Henry Ford Hospital Medical Journal

Volume 34 | Number 2 Article 6

6-1986

The Failure of Anthropometry as a Nutritional Assessment Tool

Judith J. Bencich

Diana L. Twyman

Ann Fierke

The Failure of Anthropometry as a Nutritional Assessment Tool

Judith J. Bencich, RD,* Diana L. Twyman, MS, RD,* and Ann Fierke, RD*

Anthropometric measurements are commonly used to assess body composition changes and adequacy of nutritional support in the hospitalized patient. To test their utility as nutritional assessment tools in the intensive care unit (ICU) patient, body weight, triceps skinfold (TSF), mid-arm muscle circumference (MAMC), and fluid balance and intake were collected on 21 critically ill patients during their ICU stay. Correlations were sought between adequacy of nutritional support and changes over time in weight, MAMC, fluid balance, and TSF.

A significant change over time in mean body weight ($p < 0.0001$) was seen, reflecting a mean weight loss despite a positive cumulative fluid balance of almost 20 L by day 14 for all patients ($p < 0.0001$). There was a significant change over time in the mean fractional intake of required calories ranging from 41.7% on observation day 1 to a peak of 84.0% on day 22 ($p < 0.001$).

TSF and MAMC could not be obtained on a large percentage of ICU patients due to severe edema including the mid-upper arm. Obtained measurements showed no change over the study period in TSF ($p = 0.24$) and MAMC ($p = 0.71$) despite significant changes in weight ($p < 0.0001$), caloric intake ($p = 0.0001$), and cumulative fluid balance ($p = 0.0001$).

From these data it appears that anthropometric indices of TSF and MAMC are unrelated to nutritional intake and weight in ICU patients and are therefore not of use in the nutritional assessment of this population. (Henry Ford Hosp Med J 1986;34:95-8)

Techniques for assessing alterations in body composition due to weight change have been developed and used extensively for nutrition screening in large, healthy populations (1). Among them are anthropometric measurements which include body weight per height (BW) as a measure of leanness or obesity, tricep skinfold (TSF) as a measure of subcutaneous fat stores, and mid-upper arm muscle circumference (MAMC) as an indicator of lean body mass (2). More recently, arm muscle area, a measurement derived from MAMC and TSF, has been implicated as a better indicator of skeletal protein mass than MAMC (3).

Current criticisms concerning the suitability of these standards include investigator reliability in reporting measurement errors, a failure by investigators to standardize measurement sites and techniques, and imprecise methodologies. The need for a reliable means of assessing nutritional status in the intensive care unit (ICU) patient is also clearly indicated. The validity of anthropometry in this population, however, is questionable as body measurements masked by generalized edema, even if obtainable, would be difficult to interpret.

A recent review of the clinical literature reveals a lack of anthropometric studies conducted in the critically ill ICU patient (1,2,4-16). In an effort to assess the utility of anthropometrics for nutritional assessment in critically ill patients, a study was conducted in the Surgical Intensive Care Units of Henry Ford Hospital.

Materials and Methods

In a prospective nonrandomized study, anthropometric measurements were performed on 21 critically ill patients receiving either parenteral or enteral nutritional support. Critically ill was defined as a mechanically ventilated ICU patient with a condition or conditions associated with a high degree of morbidity and mortality. Subjects were monitored for changes in body weight, TSF, MAMC, fluid balance, and nutritional intake. Data were collected during the patients' entire length of stay in the ICU. Anthropometric measurements were obtained on all subjects on day 1 of the study period and every other day thereafter. The length of each study period was dependent on the patients' length of stay in the ICU and continued nutritional support.

Anthropometric measurements were collected by trained personnel working in teams of two during scheduled physical examinations. One team member performed all measurements and verbally relayed the information to the other member who then recorded them. A single MAMC measurement was obtained from the arm of each subject with a flexible paper tape calibrated in centimeters. During the measurement, the subject was in a supine position with the forearm placed horizontally across the middle of the body, with the elbow bent to a 90 degree angle. The upper arm was marked at the midpoint between the acromion and olecranon processes, then extended alongside the body; the circumference was measured to the nearest centimeter. TSF thickness was measured by forming a fold of skin plus subcutaneous tissue (without underlying muscle) over the triceps muscle. The crest of the fold was parallel to the long axis of the

Submitted for publication: May 22, 1986.
Accepted for publication: June 24, 1986.

*Division of Trauma Surgery and Nutritional Support, Henry Ford Hospital.
Address correspondence to Ms Bencich, Division of Trauma Surgery and Nutritional Support, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, MI 48202.

Table 1
Mean Fluid Balance and Kcal Intakes

Day	Mean Cumulative Fluid Balance (mL) X 103	Mean % Intake of Required Kcal	Mean Actual Kcal Intake	Mean Daily Weight Change (kg)
1	$+1.3 \pm 0.44$	41.7 ± 8.4	940 ± 198	0
2	$+2.35 \pm 0.77$	43.0 ± 9.3	1015 ± 239	0.88 ± 1.74
3	$+3.68 \pm 0.89$	57.9 ± 9.9	1387 ± 255	1.31 ± 1.19
4	$+5.29 \pm 1.10$	74.7 ± 11.5	1793 ± 283	-0.01 ± 1.23
5	$+6.42 \pm 1.23$	74.7 ± 11.7	1748 ± 287	-0.42 ± 1.90
6	$+7.33 \pm 1.35$	68.8 ± 10.6	1617 ± 269	-5.73 ± 5.96
7	$+7.97 \pm 1.58$	66.5 ± 8.9	1540 ± 222	0.13 ± 2.42
8	$+8.37 \pm 1.94$	68.6 ± 11.5	1652 ± 299	0.62 ± 2.10
9	$+10.02 \pm 2.53$	76.6 ± 14.8	1793 ± 337	-1.89 ± 2.87
10	$+11.13 \pm 2.92$	82.8 ± 12.9	1903 ± 322	1.05 ± 2.52
11	$+11.61 \pm 2.96$	84.8 ± 12.3	1917 ± 298	0.36 ± 3.73
12	$+13.64 \pm 3.65$	79.4 ± 16.5	1877 ± 406	-1.56 ± 4.26
13	$+15.87 \pm 4.26$	81.2 ± 13.5	2038 ± 387	-0.99 ± 2.70
14	$+19.99 \pm 5.47$	85.9 ± 18.0	2100 ± 432	-5.49 ± 12.25
15	$+17.22 \pm 5.05$	78.3 ± 13.4	1921 ± 370	8.2 ± 8.62
	$p < 0.0001$	$p < 0.001$	$p < 0.0001$	$p < 0.0001$

Table 2
Correlations Between Anthropometric and Nutritional Indices

Day	Cumulative Fluid Balance	TSF (mm)	MAMC (mm)	KCAL (in)	Weight Change (kg)
1	+1.33	15.95	24.53	940	0.88
14	+19.99	16.03	22.07	2100	−5.49
p-Values	0.0001	0.24	0.71	0.0001	< 0.0001

TSF = tricep skinfold, and MAMC = mid-upper arm muscle circumference.

arm. Thickness of the fold was measured with a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, MD) held in the dominant hand. Without releasing the fold from between the thumb and the index finger, three measurements were obtained in centimeters and averaged before recording (4).

Treatment of missing data

Serial measurements of TSF thickness were not recorded 26% of the time (number of days TSF obtained/total number of days). This was due to generalized edema encompassing the upper portion of both arms. The missing values were omitted from data entry. The remainder of daily data collected on subjects was entered.

Statistical analysis

Analysis of data was based on correlations and ratios sought between actual caloric intake (expressed as percent of prescribed calories) and its effect over time on changes in body weight (BW), muscle mass (MAMC), and subcutaneous fat stores (TSF). The anova repeated measures analysis of variance was used to test daily changes in response. To test correlations of each variable (TSF, MAMC, and BW) with caloric intake, the t-test was used.

Results

One hundred percent intake of recommended prescribed calories was never achieved in all ICU patients. There was a significant change over time in the mean intake of required calories ranging from 41.7% on observation day 1 to a peak of 84.0% on day 11 ($p < 0.001$). The mean intakes reflected greater nutritional adequacy compared to most patients due to a wide range of intake levels from < 10% to > 150% of required calories (Table 1).

Despite a significantly positive mean cumulative fluid balance of almost 20 L by day 14 for all patients ($p < 0.0001$), a significant reduction over time occurred in mean body weight ($p < 0.0001$) (Table 1). Patients who had measurements obtained showed no change in TSF or MAMC during the study period despite significant changes in weight, caloric intake, and cumulative fluid balance (Table 2). There was also no significant change over time in the ratio of weight change to percent required of calories received ($p = 0.93$).

Discussion

Anthropometry, introduced in the late 19th century, gained widespread popularity in the early 1960s. Use of anthropometry as an indicator of mortality and morbidity from malnutrition was conceived during the 1960s when Fletcher and coinvestigators monitored body composition changes during disease and nutritional repletion (17). The anthropometric techniques employed by Fletcher (1962) were conducted in the study of healthy populations (17).

This concept gained credence in the 1970s when Bistrian et al (1974) and Blackburn (1977) proposed the use of MAMC measurements as a diagnostic indicator of nutritional status. This was based on the contention that MAMC reflects underlying muscle bulk and that the changes observed in serial measurements would be indicative of alterations in somatic protein mass (5). TSF changes also would be reflective of changes in subcutaneous fat stores which are related to the size of total body energy reserves. Presumably, this would indicate an individual's ability to withstand a period of relative starvation (ie, taking nothing orally for longer than five days) as frequently seen in the hospital setting.

Publications during the 1970s expressed a consensus regarding the use of MAMC, TSF, and BW as diagnostic indices of malnutrition and proposed their adoption in the nutritional assessment of hospitalized adults (14-16,18-21). It was further recommended that these anthropometric parameters be evaluated according to sex-specific standards of reference to improve their validity (14-16,18-21).

Several population surveys conducted during the 1960s and 1970s produced standard reference ranges by which to evaluate anthropometric measurements. The Health Examination Survey of 1960-1962, the Ten State Nutrition Survey (TSNS) of 1968-1970, and the Health and Nutrition Examination Survey (HANES 1) of 1971-1974 were all large-scale cross-sectional anthropometric surveys of the American population.

Data from the HANES 1 study (1961) correlated body weight for sex and age to population percentiles; however, data were not analyzed for frame size or height (13). TSNS data were overrepresentative of the poor; the population sample was heavily weighed toward the lower-income groups in each state (12). Other frequently used reference standards derived from incomplete and inaccurate population studies include Jelliffe's standards and Frisancho's tables. Both sets of standards were developed from data considered to be nonrepresentative of the United States population (13,22,23). Jelliffe's standards, published in 1966, were a composite of various upper arm anthropometric measurements derived from different age-sex populations.

Close examination of Jelliffe's sources reveal an arbitrary selection of subjects and body measurement sites (22). For example, during 1960 to 1961, Turkish, Greek, and Italian military personnel with various body dimensions were measured for correct uniform sizing (22). These measurements served as the source of standards for men's biceps circumference references (22). In women, the source of arm circumference standards involved a survey conducted by The Bureau of Home Economics from 1939 to 1940 of 15,000 female subjects (22). The sources for TSF standards are not reported. Consequently, Jelliffe's standards must be considered irrelevant as a reference source for anthropometric indices since they were not collected using accepted scientific methodologies.

In the appraisal of nutritional assessment techniques for the surgical intensive care patient, conventional anthropometric indices (MAMC, TSF, and BW) are questionable because of many inherent limitations (22-24). These limitations include inconsistency in identification of the measurement site and irreproducibility of the measurement due to the subjective nature of the technique. Obesity and generalized edema also result in technical errors. Interpretation of such data is extremely difficult as certain assumptions must be accepted concerning distribution of total body water, hydration status, and estimated lean body mass and fat stores when relating them to body composition. Differences in fat compressability among sexes and body types (ie, obese) are completely disregarded in TSF data collection and not addressed in the reference standards (22-24).

Recently, Lohman (25) noted that more than 100 regression equations have been developed during the past three decades relating skinfolds and other anthropometric indices to body fatness. The primary difficulty with regression equations is that they are based on a criterion method which has never been validated against a direct method of assessment. From review of the literature, it appears that these purported "gold standards" of reference such as hydrostatic weighing are of questionable validity. Until the accuracy of anthropometric measurements can be improved and the validity of an accessible criterion standard established, there is little to be gained by regression equations which predict body fatness.

In an effort to minimize the variability in nutritional assessment, more objective, direct methods of body composition analysis need to be investigated. There is a particular need to develop techniques which assess static daily fluid changes, and relate them to changes in body tissue compartments. This is of great importance in the ICU patient where assumed relationships between lean body mass versus TSF are inaccurate secondary to severe third spacing of fluid postsurgery or vigorous fluid resuscitation (26).

Bioelectrical impedance analysis is one method of assessing body composition which utilizes sufficient precision and sensitivity in tracking significant changes in short periods (27). As a direct relationship exists between electrical conductivity and total body water, percentage of body fat can be calculated from total body water with the use of densitometric equations. Application of such methods may provide a means of assessing and monitoring surgical/critically ill patients who require nutritional support of population specific equations.

Other sophisticated methods of body composition analysis include isotopic dilution methods (28), in vivo neutron activation analysis (29), computed tomography (30), nuclear magnetic resonance (30), and photon absorptiometry (31). Although these methods are more accurate than anthropometry, they are far too expensive and cumbersome for daily use and have limited practicality in the hospital setting. A simple, noninvasive, reliable indicator of body composition changes which can be clinically useful and provide similar information obtained from more sophistocated methods is needed.

Weight change in the ICU patient is statistically related to two variables: adequacy of nutritional support as a percentage of required calories, and fluid balance. While significant changes over time were observed in body weight, caloric intake, and fluid balance, there were no significant corresponding changes in tricep skinfold and mid-upper arm muscle circumference. We can conclude from these data that anthropometric indices (TSF, MAMC, and weight change) do not exclusively reflect nutritional status in the ICU patient.

References

1. Baker JP, Detsky AS, Whitwell J, Langer B, Jeejeebhoy KN. A comparison of the predictive value of nutritional assessment techniques. Hum Nutr Clin Nutr 1982;36C:233-41.

2. Frisancho AR. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 1981;34:2540-5.

3. Grant JP. Handbook of total parenteral nutrition. Philadelphia: W.B. Saunders Company, 1980:19.

4. Boles JM, Garve MA, Younou PY, Mialon P. Nutritional status in intensive care patients: Evaluation in 84 unselected patients. Crit Care Med 1983;11:87-90.

5. Bastow MD. Anthropometrics revisited. Proc Nutr Soc 1982;41:381-8.

6. Frisancho AR. Triceps skin fold and upper arm muscle size norms for assessment of nutritional status. Am J Clin Nutr 1974;27:1052-8.

7. Goode AW. The scientific basis of nutritional assessment. Br J Anaesth 1981;53:161-7.

8. Dixon JK. Validity and utility of anthropometric measurements: A survey

of cancer outpatients. J Am Diet Assoc 1985;85:439-44.

9. Klidjian AM, Archer TJ, Foster KJ, Karran SJ. Detection of dangerous malnutrition. JPEN 1982;6:119-21.

10. Rich AJ. The assessment of body composition in clinical conditions. Proc Nutr Soc 1982;41:389-403.

11. Studley HD. Percentage weight loss. A basic indicator of surgical risk. JAMA 1936;106:458-60.

12. Moore FD, Lister J, Boyden CM. The skeleton as a feature of body composition. Hum Biol 1968;40:135-88.

13. Jelliffe DB. The assessment of the nutritional status of the community. WHO Monograph 1966:53.

14. Butterworth CE, Blackburn GL. Hospital malnutrition. Nutr Today 1975;2:8-18.

15. Blackburn GL, Bistrian BR, Maini BS, et al. Nutritional and metabolic assessment of the hospitalized patient. JPEN 1977;1:11-22.

16. Blackburn GL, Thorton PA. Nutritional assessment of the hospitalized patient. Med Clin North Am 1979;63:1103-15.

17. Brozek J. Physique and nutritional status of man. Hum Biol 1956;28:124-40.

18. Buergel N. Monitoring nutritional status in the clinical setting. Nurs Clin North Am 1979;14:215-27.

19. Chilimindris CP. Metabolic and nutritional assessment in adult surgical patients. Md State Med J 1979;28:55-9.

20. Kaminski MV, Jeejeebhoy KN. Nutritional assessment: Diagnosis of malnutrition and selection of therapy. Am J Intraven Ther Clin Nutr 1979;7:31-50.

21. Kaminski MV, Ruggiero RP, Mills CB. Nutritional assessment: A guide to diagnosis and treatment of the hypermetabolic patient. J Fla Med Assoc 1979;66:390-6.

22. Bishop CW, Ritchey SJ. Evaluating upper arm anthropometric measurements. J Am Diet Assoc 1984;84:330-4.

23. Gray GE, Gray LK. Validity of anthropometric norms used in the assessment of hospitalized patients. JPEN 1979;3:366-8.

24. Burgert SL, Anderson CF. An evaluation of upper arm measurements used in nutritional assessment. Am J Clin Nutr 1979;32:2136-42.

25. Lohman TG. Skinfolds and body density and their relation to body fatness: A review. Hum Biol 1981;53:181-225.

26. Van Itallie TB, Segal KR, Young MY, et al. Clinical assessment of body fat content in adults: Potential role of electrical impedance methods. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:5-8.

27. Katch FI. Assessment of lean body tissues by radiography and by bioelectrical impedance. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:65-70.

28. Scholler DA, Kushner RF, Taylor P, et al. Measurement of total body water: Isotope dilution techniques. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:24-9.

29. Beddoe AH, Strat SJ, Hill GL, et al. New approaches to clinical assessment of lean body tissues. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:65-70.

30. Heymsfield SB. Clinical assessment of lean tissues: Future directions. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:53-9.

31. Spencer H, Kramer LB. Nutritional and other factors influencing skeletal status. In: Report of the Sixth Ross Conference on Medical Research: Body composition assessments in youth and adults. Columbus: Ross Laboratories, 1985:33-7.