
>165	70.9 ± 0.1†	43.4 ± 0.1	5.65 ± 0.02†
BMI (kg/m^{2.5})			
<27.4	70.6 ± 0.1	43.5 ± 0.1	5.50 ± 0.02
27.4-31.0	70.4 ± 0.1	43.3 ± 0.1	5.70 ± 0.02†
31.1-36.1	71.2 ± 0.1†	43.3 ± 0.1	5.81 ± 0.02†
>36.1	72.1 ± 0.1†	42.9 ± 0.1†	5.85 ± 0.02†
AMA (cm²)			
<26.6	70.4 ± 0.1	43.3 ± 0.1	5.64 ± 0.02
26.6-31.6	70.8 ± 0.1†	43.5 ± 0.1	5.66 ± 0.02
31.7-38.2	71.0 ± 0.1†	43.3 ± 0.1	5.74 ± 0.02†
>38.2	72.1 ± 0.1†	43.1 ± 0.1	5.82 ± 0.02†
TSF (mm)‡			
<18	70.6 ± 0.1	43.2 ± 0.1	5.51 ± 0.02
18-23	70.7 ± 0.1†	43.4 ± 0.1	5.71 ± 0.02†
24-29	71.1 ± 0.1†	43.4 ± 0.1	5.80 ± 0.02†
>29	71.9 ± 0.1†	43.1 ± 0.1	5.81 ± 0.02†
SSF (mm)			
<11.0	—	—	5.51 ± 0.02
11.0-17.0	—	—	5.66 ± 0.02†
17.1-25.3	—	—	5.82 ± 0.02†
>25.3	—	—	5.86 ± 0.02†
Men			
Weight (kg)			
<69.2	71.1 ± 0.1	43.7 ± 0.1	5.46 ± 0.02
69.2-77.1	70.9 ± 0.1	44.1 ± 0.1†	5.70 ± 0.02†
77.2-85.7	70.9 ± 0.1	44.3 ± 0.1†	5.79 ± 0.02†
>85.7	71.3 ± 0.1	44.2 ± 0.1†	5.85 ± 0.02†
Stature (cm)			
<169	71.5 ± 0.1	44.1 ± 0.1	5.72 ± 0.02
169-174	71.1 ± 0.1†	43.9 ± 0.1	5.73 ± 0.02
175-179	70.7 ± 0.1†	44.0 ± 0.1	5.73 ± 0.02
>179	70.9 ± 0.1†	44.2 ± 0.1	5.62 ± 0.02†
BMI (kg/m²)			
<22.9	70.9 ± 0.1	43.7 ± 0.1	5.40 ± 0.02
22.9-25.5	70.8 ± 0.1	44.1 ± 0.1†	5.67 ± 0.02†
25.6-27.9	71.0 ± 0.1	44.2 ± 0.1†	5.82 ± 0.02†
>27.9	71.5 ± 0.1	44.3 ± 0.1†	5.90 ± 0.02†
AMA (cm²)			
<44.0	71.0 ± 0.1	43.7 ± 0.1	5.48 ± 0.02
44.0-51.4	70.8 ± 0.1	44.0 ± 0.1†	5.72 ± 0.02†
51.5-59.9	71.0 ± 0.1	44.3 ± 0.1†	5.74 ± 0.02†
>59.9	71.4 ± 0.1	44.2 ± 0.1†	5.84 ± 0.02†
TSF (mm)			
<7.6	71.1 ± 0.1	43.7 ± 0.1	5.47 ± 0.02
7.6-11.0	70.9 ± 0.1	44.2 ± 0.1†	5.73 ± 0.02†
11.1-14.5	70.7 ± 0.1	44.1 ± 0.1†	5.78 ± 0.02†
>14.5	71.6 ± 0.1†	44.2 ± 0.1†	5.81 ± 0.02†
SSF (mm)			
<10.3	—	—	5.40 ± 0.02
10.3-14.5	—	—	5.70 ± 0.02†
14.6-20.8	—	—	5.80 ± 0.02†
>20.8	—	—	5.89 ± 0.02†

* $\bar{x} \pm \text{SEM}$.

† Significantly different from reference (first) quartile at $p < 0.05$.

‡ TSF, triceps skinfold thickness.

cantly greater by weight, BMI, skinfold thickness, and AMA measurements through all quartiles of men and women (Table 2). Conversely, cholesterol concentrations are significantly lower in higher stature quartiles of men and women. The relationship of cholesterol concentration to estimate of body fatness is greater for subscapular skinfold thickness (an estimate of central fatness) than for triceps skinfold thickness (an estimate of peripheral fatness).

Discussion

The degree of correlation for the associations between anthropometric variables and biochemical and hematologic indices is limited by the minimal variability in these values that is compatible with life. In addition to illustrating the systematic relations between anthropometric variables and biochemical indices by sex, Tables 1 and 2 on a probability sample of US men and women may provide a reference standard for guidance in physical assessment of individuals of various constitutions. For example, marginally low hemoglobin concentration and hematocrit in a short, slight women may be considered of no particular clinical significance whereas the same values in a tall, heavy, obese woman may be indicative of clinical anemia.

In previous studies (25-27) hemoglobin concentrations of 100-110 g/L in Asian women of childbearing age had no statistical or clinical significance nor predictive value for pregnancy outcome. However, these concentrations are clinically indicative of mild-to-moderate anemia in US women and have long been associated with poor pregnancy outcome (28). The average shorter stature, lighter weight, and decreased body fat and lean body mass of Asian compared with US women (9, 29, 30) may partially account for these earlier observations.

Over the past decade there has been renewed interest in the possibility that differences in hemoglobin concentrations may exist among white, black, and Asian populations during childhood, adulthood, and pregnancy (25, 31-33). Nicklas et al (34) recently reported contrasts between white and black children in hemoglobin concentrations and dietary patterns related to hematopoiesis in the Bogalusa Heart Study. After controlling for variations in dietary patterns of the children, the investigators concluded that in all likelihood differences in hemoglobin concentrations exist between white and black children that are independent of differences in intake of specific blood-building nutrients and maturational changes. It would be potentially useful to present these analyses controlled for body size and body composition to clarify the nature of these differences in hemoglobin concentrations, because there may be systematic differences in body size and body composition between black and white children in the Bogalusa study (35). There are systematic differences in age-specific body size and body composition between white and black children in other populations in the United States and around the world

that may have further implications for adult health status (30). It is important to consider whether constitutional factors may play a role in determining the differences in hemoglobin concentrations in black and white children before it can be definitively concluded that these differences are inherent by population group.

In studies on adults that did not assess body size or body composition (15, 16), high hematocrits in women were associated with high cholesterol concentrations as well as high blood pressure and increased mortality. Although various mechanisms were proposed to explain these associations (16), obesity was not considered as a possible link among these factors as related to both high hematocrits and high cholesterol concentrations in our results.

Serum protein concentrations were considered to be weakly related to lean body mass (3, 5). Our results indicate that serum albumin concentrations are weakly related to lean body mass in men whereas total protein concentrations are weakly related to lean body mass in women. This divergent association of albumin and total protein concentrations with respect to body composition between men and women is notable. The decrease in serum albumin concentrations with weight in women and the increase with weight in men may be related to the observation that on average a greater proportion of incremental body mass (weight) is due to body fat relative to lean body mass in women as compared with men in this population (19).

Increased weight and body fat have been associated with increased serum cholesterol concentrations. BMI appears to be somewhat more strongly associated with cholesterol concentration than does body weight alone, suggesting that BMI may be preferred as an indicator of risk for cardiovascular disease, for example. Lean body mass is also significantly associated with serum cholesterol concentrations, and BMI is correlated to lean body mass (19) as well as to body fat. Central obesity (as estimated by subscapular skinfold thickness measurement) is also more significantly related to cholesterol concentrations than is peripheral obesity (triceps skinfold thickness), which is consistent with recent observations in a Costa Rican population by Bailey et al (4). Baumgartner et al (36) also recently observed small but significant associations of centripetal fat pattern with blood pressure in men and with high plasma triglyceride and low plasma high-density-lipoprotein cholesterol in women.

These observations indicate the significance of constitutional factors in establishing clinical standards for serum biochemical indices in US men and women and for interpreting relations among body size and composition, biochemical and hematologic indices, and chronic diseases.

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References

- Garn SM, Ryan AS, Higgins MW. Implications of fatness and leanness. *Am J Phys Anthropol* 1982;57:191(abstr).
- Bistrián BR, Blackburn GL, Hallowell E, Heddlé R. Protein status of general surgical patients. *JAMA* 1974;230:858-60.
- Young GA, Hill GL. Assessment of protein-calorie malnutrition in surgical patients from plasma proteins and anthropometric measurements. *Am J Clin Nutr* 1978;31:429-35.
- Bailey S, Campos H, Schosinsky K, Mata L. Relationship of upper body fat distribution to serum glucose and lipids in a Costa Rican population. *Am J Phys Anthropol* 1987;73:111-7.
- Haas JD, Flegal KM. Anthropometric measurements. In: Newell GR, Ellison NM, eds. *Nutrition and cancer: etiology and treatment*. New York: Raven Press, 1981:23-40.
- Heymsfield SB, Stevens V, Noel R, McManus C, Smith J, Nixon DW. Biochemical composition of muscle in normal and semi-starved human subjects: relevance to anthropometric measurements. *Am J Clin Nutr* 1982;36:131-42.
- Eyster E, Bernene J. Nosocomial anemia. *JAMA* 1973;223:73-4.
- Bailey SM. Human physique and susceptibility to noninfectious disease. *Yearbook Phys Anthropol* 1985;28:149-73.
- Micozzi MS. Nutrition, body size and breast cancer. *Yearbook Phys Anthropol* 1985;28:175-206.
- Kark JD, Smith AH, Hames CG. The relationship of serum cholesterol to the incidence of cancer in Evans County, Georgia. *J Chronic Dis* 1980;33:311-22.
- Cambien F, Ducimetiere P, Richard J. Total serum cholesterol and cancer mortality in a middle aged male population. *Am J Epidemiol* 1980;112:388-94.
- Salmond CE, Beaglehole R, Prior IAM. Are low cholesterol values associated with excess mortality? *Br Med J* 1985;290:422-4.
- Schatzkin A, Hoover RN, Taylor PR, et al. Serum cholesterol and cancer in the NHANES I epidemiological follow-up study. *Lancet* 1987;2:298-301.
- Stevens RG, Jones DY, Micozzi MS, Taylor PR. Body iron stores and the risk of cancer. *N Engl J Med* 1988;319:1047-52.
- Carter CL, McGee D, Reed D, Yano K, Stemmermann G. Hematocrit and the risk of coronary heart disease: the Honolulu Heart Program. *Am Heart J* 1983;105:674-9.
- Campbell MJ, Elwood PC, Mackean J, Waters WE. Mortality, haemoglobin level and hematocrit in women. *J Chronic Dis* 1985;38:881-9.
- National Center for Health Statistics. Weight and height of adults 18-74 years of age. United States 1971-74. Hyattsville, MD: National Center for Health Statistics, 1979. (Vital and health statistics series 11, #211 [DHEW publication (PHS) 79-1659].)
- National Center for Health Statistics. Obese and overweight adults in the United States. Hyattsville, MD: National Center for Health Statistics, 1983. (Vital and health statistics series 11, #230 [HSSH publication (PHS) 83-1680].)
- Micozzi MS, Albanes D, Jones DY, Chumlea WC. Correlations of body mass indices with weight, stature and body composition in men and women in NHANES I and II. *Am J Clin Nutr* 1986;44:725-31.
- Jelliffe DB. *The assessment of the nutritional status of the community*. Geneva: World Health Organization, 1966. (WHO monograph 53.)
- Heymsfield SB, McManus C, Smith J, Stevens V, Nixon DW. Anthropometric measurement of muscle mass: revised equations for calculating bone free arm muscle area. *Am J Clin Nutr* 1982;36:680-90.
- Frisancho AR, Flegel PN. Elbow breadth as a measure of frame size for US males and females. *Am J Clin Nutr* 1983;37:311-4.
- Singer JD, Granahan P, Goodrich NN, et al. Diet and iron status, a study of relationships. Hyattsville, MD: National Center for Health Statistics, 1982. [Series II, #229, DHHS publication (PHS) 83-1679.]
- Diem K, ba-Geigy
- Micozzi Health I
- Micozzi Health C
- Micozzi Bol Of S
- Aubry R in relat
- at specia
- Meredith rary hu
- 1971;34
- Micozzi adult br
31. Dallma concent

24. Diem K, Lentner C. *Documenta Geigy: scientific tables*. Basel: Ciba-Geigy Ltd, 1970.
25. Micozzi MS. On definition of anemia in pregnancy. *Am J Public Health* 1978;68:907-8 (letter).
26. Micozzi MS. On definition of anemia in pregnancy. *Bull Pan Am Health Organ* 1979;13:92-3(abstr).
27. Micozzi MS. On the definition of anemia in the pregnant woman. *Bol Of Sanit Panam* 1980;89:597-8 (in Spanish).
28. Aubry RH, Nesbitt REL. High risk obstetrics I. Perinatal outcome in relation to a broadened approach to obstetric care for patients at special risk. *Am J Obstet Gynecol* 1969;105:241-7.
29. Meredith HV. Worldwide somatic comparisons among contemporary human groups of adult females. *Am J Phys Anthropol* 1971;34:89-132.
30. Micozzi MS. Cross-cultural correlations of childhood growth and adult breast cancer. *Am J Phys Anthropol* 1987;73:525-37.
31. Dallman PR, Barr GD, Allen CM, Shinefield HT. Hemoglobin concentration in white, black, and oriental children: is there a need for separate criteria in screening for anemia? *Am J Clin Nutr* 1981;31:377-80.
32. Owen GM, Yanochik-Owen A. Should there be a different definition of anemia in black and white children? *Am J Public Health* 1977;67:866-8.
33. Garn SM, Shaw HA, Guire KE. Apportioning black-white hemoglobin and hematocrit differences during pregnancy. *Am J Clin Nutr* 1977;30:461-2.
34. Nicklas TA, Frank GC, Webber LS, et al. Racial contrasts in hemoglobin levels and dietary patterns related to hematopoiesis in children: the Bogalusa Heart Study. *Am J Public Health* 1987;77:1320-3.
35. Foster TA, Voors AW, Webber LS, Frerichs RR, Berenson GS. Anthropometric and maturation measurements of children, ages 5 to 14 years, in a biracial community. The Bogalusa Heart Study. *Am J Clin Nutr* 1977;30:582-91.
36. Baumgartner RN, Roche AF, Chumlea NC, Siervogel RM, Glueck CJ. Fatness and fat patterns: associations with plasma lipids and blood pressures in adults, 18 to 57 years of age. *Am J Epidemiol* 1987;126:614-28.