8-1991

Comparison of Body Assessment Using Bioelectrical Impedance and Skinfold Measurements in the Critically Ill

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COMPARISON OF BODY ASSESSMENT USING BIOELECTRICAL IMPEDANCE AND SKINFOLD MEASUREMENTS IN THE CRITICALLY ILL

by

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A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education and Recreation

Western Michigan University
Kalamazoo, Michigan
August 1991

COMPARISON OF BODY ASSESSMENT USING BIOELECTRICAL IMPEDANCE AND SKINFOLD MEASUREMENTS IN THE CRITICALLY ILL

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This investigation compared two body fat assessment techniques, skinfold thicknesses and bioelectrical impedance, in an elderly population. Ten healthy adults and ten critically ill adults, aged 55-93 years, were tested. The body fat measurements were taken over a two-week period. Electrolyte levels, sodium and potassium, and hydration status were monitored. Intraclass reliability coefficients were calculated using a repeated measures analysis design (ANOVA). Bioelectrical impedance was not found to be a reliable method for estimating body composition in this study; reliability coefficients were $\underline{R} = .83$, $\underline{R} = .98$, $\underline{R} = .83$, and $\underline{R} = .32$ for healthy males, healthy females, critically ill males, and critically ill females, respectively. The electrolytes and hydration status were within normal ranges and, therefore, were not accountable for the unreliable results of bioelectrical impedance. In this study, bioelectrical impedance was not a valid or reliable method for estimating percent body fat in an older population, healthy or ill.

ACKNOWLEDGEMENTS

First, I would like to express my sincere thanks to my advisor, Dr. Mary Dawson, for all her advice and encouragement in completing my thesis. I would also like to thank the rest of my advisory committee, Dr. Roger Zabik and Dr. Debra Berkey, for their much appreciated assistance.

I am very grateful for my parents and my husband who are supportive of my many projects and endeavors.

Lastly, thank you to Dr. Alvaro Skupin and all the subjects for their participation.

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Order Number 1345530

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CHAPTER I

INTRODUCTION

The assessment of human body composition has played an important role in the determination of nutritional status in clinical and metabolic settings as well as an indicator of muscle mass in professional and amateur sports. For a variety of reasons, body fat analysis is a very popular practice in contemporary Western culture. People want to be fit and know the status of their fitness. Professional and amateur athletes care about body fat for aesthetic and health reasons and perhaps, most importantly, to gain a competitive edge. Athletes often try to achieve a certain level of body fat, depending on the demands of the sport (Nash, 1985). Athletes may use unsafe practices, such as very low calorie dieting, high protein diets, or diuretics to obtain desired weight. These practices lead to an increased risk of losing lean body mass rather than fat mass. Precise body fat measurements could help prevent unsafe weight control methods (Nash, 1985).

Precise body fat measurements are also needed by physicians. Physicians are able to administer more exact drug and anesthetic doses to patients when a patient's body composition is known. The average elderly patient uses more than twice as many medications as the average young adult, placing the elderly at risk of increased drug-nutrient interactions (Tramposch & Blue, 1987). Knowing body composition would help when prescribing drugs for the elderly since they have a lower percent lean body mass and a higher percentage total body fat. Determining drug doses based on body weight could lead to larger doses of drugs than are therapeutically necessary (Nash, 1985).

The measurement of body composition provides additional information for counseling clients on diet and exercise programs. If the percentage body fat is known, it is possible to calculate the desired weight: Desired weight = current weight - [(current weight x (% fat/100)] / [1.00 - (ideal % fat/100)] (Jackson & Pollock, 1985).

Optimal percentage body fat varies with the goal of the client. For example, an athlete's optimal percentage fat could depend on his or her particular sport. For the average person, the acceptable ranges for body fat are fairly broad: 12-25% for men, 18-30% for women (Henson, 1988).

Many methods of body composition analysis have been developed such as hydrostatic weighing, total body water, determination by isotope dilution, computed tomography, and measurement of total body potassium. However, these methods are expensive and not necessarily appropriate for clinical applications (Lukaski, 1987). Height/weight charts as well as body mass indices are inexpensive and readily available for use in a variety of situations but are not necessarily accurate in the determination of body composition (Chumlea, Roche, & Mukherjee, 1987). In addition, skinfold measurements are widely used in clinical settings but are subject to both errors of measurement and biological variability (Bulbulian, 1984). Bioelectrical impedance is an accurate predictor of human body composition in comparison with other available methods. Advantages of bioelectrical impedance are portability, safety, convenience and cost (Lukaski, 1987).

Statement of the Problem

The problem of the study was to compare body fat assessment methods among the critically ill population. The investigation of the problem was concurrent with the examination of the following subproblems:

1. Percent body fat was compared using bioelectrical impedance versus skinfold measurements in critically ill patients.

2. Percent body fat was compared using bioelectrical impedance versus skinfold measurements in older, healthy adults.

3. The relationship of sodium, potassium, and hydration status with percentage body fat was examined.

Purpose of the Study

The purpose of the study was to find a suitable body composition assessment method for the older population, healthy and diseased. This is needed for the hospitalized elderly patient to determine nutritional requirements and drug dosages. Body composition may undergo change among the elderly including increased body fat and decreased muscle mass (Nash, 1985). The elderly are also at higher risk for illness and dehydration (Tramposch & Blue, 1987). Therefore, the body composition methods used on older adults need to be sensitive to these changes.

Need for the Study

The advantages of bioelectrical impedance are portability, safety, convenience and purportedly acceptable levels of reliability and accuracy of body composition estimates in healthy adults (Lukaski, Johnson, Bolonchuck, & Lyken, 1985). Bioelectrical impedance appears to be well suited for population and epidemiological surveys. The major drawback is the lack of validation in data obtained from patients with abnormal electrolyte distributions (Lukaski, 1987) and the inconsistency of validation reported by others (Nash, 1985).

Delimitations

The delimitations of the study were 10 critically ill patients in the Pulmonary and Medical Intensive Care Units of Sinai Hospital of Detroit and 10 healthy adults from the outlying community. Equal numbers of males and females were represented in both the critically ill group and the healthy group. Subjects' ages were 50 years or older.

The critically ill group had no exclusion criteria. The healthy group excluded subjects with the following conditions: diabetes mellitus, congestive heart failure, malnutrition, pancreatitis, obesity (greater than 40% ideal body weight), liver disease, chronic alcoholism, renal disease, lupus erythematosus, hypothyroidism, and hyperthyroidism. The healthy group excluded subjects taking the medications corticosteriods or investigational drugs.

Limitations

The major limitation of this study was the choice of skinfold measurements for body composition determination. A more precise method, such as hydrostatic weighing was preferred. Due to the population studied, however, hydrostatic weighing was inappropriate and skinfold measurements were used as the method of choice.

Hypotheses

The following hypotheses were proposed:

1. Bioelectrical impedance is a valid predictor of body composition in the healthy, older adult.

2. Bioelectrical impedance elicits different values than skinfold measurements in the critically ill patient.

3. If the electrolytes or hydration status are not within normal limits, bioelectrical impedance elicits different values of percent body fat compared to skinfold measurements.

Definition of Terms

For the purposes of this study, the following terms were defined:

1. Anthropometry: the measurement of body size, weight, and proportions, including skinfold measurements. Anthropometry provides information about body stores of fat and muscle (Chumlea et al., 1987).

2. Basal Metabolism: the energy requirements needed for involuntary and voluntary activities to maintain present weight (Krause & Mahan, 1979).

3. Bioelectrical Impedance: a method of assessing body composition by measuring the electrical resistance of the body. The principle is based on the fact that lean tissue contains almost all of the water and conducting

electrolytes in the body. Therefore, conductivity is much greater in the lean tissue or fat-free mass than in fat mass (Lukaski, 1987). The less electrical resistance measured, the more lean tissue a person has, and therefore, less fat (Nash, 1985).

4. Lean to Fat Ratio: the proportion of lean and fat tissues in the body. The ideal ratio for men is 4.5:1 and for women it is 3.0:1 (Twyman & Liedke, 1987).

5. Percent Body Fat: the percentage of tissue which is composed of adipose tissue cells or fat. A range of body fat of 12 to 25% in males and 18 to 30% in females is conducive to good health (Henson, 1988). Clinicians recommend a minimal body fat for men of 3 to 7% and for women 10 to 20% (Fox, Boylan, & Johnson, 1987).

6. Phase Angle: measurement of the amount of intact cells. The phase angle is a linear method of measuring the relationship between resistances and reactances. Phase angle can range from 0 to 90 degrees with the average for a healthy individual being 4 to 15 degrees. Lower phase angles are associated with high reactances and large quantities of intact cell membranes (Twyman & Liedke, 1987).

7. Reactance: the resistance of the electrical current to penetrate cell membranes (Twyman & Liedke, 1987).

8. Resistance: the impedance of the electrical current to pass through intracellular and extracellular fluid. In the body, conductivity is much greater in the lean tissues due to the presence of large amounts of water and conducting electrolytes. On the other hand, fat and bone are poor conductors because of the low amounts of fluid and conducting electrolytes available (Twyman & Liedke, 1987).

9. Skinfold Measurements: a measure of subcutaneous fat by the instrument known as a skinfold caliper. A mathematical formula is used to calculate the percent of body fat that is distributed in an individual. For the purposes of this study, the ideal standard percent body fat for men was 15 to 18% and 22 to 25% for women (Jackson & Pollock, 1980).

10. Total Body Water: the single largest component of the human body. It is determined by the proportion of lean and fat tissues. Fat tissue is composed of 14 to 22% water while lean tissue contains 71 to 75%. The average amount of water is approximately 60% for men and 55% for women. Overhydration is termed edema and underhydration is called dehydration (Krause & Mahan, 1979).

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study was to compare two different body composition techniques, bioelectrical impedance and skinfold measurements, among an elderly population. The goal of this chapter is to present the results of various research investigations conducted in the area of body composition assessment. An overview of the traditional methods along with some of the newest methods is presented. Studies which have determined the validity and reliability of various assessment techniques also are discussed.

Body Composition

Most body composition techniques are based upon the concept that the body consists of two chemically distinct compartments. They are the fat and the fat-free (Brozek, Grande, Anderson, & Keys, 1963). The composition of the fat-free body is thought to be relatively constant with a density of 1.1g/cc at 37 degrees Celsius, a water content of 72-74%, and a potassium content of 60-70 MMOL/kg in men and 50-60 MMOL/kg in women. Fat has a density of 0.900 g/cc at 37 degrees Celcius and is potassium free (Lukaski, 1987).

With the two compartment model, the fat and the fat-free, Keys and Brozek (1953) separated the composition of the body into four chemical groups: water, protein, ash or bone mineral, and fat. All body composition methods, to date, have been developed on the basis of these two and four component models (Lukaski, 1987).

Total Body Water

Total body water (TBW) is based upon the findings that water is not present in stored fat or triglyceride and that water maintains a relatively fixed fraction, 73.2%, of the fat-free mass. Researchers have used isotopes of hydrogen, deuterium, and tritium to measure body water volumes by isotope dilution in healthy and ill individuals (Lukaski, 1987).

With the isotope-dilution technique, the assumptions are made that the isotope has the same distribution volume as water, the isotope is exchanged by the body in a manner similar to water, and the isotope is nontoxic in the small amounts used (Panaretto, 1968).

The procedure for using tritium or deuterium includes the ingestion or the intravenous injection of the tracer, an equilibration period, and a sampling period. The calculation of total body water volume is based upon the relationship: $C1V1 = C2V2$, where $C1V1$ is the amount of tracer given, C2 is the final concentration of tracer, and V2 is the volume of TBW (Panaretto, 1968).

Total Body Potassium

Total body potassium (TBK) is used to estimate fat-free mass in humans and animals by external counting of potassium-40. This is possible because potassium is not present in stored triglyceride and exists in the body at a known natural abundance, 0.012%. Potassium-40 also emits a characteristic gamma ray at 1.45 MeV (Forbes & Hursh, 1963).

Measurement of TBK requires specially constructed counters that consist of a large shielded room containing a gamma ray detection system connected to a recording device. The detectors consist of large thallium-activated sodium iodide crystals positioned near the subject, and large hollow cylinders in which the walls contain scintillation material. The subject is completely surrounded by the detector (Lukaski, 1987).

Once TBK is determined, fat-free mass is estimated with a factor dependent upon the potassium content of the fat-free mass. The constants are 2.5 and 2.31 g potassium/kg fat-free mass for men and women, respectively. The constants are based upon chemical analysis of human cadavers and the high correlation between potassium and water (Forbes & Hursh, 1963). With this method and accurate equipment, absolute measurements of TBK are obtained. The procedure, however, is extremely expensive (Lukaski, 1987).

Urinary Creatinine Excretion

Creatine is mainly located in skeletal muscle, mostly in the form of creatine phosphate. Creatinine is formed by the nonenzymatic hydrolysis of free creatine during the dephosphorylation of creatine phosphate. Urinary creatinine excretion is assumed to be related to fat-free mass and muscle mass (Forbes & Bruining, 1976).

Urinary creatinine excretion, however, has several drawbacks that affect the procedure's validity. The greatest problem is the large individual variability in daily urinary creatinine excretion. Daily creatinine output ranges from 11 to 20% for individuals consuming unrestricted diets and can be lowered by individuals eating meat-free diets. The variability is due to the renal processing of creatinine since it is both filtered and secreted by the kidney (Lukaski, 1987).

Diet also can affect daily creatinine excretion, such as the significant reductions found in healthy men consuming meat-free diets for several weeks (Lukaski & Mendez, 1980). Changes in creatinine output are related directly to dietary creatine intake. Crim, Calloway, and Margen (1975) consecutively fed healthy young men 0.23 g creatine per day for 9 days, 10 g creatine per day for 10 days, and a creatine-free diet for 71 days. Urinary creatinine excretion increased 10 to 30% with creatine feeding and decreased during the creatine free diet.

Densitometry

The assessment of body composition by measurement of whole-body density is a common method used for healthy people. This technique is based upon the assumption that it is possible to determine the fat and the fat-free components from the measured whole-body density (Keys & Brozek, 1953). The most widely used method is the determination of body volume according to Archimedes' Principle, which states that the volume of an object submerged in water equals the volume of water the object displaced. Comparing the mass in air with the mass in water and correcting for the density of the water corresponding to the water temperature at the time of the underwater weighing, provides the body volume. With this method residual lung volume is determined since residual lung volume contributes 1 to 2 liters in the estimate of total body volume (Buskirk, 1961).

Hydrostatic Weighing

The hydrostatic procedure consists of weighing the subject nude or in a bathing suit in air and then weighing again while completely submerged. The subject should be in maximum expiration with the breath held long enough for weight to be recorded. Bathing caps should not be worn as they trap air bubbles. At least three successive underwater weighings should be made for the most accurate result. The temperature of the water and the air plus the weight of the submerged chair should be recorded. Residual lung volume is also measured (Forbes, 1987).

This technique is not suited to young children, the elderly, or those who are ill or have pulmonary problems (Forbes, 1987). This method can be quite accurate and is considered to be the gold standard of body composition techniques.

Water Displacement

The procedure for water displacement is the same as that for hydrostatic weighing except that the actual volume of water displaced by the subject is measured rather than the loss in weight in water (Forbes, 1987). Water displacement is measured when the subject submerges under water and the increase in water level is measured using a calibrated, fine bore burette connected to the tank. Residual lung volume is also determined. This technique has not gained wide acceptance because of the difficulties in determining the changes in volume in the tank needed to obtain the accuracy associated with the hydrostatic weighing method (Lukaski, 1987).

Anthropometry

A major store of fat deposit in the body is located subcutaneously. Skinfold measurements have proved to be a fairly accurate method of measuring subcutaneous fat at a given site. Research supports the concept that the sum of several skinfold sites is a good measure of total subcutaneous fat. Since total subcutaneous fat is associated with total body fat, it is assumed that the sum of skinfold measurements is a way to estimate percent body fat (Lohman, 1981).

Skinfold measurements are widely used in clinical settings but are subject to both errors of measurement and biological variability (Bulbulian, 1984). This approach is based upon two assumptions: (1) the thickness of the subcutaneous adipose tissue reflects a constant proportion of the total body fat and, (2) the sites selected for measurement represent the average thickness of the subcutaneous adipose (Lukaski, 1987).

The measurement of skinfold thickness is made by grasping the skin and adjacent subcutaneous tissue between the thumb and forefinger, shaking gently to exclude underlying muscle, while pulling the fold away from the body to allow the calipers to measure the thickness. Several duplicate readings are taken at each site to improve the accuracy and the replication of the measurements (Behnke & Wilmore, 1974).

The precision of skinfold measurements are dependent upon the skill of the anthropometrist and the site measured. Generally, a 95% accuracy rate can be attained easily by a trained and experienced individual (Bulbulian, 1984). This error can increase slightly if skinfold thicknesses either become very large (>15 mm) or small (<5 mm) (Lukaski, 1987).

Anthropometric data can be difficult to obtain from the elderly, especially if they are bedridden. With the availability of recumbent anthropometric methods, it is possible to collect and compute indirect anthropometric measures of body composition in the elderly regardless of the age or mobility level (Chumlea, Roche, & Mukherjee, 1986). Chumlea et al. (1986) measured weight, stature, midarm muscle area (MAMA), and triceps skinfolds in a sample of 119 elderly white men and 150 elderly white women. All indices were significantly and negatively associated with age. Sex-specific means, standard deviations, and percentiles for weight divided by stature squared (W/S2) and midarm muscle area were presented at 65, 70, 75, 80, 85, and 90 years of age. Women had significantly larger mean values for W/S2 at 90 years, but the men had significantly larger mean values at 65 years and for MAMA at all ages.

Stature is usually a measure of questionable value in the elderly because of the degenerative changes that occur with age. However, stature can now be estimated accurately from a recumbent measure of knee height, and age (Chumlea, Steinbaugh, Roche, Mukherjee, & Gopalaswamy, 1985). Therefore, W/S2 can be used as an indirect index of obesity. Midarm muscle area is an accepted index of body protein stores and triceps skinfold is reported to be highly correlated with total body fat in elderly men and women (Chumlea, Roche, & Webb, 1984).

Weight/Height Tables

Many clinicians rely on weight-for-height tables for evaluating nutritional status. The most commonly used weight-for-height tables are those published by the Metropolitan Life Insurance Company (New York). This can be unfortunate because the tables were developed for insurance purposes and not as guides for nutritional status (Frisancho, 1988). Also, it is generally assumed that a value greater than the desirable weight means that the individual is obese. This is an invalid assumption because these tables do not take into account body composition, which is essential for an assessment of fatness (Frisancho, 1988).

It is difficult to make any assumptions regarding nutritional status on the basis of weight alone. Weight represents the sum of fat, protein, and bone mineral, and any of these components may change in an unpredictable manner (Frisancho, 1988). Edema and ascites increase water retention, resulting in maintenance of weight although protein and fat may have been lost (Buergel, 1979).

Weight is also a poor measurement when calorie or energy intake is sufficient but protein intake is not sufficient. Therefore, fat can be preserved while protein stores decline (Buergel, 1979). A good example is the disease, Kwashiorkor, a wasting disease characterized by a diet low in protein but not low in energy. This can also be seen in wasting malnutrition as it occurs in elderly patients where weight can vary deceptively due to differences in hydration or to the presence of tumors (Frisancho, 1988). Also, the extracellular mass in the body increases as a result of malnutrition minimizing the change in body weight (Shizgal, 1985).

Since wasting malnutrition causes the depletion of body protein stores, skinfold measurements or midarm circumferences are better indicators of malnutrition. However, one researcher believed that in undernutrition there is a shift of fat storage deposits to subcutaneous sites other than the triceps and scapular thicknesses or that the fat shifts from subcutaneous sites to deep, visceral sites (Spurr, Barac-Nieto, Lotero, & Dahners, 1981).

On the other hand, some clinicians believe that body weight determinations are important for hospitalized patients, especially in those patients receiving total parenteral nutrition (TPN) or enteral alimentation by feeding tube (TF) (Guenter, Moore, Crosby, Buzby, & Mullen, 1982). It is important to obtain weights to monitor fluid balance and to measure nutritional therapeutic efficacy (Guenter et al., 1982). Since actual tissue losses and gains greater than 0.5 pounds per day are almost impossible, this reflects changes in total body water, which has therapeutic implications (Guenter et al., 1982).

Body mass index (BMI) is another method for determining ideal or appropriate weight. The method divides weight in kilograms by height in meters squared (Peterson & Peterson, 1988). The body weights associated with a BMI of 20 to 25 kg/sq m show no increased risk of cardiovascular disease, gallbladder disease, hypertension, or diabetes. If the BMI is less than 20 kg/sq m, individuals have increased risk of respiratory disease, digestive disease, and metabolic complications. Individuals with a BMI of 25 to 30 kg/sq m have low risk of the above diseases, those with a BMI between 30 and 40 kg/sq m have a moderate risk, and those with a BMI greater than 40 kg/sq m are at high risk (Peterson & Peterson, 1988). Another scale, developed by Bray and Gray (1988), has been used to interpret BMI scores: (a) 20-24.9 indicates normal or ideal weight, (b) 25-29.9 indicates overweight, (c) 30-40 represents severe overweight, and (d) values greater than 40 indicate massive overweight.

Body Fat Distribution

Epidemiological studies have suggested that body fat distribution is an independent factor in the development of risk factors associated with obesity, especially in the presence of cardiovascular risk factors (Bandani & Dietz, 1987).

Fat distribution can be determined using a variety of anthropometric measures. Waist:hip girth ratio (WHR) is the most popular index to describe upper segment obesity, although circumferences and skinfold thicknesses at the arm and thigh are also used frequently (Bandani & Dietz, 1987).

Increased upper segment obesity is least desirable for body fat distribution. One reason is that it is correlated with abnormal glucose tolerance in adults. Subjects with increased upper segment fatness show an increase in fasting insulin levels and an increase of the glucose curve in response to an oral glucose tolerance test (Kissebah et al., 1982). Diabetic women also have a greater WHR than those with normal glucose levels (Bandani & Dietz, 1987).

Upper body obesity has also been associated with an increased risk of atherosclerosis in both men and women. Statistically significant correlations of WHR with the development of stroke and ischemic heart disease were found in a 13-year study of 54 year-old men. After adjusting for smoking, blood pressure, and cholesterol levels, the WHR was not an independent predictor of the diseases. However, WHR was more closely associated with cardiovascular risk than were other indexes of obesity (Larsson et al., 1984).

In adults, both percent body fat and total body fat are significantly and positively correlated with systolic and diastolic blood pressure (Roche, Siervogel, Chumlea, & Webb, 1981). Roche et al. speculated that percent body fat is closely related to gallbladder disease, gout, and fatty infiltration of the heart whereas excess total body fat places additional mechanical loads on the heart and joints and an increased metabolic burden on the liver.

Total Body Nitrogen

A rather new method, using gamma emission after irradiation, measures total body nitrogen by neutron activation. This method has been used with total body potassium to separate the muscle and non-muscle components of fat-free mass. Unfortunately, the technique requires a small dose of radiation and, therefore, is generally unsuitable for use in most people (Bandani & Dietz, 1987).

Infrared Interactance

The newest, most convenient method on the market today is the Futrex-5000 body fat analyzer. The method, for use in body fat determinations, was discovered accidently. The previous purpose of this procedure was to analyze the composition of meats by the U.S. Department of Agriculture. Conway, Norris, and Bodwell (1984) from the USDA's Beltsville Human Nutrition Research Center developed and applied the infrared interactance (IRI) method to humans. IRI is based on the principles of light absorption, reflection, and near-infrared spectroscopy. A light beam enters the body through a fiber optic probe, which is pressed lightly against the skin; the interactive radiation is collected and scanned by a detector. Since the spectrum of the light beam is changed by the presence of fat, the detected shifts of the spectrum can be converted into percentage body fat via computer applications of logarithms and ratios (Stensland, 1988).

One study determined percent body fat in 53 adults, aged 25 to 65 years. Investigators compared infrared interactance with deuterium oxide dilution (r=.94), skinfold (r=.90), and ultrasound (r=.89) measurements (Conway et al., 1984).

Futrex, Incorporated (Nashville, Tennessee) developed the IRI methodology into a portable instrument and percent body fat results have been documented within two percent of the hydrostatic method. The IRI has also been demonstrated effective for body weight from the morbidly obese to the very lean. The IRI method has many advantages since there is no need for special technique or training, the test can be completed in 10 seconds, and is relatively inexpensive, approximately $1900.

Photon Activation Analysis

The photon activation analysis (PAA) technique has been recently developed for body composition studies. PAA can measure total body oxygen (TBO), total body nitrogen (TBN), and total body carbon (TBC). Total body protein (TBP) can be derived from TBN and total body fat (TBF) from TBC (Ulin, Meydani, Zamenhof, & Blumberg, 1986). Also, it is possible to determine total body water (TBW), a parameter for the determination of lean body mass (LBM), from TBO (Ulin et al., 1986).

The PAA technique is based on detection of induced radioactivity resulting from photonuclear reactions in the body. The procedure is noninvasive and has been estimated to require a whole-body radiation dose of 1-2 cGy (1000-2000 mrem) for human subjects. The PAA technique was created as a means of assessing the nutritional status of cancer patients undergoing radiation therapy. Much of the necessary equipment, which includes a high-energy electron accelerator and whole-body counting apparatus, is available in the radiation therapy departments of many major hospitals, which reduces the cost of PAA to a reasonable amount (Ulin et al., 1986).

Electrical Conductance

The method for determining body impedance is based upon the conduction of an applied electrical current in the human body.

> In biological structures, application of a constant low level alternating current results in an impedance to the spread of the current that is frequently dependent. The living organism consists of intra- and extracellular fluids that behave as electrical condensors and are regarded as imperfect reactive elements. At low frequencies (1 kHz), the current passes mainly through the extracellular fluid while at higher frequencies (500-800 kHz) it passes through the extra- and intracellular fluids. In this manner, body fluids and electrolytes are responsible for electrical conduction (eg, 1/resistance) and cell membranes are involved in capacitance (Lukaski, 1987, p.547).

Bioelectrical Impedance

Bioelectrical impedance is based upon the principle that the impedance of a geometrical system is related to conductor length and configuration, its cross-sectional area, and signal frequency. Electrical conduction is related to the water and electrolyte distribution in the conductor. Conductivity is much greater in the fat-free mass than in the fat mass of the body since fat-free mass contains most all of the water and conducting electrolytes (Twyman & Liedke, 1987).

A four terminal impedance plethysmograph is used to make determinations of resistance and reactance (Twyman & Liedke, 1987). The tetrapolar method is used and is discussed in depth in Chapter III.

Total Body Electrical Conductivity

Total body electrical conductivity (TOBEC) also relies upon the differences in electrical conductivity and the properties of the fat-free and fat tissues to estimate body composition (Presta, Wang, et al., 1983). The instrumentation used is similar to that of the commercial device developed for determination of lean tissue in meat and live animals (Lukaski, 1987).

During this procedure, the subject lies on a table that slides into a chamber. The chamber has an electromagnetic coil around itself and the coil induces an electromagnetic force. The subject disrupts that field by passing through the electromagnetic coil and the size of that disruption is proportional to the electrical conductivity of the person. TOBEC takes 64 readings of lean body mass conductivity within a ten-second period and prints the average reading (Nash, 1985).

Computerized Tomography

Computerized tomography (CT) is a radiographic technique to determine regional body composition. This method is capable of distinguishing fat from other tissues (Forbes, 1987).

> The CT system consists of a collimated x-ray source and detectors aligned at opposite poles of a circular gantry. Lying on a movable platform, the subject is advanced through the central aperture of the gantry.... As the x-ray beam is rotated around the subject, information about the intensity of the attenuated x-ray beam is recorded and stored. The scanner computer then applies complex algorithms to the stored series of profiles to reconstruct cross-sectional images.... For each individual volume of tissue, the CT scanner measures the x-ray attenuation within that voxel independently of the remainder of that tissue. The reconstructed picture represents not the image at the surface of a cut but rather an average representing the full thickness of the slice (Lukaski, 1987, p.548).

> In observing the film, lower densities appear black and higher densities are white with air and bone at the low and high ends of absorption, respectively. Therefore, high image contrast is seen between bone, fat, and fat-free tissues (Borkan et al., 1982, p. 173).

CT has been recently validated as a reliable method for the evaluation of the size of subcutaneous and visceral fat deposits (Enzi et al., 1986). However, routine use of CT for body composition at this time is not recommended because of its cost, availability, and the radiation involved (Lukaski, 1987).

Ultrasound

Ultrasound is a noninvasive technique to measure subcutaneous fat thickness. Ultrasound scanners are capable of measuring subcutaneous fat at depths of 100 mm or more without tissue compression, as with skinfold calipers, and can reliably detect density interfaces with an accuracy of 1 mm (Fanelli & Kuczmarski, 1984).

Comparison Between Body Composition Methods

Lukaski et al. (1985) assessed fat-free mass by bioelectrical impedance (BIA) on 37 healthy men. Fat-free mass (FFM) was assessed by hydrodensitometry and ranged from 44.6 to 98.1 kg. Total body water (TBW) determined by D2O dilution was 50.6 ± 10.3 L. Total body potassium (TBK) determined from whole body counting was 167.5 ± 38.1 g. Test-retest correlation coefficient was R = .99 for a single BIA measurement and the reliability coefficient for a single BIA measurement over 5 days was R = .99. Linear relationships were found between BIA values and FFM (r=.86), TBW (r=.86), and TBK (r=.79). The correlation coefficients increased when the predictor Ht2/BIA was regressed against FFM (r=.98), TBW (r=.95), and TBK (r=.96). This difference was significant at p <.01. The researchers concluded that bioelectrical impedance may be a reliable and valid method for the estimation of body composition but that further research is recommended in individuals with abnormal body composition.

Deurenberg, Westrate, and van der Kooy (1989) tested 12 healthy subjects on body weight, body density, and bioelectrical impedance. The subjects consumed a very low calorie diet for 2 days to achieve a weight loss mostly from loss of glycogen and water which is considered to be fat-free mass. Loss of fat-free mass as measured by densitometry was 1.2 ± .8 kg. Weight loss was 1.3 ± .5 kg. There were no statistically significant differences between loss in body weight and loss in fat-free mass measured by densitometry. Reduction of fat-free mass as determined from bioelectrical impedance was .5 ± .8 kg, which was significantly different from body-weight loss and loss of fat-free mass as measured by densitometry. The investigation concluded that a change in fat-free mass caused by loss of glycogen plus water will not be detected by the bioelectrical impedance method. It is possible that the loss of glycogen plus water does not occur proportionally with changes in the intracellular mineral content of the body. Therefore, body-weight loss from depletion of glycogen stores will not affect total body impedance.

Twyman and Liedke (1987) studied the validity of bioelectrical impedance for measuring changes in body fat (percent body fat) and lean body weight (LBW) in 10 subjects. These subjects were placed on a six week diet and exercise program with a 98% compliance with the program. Subjects lost an average of 6 kg body weight and 4% body fat during the 6 weeks. Measurement of body fat and LBW were done before and after weight loss with hydrostatic weighing (HW) and bioelectrical impedance

(BIA). There was a high correlation between changes in percentage body fat and LBW between HW and BIA (r=.92). The authors concluded that BIA can accurately detect changes in percentage body fat and LBW.

In a study by Katch, Soloman, Shayvitz, and Shayvitz (1986), 13 cardiac and 11 pulmonary patients were measured by BIA and HW. BIA showed poor correlation (r=.14, p <.01) with a standard error of estimate of 5.58%. Results indicated that whatever intrinsic relationship is supposed to exist between TBW and body mass in younger, normal patients may not apply to an older, abnormal population.

Lukaski, Bolonchuck, Hall, and Siders (1986) determined percent body fat (BF), fat-free mass (FFM), and fat mass (FM) in 114 healthy men and women, ages 19-50 years, by hydrostatic weighing (HW), skinfold measurements (SF), and bioelectrical impedance (BIA). Double cross validation from two measurements (pre and post studies) along with multiple regression analyses and Pearson Product-Moment Correlation Coefficients were used to determine reliability and validity, respectively. Significance level was inferred at the p <.05 level. In both men and women, there were no significant changes in the magnitude between pre and post data for all measurements of body composition (p <.05). For BF there was a higher correlation for BIA versus HW (r=.928) than for BIA versus SF (r=.877). This difference was significant (p <.05). Results were similar for FFM.

In a study by Kushner and Schoeller (1986), 58 subjects, males and females, were grouped by weight. TBW was determined in 18 subjects using BIA and deuterium-dilution data from the 58 subjects. The two methods were compared by multiple regression analysis. For males, there was a high correlation between BIA and deuterium-dilution (r=.988) for TBW, while in females, correlation was r=.975. Coefficient of variation was used to determine reliability within the day for BIA and this difference was approximately 1.3 percent.

Kuczmarski, Fanelli, and Koch (1987) wanted to determine whether an ultrasound scanner was a better predictor of body density in obese adults than skinfold calipers with hydrostatic weighing used as the standard. The investigators tested 44 white, obese adults of both sexes. Subcutaneous fat thickness was measured at 6 body sites with a Lange caliper and an ADR 2130 ultrasound scanner. By hydrostatic weighing, mean body density was 1.10 $\pm$ .02 g/ml and percentage body fat was 41.7 $\pm$ 7.8%, respectively. The best predictors of body density were found to be the thigh and biceps sites with ultrasound (r=.82) and the triceps site with the calipers (r=.633). The researchers concluded that ultrasound was a better technique than the calipers in measuring subcutaneous fat in an obese population.

In another study, Lukaski et al. (1985) assessed the reliability and validity of BIA in 37 healthy men, aged 19-42 years, by comparison with HW and TBK. Standard regression analysis was used to correlate resistance (R), the in-phase vectors, reactance (Xc), the sum of phase vectors, with the two standard measures of body composition. Significant differences between correlation coefficients were determined by using Z-transformations. R was significantly correlated ($p < .0001$) with FFM (r=.98), TBW (r=.95), and TBK (r=.96). Xc was less significantly correlated ($p < .001$) with standard measurements (r=.70) between Xc and Z versus R and Z.

Body composition was assessed with bioelectrical impedance and hydrostatic weighing in 144 college age male and female subjects. There was a significant correlation between body fat (r=.86), TBW (r=.947), and LBM (r=.934) between the two methods. Significance level was at $p <$ .001 (Twyman & Liedke, 1987).

Body composition of college men and women basketball players was performed along with the determination of nutrient adequacy of diets (Nowak, Knudson, & Schulz, 1988). The sample included 16 male and 10 female intercollegiate basketball players from the same university. Percent body fat was measured with bioelectrical impedance for all players while 12 of the men had body compositions assessed by skinfold measurements for comparison purposes. Analysis by correlated t test of the mean percent body fat values showed no significant differences between the subjects. The mean for bioelectrical impedance was 10.8% ± 3.13% and the mean for skinfold measurements was 8.62% ± 3.44%.

Total body fat, determined by five different techniques, was applied to a population of normal subjects and to a group of cancer patients from ages 20-79 years. The techniques included total body potassium used in a compartmental analysis (TBN + TBK), total body nitrogen (TBN), total body water (TBW), and skinfold measurements (SF). The percentage of total body fat (TBF), whether estimated from TBK, TBN + TBK, or TBW, showed a significant increase with age from 20-79 years. The body weight of the males remained rather constant over the age span; therefore the absolute mass of body fat also increased with age. Body fat determination by SF, however, remained constant over the age span in both males and females. At all ages, females had consistently higher percentages of mean body fat levels than males (Cohn et al., 1981).

For the 20 to 29 year age group, all five methods yielded comparable body fat measurements. For the older groups, however, there were more differences in the results. The mean percentage body fat estimated from the skinfold technique was consistently the lowest value, while the TBN + TBK measurements gave the highest values. The other techniques had values between the SF and TBN + TBK measurements. The r values were as follows: TBW versus SF (r=.695), TBK versus SF (r=.572), TBN + TBK versus SF (r=.699), and TBN versus SF (r=.667) (Cohn et al., 1981).

These inconsistent results in skinfold measurements indicated the need for an age correction factor with the skinfold data. The correlation of fat by skinfold with fat derived by the other four methods varies from .57 to .70 units. The value for the paired z indicated that the estimates of fat obtained by the skinfold method are statistically different from the other methods. Age is implied to be a significant factor because of the close correlation among the values of fat obtained with the various methods for subjects in the 20-29 year age group, as contrasted with the increasingly weaker correlation with increasing age (Cohn et al., 1981).

For patients with cancer or other wasting diseases, total body nitrogen was determined to be a better predictor of body fat than total body water, total body potassium, and skinfold measurements (Cohn et al., 1981).

Roche et al. (1981) calculated correlations between selected anthropometric measures and estimates of percent body fat and total body fat. Data from 405 white children and adults, aged 6 to 49 years, were used. Underwater weighing was done to estimate body density from which percent body fat was derived. Weight and stature were also measured. Skinfold measurements at the triceps, subscapular, and suprailiac sites were made on the left side of each participant using Holtain calipers. The investigators concluded that the triceps skinfold is the best single indicator of percent body fat in children and women (r=.70) and weight/stature is the best single indicator of total body fat in girls and adults (r=.87, r=.92). For men, weight/stature is the best indicator of percent body fat (r=.77) and among boys the subscapular skinfold is the best indicator of total body fat (r=.73) (Roche et al., 1981).

Comparisons of body fat were made using 49 chronically undernourished adult males. The subjects were classified as having mild, intermediate, or severe nutritional compromise based upon their body weight/height ratio, serum albumin, and creatinine/height index. Body fat was calculated from total body water and from triceps and scapular skinfold measurements. These same comparisons were then done in 19 of the severely undernourished subjects during a 2 1/2-month period of refeeding. Results indicated that the correlations between body fat estimated from both total body water and skinfold measurements are acceptable (r=.80) in mildly undernourished subjects but the statistical significance disappears as the degree of undernourishment becomes more severe. After the 2 1/2-month refeeding period, there was still no statistically significant relationship between body fat and skinfold measurements. The investigators concluded that the triceps and scapular skinfolds do not adequately represent body fat in chronically undernourished adult males and suggested that new equations are required which take into account nutritional status and possible shifts in fat deposit sites in the nourished (Spurr et al., 1981).

Lean body mass (LBM) was determined by the methods of total body electrical conductivity (TOBEC) and hydrostatic weighing. The sample consisted of 32 men and women varying widely in age (20 to 53 years), body weight (99 to 341 pounds), and body fat (9.5 to 53.0 percent). The TOBEC method was found to be extremely reliable (r=.999) and the authors concluded that this method, TOBEC, of determining body composition is extremely promising, especially since the method is simple, quick, objective, and noninvasive (Presta, Segal, Gutin, Harrison, & Van Itallie, 1983).

Measurement of body composition can provide useful information for determining desirable weight which is more individualized than referring to height/weight charts that do not consider the proportions of lean body mass to fat. Currently, there are several methods available for estimating body composition. Some methods have proven their worth, such as skinfold thicknesses, while the newer techniques require more research for validation.

Bioelectrical impedance is a safe method, but there may be several sources of experimental error. These sources of error can alter values due to misplacement of electrodes, use of ineffective electrodes, and failure to accurately determine measurement-dependent data such as age, sex, height, activity level, and frame size (Fox et al., 1987).

Considerably more data are required of bioelectrical impedance, especially in older and abnormal subjects. The elderly have reduced bone mineral content that may affect the results of body composition estimation with bioelectrical impedance (Nash, 1985). The use of bioelectrical impedance is questionable in the accurate estimation of the body fat content and lean body mass in hospitalized patients, including those with a long history of disease (Katch et al., 1986). Therefore considerable caution in the clinical setting needs to be undertaken.

CHAPTER III

DESIGN AND METHODOLOGY

The purpose of the study was to compare percent body fat measured by bioelectrical impedance and skinfold thicknesses in an elderly population. This chapter describes the subjects, experimental design, and treatments, as well as techniques of measurement of the variables chosen for study.

Subjects

A total of 20 men and women (N=20) served as subjects for this study. Half of the subjects, 4 women and 6 men, were critically ill patients in the Pulmonary and Medical Intensive Care Units of Sinai Hospital, Detroit, Michigan. Subjects were selected on the following criteria: (a) continued hospital stay for at least two weeks, (b) not expected to expire for the duration of the study, and (c) those patients of Dr. Alvaro Skupin who were interested in the study.

The remaining 10 subjects were healthy adults from the outlying community. They were chosen from the Phase III Program of the Cardiovascular Center for Health, Sinai Hospital, Detroit, Michigan. Healthy subjects were matched as closely as possible to the ill subjects on the basis of gender, height, weight, and age. All subjects were age 50 or older.

The descriptive statistics for the characteristics of the subjects were calculated. The mean age of the healthy subjects was 68.2 years, the standard deviation was 5.44 years. The critically ill subjects' mean age was 74.6 years, the standard deviation was 10.60 years. Of the critically ill subjects, 3 males were black. The remaining male subjects and the female subjects were Caucasian. Four of the healthy subjects were black, 2 males and 2 females. The other healthy subjects were Caucasian. The mean height of the females was 157.82 cm and 158.98 cm for the healthy and the critically ill, respectively. The standard deviations 7.29 cm and 14.02 cm represented the variability found in the standing heights of the healthy and critically ill females, respectively. The mean height of the critically ill males was 171.88 cm, the standard deviation was 6.81 cm. The mean height of the critically ill males was 170.80 cm, the standard deviation was 11.24 cm. The mean weights for the females were 69.08 kg and 59.60 kg, the standard deviations were 16.89 kg and 6.49 kg for the healthy and critically ill, respectively. The mean weights for the males were 74.25 kg and 73.85 kg, the standard deviations were 15.26 kg and 16.22 kg for the healthy and critically ill, respectively. The mean body mass index

(BMI) of the females were 27.38 kg/m2 and 23.62 kg/m2, the standard deviations were 5.48 kg/m2 and 1.00 kg/m2 for the healthy and critically ill groups, respectively. The mean BMI of the healthy males was 25.02 kg/m2, the standard deviation was 4.40 kg/m2. The mean BMI of the critically ill males was 24.98 kg/m2, the standard deviation was 3.50 kg/m2.

Instrumentation

Skinfolds

Skinfold measurements have been demonstrated to be a fairly accurate method of measuring subcutaneous fat at specific sites. Research supports the concept that the sum of several skinfold sites is an accurate measure of total subcutaneous fat. Therefore, since total subcutaneous fat is associated with total body fat, it is accepted that the sum of skinfold measurements is a valid way to estimate percent body fat (Lohman, 1981).

The reliability of skinfold measurements is dependent upon the skill of the anthropometrist and the site measured. Generally, a 95% accuracy rate can be attained easily by a trained and experienced individual (Bulbulian, 1981). The data generated in this study, derived from the application of the Jackson and Pollock Formula was R = .92 with a standard error of .007 (Baumgartner & Jackson, 1991). Percent fat using skinfolds was calculated from body density using Jackson and Pollock equations, $r < .97$ (Baumgartner & Jackson, 1991).

The author has been performing skinfold measurements on patients for 2 years. Therefore, it was determined that the author was qualified to perform skinfold measurements on the subjects.

Bioelectrical Impedance

Bioelectrical impedance is a much newer method of estimating percent body fat. Although it extrapolates lean body weight by regression formulas, this method has received favorable responses in research fields (Peterson & Peterson, 1988). However, some researchers have concerns that bioelectrical impedance may vary with the degree of hydration, recent electrolyte intake, or stage of the menstrual cycle (Schorin, 1990).

Lukaski et al. (1985) reported a reliability coefficient of .99 when measuring a single bioelectrical impedance analysis over 5 days. The study by Lukaski et al. measured 37 healthy males. A study by Jackson, Pollock, Graves, and Mahar (1988) reported the standard error of estimate for bioelectrical impedance to be 6.4% fat and 6.3% fat for women and men, respectively. Comparing the standard error of estimate of bioelectrical impedance to that of body mass index (BMI), Jackson et al. found BMI to be more accurate. The standard errors of estimate for BMI were 3.6% fat and 3.3% fat for women and men, respectively. In addition, Jackson et al. reported the standard error of estimates to be between 3% and 4% body fat for skinfolds depending on degree of obesity. BMI was found to be comparable to skinfolds with respect to the standard error of measurement. Therefore, the standard error of bioelectrical impedance is about twice as great as skinfolds or BMI.

Body Mass Index

Body mass index (BMI) or weight divided by stature squared is an index of obesity and is the best simple indicator of the total amount of body fat (Chumlea et al., 1987). A study by Roche et al., (1981) reported a reliability coefficient for body mass index and percent body fat of .77 for men and .76 for women.

Experimental Procedures

Skinfolds

According to the method of Behnke and Wilmore (1974), skinfold thickness was measured to the nearest millimeter (mm) on the right side of the body using the Lange Skinfold Caliper. Sites measured included triceps, suprailium, and thigh for women and thigh, abdomen, and chest for men. The means of three trials were recorded for each site.

Bioelectrical Impedance

The tetrapolar method was used to minimize contact impedance or skin-electrode interaction (Nyboer, 1970). Subjects were instructed to refrain from food for 5 hours, ingest no alcohol for 24 hours, and avoid exercise for 12 hours. Subjects remained clothed but without shoes or socks. All subjects were placed in a supine position on a mat, with limbs away from the trunk. Two aluminum foil surface electrodes were placed on the dorsal surfaces of the right hand at the distal metacarpals and two electrodes were placed on the right foot at the distal metatarsals. Specifically, detector electrodes were applied at the right pisiform prominence of the wrist and between the medial and lateral malleoli at the ankle. A current of 800 microamperes at 50 kilohertz was introduced into the subjects at the distal electrodes of the hand and foot and the voltage drop was detected by the proximal electrodes. Determinations of resistance and reactance were measured using electrodes placed on the ipsilateral and contralateral sides of the body. The lowest resistance value for an individual was used to calculate conductance and to predict fat-free mass (Lukaski, 1987). A Model BIA 101, RJL System was used.

Critically Ill Subjects

Bioelectrical impedance and skinfold measurements were determined in the critically ill patients daily for 14 days. Measurements were taken first thing in the morning, prior to breakfast. Body mass index was calculated from the height and weight of the patient. Body weights, electrolytes, and water balance were also monitored daily. A bed scale was attached to the subject's hospital bed, allowing weight to be continuously monitored. Weight was also charted in the morning.

Electrolytes, sodium and potassium, were measured each morning by laboratory personnel. Ten ml of blood was drawn into a red top serum separator tube. The blood was allowed to clot and then was spun for 10 minutes in an Adams Analytical Centrifuge. In the final step, the blood was placed in a Hitachi 747 Automatic Analyzer for 12 minutes. Laboratory results were placed in the subject's chart the following day. Water balance was monitored by nursing personnel. All liquids consumed and all urinary output in a 24 hour period were recorded daily in the Input and Output section of the patient chart. These data were collected for fourteen consecutive days.

Healthy Subjects

Healthy subjects had bioelectrical impedance measurements, skinfold measurements, body weights, and electrolytes done twice in a 7-day period, on Day 1 and Day 7. Measurements were taken in the afternoon before the subject's Phase III exercise class. Subjects were instructed to fast for at least 4 hours, to avoid alcohol for 24 hours, and to abstain from exercise for 12 hours. Body weight was measured on a medical scale and rounded off to the nearest half-pound. Electrolytes were drawn by a nurse clinician and taken to the laboratory at Sinai Hospital. Body mass index was calculated from the subject's height and weight. The healthy subjects repeated these procedures twice, seven days apart. It was assumed that day-to-day fluctuations would be minimal in a healthy subject and the costs of laboratory fees would not warrant daily measurement.

Data Analysis

Measurement theory states that an instrument must be reliable to be valid. Therefore, data analysis for this study will occur in two stages: reliability followed by validity.

Reliability

According to measurement theory, for an instrument to be valid it first must be reliable. Therefore, the reliability of skinfolds and bioelectrical impedance was calculated on both the healthy subjects and the critically ill subjects. Reliability was estimated with an intraclass coefficient which utilized a one-way ANOVA model.

Coefficients were calculated for four groups: healthy males, healthy females, critically ill males and critically ill females.

Validity

Pearson Product Moment Correlations were to be used to calculate concurrent validity. Skinfold measurements were correlated with bioelectrical impedance analysis.

Analysis of Variance

Analysis of Variance (ANOVA) was used to compare the results of percent body fat of both measurement techniques in healthy subjects versus the critically ill subjects. A split plot factorial ANOVA design was employed with 3 dependent variables, percent body fat, sodium level, and potassium level, to examine if an interaction existed between these variables.

CHAPTER IV

RESULTS AND DISCUSSION

The problem of the study was to compare body fat assessment methods in an elderly population. The body composition techniques employed were bioelectrical impedance and skinfolds over a two week period. The elderly population studied consisted of two groups: a critically ill group and a healthy group.

Analysis of Variance (ANOVA) was used to compare percent body fat measured by skinfold thicknesses and bioelectrical impedance in healthy subjects and critically ill subjects over one week. The sample was comprised of 20 subjects: 10 healthy and 10 critically ill individuals.

Results

Laboratory Tests

Electrolytes

The mean sodium level of the healthy subjects was 139.5 MMOL/L, the standard deviation was 2.58 MMOL/L. The mean sodium level of the critically ill subjects was 136.3 MMOL/L, the standard deviation was 2.49 MMOL/L. The mean potassium level was 4.94 MMOL/L and 4.32 MMOL/L for the healthy group and the critically ill group, respectively. The standard deviations 0.54 MMOL/L and 0.67 MMOL/L represented the variability found in the potassium levels of the healthy and critically ill groups, respectively. Both electrolytes, sodium and potassium, were within normal limits. See Table 1.

Table 1

Descriptive Means of the Healthy Group and the Critically Ill Group

	BMI	Weight (kg)	SF(%)	BIA(%)	Sodium (MMOL/L)	Potassium (MMOL/L)
Healthy Men	25.02	74.25	20.44	18.65	138.83	5.20
Healthy Women	27.38	69.08	26.56	29.98	140.50	4.55
Ill Men	24.98	73.85	21.83	21.54	136.49	4.04
Ill Women	23.62	59.60	21.76	26.38	135.75	4.10

Albumin and Total Protein

Albumin and total protein, indicators of the body's protein stores, were measured for the critically ill subjects. The mean albumin level was 2.98 gm/dl, the standard deviation was 0.50 gm/dl. The mean total protein level was 6.01 gm/dl, the standard deviation was 0.67 gm/dl. The mean total protein level was within the normal range, 6.0-8.0 gm/dl. The mean albumin level, however, was below the normal range, 3.5-5.3 gm/dl, which indicated protein-calorie malnutrition, nephrosis or other liver disease, or edema (Thiele, 1980).

Skinfolds

The intraclass coefficients for males were $\underline{R}$ = .74 and $\underline{R}$ = .92 for healthy and critically ill, respectively. For females, the intraclass reliability coefficients were $\underline{R}$ = .95 and $\underline{R}$ = .03 for healthy and critically ill groups, respectively. The coefficients for the healthy subjects, both male and female, were based on two repeated trials on different days. The coefficients of the critically ill groups were based on fourteen repeated trials on consecutive days. The reliability of the Jackson and Pollock Formula used in this investigation was $\underline{R}$ = .92 with a standard error of .007 (Baumgartner & Jackson, 1991).

Bioelectrical Impedance Analysis

The intraclass coefficients for males were $\underline{R}$ = .83 and $\underline{R}$ = .83 for healthy and critically ill groups, respectively. For females, the intraclass reliability coefficients were $\underline{R} = .98$ and $\underline{R} = .32$ for the healthy and critically ill groups, respectively. The intraclass coefficients for the healthy subjects, both male and female, were based on two repeated trials on different days. The coefficients for the critically ill groups were based on fourteen repeated trials on consecutive days.

Analysis of Variance

The literature indicated that electrolytes and hydration status affected the accuracy of the bioelectrical impedance measurement of body fat. Analysis of Variance (ANOVA) designs were calculated to test differences between consecutive days for selected electrolytes of critically ill subjects.

Potassium

A repeated measures ANOVA design was calculated on the dependent variable potassium. The independent variables for the design were gender and days. Levels of days were fourteen. The ANOVA indicated no significant difference between males ($\underline{M} = 4.15$) and females ($\underline{M} = 4.11$), $\underline{F}$ (1, 7) = .11, $\underline{p} < .05$. The means for the fourteen consecutive days were 4.21, 4.62, 4.34, 4.26, 3.91, 3.74, 3.84, 4.07, 3.97, 3.98, 4.28, 4.38, 4.18, and 4.04 MMOL/L, respectively. The analysis of variance indicated no significant difference between days, F (13, 91) = 1.50, p < .05. The interaction effect of gender and potassium showed no significant differences, F (13,91) = .6, p < .05. See Table 2 for an ANOVA summary.

Table 2

ANOVA Summary of Potassium Over Fourteen Consecutive Days for the Critically Ill Group

Source	S.S.	df	M.S.	F
Between Subjects				
Gender (G)	.06	1	.06	.11
Error	3.98	7	.57	
Within Subjects				
Potassium (P)	6.83	13	.53	1.50
G X P	2.74	13	.21	.60
Error	31.98	91	.35	

*F (13, 91) = 1.50, p < .05

Sodium

A repeated measures ANOVA design was calculated on the dependent variable sodium. The independent variables for this ANOVA were gender and days. The ANOVA indicated no significant difference between males ($\underline{M}$ = 137.69) and females ($\underline{M}$ = 133.75), $\underline{F}$ (1, 7) = .93, $\underline{p} < .05$. The means for the fourteen consecutive days were 136.44, 137.67, 136.33, 136.67, 137.33, 136.22, 136.22, 136.44, 134.78, 136.33, 135.11, 136.00, 135.11, and 144.89 MMOL/L, respectively. The analysis of variance indicated no significant difference between days, $\underline{F}$ (13,91) = .43, $\underline{p} < .05$. The interaction effect of gender and sodium showed no significant difference, $\underline{F}$ (13,91) = .91, $\underline{p} < .05$. See Table 3 for an ANOVA Summary.

Table 3

ANOVA Summary of Sodium Over Fourteen Consecutive Days for the Critically Ill Group

Source	S.S.	df	M.S.	F
Between Subjects				
Gender (G)	116.57	1	116.57	.93
Error	879.01	7	125.57	
Within Subjects				
Sodium (S)	538.03	13	41.39	.43
G X S	1143.80	13	87.98	.91
Error	8786.39	91	96.55	

*$\underline{F}$ (13, 91) = .43, $\underline{p} < .05$

Validity

Due to the lack of reliability reported in this investigation, validity was not statistically calculated. The content of bioelectrical impedance results across days was examined for both groups, healthy and critically ill.

Healthy Subjects

Bioelectrical impedance differences between the two days for healthy males ranged from a minimum of 1.8% to a maximum difference of 6.6% fat. This increase should be accompanied by an increase in weight. The weight increases for each person do not match the percent fat difference. For example, for males, Subjects 4, 5 and 7 showed no gain in weight from Day 1 and Day 2 but showed gains in percent fat of 5.8, 4.6 and 1.8, respectively. Subjects 1 and 10 weight difference was .5 kg and their respective percent fat differences were 2.6 and 6.6. Refer to Table 4 for individual subject's statistics.

Table 4

Bioelectrical Impedance and Weights for Day 1 and Day 2 for Healthy Subjects

Subject	Gender	%FAT Day 1	% FAT Day 2	BIA Difference
1	M	21.4	18.8	2.6
2	M	32.2	26.3	5.9
4	M	25.5	19.7	5.8
5	M	12.4	17.0	4.6
7	M	17.9	16.1	1.8
10	M	19.7	26.3	6.6
3	F	32.1	27.7	4.4
6	F	27.7	27.7	0.0
8	F	18.0	19.2	1.2
9	F	24.7	27.4	2.7

Subject	Gender	Weight(kg) Day 1	Weight(kg) Day 2	Weight Difference
1	M	69.5	69.0	.5
2	M	103.6	100.0	3.6
4	M	76.8	76.8	0.0
5	M	67.7	67.7	0.0
7	M	60.9	60.9	0.0
10	M	67.0	67.5	0.5

Table 4--Continued

Subject	Gender	Weight(kg) Day 1	Day2	Weight Difference
3	F	58.6	58.6	0.0
6	F	85.0	82.7	2.3
8	F	50.9	50.4	0.5
9	F	81.8	81.4	0.4

The healthy female subjects showed very different patterns of weight differences and percent fat differences. Subject 3 showed no gain in weight but a difference of 4.4% fat was evident between Day 1 and Day 2. Subject 6 showed the opposite, no difference in percent body fat but a difference of 2.3 kg of weight from Day 1 to Day 2. Female Subjects 8 and 9 exhibited weight changes of 0.5 and 0.4 kg, respectively, and 1.2 and 2.7% body fat, respectively.

Critically Ill Subjects

Bioelectrical impedance ranges across the fourteen consecutive days for males indicated a minimum range of 12.9 for Subject 5 and a maximum range of 30.3 for Subject 7. Subjects 5 and 7 showed a weight range across fourteen days of 5.5 kg and 5.4 kg, respectively. No consistent pattern was evident between bioelectrical impedance ranges and weight ranges for male critically ill subjects.

The same relationship was evident between bioelectrical impedance ranges and weight ranges for the critically ill females. Subjects 9 and 4 had similar bioelectrical impedance ranges, 16.6% and 16.6%, respectively, but very different weight ranges, 13.9 kg and 3.1 kg, respectively. Table 5 shows the bioelectrical impedance ranges and weight ranges for male and female critically ill subjects.

Table 5

Bioelectrical Impedance and Weight for Fourteen Days for the Critically Ill Subjects

Subject	Gender	BIA(%) Mean	BIA(%) Range	Weight(kg) Mean	Weight(kg) Range
1	M	11.46	27.8	68.30	2.1
2	M	24.36	24.6	72.76	3.0
3	M	35.93	27.0	80.05	17.3
5	M	-0.20	12.9	56.42	5.5
7	M	45.94	30.3	99.62	5.4
8	M	11.58	24.5	62.67	3.9
6	F	4.90	38.8	74.04	14.9
9	F	25.11	16.6	52.34	13.9

Table 5--Continued

Subject	Gender	BIA(%) Mean	BIA(%) Range	Weight(kg) Mean	Weight(kg) Range
10	F	40.52	6.6	52.18	15.5
4	F	21.21	16.6	61.06	3.1

Discussion

In the present study, skinfold thicknesses and bioelectrical impedance were compared on two occasions in healthy subjects and over a two-week period in critically ill subjects. In previous studies, the correlation of bioelectrical impedance with other measures of body composition has varied. Lukaski et al. (1986) tested 114 healthy men and women for percent body fat and bioelectrical impedance correlated well (r = .928) with hydrostatic weighing. Nowak et al. (1988) measured body fat in twelve college students and there was no significant difference between bioelectrical impedance and skinfold thicknesses. On the other hand, Katch et al. (1986) and Lukaski et al. (1985) both concluded that bioelectrical impedance may not be suitable for an older, abnormal population.

Skinfold thicknesses are considered to be the most practical technique which provides reasonably accurate estimates of percent body fat (Jackson & Pollock, 1985). A ninety-five percent accuracy rate can be attained by a trained and experienced tester (Bulbulian, 1984). However, in a study by Cohn et al. (1981) skinfold thicknesses correlated poorly with other measurement techniques in older subjects. Spurr et al. (1981) concluded that skinfold thicknesses do not adequately represent body fat in malnourished individuals due to possible shifts in fat deposit sites. It is possible that some of the critically ill subjects in the present study were malnourished based on their low albumin levels and therefore their skinfolds may not be as accurate as in a normal population. Therefore, both measurement techniques, skinfold thicknesses and bioelectrical impedance, were subject to error.

In the current study, the first hypothesis made was that bioelectrical impedance is a valid predictor of body composition in the healthy, older adult. For an instrument to be valid, it first must be reliable. The reliabilities of bioelectrical impedance tests on males, both healthy and critically ill, were .83 and .83, respectively. Although, these coefficients are high they do not compare to the coefficient of Lukaski et al. (1985), .99 for healthy males. The bioelectrical impedance coefficients for women show no consistency, .98 and .32 for healthy and critically ill subjects. The difference between the two groups of female subjects is greater than differences expected due to the large standard error of estimate reported by Jackson et al. (1988).

The reliability of skinfolds for this study revealed inconsistencies within the study as well as in comparison to the literature. The range within the study was .03 to .95 for critically ill and healthy female subjects, respectively. Compared to the reliability reported by Jackson et al. in the Jackson and Pollock formula, $\underline{R} = .92$, the reliability of the healthy females, $\underline{R} = .95$, is within an expected range. However, the critically ill females, $\underline{R} = .03$ indicates a large amount of measurement error. Improper site selection is the most common error in skinfold measurements (Jackson & Pollock, 1985) and the most likely source of error with skinfold thicknesses in the present study. Other studies have also demonstrated more difficulty with the accuracy of skinfold thicknesses in an older population and an older, abnormal population. This same phenomenon was evident in the males but to a smaller degree: $\underline{R} = .74$ and $\underline{R} = .92$ for healthy and critically ill groups, respectively.

Bioelectrical impedance has several potential sources of experimental error. These include altered values due to misplacement of electrodes, use of ineffective electrodes and failure to accurately determine measurement-dependent data such as height, weight, and activity level (Fox et al., 1987). The variability of the results from bioelectrical impedance from week one to week two, however, was too great for measurement error to account for the differences. In this study, bioelectrical impedance was not a valid predictor of body composition in the healthy, older adult.

The second hypothesis stated that bioelectrical impedance elicits different values than skinfold measurements in the critically ill patient. Since both bioelectrical impedance and skinfold thicknesses were unreliable in the study, it was not possible to compare the results of both methods. Therefore, the hypothesis was not addressed.

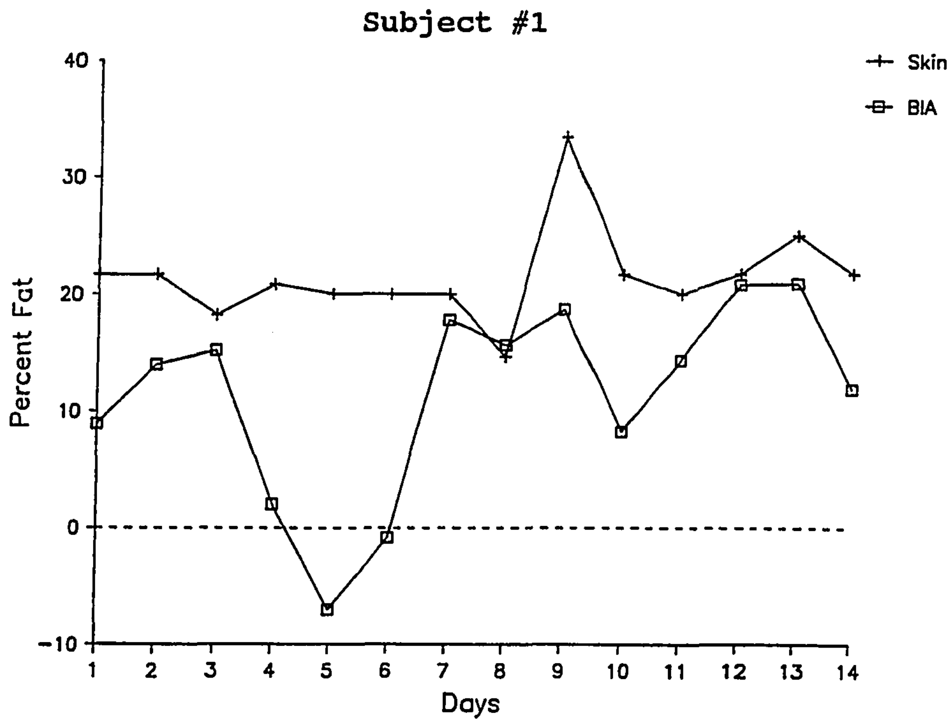
If the electrolytes or hydration status are not within normal limits, bioelectrical impedance elicits different values of percent body fat compared to skinfold measurements according to the last hypothesis. The mean result for sodium in the healthy group was 139.5 MMOL/L. The mean result of sodium in the critically ill group was 136.3 MMOL/L. The normal range for sodium is 135-150 MMOL/L according to the laboratory at Sinai Hospital, Detroit, Michigan. The mean results for potassium in the healthy and critically ill group was 4.94 MMOL/L and 4.34 MMOL/L, respectively. The normal range for potassium is 3.6 - 5.2 MMOL/L per Sinai Hospital. These results for sodium and potassium were all within normal ranges. Therfore, abnormal electrolyte values cannot explain the unreliable and invalid results of bioelectrical impedance in the study. The hydration status was not measured in the healthy subjects. All healthy subjects appeared well-nourished, without any apparent edema or dehydration. The mean result for input of fluids in the critically ill was 2750.81 milliliters. The mean result for output of fluids in the critically ill was 2309.66 milliliters. There was no evidence of dehydration or edema in the critically ill subjects.

Albumin and total protein levels were below normal for the majority of the critically ill subjects. The mean albumin level was 2.98 gm/dl and the mean total protein level was 6.01 gm/dl. The normal values, according to the laboratory at Sinai Hospital, are 3.5-5.3 gm/dl for albumin and 6.0-8.0 gm/dl for total protein. The low values of albumin and total protein are observed in malnutrition. Elevated albumin levels are seen in dehydration (Thiele, 1980). Since none of the critically ill patients had elevated albumin levels, it was assumed that they had normal hydration status.

Since both electrolytes and hydration status were within normal limits in the two subject groups, the effect of abnormal values on bioelectrical impedance was not considered a factor in this study.

In three normal weight subjects and one underweight subject, bioelectrical impedance resulted in negative percent body fat (see Figure 1). This is not possible in living subjects. No negative numbers were obtained for the overweight and obese subjects. Negative numbers may have occurred because of faulty electrodes or equipment or misplacement of electrodes (Fox et al., 1987). Negative numbers also may have resulted from small changes in total body water. Measured resistance, with bioelectrical impedance, can be affected by anything which changes total body water, such as diuretic use, edema, ascites, heart failure, or dehydration (Nash, 1985). Nine out of the ten critically ill patients were on diuretics at the time of the study. Therefore, diuretic use could have affected the results from bioelectrical impedance.

In the overweight and/or obese subjects, bioelectrical impedance estimates were almost always higher than the Skinfold thickness measurements. Figure 2 illustrates the trend for higher percent body fat estimates in overweight and obese subjects. In the remaining obese subject, bioelectrical impedance measurements are lower than



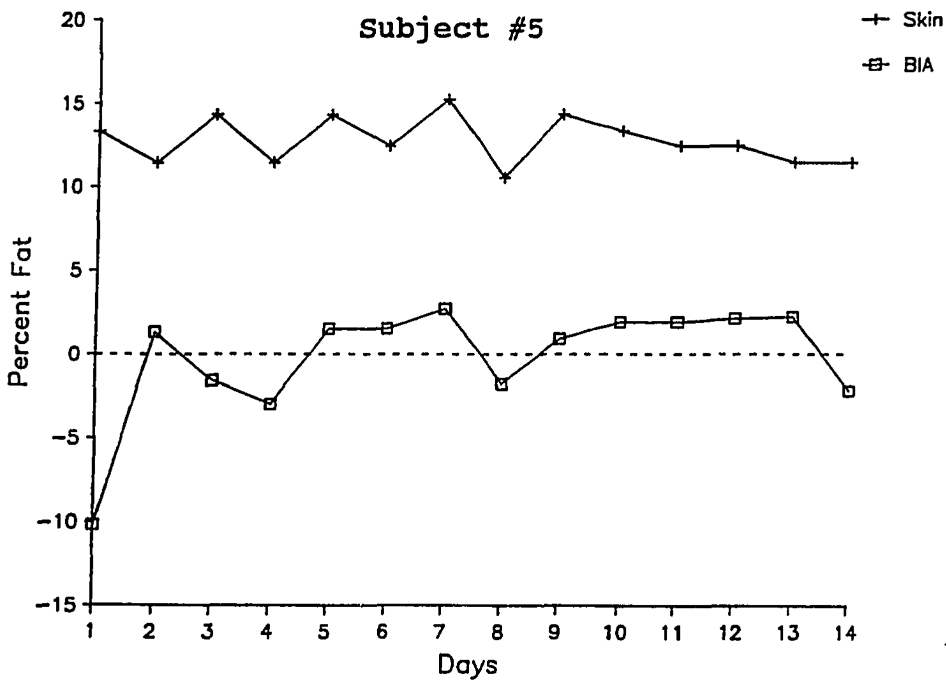
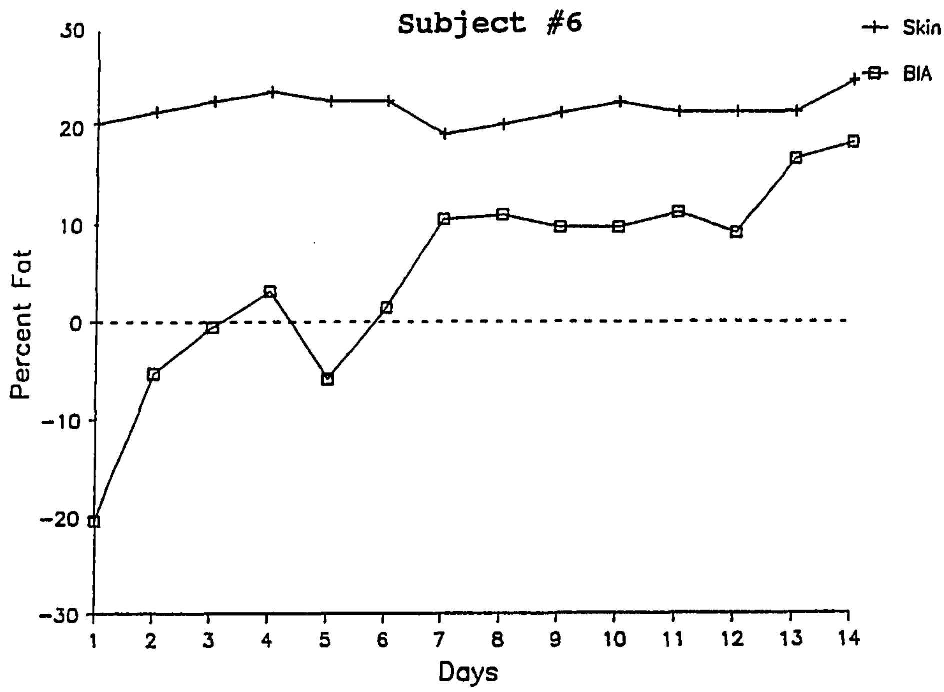
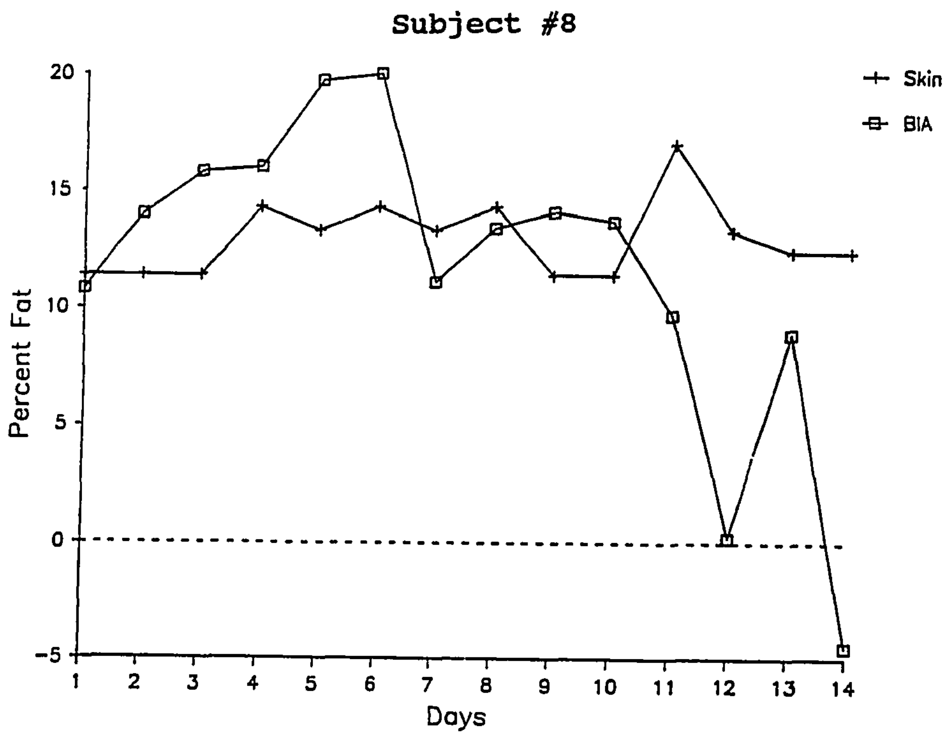


Figure 1. Percent Body Fat for Normal Weight and Underweight Subjects.

Figure 1--Continued





skinfold measurements one half of the time and higher than skinfold measurements the remaining half of the time.

With obese subjects, technical errors may result with skinfold thickness measurements (Bencich, Twyman, & Fierke, 1986). Alterations in fat compressibility in the obese may make skinfold thickness measurements more difficult (Chumlea et al., 1987). This may explain why skinfold measurements in the obese in the current study were much lower than the bioelectrical impedance measurements.

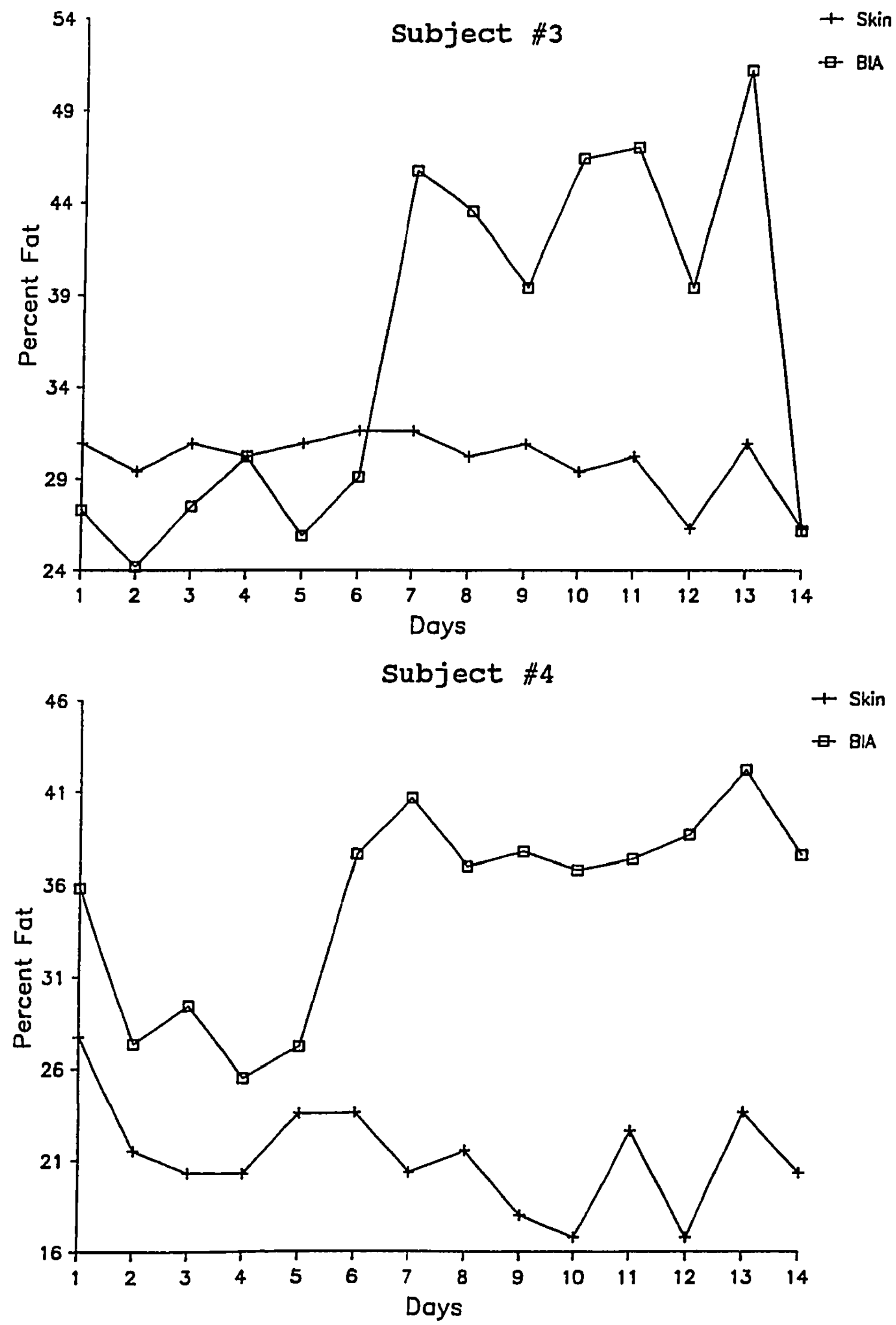
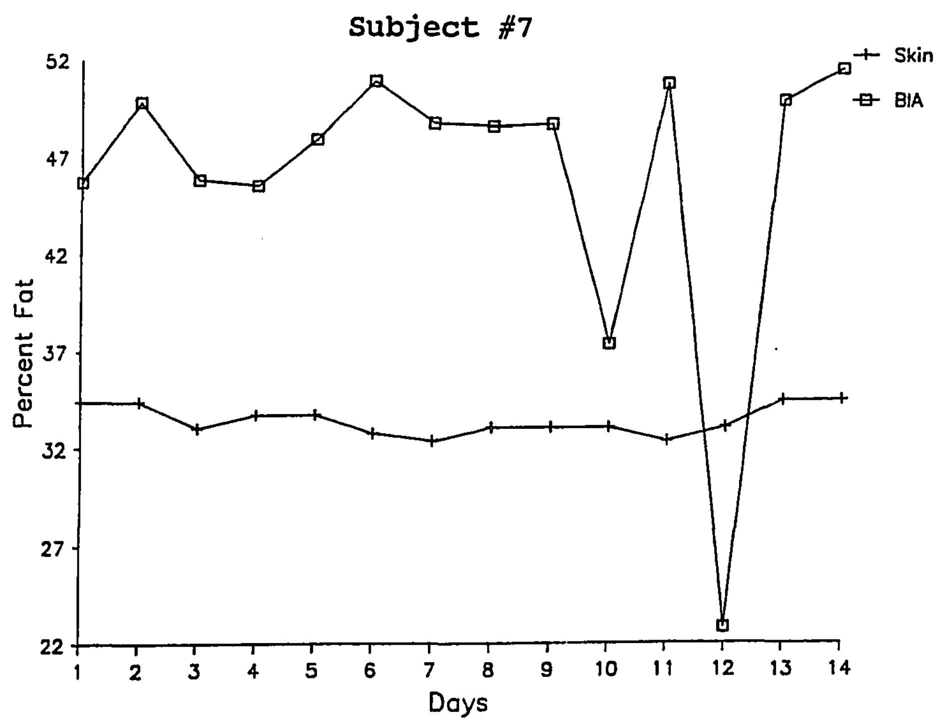
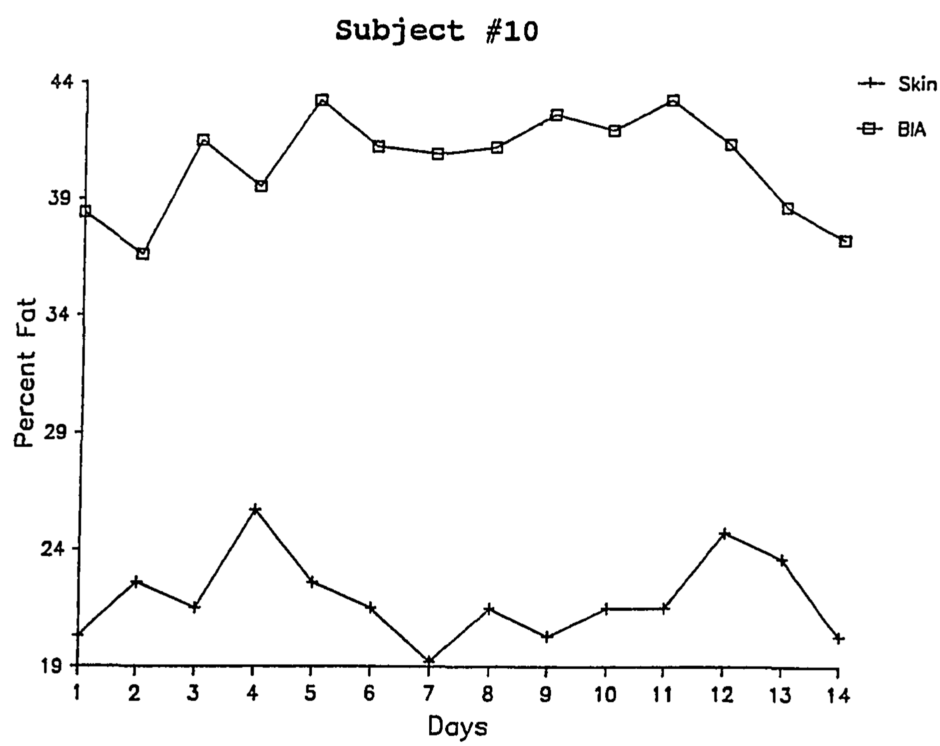


Figure 2. Percent Body Fat for Overweight and Obese Subjects.

Figure 2--Continued





In the remaining normal weight subjects, bioelectrical impedance was usually a higher percentage than skinfold measurements (Figure 3).

Subject #2

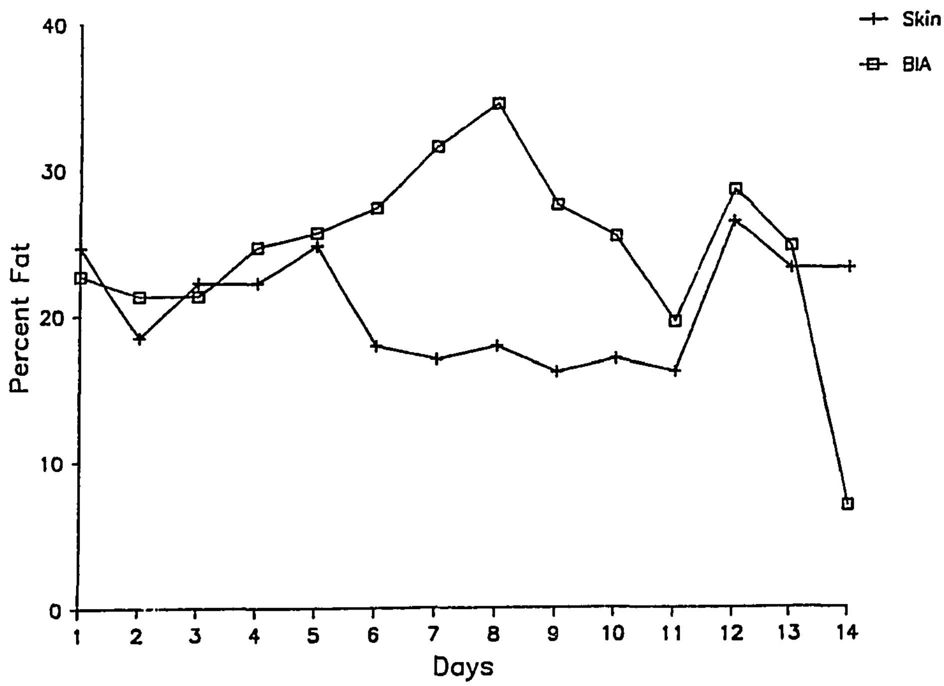


Figure 3. Percent Body Fat for Normal Weight Subject.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The study compared body fat assessment methods in an elderly population. The research is discussed under the following headings: (a) summary, (b) findings, (c) conclusions, and (d) recommendations.

Summary

This investigation was conducted to compare two body fat assessment techniques, skinfold thicknesses and bioelectrical impedance, in an elderly population composed of healthy subjects and critically ill subjects. The body fat measurements were taken over a two-week period. Electrolyte levels, sodium and potassium, and hydration status were also monitored.

A total of 20 consenting subjects were studied. Half of the subjects were critically ill patients at Sinai Hospital, Detroit, Michigan. The remaining subjects were healthy adults from the community. All subjects were 50 years of age or older.

Skinfold thicknesses and bioelectrical impedance were measured in the critically ill subjects every morning for 14 days. Body weights, electrolytes, and hydration status were monitored daily.

Skinfold thicknesses and bioelectrical impedance were measured twice in a 7-day period, Day 1 and Day 7, on the healthy subjects. Electrolytes were also drawn.

Interclass reliability coefficients were calculated using a repeated measures analysis design (ANOVA) (Baumgartner, 1989). Reliability coefficients were calculated on four groups: male healthy subjects, female healthy subjects, male critically ill subjects, and female critically ill subjects.

Analysis of Variance (ANOVA) was employed to compare the results of percent body fat of skinfold thicknesses and bioelectrical impedance in healthy subjects and the critically ill subjects. Sodium and potassium were the dependent variables.

Findings

The first hypothesis stated was that bioelectrical impedance is a valid predictor of body composition in the healthy, older adult. Since bioelectrical impedance was not a reliable method for estimating body composition in this present study, bioelectrical impedance is also not a valid predictor of body composition in the healthy, older adult. This hypothesis was rejected based upon the results of the current study; reliability coefficients were $\underline{R}$ =.83, $\underline{R}$ = .98, $\underline{R}$ = .83, and $\underline{R}$ = .32 for healthy males, healthy females, critically ill males and critically ill females, respectively.

The second hypothesis was that bioelectrical impedance elicits different values than skinfold measurements in the critically ill patient. Both body composition methods, bioelectrical impedance and skinfold thicknesses, were shown to be unreliable in this study. It is not possible to compare the results from two unreliable procedures. Therefore, the hypothesis was not addressed.

It was stated in the last hypothesis that if the electrolytes of hydration status were not within normal limits, bioelectrical impedance elicits different values of percent body fat compared to skinfold measurements. The results for sodium and potassium were all within normal ranges. The mean sodium levels were 139.5 MMOL/L and 136.3 MMOL/L for the healthy group and the critically ill group, respectively. The mean potassium values were 4.94 MMOL/L for the healthy group and 4.32 MMOL/L for the critically ill group. There was no evidence of abnormal hydration status in either population. Therefore, it was not possible to accept or reject this hypothesis.

Conclusions

The conclusion drawn from these data was that bioelectrical impedance was not a valid predictor of body composition in the healthy, older adult. Bioelectrical impedance was also not a valid or reliable method for estimating percent body fat in an older, critically ill population.

Recommendations

Further study in the area of body composition with different measuring techniques and population groups is needed for a greater understanding of the dynamics of body fat assessment. Although this study was limited to a small, older adult population, the following recommendations were made:

1. The same study could be repeated except the healthy subjects should be measured daily for 14 days as were the critically ill subjects.

2. The study should increase the size of the sample. This may decrease measurement error and increase the power of the design.

3. Different degrees of illness should be studied rather than critically ill patients from an intensive care unit versus a healthy population. Individuals with chronic disease may be appropriate subjects to study in the area of body fat assessment.

Appendix A

Human Consent Forms

APPENDIX A

INFORMED CONSENT FOR BODY COMPOSITION STUDY

Name: ______________________________ Date: ____________

I hereby voluntarily consent to participate in an investigational program to evaluate two different body composition measurements for accuracy and reliability. The techniques are bioelectrical impedance and skinfold measurements. Blood will be drawn by a nurse clinician to measure electrolytes.

I understand there are no risks involved in this study. I understand that the possible direct benefit to me individually from this study is to obtain my percent body fat results.

PROGRAM PROCEDURES

Body fat analysis using both body composition techniques will be done twice 7 days apsrt while at the Cardiac Rehab Phase III Program at the Jewish Community Center. Prior to your sceduled tests, we ask that you:

1. Refrain from food for 5 hours.
2. Refrain from exercise for 12 hours.
3. Refrain from alcohol intake for 24 hours.

I understand that I will not receive payment for undergoing these tests and that, in the unlikely event that physical injury results from these procedures, I will not be compensated and will receive medical treatment through Sinai Hospital only if arranged for by my personal physician, through the usual channels and methods for payment.

The information which is obtained will be treated as privileged and confidential and will not be relased or revealed to any person, except my private physician, without by expressed written consent. The information obtained, however, may be used without identification for a statistical or scientific purpose with my right of privacy retained.

I have read the foregoing and I understand it and any questions which may have occurred to me have been answered to by satisfaction. I am aware that I have the right to wighdraw from the study at any time. I have been given a signed copy of this consent form. If I have any further questions, I am to contact Betsey Gohlke at (313) 493-6464.

Volunteer's Signature ______________________ Date __________

Investigator's Signature ______________________ Date __________

Appendix B

Letters

SINAI HOSPITAL OF DETROIT
6767 WEST OUTER DRIVE
DETROIT, MICHIGAN 48235-2899

May 2, 1989

Ms. Betsy Kurleto, R.D.
Center for Cardiovascular Research
Sinai Hospital of Detroit
6767 West Outer Drive
Detroit, MI 48235

Dear Ms. Kurleto:

I am pleased to inform you that the Medical Research Committee at its meeting of April 28, 1989 approved your research project entitled "Comparison of Body Assessment Using Bioelectrical Impedance and Skinfold Measurements in the Critically Ill".

The Medical Research Committee of Sinai Hospital (IRB) is in compliance with the requirements in Part 56, Subchapter D., Part 312 of the 21 Code of Federal Regulations published January 17, 1981.

For the purpose of identification, this project will be known as Project 89-25. Please remember that the rules of the Medical Research Committee require that you submit a progress report if the duration of the project extends longer than one year. You will also be required to submit a final report at the time the project is terminated.

To be in compliance with Federal Regulations, you are reminded that all participants must receive a copy of a signed Consent form for their records.

Sincerely yours,

Albert J. Whitty Ph.D.

Albert J. Whitty, Ph.D., Chairman
Medical Research Committee

AJW/pmc

1A00*

Appendix C

Healthy Subject Data

APPENDIX C

HEALTHY DATA

Subject	Day	Sex	Ht(cm)	Wt(kg)	Skinfolds %BF	Skinfolds FFM	Skinfolds FM	Na	K
01	1	M	175.3	69.5	21.4	54.6	14.9	140	6.4
01	7	M	175.3	69.0	18.8	56.0	13.0	134	4.7
02	1	M	178.0	103.6	32.2	70.2	33.4	143	6.7
02	7	M	178.0	100.0	26.3	73.7	26.3	144	4.2
03	1	F	157.5	58.6	32.1	39.8	18.8	135	5.2
03	7	F	157.5	58.6	27.7	42.4	16.2	138	3.5
04	1	M	165.0	76.8	25.5	57.2	19.6	139	7.6
04	7	M	165.0	76.8	19.7	61.7	15.1	135	4.5
05	1	M	180.3	67.7	12.4	59.3	8.4	136	6.3
05	7	M	180.3	67.7	17.0	56.2	11.5	142	3.0
06	1	F	156.2	85.0	27.7	61.5	23.5	145	4.4
06	7	F	156.2	82.7	27.7	59.8	22.9	141	4.4
07	1	M	167.6	60.9	17.9	50.0	10.9	142	4.1
07	7	M	167.6	60.9	16.1	51.1	9.8	136	4.7
08	1	F	150.0	50.9	18.0	41.7	9.2	143	5.0
08	7	F	150.0	50.4	19.2	40.7	9.7	136	4.6
09	1	F	167.6	81.8	24.7	61.6	20.2	142	4.5
09	7	F	167.6	81.4	27.4	59.1	22.3	142	4.8
10	1	M	165.1	67.0	19.7	53.8	13.2	137	6.1
10	7	M	165.1	67.5	26.3	49.7	17.8	140	4.5

HEALTHY DATA

Subject	Day	Sex	Ht(cm)	Wt(kg)	%BF	BIA FFM	FM	%TBW	BMI
01	1	M	175.3	69.5	15.4	58.8	10.7	62.5	22.6
01	7	M	175.3	69.0	13.8	59.5	9.5	64.3	22.4
02	1	M	178.0	103.6	19.9	83.0	20.6	55.0	32.7
02	7	M	178.0	100.0	17.8	82.1	17.9	56.9	31.6
03	1	F	157.5	58.6	31.7	40.0	18.6	50.6	23.6
03	7	F	157.5	58.6	30.4	40.8	17.8	51.8	23.6
04	1	M	165.0	76.8	20.6	61.0	15.8	57.4	28.2
04	7	M	165.0	76.8	21.6	60.2	16.6	56.6	28.2
05	1	M	180.3	67.7	16.1	56.8	10.9	62.3	20.8
05	7	M	180.3	67.7	19.5	54.5	13.2	59.6	20.8
06	1	F	156.2	85.0	32.3	57.5	27.5	48.8	34.8
06	7	F	156.2	82.7	32.3	55.9	26.8	48.9	33.9
07	1	M	167.6	60.9	14.8	51.9	9.0	64.8	21.7
07	7	M	167.6	60.9	14.0	52.4	8.5	65.6	21.7
08	1	F	150.0	50.9	30.4	35.4	15.4	53.7	22.6
08	7	F	150.0	50.4	29.8	35.7	15.2	54.3	22.4
09	1	F	167.6	81.8	36.7	51.8	30.0	43.5	29.1
09	7	F	167.6	81.4	34.2	53.5	27.9	45.9	29.0
10	1	M	165.1	67.0	16.8	55.8	11.3	61.7	24.6
10	7	M	165.1	67.5	15.5	57.0	10.4	62.9	24.8

Appendix D

Critically Ill Subject Data

APPENDIX D

Critically Ill Subject Data

Subject #01 Age 55 Sex M Height 182.9 cm Weight 68.1 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	68.1	21.7	53.3	14.8	8.9	62.1	6.0	70.1
2	69.9	21.7	54.7	15.2	14.0	60.2	9.8	64.0
3	68.2	18.2	55.8	12.4	15.2	57.8	10.4	63.1
4	69.4	20.8	55.0	14.4	2.0	68.0	1.4	81.7
5	69.0	20.0	55.2	13.8	-7.0	73.9	-4.9	114.3
6	70.2	20.0	56.2	14.0	-.8	70.8	-.6	88.8
7	68.2	20.0	54.6	13.6	17.8	56.0	12.2	60.9
8	68.8	14.6	58.6	10.0	15.6	58.0	10.7	62.1
9	67.6	33.4	45.0	22.6	18.7	55.0	12.6	60.3
10	66.8	21.7	52.3	14.5	8.2	61.3	5.5	71.3
11	68.0	20.0	54.4	13.6	14.3	58.3	9.7	64.0
12	67.3	21.7	52.7	14.6	20.8	53.3	14.0	58.6
13	67.0	25.0	50.3	16.8	20.9	53.0	14.0	58.8
14	68.0	21.7	53.2	14.8	11.9	60.0	8.1	66.5

Day	Na	K	Alb	TP	I	O	BMI
1	137	4.3	-	-	4770	1800	20.3
2	136	4.3	-	-	4350	2250	20.9
3	138	4.1	-	-	3475	900	20.4
4	136	4.1	-	-	3630	1225	20.7
5	134	4.5	3.2	6.2	3140	1460	20.6
6	135	4.2	-	-	3265	1150	21.0
7	134	4.6	-	-	3580	1475	20.4
8	133	4.7	-	-	3210	2090	20.6
9	135	5.0	-	-	2980	1725	20.2
10	130	5.0	3.5	6.8	2400	1300	20.0
11	132	4.7	-	-	2280	750	20.3
12	133	5.0	-	-	2950	925	20.2
13	132	4.6	-	-	2975	1190	20.0
14	134	4.4	-	-	3000	850	20.3

Critically Ill Subject Data

Subject #02 Age 71 Sex M Height 173.9cm Weight 73.0kg

Flow Sheet

Day	Wt(kg)	Skinfolds %BF	Skinfolds FFM	Skinfolds FM	BIA %BF	BIA FFM	BIA FM	BIA %TBW
1	73.0	24.6	55.0	18.0	22.7	56.4	16.5	56.6
2	71.2	18.5	58.0	13.2	21.3	56.0	15.2	57.8
3	73.6	22.2	57.3	16.3	21.3	57.9	15.7	57.4
4	73.8	22.2	57.3	16.3	24.6	55.5	18.1	55.4
5	73.3	24.7	55.2	18.1	25.6	54.5	18.8	54.9
6	71.4	17.9	58.6	12.8	27.3	51.9	19.5	54.2
7	73.0	17.0	60.6	12.4	31.5	50.0	22.9	52.0
8	72.6	17.9	59.7	12.9	34.4	47.6	24.9	50.9
9	71.5	16.1	60.0	11.5	27.5	51.9	19.6	54.1
10	73.0	17.0	60.6	12.4	25.3	54.5	18.5	55.1
11	73.0	16.1	61.2	11.8	19.5	58.7	14.3	58.8
12	76.4	26.3	25.6	9.1	28.5	54.6	21.8	52.9
13	72.1	23.1	55.4	16.7	24.6	54.3	17.8	55.6
14	70.8	23.1	54.4	16.4	6.9	65.9	4.9	72.4

Day	Na	K	Alb	TP	I	O	BMI
1	141	4.2	3.8	6.7	3675	3575	24.1
2	140	4.1	-	-	3955	3525	23.5
3	137	4.2	-	-	3230	1800	24.3
4	135	4.6	3.6	6.4	2900	3150	24.4
5	138	3.7	-	-	2549	3575	24.2
6	136	4.1	-	-	3820	3100	23.6
7	132	3.8	-	-	3560	2900	24.1
8	130	4.2	-	-	3845	3125	24.0
9	133	4.2	-	-	3475	2575	23.6
10	128	3.5	-	-	3650	2475	24.1
11	128	3.6	-	-	3064	3500	24.1
12	129	3.3	3.3	7.8	3325	2350	25.3
13	128	3.6	-	-	3105	3400	23.8
14	130	3.6	-	-	3300	2800	23.4

Critically Ill Subject Data

Subject #03 Age 69 Sex M Height 167.6cm Weight 79.3kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	79.3	30.9	54.8	24.5	27.3	57.5	21.6	53.1
2	72.1	29.4	50.9	21.2	24.2	54.8	17.5	55.8
3	73.4	30.9	50.7	22.7	27.5	53.2	20.2	53.8
4	72.8	30.2	50.8	22.0	30.2	50.7	22.0	52.6
5	73.9	30.9	51.0	22.8	25.9	54.7	19.2	54.6
6	83.7	31.6	57.3	26.4	29.1	59.3	24.3	51.7
7	86.5	31.6	59.2	27.3	45.7	46.7	39.4	45.3
8	89.4	30.2	62.4	26.9	43.5	50.5	38.8	45.6
9	85.2	30.9	58.7	26.3	39.4	51.5	33.4	47.4
10	82.9	29.4	58.5	24.4	46.4	46.9	35.8	46.4
11	82.4	30.2	57.5	24.9	47.0	43.6	36.7	45.4
12	81.6	26.3	60.1	21.5	39.4	49.4	32.2	47.8
13	83.2	30.9	57.5	25.7	51.2	40.6	42.5	44.3
14	74.3	26.3	54.8	19.5	26.2	54.7	19.4	54.4

Day	Na	K	Alb	TP	I	O	BMI
1	139	2.8	2.8	5.2	1775	2155	28.2
2	141	3.8	-	-	1210	2150	25.7
3	135	4.0	-	-	1200	1350	26.1
4	132	4.2	-	-	1624	995	25.9
5	137	3.9	-	-	2275	1060	26.3
6	139	4.4	-	-	2650	1550	29.8
7	137	4.1	3.2	5.3	2890	2850	30.8
8	134	4.2	-	-	4230	3110	31.8
9	137	4.1	-	-	3545	4200	30.3
10	145	4.0	3.9	6.1	3355	4200	29.5
11	141	4.1	-	-	3210	2300	29.3
12	139	4.2	-	-	2690	2600	29.0
13	137	4.0	-	-	4505	2400	29.6
14	137	3.9	-	-	3405	1800	26.4

Critically Ill Subject Data

Subject #04 Age 79 Sex F Height 157.5 cm Weight 61.2 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	61.2	27.7	44.3	16.9	35.8	39.3	21.9	46.5
2	61.1	21.5	48.0	13.1	27.3	44.4	16.7	54.7
3	60.3	20.3	48.1	12.2	29.4	42.6	17.7	52.8
4	61.2	20.3	48.8	12.4	25.5	45.5	15.6	56.4
5	61.4	23.6	46.9	14.5	27.2	44.7	16.7	54.8
6	62.6	23.6	47.8	14.8	37.6	39.0	23.5	44.7
7	62.0	20.3	49.4	12.6	40.6	36.8	25.2	50.6
8	62.0	21.5	48.7	13.3	36.9	39.1	22.9	45.5
9	62.0	18.0	50.8	11.2	37.7	38.6	23.4	44.7
10	59.5	16.8	49.5	10.0	36.7	37.7	21.8	45.8
11	60.7	22.6	47.0	13.7	37.3	38.1	22.6	45.2
12	61.7	16.8	51.3	10.4	38.6	38.2	23.4	44.4
13	59.7	23.6	45.6	14.1	42.1	34.6	25.1	50.7
14	59.5	20.3	47.4	12.1	37.5	37.2	22.3	45.1

Day	Na	K	Alb	TP	I	O	BMI
1	137	3.7	-	-	3550	2475	25.4
2	125	4.3	-	-	3935	2475	24.6
3	133	4.3	-	-	2125	2400	24.3
4	134	4.3	-	-	2500	2575	25.4
5	132	4.1	-	-	3420	4975	24.8
6	132	3.4	-	-	3020	4950	25.2
7	137	3.7	2.6	4.8	2950	3100	25.0
8	143	3.8	2.9	5.4	2350	2725	25.0
9	140	3.9	-	-	2545	2675	25.0
10	144	4.3	-	-	3265	2615	24.0
11	134	3.8	-	-	3265	1575	24.5
12	136	4.4	2.8	5.0	2750	3035	24.9
13	136	4.2	-	-	2990	2675	24.1
14	136	4.6	-	-	3015	2300	24.0

Critically Ill Subject Data

Subject #05 Age 93 Sex M Height 155.0 cm Weight 56.5 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	56.5	13.3	49.0	7.5	-10.2	62.3	-5.8	140.9
2	55.6	11.4	49.3	6.3	1.3	54.9	0.7	86.4
3	58.1	14.3	49.3	8.3	-1.6	59.0	-0.9	93.3
4	57.4	11.4	50.9	6.5	-3.0	59.0	-1.7	98.4
5	57.2	14.3	49.0	8.2	1.5	56.3	0.9	85.5
6	55.4	12.4	48.5	6.9	1.5	54.6	0.9	85.9
7	59.7	15.2	50.6	9.1	2.7	57.9	1.6	83.3
8	57.1	10.5	51.1	6.0	-1.8	58.1	-1.0	94.4
9	54.4	14.3	46.6	7.8	0.9	53.9	0.5	87.6
10	54.2	13.3	47.0	7.2	1.9	53.1	1.1	85.3
11	56.1	12.4	49.2	6.9	1.9	55.0	1.1	84.9
12	56.0	12.4	49.1	6.9	2.1	54.8	1.2	84.5
13	56.2	11.4	49.6	6.4	2.2	54.7	1.3	84.1
14	56.0	11.4	49.6	6.4	-2.2	57.2	1.2	95.9

Day	Na	K	Alb	TP	I	O	BMI
1	144	5.2	2.4	5.1	2900	1325	23.5
2	143	6.3	1.7	3.9	3815	2300	23.1
3	139	4.7	-	-	2430	2650	24.2
4	135	4.7	-	-	2450	4075	23.9
5	140	3.4	-	-	4265	4700	23.8
6	139	2.8	-	-	3790	2950	23.0
7	143	3.5	-	-	2575	2500	24.8
8	143	3.7	-	-	2150	2400	23.8
9	138	3.1	3.5	6.1	2585	1700	22.6
10	144	4.2	-	-	2415	1150	22.6
11	140	4.5	-	-	1500	1175	23.4
12	137	3.4	3.3	5.0	2020	1625	23.3
13	142	3.3	-	-	2225	1900	23.4
14	140	3.9	3.5	5.8	2080	2350	23.3

Critically Ill Subject Data

Subject 06 Age 83 Sex F Height 179.0 cm Weight 68.5 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	68.5	20.3	54.6	13.9	-20.6	82.6	-14.0	97.2
2	69.4	21.5	54.5	14.9	-5.3	73.1	-3.7	82.7
3	69.4	22.6	53.7	15.7	-0.6	69.9	-0.4	78.2
4	71.5	23.6	54.6	16.9	3.1	69.2	-2.2	74.6
5	67.6	22.6	52.4	15.3	-5.9	71.7	-3.9	83.3
6	69.8	22.6	54.0	15.8	1.4	68.8	-0.9	76.3
7	70.7	19.2	57.1	13.6	10.5	63.3	7.4	67.5
8	74.0	20.3	59.0	15.0	11.0	65.9	8.1	67.0
9	74.7	21.5	58.6	16.1	9.7	67.3	7.3	68.2
10	82.5	22.6	63.9	18.6	9.7	74.4	8.0	68.2
11	82.0	21.5	64.4	17.6	11.2	72.6	9.2	66.7
12	81.6	21.5	64.1	17.5	9.1	74.2	7.4	68.8
13	77.8	21.5	61.1	21.5	16.7	64.8	12.9	61.5
14	77.1	24.7	58.1	19.0	18.4	63.0	19.2	59.9

Day	Na	K	Alb	TP	I	O	BMI
1	124	3.6	1.1	6.7	3380	2645	21.4
2	142	5.4	1.2	7.7	3210	3325	21.6
3	143	5.5	2.0	7.2	2465	1530	21.6
4	152	4.0	-	-	2610	2275	22.3
5	150	3.0	-	-	1855	1950	21.1
6	145	2.9	2.7	8.1	2884	2800	21.8
7	143	3.0	-	-	2880	1775	22.1
8	142	4.0	-	-	3740	470	23.1
9	135	4.4	-	-	3580	400	23.3
10	135	4.3	-	-	4260	1590	25.7
11	134	4.5	-	-	2480	2800	25.6
12	135	4.7	2.0	6.1	1420	3775	25.5
13	134	4.1	-	-	2415	3450	24.3
14	135	3.3	1.9	6.4	1730	3100	24.1

Critically Ill Subject Data

Subject #07 Age 68 Sex M Height 182.9 cm Weight 102.8 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	102.8	34.4	67.4	35.4	45.7	55.8	46.9	43.8
2	102.1	34.4	67.0	35.1	49.8	51.3	50.9	42.7
3	98.7	33.0	66.1	32.6	45.8	53.5	45.1	44.1
4	97.4	33.7	64.6	32.8	45.5	53.1	44.3	44.2
5	99.3	33.7	65.8	33.5	47.9	51.7	47.6	43.4
6	99.7	32.7	67.1	32.0	50.9	48.7	50.4	42.7
7	100.5	32.3	68.0	32.5	48.7	51.5	49.0	43.1
8	98.8	33.0	66.2	32.6	48.5	50.9	47.9	43.3
9	98.5	33.0	66.0	32.5	48.6	50.6	47.9	43.3
10	98.0	33.0	65.7	32.3	37.3	61.4	36.6	46.8
11	98.5	32.3	66.7	31.8	50.6	48.6	49.9	42.9
12	100.5	33.0	67.3	33.2	22.8	77.6	22.9	53.4
13	100.0	34.4	65.6	34.4	49.7	50.3	49.7	42.9
14	100.5	34.4	65.9	34.6	51.3	48.9	51.5	42.5

Day	Na	K	Alb	TP	I	O	BMI
1	135	3.6	-	-	2025	1950	30.7
2	134	3.7	-	-	2500	2245	30.5
3	142	3.6	3.1	-	2000	2300	29.5
4	138	3.4	-	-	1550	1700	29.1
5	138	3.1	-	-	1220	1975	29.7
6	139	3.6	3.4	6.5	2250	1225	29.6
7	-	-	-	-	1600	2825	30.0
8	-	-	-	-	1170	2300	29.5
9	-	-	-	-	1370	1625	29.4
10	-	-	-	-	560	500	29.3
11	-	-	-	-	1975	3225	29.4
12	-	-	-	-	1500	1000	30.0
13	-	-	-	-	1800	1325	29.9
14	-	-	-	-	1180	1300	30.0

Critically Ill Subject Data

Subject #08 Age 77 Sex M Height 162.5 cm Weight 63.0 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	63.0	11.4	55.8	7.2	10.8	56.4	6.8	68.7
2	63.0	11.4	55.8	7.2	14.0	54.3	8.9	65.2
3	63.9	11.4	56.6	7.3	15.8	54.0	10.1	63.4
4	62.0	14.3	53.1	8.1	16.0	52.7	10.0	63.5
5	62.2	13.3	53.9	8.3	19.7	50.0	12.2	60.7
6	61.3	14.3	52.5	8.8	20.0	49.0	12.3	60.6
7	62.7	13.3	54.4	8.3	11.1	55.8	6.9	68.4
8	64.0	14.3	54.8	9.2	13.4	55.4	8.6	65.6
9	62.3	11.4	55.2	7.1	14.1	55.2	7.1	65.4
10	61.8	11.4	54.8	7.0	13.7	53.3	8.5	65.8
11	61.4	17.0	50.4	11.0	9.0	55.8	5.5	71.3
12	62.5	13.3	54.2	8.3	0.2	62.3	0.1	87.3
13	62.1	12.4	54.4	7.1	8.9	56.6	5.5	71.3
14	65.2	12.4	57.1	8.1	-4.5	68.0	-3.0	102.7

Day	Na	K	Alb	TP	I	O	BMI
1	138	5.7	2.9	5.7	1595	1950	23.8
2	141	4.9	2.7	5.5	1621	2600	23.8
3	137	3.6	2.6	5.2	2030	2975	24.2
4	140	3.5	2.7	5.6	2330	2375	23.5
5	138	3.4	3.2	6.3	2371	1325	23.6
6	134	3.4	2.9	6.0	3180	1450	23.2
7	136	3.9	2.9	7.4	2570	1925	23.7
8	135	4.0	3.0	5.8	2166	1050	24.2
9	134	3.9	2.8	5.6	1144	1207	23.6
10	132	4.3	3.3	6.7	1932	1050	23.4
11	134	4.8	-	-	1260	580	23.2
12	134	5.2	-	-	1580	300	23.7
13	134	4.9	2.7	5.1	2020	600	23.5
14	130	4.4	2.6	5.2	750	745	24.7

Critically Ill Subject Data

Subject #09 Age 86 Sex F Height 152.4 cm Weight 54.1 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	54.1	21.5	42.5	11.6	22.8	41.8	12.3	60.4
2	53.7	18.0	44.0	9.7	30.1	37.5	16.1	53.5
3	51.0	20.3	40.6	10.4	26.0	37.7	13.2	57.6
4	55.9	20.3	44.6	11.3	32.2	37.9	18.0	51.2
5	54.7	20.3	43.6	11.1	29.8	38.3	16.2	53.7
6	56.5	22.6	43.7	12.8	29.7	39.6	16.7	53.6
7	50.4	23.6	38.5	11.9	26.4	37.1	13.3	58.2
8	50.9	22.6	39.4	11.5	20.8	40.3	10.6	62.6
9	56.9	20.3	45.3	11.6	29.0	40.3	16.5	54.2
10	55.2	23.6	42.2	13.0	27.1	40.2	15.0	56.1
11	53.5	26.7	39.2	14.3	25.2	40.1	13.5	58.1
12	54.6	23.6	41.7	12.9	20.5	43.3	11.2	62.5
13	42.7	22.6	33.1	9.6	16.3	35.8	6.9	68.0
14	42.6	22.6	33.0	9.6	15.6	35.9	6.6	68.8

Day	Na	K	Alb	TP	I	O	BMI
1	131	4.1	2.5	5.8	1300	2275	23.3
2	132	4.4	-	-	900	1870	23.1
3	130	4.1	-	-	1550	1040	22.2
4	131	4.1	-	-	2530	2210	24.3
5	132	4.4	-	-	2850	2450	23.7
6	130	4.4	-	-	2400	1450	24.6
7	128	3.9	-	-	1475	1120	21.7
8	130	4.1	2.5	5.9	4100	2800	21.9
9	127	3.7	-	-	3225	4200	24.7
10	129	2.9	-	-	3550	3675	23.8
11	136	4.4	2.9	6.2	2643	3550	23.0
12	136	4.6	-	-	3820	2750	23.5
13	135	5.2	-	-	2460	3620	18.4
14	134	4.9	-	-	4350	5000	18.3

Critically Ill Subject Data

Subject #10 Age 65 Sex F Height 147.0 cm Weight 55.0 kg

Flow Sheet

		Skinfolds			BIA			
Day	Wt(kg)	%BF	FFM	FM	%BF	FFM	FM	%TBW
1	55.0	20.3	43.8	11.2	38.4	33.9	21.1	46.2
2	51.6	22.6	39.9	11.7	36.6	32.7	18.9	48.3
3	53.1	21.5	41.7	11.4	41.5	31.1	22.0	43.4
4	52.2	25.7	38.8	13.4	39.5	31.6	20.6	45.5
5	53.6	22.6	41.5	12.1	43.2	30.5	23.1	41.8
6	54.5	21.5	42.8	11.7	41.2	32.0	22.5	43.5
7	53.5	19.2	43.2	10.3	40.9	31.7	21.9	44.0
8	54.4	21.5	42.7	11.7	41.2	32.0	22.5	43.5
9	57.4	20.3	45.5	11.6	42.6	32.9	24.4	41.9
10	55.9	21.5	43.9	12.0	41.9	32.4	23.4	42.7
11	53.5	21.5	42.0	11.5	43.2	30.5	23.1	41.8
12	50.1	24.7	37.7	12.4	41.3	29.4	20.6	44.0
13	43.8	23.6	33.5	10.3	38.6	26.9	16.9	47.5
14	41.9	20.3	33.4	8.5	37.2	26.3	15.5	49.3

Day	Na	K	Alb	TP	I	O	BMI
1	137	4.3	3.2	5.4	3700	2775	25.5
2	139	4.1	-	-	3550	2000	23.9
3	135	4.6	-	-	3575	3900	24.6
4	135	4.8	-	-	3505	3275	24.2
5	135	4.8	-	-	3600	2450	24.8
6	136	4.1	-	-	3425	2450	25.2
7	136	4.1	-	-	3460	2400	24.8
8	138	3.9	-	-	3875	2630	25.2
9	134	3.4	2.9	4.7	2685	2500	26.6
10	140	3.3	-	-	3300	2570	25.9
11	137	4.1	-	-	4275	2470	24.8
12	145	4.6	-	-	3910	7370	23.2
13	138	3.7	-	-	3510	2875	20.3
14	128	3.4	4.2	6.3	1900	650	19.4

Appendix E

Table of Descriptive Data of Critically Ill Subjects for Fourteen Days

APPENDIX E

Descriptive Data of Critically Ill Subjects for Fourteen Days

Subject	BMI	Wt(kg)	SF(%)	BIA(%)
1	20.42±0.29	68.30±0.99	21.46±3.98	11.46± 8.38
2	24.04±0.46	72.76±1.36	20.48±3.46	24.36± 6.44
3	28.48±1.96	80.05±5.52	29.98±1.63	35.93± 9.91
4	24.72±0.46	61.06±0.96	35.01±5.33	21.21± 2.85
5	23.48±0.58	56.42±1.38	12.71±1.38	-0.20± 3.44
6	23.11±1.60	74.04±5.12	21.86±1.36	4.90±10.38
7	29.76±0.44	99.62±1.48	33.38±0.75	45.94± 7.54
8	23.72±0.40	62.67±1.04	12.97±1.58	11.58± 6.78
9	22.54±1.90	52.34±4.40	22.04±2.05	25.11± 5.21
10	24.16±1.94	52.18±4.19	21.91±1.73	40.52± 2.13

Subject	Sodium (MMOL/L)	Potassium (MMOL/L)	Input (ml)	Output (ml)
1	134.21±2.08	4.54±0.31	3286.00±667	1363.57±464
2	133.21±4.44	3.91±0.36	3389.50±398	2989.28±537
3	137.86±3.11	3.98±0.36	2754.64±1043	2337.14±1010
4	135.64±4.62	4.06±0.33	2977.14±495	2896.43±943
5	140.50±2.67	4.05±0.92	2707.14±768	2342.86±1037
6	139.21±7.41	4.05±0.80	2774.21±804	2313.64±1097
7	137.67±2.62	3.50±0.20	1621.43±511	1821.07±734
8	135.50±2.92	4.28±0.70	1896.36±631	1438.00±817
9	131.50±2.74	4.23±0.52	2653.78±1079	2715.00±1178
10	136.64±3.60	4.08±0.49	3447.86±568	2879.64±1472

Appendix F

Table of Descriptive Data of Healthy Subjects by Week

APPENDIX F

Descriptive Data of Healthy Subjects By Week

	BMI (Mean ± SD)	Wt(KG) (Mean ± SD)	SF(%) (Mean ± SD)	BIA(%) (Mean ± SD)
Week 1	26.06±4.61	72.18±14.44	23.16±6.12	23.47±7.93
Week 2	25.84±4.31	71.50±13.51	22.62±4.59	23.89±7.59

	Sodium (MMOL/L) (Mean ± SD)	Potassium (MMOL/L) (Mean ± SD)
Week 1	140.20±3.19	5.63±1.09
Week 2	138.80±3.28	4.29±0.56

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