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# VALIDATION OF CURRENT BODY COMPOSITION ESTIMATION EQUATIONS FOR MEN OVER 60 YEARS OF AGE


by
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A thesis submitted in partial fulfillment
of the requirements for the degree of

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## ABSTRACT

This study compared five skinfold estimation equations for body composition (Jackson and Pollock's Sum of 7 and Sum of 3; Jackson & Pollock's Sum of 4 and Sum of 3 for the YMCA, and Durnin and Womersley's Sum of 7) with percent fat obtained from underwater weighing in older males. Subjects were ninety-seven adult males, aged 60-80 years (M=66, SD=4.53) and varying in height (M=174.5 cm, SD=5.99) and weight (M=80.95 kg, SD=13.37). Skinfold measurements were taken with Lange calipers at biceps, triceps, chest, subscapular, abdominal, suprailiac, midaxilla, and thigh sites. Underwater weight was determined in a seated position utilizing a load cell system with residual volume (RV) measured at the time of weighing. Each subject performed ten trials with the last six trials averaged for calculations.

Correlation analysis indicated that the skinfold estimation equations achieved a mean correlation of .74 with underwater weighing. Jackson and Pollock's Sum of 7 equation (JP$\Sigma$7) yielded the highest correlation with underwater weighing (.78) and Durnin and Womersley's equation (DW) the lowest correlation (.72). A one-way repeated measures analysis of variance indicated that all five

equations used with the present studies population produced significantly different results than underwater weighing. A follow-up test indicated that a) the YMCA's Sum of 4 and Sum of 3 equations were not significantly different from each other, nor were b) Jackson and Pollock's Sum of 7 and Sum of 3, however, a and b were significantly different from each other. The data showed that these equations are not as valid with the present study's population as with those from which the equations were derived.

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My core group of friends have been phenomenal!! Thanks for your energy, time and support: Ilene Gerardi, Stefan Zander, Rleen Joy, and Debra March. Suddenly, I feel the urge to write a run-on sentence . . .

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# CHAPTER 1

## Introduction

An increased awareness of the importance in achieving physical fitness and health has caused many individuals to develop exercise goals. Many have joined health clubs, YMCA's or hired personal trainers to reach these goals. This rise in health and fitness consciousness has lead to an increase in the assessment of physical fitness including tests for muscular strength, muscular endurance, cardiorespiratory fitness, flexibility, and body composition. With the media (newspapers, radio, magazines, TV) emphasizing the importance of diet, nutrition and correct body weight, there has been a special interest in body composition.

Researchers have spent the last fifty years refining techniques to measure body composition. Many techniques are used in the laboratory setting, and are considered to be the criterion techniques. Determination of body density through underwater weighing (UWW) is the most accepted of these techniques (Jackson & Pollock, 1985). Underwater weighing requires extensive and costly equipment, a knowledgeable staff, and considerable time and effort from the subject. Since underwater weighing has been unsuitable for mass testing, easier and more simple field techniques have been developed. Extensive research has been completed to develop these field techniques for body composition assessment which use 'simple to take' measurements without the loss of reliability and validity.

Most body composition studies divide the body into two compartments: lean body weight (LBW) which is the weight of the lean body (muscle, bone, organs), and fat weight which consists of essential fat and storage fat. Estimation equations for body density or percentage of body fat have been developed from anthropometric measurements such as skinfold measures, bone diameters, height, weight, and circumferences. These estimation equations have been validated against percent body fat determined by underwater weighing, where a regression model has been developed to determine which combination of anthropometric variables and age yields the closest values to the underwater weight body fat results.

The earlier estimation equations were population specific in that they usually applied to a small, homogeneous sample. The literature has well over 100 different equations based on multiple combinations of anthropometric variables to predict body composition, and ". . . much of the work has been conducted on young men and women with considerably fewer studies on children and older adults" (Lohman, 1981).

To alleviate the use of numerous equations with various populations, 'generalized equations' were developed on larger sample sizes which varied in age and body fat. "The advantage of generalized equations is that one equation replaces several without a loss in prediction accuracy" (Jackson & Pollock, 1985). While there have been many estimation equations developed for 18 to 50 year olds, few of these equations incorporate the over 60 population.

Studies show that equations generally derived from younger populations are not applicable to older subjects (Deurenberg, Vander Kooij, Evers, and Hulshof,1990). All five of the estimation equations used in this study are generalized in nature; they apply to 16-72 year old males. When assessing body composition for the older population, the choice of estimation equation is limited. Single skinfold measurements have been used to aid in the nutritional assessment of the older population, however, no generally accepted estimation equation has been suggested.

## Statement of the Problem

The purpose of this study was to determine the validity of five commonly used estimation equations for predicting body fat percentage in men over 60 years. A subproblem of this study was to consider the validity of these five equations on percent body fat at the extremes (one and half standard deviations [1.5 SD] above and below the mean percent fat) of the present sample population. Four of the five estimation equations were from the same database developed by Jackson and Pollock (1978). The five equations are discussed below.

1. Jackson and Pollock's Sum of 7 Equation - JPΣ7 (Jackson & Pollock, 1978). This equation for body density was designed to take the place of several population specific equations. Chosen for its wide use in the literature, this equation uses the sum of the pectoral, midaxilla,

abdomen, suprailiac, thigh, subscapular, and triceps skinfold measurements. Body density from this equation may be converted to percentage of body fat. This study used Siri's (1961) equation for this conversion.

2. Jackson and Pollock's Sum of 3 Equation - JPΣ3 (Jackson & Pollock, 1978). As above, this equation has been referenced considerably in the literature and involves skinfold measurements on the pectoral, abdominal and thigh sites. Siri's equation (1961) was also used to convert body density to body fat percentage.
3. YMCA's Sum of 4 Equation - YMCAΣ4 (Golding, Myers, & Sinning, 1989). This equation was developed by Jackson and Pollock specifically for the YMCA test battery, and it estimates body fat from the sum of the abdomen, ilium, triceps and thigh skinfold sites. It was chosen for this study because of its wide use.
4. YMCA's Sum of 3 Equation - YMCAΣ3 (Golding, et al., 1989). This equation was developed along with the sum of 4 equation, except that the thigh skinfold site was deleted. It was chosen for its wide use, as well as the fact that it may be difficult to obtain skinfold measurements on the leg, so an alternate equation may be necessary.
5. Durnin and Womersley's Equation - DW (Durnin & Womersley, 1974). This equation estimates body density and has been one of the prevalent generalized equations

in the literature. It uses the biceps, triceps, subscapular, and suprailiac skinfold sites.

## Limitations

1. This study involved 97 apparently healthy male volunteers between the ages of 60-80 years. Since these were volunteers, this was not a random sample.
2. Only five estimation equations were compared with percent body fat from underwater weighing. The results can not be extended to any other equations.
3. The apparatus for measuring residual volume at the time of underwater weighing was not tested for reliability prior to data collection, however, it was experimentally validated by a residual volume (RV) model.

## Assumptions

1. As lung volume was determined at the time of underwater weighing, it was assumed that the procedure accurately measured the amount of air in the lungs at this time.
2. It was assumed that the tester was reliable in obtaining skinfold measurements.
3. Since residual volume requires maximal exhalation on the part of the subject, it was assumed that all subjects exhaled maximally.

## Need for the Study

The increase in man's longevity and the growing interest in preventive medicine supports more research that must be performed on older populations. Body composition studies have historically used young men and women as subjects. There have been few studies dealing with body composition on those over 60 years of age. "Information on the anthropometric measurement of the elderly population . . . is comparatively limited" (Vir & Love, 1980) and ". . . the need for future work is to cross-validate the generalized equations with defined groups to insure that the predictive accuracy is consistent for all groups measured" (Jackson & Pollock, 1982).

# CHAPTER 2

## Related Literature

The two-component model has been the basis for body composition studies since introduced by Behnke in the 1940's. This model states that the body can be divided into two compartments: fat weight and fat-free weight (or lean body weight). Numerous methods have been developed to assess these two components of body composition. Most methods measure one variable from which total fat-free mass is estimated. "The most reliable methods . . . available for estimating body fat and the fat-free mass involve the measurement of total body water, total body potassium or body density" (Womersley, Durnin, Boddy, & Mahaffy, 1976). Several authors discuss the various methods for measuring body composition (Brodie, 1988a, 1998b; Lukaski, 1987).

Body density has traditionally been measured by the underwater weighing method. Considered the “gold standard”, underwater weighing relies on several assumptions for accurately determining body density:

a) the density of human fat and fat-free tissue is known,

b) the density and composition of both the fat and fat-free body remain relatively constant and similar among individuals,

c) each component remains proportional relative to the whole body (Wilmore, 1984).

This chapter reviews the literature, and discusses both the applicability of these assumptions to older individuals, as well as the implications for body composition methodology with older populations.

## Age Associated Effects

### Effect of Age on Body Density

Total body density includes the density of both fat-free tissue and fat tissue. There is a progressive decline in body density with age, although no specific value has been suggested (Krzywicki & Chin, 1967; Masoro, 1981; Rossman, 1979; Womersley et al., 1976). Arnold, Bartley, Tont and Jenkins (1965) reported a ". . . slight progressive decrease (in mean body density) for the sixth through the eighth decades of life." When comparing the body densities of younger and older males, Krzywicki and Chin (1967) found a difference of .043 gm/ml for the mean body density of 17 to 19 year olds (1.060 gm/ml) as compared to that of 65 to 69 year olds (1.017 gm/ml). Durnin and Womersley (1974) found young adult males to have a body density of 1.08 gm/ml, and older males (70 years) to have a density of 1.03 gm/ml. Blanchard, Conrad, and Harrison (1990) found a signficantly lower fat-free mass estimate in elderly women as compared to young women. This age-associated decrease in body density may be due to decreased physical activity, resulting in reduced muscle mass and a tendency to gain fat tissue with age (Watson, 1985).

For calculations, the value used for the density of the fat-free body is 1.100 gm/ml (Durnin & Womersley, 1974; Keys & Brozek, 1953). However, this density value is lower than 1.10 gm/ml for older populations and varies with individuals (Lohman, 1981). Womersley et al., (1976) reported that older, non-obese women have a slightly lower fat-free mass density of 1.090 gm/ml. Another study found a significant change in the chemical composition of fat-free tissue which results in a decreased FFM density with age (Deurenberg, P., Westrate, J.A., vanderKooy, K., 1989). The variability of the fat-free body in older individuals can be contributed to mostly changes in body water and mineral content (Lohman, 1981; Womersley et al., 1976). The degree of variation with fat-free tissue has not been well defined in older populations (Lohman, 1984). Using $^{40}K$ counting, Forbes (1976) found an average loss of 3 kg of lean body mass per decade. Because of the change in fat-free tissue, researchers are currently suggesting the use of a 4 compartment model to improve body composition estimates (Chumlea, Baumgartner, and Vellas, 1991). Baumgartner, Heymsfield, Lichtman, Wang, and Pierson (1991) have demonstrated that results based on the 2 compartment model yield significantly different estimates of body composition than a 4 component model.

## Effect of Age on Fat and Fat Distribution

The density of fat tissue is reported to be .90 gm/ml, and fat tissue density does not appear to be effected by age (Womersley et al., 1976). In Masoro's (1981) summary of age-associated effects on

adipose tissue mass and related measurements, conflicting reports are listed as to whether the total amount of fat remains constant with age, or if it increases with age. Other studies reported that total body fat does increase with age, although no quantitative values have been presented (Blanchard et al., 1991; Borkan & Norris, 1977; Fryer & Shock, 1962; Kenney, 1985; Steen, 1979; Steen, Lundgren & Isaksson, 1985; Watson, 1985; Young, Blondin, Tensuan & Fryer, 1963).

Some researchers (Borkan & Norris, 1977; Borkan, Hults, Gerzof, & Robbins, 1985; Kenney, 1985) hypothesize the redistribution of fat from subcutaneous locations to internal locations resulting in a centripetalization (shifting towards the middle portion of the body) and internalization of body fat with age. This redistribution of fat tends to occur later in women than in men (Kenney, 1985). In men, subcutaneous fat increases in the region of the greater trochanter but decreases in the abdominal region through middle age (Borkan & Norris, 1977). Other researchers suggest a similar shift (Young et al., 1963), although no quantitative values have been reported.

The distribution of total body fat varies with gender and race. Jackson and Pollock (1978;1980) found ". . . no sex difference for the sum of all seven skinfolds, but the skinfolds for women were larger in the limbs, while the men had more skinfold fat at the chest, axilla and suprailiac sites." Durnin and Womersley (1974) found males to have a higher proportion of their body fat located subcutaneously than females. They (Durnin & Womersley,1974) also reported that a

given skinfold corresponded to a considerably lower body density in women than in men. A conflicting report by Hattori, Numata, Ikoma, Matsuzaka and Danielson (1991) found that females have a greater proportion of subcutaneous fat than males. Garn, Sullivan and Hawthorne (1988) reported similar results with women having a greater proportion of subcutaneous fat than men. Mexican and Black Americans have more fat in the trunk area than Anglo Americans (Greaves, Puhl, Baranowski, Gruben, & Seale, 1989).

In summary, body density decreases with age in both older men and women, however, the exact values for the density of older populations is not available due to a lack of research on this topic. The density of fat tissue is not affected by age, and there are conflicting reports on whether total fat increases, decreases or merely shifts positions in the body (from subcutaneous to internal locations). The distribution of fat varies with gender and race, where more fat is found in the trunk area of Mexicans and Blacks than their white counterparts. There are conflicting reports whether females carry more internal or subcutaneous fat than males.

Effect of Age on Height and Weight

Extensive research has found that stature decreases with age (Chumlea, Roche, & Webb, 1984; Watson, 1985). A decline in stature of approximately 1 cm per decade occurs after 40 years (Kenney, 1985). Shephard (1987) reported a slightly larger decline in stature of 2 cm per decade. This loss in height occurs as a result of a loss in

foot arches, spinal curvature, and decreased connective tissue in the intervertebral discs (Kenney, 1985; Shephard, 1987; Watson, 1985). Because of declining fat-free mass, mean body weight also decreases with age (Fryer & Shock, 1962; Rossman, 1979; Watson, 1985). After ages 65 to 70, total body weight decreases without an increase in fat tissue (Young, et al., 1963).

Effect of Age on Lung Volumes

The respiratory system relies partially on the elasticity of the lung cavity and the thoracic muscle mass to effectively deliver respiratory gases. Vital capacity or the maximum ventilation capacity decreases with age due to age-associated changes in lung elasticity and the loss of muscle mass in the thoracic region (Kenney, 1985). Residual volume, defined as the amount of air remaining in the lungs after a maximal exhalation, increases with age (Kenney, 1985; Whitbourned, 1985). In 1960, Brozek found the residual volume of older men to be .6 liters higher than that of their young counterparts.

Age Associated Effects and Body Composition Methodology

Many methods are currently being used, both in the field and in the laboratory, to assess an individual's body composition. Several authors have presented summaries of these various techniques and their principles, advantages, disadvantages, cost, and experimenter training requirements (Brodie, 1988a, 1988b; Lukaski, 1987). Some

of the common methods of estimating body weight, body composition, and percent body fat are summarized below.

Height/Weight Tables

Height/weight tables have historically been used to determine an individual's ideal body weight. Some weight for height indices indicate adiposity in an attempt to predict body fat from a simple measure (Brodie, 1988a). However, height/weight tables do not accurately assess body composition because only mass and stature are measured (Montague, 1960). Height and weight tables can be misleading in that an individual may be overweight according to the tables, yet the weight may be due to either added fat tissue or to increased muscle mass. These tables have not been adjusted for age, and yet body composition changes with age (Yearick, 1978). Height/weight tables may be appropriate for gathering descriptive data for the older population, but not for determining body composition, obesity indices, or nutritional adequacy. Some attempts have been made to create an average height/weight table for older populations for the purpose of comparison (Master, Lasser, & Beckman, 1960), however, no studies have made use of the table.

Skinfold Measurements

Skinfold measurements have been one of the most widely used, and considered the best field method for assessing body composition. They are relatively easy to perform, quick to measure, and require

only the purchase of a skinfold caliper. They are "subject-friendly" in that minimal requirements are placed on the subject with only a pinch of skin and subcutaneous tissue in several locations. Skinfold calipers have been designed to measure the thickness of subcutaneous fat (in millimeters) at various locations. These measurements can be then used to compare with norms of individual skinfold thicknesses, or used in equations which estimate body density or body fat percentage.

Skinfold compressibility can affect skinfold measurements when used with older populations as compared to younger populations. Skinfold compressibility decreases with age (Brozek & Kinsey, 1960; Durnin & Womersley, 1974). Brozek and Kinsey (1960) compared skinfold compression on 20 to 69 year old males, and found the largest differences were in the 40 to 69 year old group where compression decreased in a non-uniform fashion. Becque, Katch, and Moffatt (1986) reported that reading the caliper measurement within 4 seconds would minimize skinfold compression, which may limit compression effects on older populations. Although no regional differences were found on female subjects, males exhibited greater compression at the iliac site (Becque et al., 1986).

The Food and Nutrition Board of the National Research Council of the United States has established that the standard pressure exerted by a skinfold caliper must be 10 gm/mm2. Different calipers, however, have varying jaw surface areas to accomodate this

standard jaw pressure. The Harpenden calipers, for example, have a total jaw pressure of 900 gms, whereas the Lange calipers only have 300 gms (Golding & Lindsay, 1989). Studies have shown that this difference in total jaw pressure does result in significantly different skinfold measurements, thus, different percent fat estimates (Gruber, Pollock, Graves, Colvin, & Braith, 1990; Kelley, Golding, & Tandy, 1991; Schmidt & Carter, 1991).

Selection of Skinfold Sites

Skinfold sites are chosen at locations where subcutaneous fat normally occurs: posterior upper arm, abdomen, hips, and upper thigh. When using skinfold measurements in estimation equations for percent body fat, the choice of skinfold site is governed by the equation. Most nutritional adequacy studies for the elderly have reported the sum or mean values for individual skinfold sites as opposed to choosing an estimation equation for total percent fat (Friedlaender, Costa, Bosse, Ellis, Rhoado & Stoudt, 1977; Fryer & Shock, 1962; Shephard, 1987; Steen, 1979; Vir & Love, 1980; Yearick, 1978).

There is little agreement over which skinfold site, in combination or separately, produce the best results for predicting body composition. However, the most common sites in the literature are triceps, subscapular, suprailiac, abdominal, and thigh (Katch & Katch, 1980). "It seems that skinfold measurements on the trunk (suprailiac and abdomen) may be more reliable predictors of body

fat in males, whereas extremity skinfold measurements (triceps, biceps and thigh) seem to be more accurate in females" (Watson, 1985). Rossman (1979) reported the most reliable skinfold measurement in relation to weight was the abdominal site for both males and females. The subscapular measurement correlated the best with body density according to Young et al., (1963). Vir and Love (1980) found that the triceps skinfold is a poor criterion measure of fat in men.

Underwater Weighing

Considered the "gold standard", the underwater weighing technique (densitometry, hydrostatic weighing) is not a good field test. It requires extensive equipment and facilities, a trained experimenter, and considerable practice and time on the part of the subject.

The assumption underlying the conversion of body density to percent body fat is that fat tissue has a density of .90 gm/ml and fat-free tissue have a density of 1.10 gm/ml. With these assumptions, whole body density can be measured and fat content can be calculated (Garrow, 1982). These assumptions have been questioned and have been found to be invalid (Clarys, Martin & Drinkwater, 1984; Martin & Drinkwater, 1991; Womersley et al., 1974), however, no correction to the literature has been made. Studies have reported that adipose-tissue-free weight varied considerably with cadavers (Clarys et al, 1984). Womersley et al, (1974) studied the fat-free

mass in men and women of various body types and ages from measurements of body density and total body potassium, and reported significant changes in FFM density and potassium content especially with older individuals. Underwater weighing systems use Archimedes Principle to determine body volume, and body volume is then used to compute body density with the following formula.

$$D = \frac{mass}{volume}$$

The underwater weighing measurement is affected by the temperature of the water (density of the water), the volume of air in the subject's lungs, and the weights added to the body to decrease buoyancy effects. Brozek and Key's (1953) equation for underwater weighing was used for body density determination.

$$D = \frac{Wa}{\frac{Wa - (W H_2O - Ws)}{D H_2O} - RV}$$

Wa = subject's land weight (weight in air) in grams
$WH_2O$ = subject's weight in water in grams
Ws = total sinker weight in grams
RV = residual volume in liters
$DH_2O$ = density of water at a specific water temperature

To decrease measurement errors for weight under water, eight to ten trials have been suggested with the last three weights for each trial averaged for calculation purposes (Roche, 1987). Researchers have historically used the Chatillon Autopsy Scale to record weight in water. This scale allows for considerable error as water movement

causes large fluctuations in the scale movement, making it difficult to obtain accurate weight readings. The strain gauge or load cell system is preferable (Brodie, 1988; Donahue, Golding & Cummings, 1988; Fahey & Schroeder, 1978; Roche, 1987).

Residual Volume

Accuracy of body density determination is directly related to the correct measurement of the air volume in the lungs at the time of weighing. Some of the methods used to determine this lung volume include predicting residual volume (RV) from a chart or vital capacity measurements (VC); measuring RV 'on land' and assuming an equal value as if measured in water; measuring RV at the time of the actual underwater weighing. When residual volumes are not measured directly (for example, estimating RV from vital capacity) an additional error of .003 gm/ml is made in the determination of body density (Lohman, 1981). Researchers have reported that measuring RV on land yields different results than measuring RV in water, however, the difference is not well established (Lohman, 1981). Girandola, Wiswell, Mohler, Romero and Barnes (1977) suggest a difference of 200 to 300 ml for RV on land versus RV in water that can give a 4 to 5% difference in the eventual percent fat determination. This difference may be due to the increased hydrostatic pressure on the walls of the thorax as a result of water immersion. Because of the possible differences found between land and water measurements, residual volume should be measured at

the time of weighing (Behnke, 1942; Girandola et al., 1977; Lohman, 1981; Welch & Crisp, 1958; Withers & Hamdorf; 1989).

Residual volume values may show a greater variability among older individuals as compared to younger individuals. Studies involving young men and women showed less variability for residual volume measurements than studies performed with older men. Few studies have reported the variability when testing older populations, however, Latin and Ruhling (1986) reported a standard deviation (SD) in residual volume of .41 with older men aged 56-70 years. Forsyth, Plyley and Shephard (1988) found a considerably lower standard deviation of .233 with residual volume in the water for young men and women. Ostrove and Vaccaro (1982) found a similar variability of .186 when testing residual volume in water with young women. In their study with young men, Craig and Ware (1967) found an SD of .03. Although variability of residual volume increases with age, if the measurement of RV occurs at the time of weighing, this variability is insignificant.

## Estimation Equations

There are well over 100 estimation equations that are used for the prediction of body composition (Jackson & Pollock, 1982; Lohman, 1981). There is no consensus as to which equations are best, however, most equations that are used have a high correlation with underwater weighing. "Many researchers have published regression equations with functions to predict hydrostatically

measured body density from various combinations of anthropometric variables" (Jackson and Pollock, 1985). Estimation equations can also predict percent body fat from body density. New equations are now being developed from bioelectrical impedance, infrared machines, and other laboratory techniques. However, the majority of equations were from regression equations based on body density determination from underwater weighing.

Population Specific Estimation Equations

Historically, body composition estimation equations have been population specific, i.e., they were developed from a homogeneous sample. "Much of the work has been conducted on young men and women, with considerably fewer studies on children and older adults" (Lohman, 1981). Population specific equations were based on a linear relationship between subcutaneous fat and body density. However, recent research shows this relationship to be curvilinear (Durnin & Rahaman, 1967; Durnin & Womersley 1974; Jackson & Pollock, 1978). The use of population specific equations is limited to the sample on which the equation was derived, thus, is not appropriate for broad testing.

Generalized Estimation Equations

To alleviate some of the problems associated with population specific equations, there has been an attempt to design generalized estimation equations that deal with broad populations (Durnin &

Womersley, 1974; Jackson & Pollock, 1978). These equations account for varying age and gender, and are based on a curvilinear rather than linear relationship between subcutaneous fat and body density (Jackson & Pollock, 1985). Jackson and Pollock (1978) validated their Sum of 7 equation (JP$\Sigma$7) and Sum of 3 (JP$\Sigma$3) equation with 18-61 year old men and found that age accounted for a significant proportion of body density variance. When cross-validated with a similar sample, both the JP$\Sigma$7 and JP$\Sigma$3 equations exhibited a high (.915-.917) correlation between predicted and laboratory determined body density. A list of the five generalized estimation equations used in this study is presented in the next chapter.

## Summary

When determining the body composition of individuals, there are many reliable and accurate methods ranging from those which require extensive technical equipment and personnel to those which require a single piece of equipment and tester.

Age affects both the lean tissue and fat tissue components of the human body. Studies report a decrease in mean body density with age that may be due to the reduced muscle mass and increased fat tissue from a lack of physical activity. The fat-free mass also decreases with age, however, no quantitative values have been reported. The density of fat-free mass varies considerably with older individuals due to changes in water and mineral content. As these values are not well defined in the older population, caution

must be employed when using measures of fat-free mass to estimate percent body fat (Womersley et al., 1976). Although fat tissue density does not appear to be affected by age, there are conflicting reports as to whether the total amount of fat tissue changes with age. Several studies suggest that fat tissue is redistributed with age from external to internal locations. Fat distribution trends may also vary with females and different races. Several studies report that body weight and height decrease with age. Lung volumes are also affected by age with an increase in residual volume, and a decrease in vital capacity. However, these age-associated changes are insignificant for body density measurements if residual volume is measured at the time of underwater weighing.

Height and weight tables have historically been used to determine ideal weight, but are not appropriate measures of body composition. There are no currently accepted height/weight tables for older populations.

One of the most accepted field methods is skinfold measurements because of their relative ease and validity. Skinfold measurements can be used in an estimation equation to determine body density or percentage of body fat. Several studies (Brozek & Kinsey, 1960; Durnin & Womersley, 1974) report that skinfold compressibility decreases with age which may affect skinfold measurement, thereby, decreasing prediction equation accuracy. Becque, Katch and Moffatt (1986) reported that reading the caliper measurement within 4 seconds would minimize compression errors.

The selection of skinfold sites varies depending upon which estimation equation is used. There has been little to no agreement on which body composition estimation equation is most appropriate for the older population. Caution must be employed when choosing estimation equations for this group -- the equation must be able to account for age effects in body composition.

Estimation equations have been developed from and validated against a criterion measure, usually underwater weighing. The determination of body composition is based upon assumptions that the density of fat and fat-free tissue is known and constant, and that the components of the body remain proportional relative to the whole body (Lohman, 1984; Wilmore, 1984). The accuracy of underwater weighing is dependent upon several factors, the most important being the air in the lungs at the time of weighing. Lung volume measurements must be taken at the time of weighing. Studies report different values of lung volumes when measured on land versus in the water. Studies report a larger variability in residual volume among older individuals as compared to their younger counterparts (Withers & Hamdorf, 1989; Girandola et al., 1977). To obtain accurate weight readings, a strain gauge or load cell system is preferred.

Valid population specific body composition equations may be used for a specific population, but are not universally applicable. Many of these equations are based on skinfold measurements and are used to calculate body density or body fat percentage. Several

equations have been developed, with no single equation considered the best for older adults. Historically, these equations have assumed a linear relationship between subcutaneous fat and body density, however, this relationship is curvilinear (Jackson & Pollock, 1982; 1985; Katch & Katch, 1980).

Generalized equations were developed to be used with samples varying greatly in age and body fatness. They . . . "were developed on large heterogeneous samples using regression models that account for age and the nonlinear relationship between skinfold fat and body density" (Jackson and Pollock, 1985). They take the place of several population specific equations, and are more appropriate for broad populations.

# CHAPTER 3

## Methodology

This study was designed to show the relationship among five current body composition estimation equations and actual percent body fat as measured by underwater weighing in adult men over 60 years of age. Each subject was scheduled for two laboratory sessions.

## Orientation

Subjects attended an orientation meeting prior to testing. They completed an informed consent, a questionnaire, and were given participant guidelines such as: no food or caffeine 4-5 hours prior to testing; no strenuous exercise 12 hours prior to testing; no alcohol 24 hours prior to testing; and no diuretics or heart medications prior to testing (See Appendix A). The testing procedures were explained, and a video on the underwater weighing (UWW) procedure was shown. Participants simulated the UWW procedure while sitting, and any questions about the study or testing were answered. A one hour data collection session was then scheduled for each individual.

## Data Collection Session

### Equipment Preparation

The oxygen and carbon dioxide analyzers were turned on at least thirty minutes prior to testing to allow for adequate warm up,

and then were calibrated (See Appendix B). The underwater weighing tank was filled to the correct water level, and a weighted vest and drape (sinker weight) were placed on the scale in the water tank 30 minutes prior to testing to saturate the canvas material and to remove air bubbles. The sinker weight was then recorded by means of a ticket printer. The water temperature was taken. A sterilized mouthpiece was attached to flexible hosing to act as a snorkel to be later attached to a rebreathing bag. Six 5-liter anesthesia bags were filled with 5 liters of pure oxygen to be used for rebreathing and subsequent calculation of RV during underwater weighing using an automated system (Appendix B).

## Testing Procedures

Height was taken in centimeters from a wall-mounted stadiometer. Subjects stood erect, without shoes, with feet parallel, and heels, buttocks, head, and shoulders touching the stadiometer (Watson, 1985). Land weight was recorded in grams while standing on a Toledo 8130 Load Cell Kilogram Scale.

### Skinfold Measurements

Each of the sites to be measured was located following standardized procedures (Golding et al., 1989). Explanation and demonstration alleviated any apprehension about the skinfold measurement procedure.

1. Skinfolds were taken on the right side of the body with the tester's right hand holding the caliper, the left hand lifting the skinfold. The Lange Skinfold Caliper was used.
2. Each skinfold was lifted twice to ensure the proper fold prior to placing the calipers in front of the thumb and forefinger.
3. The jaws of the caliper were placed so that the thickness of the skinfold was measured perpendicular to its long axis when the pressure on the caliper was released.
4. Each measurement was recorded after approximately three seconds of pressure.
5. Two measurements were recorded and if they were within 1 mm, the last value was used.
6. Sites were used according to the exact procedure described by Golding, et al. (1989).
   a. Chest site - A diagonal fold on the pectoral line midway between the axillary fold and the nipple.
   b. Midaxilla site - A vertical fold on the midaxillary line at nipple level (midsternum).
   c. Suprailiac site - A diagonal fold just above the crest of the ilium.
   d. Abdominal site - A vertical fold approximately 1 inch to the right of the umbilicus.
   e. Thigh site - A vertical fold on the front of the thigh midway between groin line and the top of the patella.

f. Triceps site - A vertical fold on the back of the upper arm midway between the shoulder and elbow joints.

g. Subscapula site - A diagonal fold on the inferior angle of the scapula.

h. Biceps site - Measured vertically at the midpoint of the arm. (Lohman, Roche, & Martorell, 1989).

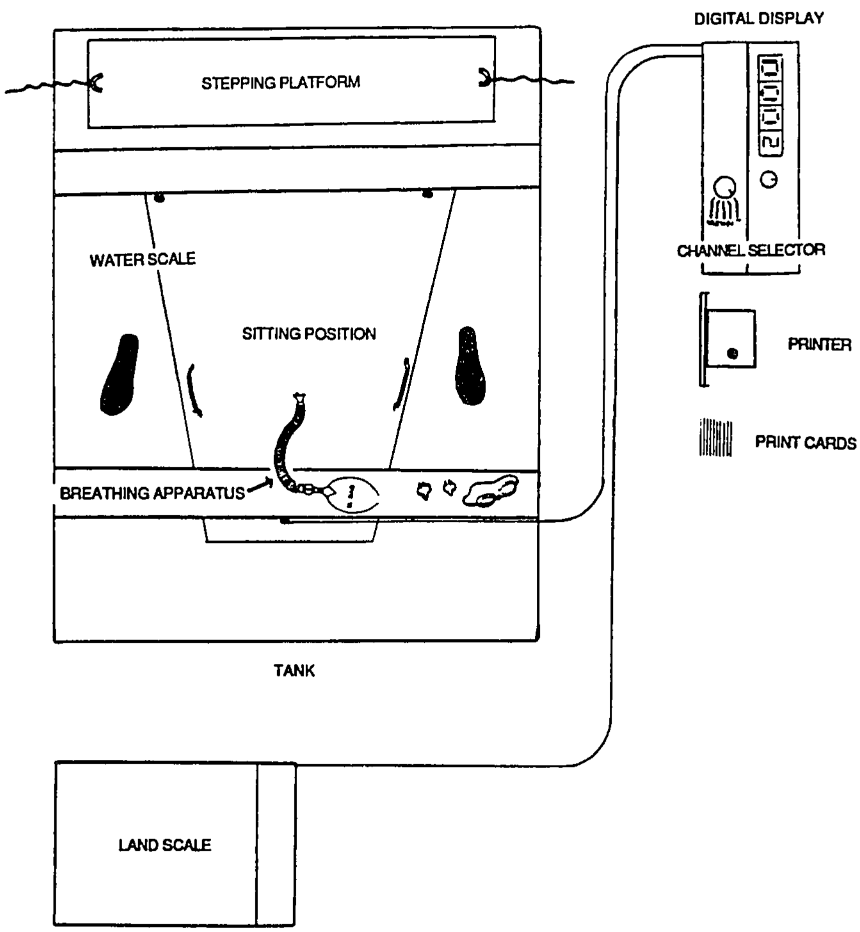
Density Determination

The underwater weighing system used a Toledo Load Cell System for both land and hydrostatic weight (See Figure 1 - view of the underwater weighing system from the top). The weight was displayed on a digital readout, and a printer recorded the weight to the nearest gram. The subject's land weight was recorded on the data collection sheet (See Appendix A).

The underwater weighing procedures were reviewed. The subject showered to remove body oils and to saturate the hair and swimsuit. The subject entered the underwater weighing tank and stepped onto black footprints (which were painted on the bottom of the tank) to avoid stepping on the weight scale. The subject was fitted with the weighted vest and was seated on the weighing scale. The weighted drape was placed over the subjects' knees to prevent a sensation of falling backwards. The mouthpiece and accompanying hose was fitted along with a noseclip, and goggles (if desired). The subject was allowed to become familiar with breathing through the snorkel.

Figure 1

Schematic of the underwater weighing system from the top view



Several practice trials were completed, and the actual underwater weighings followed. Each trial followed precise instructions (See Appendix B). The subject leaned forward and breathed through the snorkel until the water and scale became stable. The subject then exhaled maximally, and signaled when exhalation was completed. Although subjects were encouraged to maximally exhale, the volume in the lungs was measured as weight was recorded, thereby eliminating possible error in RV. The underwater weight was then printed six times.

The subject rose up to a sitting position while breathing in and out deeply, at a rate of 1 cycle per 2 seconds for a total of seven times to equilibrate the air in the lungs with the oxygen in the rebreathing bag. This procedure was repeated for a total of 10 times with the last three trials used for calculation of residual volume. The trials were repeated if anything appeared to effect the weighing, for instance, if the subject breathed too early or too late or proper mixing did not appear to occur.

When the test was completed, the mouthpiece, noseclip, goggles, weighted vest and drape were removed and the subject stepped out of the tank. Rebreathing bags were then analyzed for oxygen and carbon dioxide content and results recorded. Subjects' body density and percent body fat were calculated. The subjects received a report of body composition along with supplemental fitness handouts. (See Appendix D).

Residual Volume Determination.

Since residual volume estimations have considerable error, actual residual volume was measured using the formula developed by Wilmore (1969) because of the formula's prevalence in the literature:

$$RV = VO2 \times (b - a)/(i - d)$$

where RV = residual volume

VO2 = initial volume of oxygen in the bag

a = percent nitrogen impurity of the original oxygen

b = percent nitrogen of mixed air in the bag at the point of equilibrium

i = percent nitrogen in the alveolar air at the beginning of the experiment

## Estimation Equations

Skinfold measurements and age were used in the following estimation equations.

1. Sum of 4 Sites for the YMCA (YMCA$\Sigma$4)

Percent Fat = .29288 ($\Sigma$4) - .0005 ($\Sigma 4^2$) + .15845 (AGE) - 5.76377

$\Sigma$4 = Sum of abdomen, ilium, triceps and thigh skinfold sites
r = .901 SEE = 3.49% fat

2. Sum of 3 Sites for the YMCA (YMCA$\Sigma$3)

Percent Fat = .39287 ($\Sigma$3) - .00105 ($\Sigma 3^2$) + .15722 (AGE) - 5.18845

$\Sigma$3 = Sum of abdomen, ilium, triceps skinfold sites
r = .893 SEE = 3.63% fat

3. Jackson and Pollock's Sum of 7 Sites ($JP\Sigma7$)

Body Density = $(\Sigma7) + .00000055\ (\Sigma7^2) - .00028826\ (AGE)$

$\Sigma7$ = Sum of chest, midaxilla, iliac, abdomen, thigh, subscapular and triceps skinfold measurements
r = .902 SEE = .0078

4. Jackson and Pollock's Sum of 3 Sites ($JP\Sigma3$)

Body Density = $1.109380 - .0008267\ (\Sigma3) + .0000016\ (\Sigma3^2) - .0002574\ (AGE)$

$\Sigma3$ = Sum of chest, abdomen and thigh skinfold measurements.
r = .905 SEE = .0077

5. Durnin and Womersley's Equation (DW)

Body Density = $1.1339 - .0645 \times LOG\ (\Sigma4)$

$\Sigma4$ = Sum of biceps, triceps, subscapular and suprailiac skinfold measurements.

Once body density was determined, percent fat was calculated using the following equation.

6. Siri's Equation (Siri, 1961)

Percent Fat = $[(4.95 \div \text{Body Density}) - 4.50]\ 100$

## Statistical Analysis

There were six levels of the independent variable (method of determining percent body fat) and one dependent variable (percent body fat). A one-way repeated measures analysis of variance (1RM-ANOVA) was used to determine if there were any significant differences between percentage of body fat from the five equations and percent fat from underwater weighing using Siri's (1961) equation. Scheffe's Multiple Comparison Test was used as a post hoc

test to determine which variables were significantly different. A Pearson Product Moment Correlation Matrix was also constructed to examine the relationship between percent fat derived from the five estimation equations and from underwater weighing.

Mean, range, and standard deviation were reported for skinfold values, residual volumes, body density determination, and for percent body fat from each estimation equation. Descriptive statistics were also used for height, weight, age, and percentage of fat.

To determine whether the five estimation equations were valid at the extremes of the present sample population, the data was divided into two Subgroups, A and B. Subgroup A consisted of those subjects 1.5 SD below the mean of the distribution (<20% fat), and Subgroup B consisted of those subjects 1.5 SD above the mean of the distribution (>41% fat). The percent fat determined from underwater weighing of each subgroup was then compared to the percent fat determined by each of the five estimation equations.

# CHAPTER 4

## Results and Discussion

The purpose of this study was to determine the validity of five generalized estimation equations for body fat percentage for males over 60 years of age. Ninety-seven males residing in Las Vegas, Nevada volunteered for this study. The raw data is presented in Appendix C.

Table 1 presents the physical characteristics of the subjects. The subjects' mean height (174.52 cm) and weight (80.95 kg) fell within values reported by other studies with over 60 year olds (Chumlea, Roche, & Webb, 1984; Fryer & Shock, 1962; Steen, 1979; Yearick, 1978) except for Vir & Love's study (1980) who reported a mean weight of only 66 kg.

Table 2 reports anthropometric data from similar body composition studies on older populations. Chumlea, Roche, and Webb (1984) studied body fat and body size in older adults through underwater weighing and anthropometry (skinfolds at the triceps, subscapular, biceps, midaxilla, chest, suprailiac and calf sites; circumferences at the chest, abdomen, bicep and calf sites). Vir and Love (1980) presented the mean values and frequency distribution of a set of anthropometric measurements (triceps, subscapular, and hand skinfolds; arm and abdominal circumference) on a group of instutionalized and non-institutionalized people over 65 years. Yearick (1978) studied the validity of relative weight as a measure

Table 1

Physical characteristics of subjects

| VARIABLE | MEAN | SD | RANGE |
|---|---|---|---|
| Age (years) | 66 | 4.53 | 60-80 |
| Height (cm) | 174.52 | 5.99 | 159-191 |
| Weight (kg) | 80.95 | 13.37 | 58.7-123.6 |
| Chest | 12.25 | 5.6 | 4.5 - 30 |
| Midaxilla | 20.57 | 8.18 | 7.0 - 44 |
| Suprailiac | 21.21 | 7.40 | 8.0 - 41 |
| Abdominal | 23.61 | 8.14 | 8.5 - 60 |
| Subscapular | 20.47 | 7.82 | 8.0 - 50 |
| Thigh | 16.23 | 7.01 | 5.0 - 37 |
| Triceps | 14.50 | 4.74 | 6.0 - 32 |
| Biceps | 9.89 | 4.75 | 3.0 - 20 |

of adiposity on older people compared to skinfold measurements (triceps, subscapular and supriliac skinfold sites).

Skinfold thickness were generally larger in the present study than those reported in other studies for a comparable age group (see Table 2). The distribution of subcutaneous fat in this population agrees with the reports of other studies, where more fat was located in the trunk region as compared to fat located on the limbs. In the present study, larger thicknesses were found at the following sites as compared to other studies (Chumlea, Roche, & Webb, 1984; Vir & Love, 1980; Yearick, 1978): triceps (14.50 mm), suprailiac (21.21 mm), biceps (9.89 mm), and subscapular (20.47mm) skinfolds. Smaller thicknesses were seen at the chest (12.25 mm) and midaxilla (20.57 mm) sites compared to the study by Chumlea, Roche, & Webb, (1984). There is no obvious explanation for the difference in these measurements. Results for the current study indicated a wide range of fatness as determined by underwater weighing which ranged from 13% to 51%, with a mean percentage of body fat of 31.01% (SD = 6.811).

Table 3 reports that the mean body density determined in the present study fell within the range of values reported by other researchers, except for Latin, Johnson and Ruhling's results (1987) which were considerably larger. The variability in residual volume in this study (M = 2.284 liters, SD = .455) is similar to that of Latin and Ruhling (1986). As stated earlier, this variability is insignificant

Table 2

Body composition measurements for older populations

| | Current Study 1992 | Chumlea, Roche & Webb, 1984 | Vir & Love 1980 | Yearick, 1978 |
|---|---|---|---|---|
| | Males 60-80 | Males 65-85 | Males 65-95 | Males 63-96 |
| **HEIGHT** | 174.52 ± 5.9 | 172.4 ± 5.9 | Not measured | 171.7 ± 6.6 |
| **WEIGHT** | 80.95 ± 13.37 | 77.5 ± 10.7 | 77.1 ± 13.3 | 77.1 ± 13.3 |
| **SKINFOLDS** | | | | |
| Chest | 12.25 ± 5.6 | 15.1 ± 6.1 | Not measured | Not measured |
| Midaxilla | 20.57 ± 8.18 | 21.9 ± 18. | Not measured | Not measured |
| Suprailiac | 21.21 ± 7.40 | 14.6 ± 7.9 | Not measured | 18.4 ± 5.8 |
| Abdomen | 23.61 ± 8.14 | Not measured | Not measured | Not measured |
| Thigh | 16.23 ± 7.01 | Not measured | Not measured | Not measured |
| Tricep | 14.50 ± 4.74 | 12.7 ± 5.2 | 9.3 ± 1.95 | 12.3 ± 7.0 |
| Subscapular | 20.47 ± 7.82 | 19.5 ± 9.1 | 14.5 ± 2.97 | 16.0 ± 7.2 |
| Bicep | 9.89 ± 4.75 | 6.3 ± 2.7 | Not measured | Not measured |
| **CALIPER TYPE** | Lange | Not reported | Lange | Harpenden |

Table 3

Body density values of other studies for older populations

| Author | Age | Mean Density | RV |
| --- | --- | --- | --- |
| Fryer & Shock, 1962 | 60-98 | 1.0296 | 2.211 |
| Latin, Johnson & Ruhling, 1987 | 56-70 | 1.0474 ± .0085 | 2.64 ± .41 |
| Norris, 1963 | 60-69 | 1.019 ± .021 | NR |
| | 70-79 | 1.022 ± .019 | NR |
| | 80-89 | 1.017 ± .017 | NR |
| Present Study, 1992 | 60-80 | 1.029 ± .015 | 2.284 ± .455 |

since the measurement of RV occurred at the time of underwater weighing.

Many times it is difficult to obtain accurate residual volume measurements while the person is submerged in water because the person is not comfortable holding his breath under water. An alternative may be to measure functional residual volume instead of residual volume at the time of underwater weighing. Functional residual volume (FRV) is defined as exhaling approximately 3/4 of maximal expiration. More research needs to be performed on using FRV versus RV during the underwater weighing process.

A one-way repeated measures ANOVA indicated a significant difference between the six levels of the independent variable ($F = 2.24$, $p < .05$) with five of the levels being estimation equations for percent body fat and one level being percent fat from underwater weighing. Scheffe's post hoc test indicated that all five equations were also significantly different from each other with the exception of Jackson and Pollock's (1978) Sum of 7 (JPΣ7) and Sum of 3 (JPΣ3) equations which were not significantly different from each other, nor were YMCA's Sum of 3 (YMCAΣ3) and Sum of 4 (YMCAΣ4) equations. The differences between JPΣ7/Σ3 and YMCA's Σ3/Σ4 may be due to the different skinfold sites used for the two sets of equations. It was expected that these four equations would yield similar results since the equations were generated from the same database. Durnin and Womersley's equation yielded the highest mean percent fat. With their elderly women subjects, Blanchard et al. (1990) also reported

Table 4

Percent body fat from six methods

N=97

| Method | Mean % Fat | Mean % fat by UWW | Difference |
|---|---|---|---|
| JP$\Sigma$7 | 20.70% | 30.76% | 10.06% |
| JP$\Sigma$3 | 20.52 | 30.76 | 10.24 |
| YMCA $\Sigma$4 | 23.72 | 30.76 | 7.04 |
| YMCA $\Sigma$3 | 24.56 | 30.76 | 6.20 |
| DW | 34.12 | 30.76 | 3.36 |

that percent fat was high with the DW equation as compared to JPΣ3 equation. The DW equation also resulted in the smallest percent fat difference as compared to underwater weighing. A comparison of all estimation equations used in this study is presented in Table 4.

A correlation matrix indicated the mean correlation for percent body fat was .744 between each equation and underwater weighing. The correlation coefficients (r) for each equation in this study ranged from .72 to .78, with JPΣ7 equation yielding the highest correlation, and DW's equation yielding the lowest correlation (See Figure 2). Table 5 compares the correlation coefficients from the original sample population (with underwater weighing) and the correlation coefficient from the present study's population and underwater weighing. Compared to the original sample, these lower correlations may be attributed to the fact that these equations do not reflect the effect of age on body composition beyond 60 years.

The data of this study also provide an opportunity to consider the five equations' effect on estimation of body fat with two subgroups of the present study's population. Subgroup A (n = 7) consisted of those subjects 1.5 SD below the mean of the distribution (<20% body fat); Subgroup B (n = 7) consisted of those subjects 1.5 SD above the mean of the distribution (>41% body fat). JPΣ7, JPΣ3, YMCAΣ4, and YMCAΣ3 equations were more valid with leaner men over 60 years (Subgroup A). Durnin and Womersley's equation was not as valid with this leaner subgroup. Conversely, with the obese

Figure 2

Correlation Matrix of percent body fat between five generalized estimation equations and underwater weighing

| | UWW | JP $\Sigma 7$ | JP $\Sigma 3$ | YMCA $\Sigma 4$ | YMCA $\Sigma 3$ | DW |
|---|---|---|---|---|---|---|
| UWW | 1 | | | | | |
| JP $\Sigma 7$ | 0.776 | 1 | | | | |
| JP $\Sigma 3$ | 0.746 | 0.97 | 1 | | | |
| YMCA $\Sigma 4$ | 0.744 | 0.944 | 0.966 | 1 | | |
| YMCA $\Sigma 3$ | 0.732 | 0.97 | 0.932 | 0.974 | 1 | |
| DW | 0.72 | 0.861 | 0.811 | 0.823 | 0.854 | 1 |

Table 5

Comparison of estimation equation correlation coefficients for original population and current study population

| Equation | Original Population | Present Study Population |
|---|---|---|
| JP $\Sigma 7$ | .902 | .78 |
| JP $\Sigma 3$ | .905 | .75 |
| YMCA $\Sigma 4$ | .901 | .74 |
| YMCA $\Sigma 3$ | .893 | .73 |
| DW | .7-.9 | .72 |

Table 6

Differences in the mean percent body fat at the extremes of the distribution

**PRESENT STUDY POPULATION** (N=97)

| | UWW | JPΣ7 | JPΣ7 | YΣ4 | YΣ3 | DW |
|---|---|---|---|---|---|---|
| Mean %F | 30.8% | 23.7% | 24.6% | 20.7% | 20.5% | 34.1% |
| Difference between actual and predicted % fat | 0 | 7.1 | 6.2 | 10.1 | 10.3 | -3.3 |

**SUBGROUP A** (<20% fat) N=7

| | UWW | JPΣ7 | JPΣ7 | YΣ4 | YΣ3 | DW |
|---|---|---|---|---|---|---|
| Mean %F | 17.8% | 16.5% | 17.8% | 13.2% | 12.8% | 27.4% |
| Difference between actual and predicted % fat | | 1.3 | 0 | 4.6 | 5.0 | -9.6 |

**SUBGROUP B** (>41% fat) N=7

| | UWW | JPΣ7 | JPΣ7 | YΣ4 | YΣ3 | DW |
|---|---|---|---|---|---|---|
| Mean %F | 44.2% | 31.6% | 32.0% | 28.9% | 29.1% | 41.0% |
| Difference between actual and predicted % fat | | 12.9 | 12.2 | 15.3 | 15.1 | 3.2 |

group (Subgroup B), DW's equation was more valid as compared to the other four equations (See Table 6).

In summary, this study considered the validity of five estimation equations for predicting percent fat as compared to underwater weighing in men over 60 years. The subjects' physical characteristics (height, weight, age, percent fat, and body density) were similar to other studies. Skinfold measurements were slightly larger at all sites except for the chest and midaxilla sites. There is no obvious explanation for these differences.

Statistical analysis (1way RM ANOVA) indicated that all five equations gave significantly different percent fat results than underwater weighing. A post hoc test indicated that all equations gave significantly different results from each other with the exception of JPΣ7/JPΣ3 and YMCAΣ4/YMCAΣ3 equations which were not significantly different from each other respectively.

The DW equation yielded the highest percent body fat, the smallest difference from underwater weighing results, and the lowest correlation with underwater weighing (.72) as compared to the other equations. JPΣ7 and JPΣ3 equations yielded the lowest percent body fat, the largest difference from underwater weighing results, and the highest correlation with underwater weighing (.776 and .746 respectively) as compared to the other equations.

Statistical consideration was also made regarding how well the equations predicted percent body fat at the extremes of the present study's population (<20% fat and >41% fat). The DW equation was

more accurate with obese individuals and the JP$\Sigma$7/JP$\Sigma$3 equations were more accurate with the leaner subgroup.

# CHAPTER 5

## Summary

The purpose of this study was to assess the validity of five commonly used body composition estimation equations with men over 60 years of age. While there have been many estimation equations developed for 18 to 50 year olds, few of these equations incorporate the over 60 year old population.

Many factors of aging affect body composition variables, and estimation equations must account for these effects. Mean body density decreases with age, and may be accompanied by a shift of subcutaneous fat into internal locations. Underwater weighing is based on the two compartment of body composition. This two compartment model assumes that fat and fat-free tissues have a relatively constant density, however, these density values have been shown to change with age. These assumptions are a limitation of converting body density (from underwater weighing measurements) to body fat percentage. Height and weight decline with age, as does vital capacity. Residual volume increases with age due to changes in lung elasticity and a corresponding loss in thoracic muscle mass.

Subjects were scheduled for two laboratory sessions: an orientation, and a data collection session. Height, weight, skinfolds, residual volume, and body density through underwater weighing were measured. Various combinations of these variables were used in the five estimation equations (JP$\Sigma$7, JP$\Sigma$3, YMCA$\Sigma$4, YMCA$\Sigma$3, DW)

to predict either body density or percent body fat. Siri's (1961) equation was then used to predict percent body fat from body density, and percent body fat from each equation was compared to the underwater weighing results.

The subjects were ninety-seven apparently healthy adult males, aged 60-80 years (M=66, SD=4.53) and varying in height (M=174.5 cm, SD=5.99) and weight (M=80.95 kg, SD=13.37). The subjects' height, weight, and percent body fat were similar to other comparable studies. More subcutaneous fat was located in the trunk region than on the limbs.

All five equations yielded significantly different percent fat results than underwater weighing. However, Jackson and Pollock's (1978) Sum of 7 and Sum of 3 equations were not significantly different from each other, nor were YMCA's Sum of 3 and Sum of 4 equations from each other. Correlation coefficients between the five equations and underwater weighing were relatively high (.72-.78), although they were considerably lower than the correlation coefficients reported by the original authors for each equation.

Considering the effect of these five equations on an obese subgroup (>41% body fat) of the present study's population, Durnin and Womersley's equation was more accurate, and the other four equations less accurate. With a leaner subgroup (<20% body fat), the effect was just the opposite.

## Conclusions

1. All five estimation equations gave significantly different percent body fat results than underwater weighing in an over 60 year old population. These five equations are not as valid with an over 60 male population.
2. Caution needs to be employed when estimating percent body fat in this population. It may be more appropriate to use Durnin and Womersley's equation with more obese populations (>41%) and any of the other four equations with a leaner (<20%) population.

## Recommendations

Based on the experience of this study, the following recommendations are given for future research.

1. To increase the generalizability of the five equations used in this study, skinfold data on older individuals (>60 years) should be included in the regression models for each of the following equations: JPΣ7, JPΣ3, YMCAΣ4, YMCAΣ3, DW.
2. Population specific equations should be developed specifically for older populations.
3. The current equations for converting body density to percent body fat (Siri, 1961; Brozek & Keys, 1953) need to be re-evaluated and/or new equations need to be developed to account for the age-associated changes in body density.

4. The procedures used in this study for obtaining residual volume at the time of underwater weighing should be assessed for reliability.
5. This study should be repeated with women over 60 years of age.
6. Further research needs to assess differences within the over 60 year old age group. For example, 60-64 years, 65-69 years, 70-74 years, etc.

# Appendix A

Preliminary Testing Forms

- Informed Consent
- Orientation Outline
- Questionnaire
- Participant Guidelines
- Data Collection Sheet

**CONSENT TO PARTICIPATE IN A RESEARCH STUDY**
**UNIVERSITY OF NEVADA, LAS VEGAS**

**TITLE:** Validation of current body composition prediction equations for men over 60 years of age

**SUBJECTS:** 100 male subjects 60 years of age and older with no respiratory ailments

**PROCEDURES:** Underwater weighing, skinfolds, residual lung volume, height and weight will be measured on each participant. The position for underwater weighing is sitting cross-legged and leaning forward where you will be asked to breathe through a mouthpiece with your nose clipped. You will then hold your breath for approximately 5 seconds. Skinfolds require the pinching of the skin in seven locations to determine fat thickness. Bio-impedance requires that you lie down flat for approximately 2 minutes. All measurements will be done in one day and will take less than two hours.

**RISKS:** There are virtually no risks associated with this study since no exercise nor stress is involved. There may be, however, some discomfort from the pinching of skin with skinfold measurements; from holding the breath while underwater; or from sitting cross-legged. Tripping or falling are always possibilities, however, every effort will be made to ensure your safety.

**CONFIDENTIALITY** The data collected on each subject will be available to only research personnel. Names, addresses, phone numbers will not be given out with explicit permission of the participants, nor will names be used in any reports. Each participant will receive their individual results when analysis is complete.

**RIGHT TO REFUSE OR WITHDRAW FROM THE STUDY:**
You may refuse to participate or withdraw from this study at any time.

In signing this Consent Form, you indicate that you are a volunteer for the above study; that you understand its purpose, testing procedures and risks; and that all of your questions have been answered.

______________________________ ____________
**Signature of Participant** **Date**

______________________________ ____________
**Print Name of Participant** **Date**

______________________________ ____________
**Signature of Witness** **Date**

## ORIENTATION OUTLINE

### INTRODUCTION

A. Beth and Dahn; Graduate Students in Exercise Physiology performing 2 separate projects using the same volunteers.

B. Purpose for Orientation - To familiarize them with what our research involves and what exactly they need to do as participants. There is a learning effect with one of the procedures and they need to be familiar with it and practice it.

1. Beth's Thesis
   a. What is body composition?
   b. Why is it important for an individual to know their %bf?
   c. What are the ways to estimate bf? Prediction equations
2. Dahn's Project
   a. What is bio-impedance?
   b. What is involved with the procedure?
   c. *Participant Guidelines* - these items may effect the results we get so please follow them. * Emphasize 4-5 hours and scheduling appointments. The bottom portion of this sheet is where we will write down your testing date and time so you have a written copy of this information.

### WHAT DO WE NEED THEM TO DO?

A. Schedule a 1 hour testing appointment at there convenience, keeping in mind the info re: bioimpedance.

B. At the testing session, the following measurements will be taken:
Height and Weight
* Bio-impedance
Skinfold/circumference measurements - show equip and sites
Underwater weighing
- * Go over specifics of procedure, trials
- * Since procedure is complicated, we have made a video to familiarize you with the specifics. SHOW FILM; PRACTICE
- * Are there any questions?

C. Paperwork to be completed - do not hand out papers until this is complete

1. *Participant Guidelines* - any questions?
2. *Questionnaire* - its purpose is to identify personal limitations (i.e., nonswimmer, inflexibility, someone with respiratory problems). We will review the questionnaire before we schedule you to make sure there are no problems.
3. *Informed Consent* - Standard paperwork that explains what the research study involves, what the risks and benefits are, what you are required to do, and that you may withdraw at any time. Please read it carefully (ask questions if you have any) and give to us.
4. Schedule a *testing appointment* when you have completed the paperwork. *(Write Room 206 on their appointment sheet). Include parking permit.*
5. *Results* - Report will be sent to your address with the following information: reiterate body composition info, methods, your personal results, any supplemental information you have requested.

"VALIDATION OF BODY COMPOSITION PREDICTION EQUATIONS FOR MEN OVER 60 YEARS"

QUESTIONNAIRE

1. Name ______________________________ Phone Numbers:
2. Address ______________________________ Home ____________
   ______________________________ Work ____________
   ______________________________
3. Date of Birth ____________ Age ________
4. Are you currently taking a diuretic? If so, please list the type. ____________
5. Do you have any respiratory ailments? If so, please describe. ____________
   ______________________________
6. Do you have any back, knee or neck problems? If so, please describe. ____________
   ______________________________
   ______________________________
7. Do you swim? Please describe. ______________________________
8. Does putting your head under water bother you? ____________
9. Do you have poor flexibility in your low back, leg area? If so, please describe. ______
   ______________________________
10. Have you ever smoked cigarettes, cigars (regularly)? If so, please describe. ______
    ______________________________
11. How do you consider your current physical fitness activity? (Light, moderate, strenuous.) Please describe. ______________________________
    ______________________________
12. Have you ever competed in the Senior Olympics? If so, please list events and years competed (i.e., swimming 1989-1991). ______________________________
    ______________________________

UNLV EXERCISE PHYSIOLOGY
RESEARCH STUDY

TITLE: Validation of current body composition prediction equations for men over 60 years of age.

## PARTICIPANT GUIDELINES

So that we don't waste your time, we have developed a few guidelines for participating in this study. While they may seem trivial, they do effect the outcome of our results. On the **day that you are scheduled for testing,** please avoid the following:

* No food 4-5 hours prior to testing
* No caffeine 4-5 hours prior to testing
* No strenuous exercise 12 hours prior to testing
* No alcohol 24 hours prior to testing
* No diuretics prior to testing (heart medication or steroids)
* Bring swim trunks, a towel and your **smile**!

---

NAME: ____________________________

TESTING DATE: ___________________

TESTING TIME: ___________________

**THANK YOU!!!**

Beth Kelley/Dahn Shaulis UNLV Exercise Physiology Lab
(702) 739-3767 or (702) 897-2474

**"VALIDITY OF BODY COMPOSITION PREDICTION EQUATIONS FOR MEN OVER 60 YEARS"**

NAME ______________________________ DATE __________

A. MISCELLANEOUS DATA

1. Height________in ______cm Informed Consent? ________
2. Weight________lbs ______kg Questionnaire? ______ Age__________

B. SKINFOLD MEASUREMENTS (mm)

1. Pectoral ________ 4. Suprailiac ________ 7. Triceps ______
2. Midaxilla ________ 5. Abdomen ________ 8. Scapula ______
3. Ilium ________ 6. Thigh ________ 9. Biceps ______

C. UWW - VALUES

1. Sinker Wt ________________gm
2. Land Wt________________gm
3. Pure O2 __________
4. Pure CO2 ___________
5. H2O Temp___________ °F
6. H20 Density ________________

a. FRV#________ Vb ______
%O2 ________ %CO2 _________
Mean Weight ____________ gms
Comments ______________________

b. FRV#________ Vb ______
%O2 ________ %CO2 _________
Mean Weight ____________ gms
Comments ______________________

c. FRV#________ Vb ______
%O2 ________ %CO2 _________
Mean Weight ____________ gms
Comments ______________________

a. RV# _________ Vb_______
%O2 _________ %CO2_______
Mean weight _________ gms
Comments ____________________

b. RV# _________ Vb_______
%O2 _________ %CO2_______
Mean weight _________ gms
Comments ____________________

c. RV# _________ Vb_______
%O2 _________ %CO2_______
Mean weight _________ gms
Comments ____________________

# Appendix B

## Calibration Procedures

Oxygen and Carbon Dioxide Analyzers

Solenoid Timer

## Experimenter Instructions

CALIBRATION OF OXYGEN AND CARBON DIOXIDE ANALYZERS

A. EQUIPMENT

$O_2$ analyzer

Drierite

Screwdriver

Cal Gas - 100% nitrogen

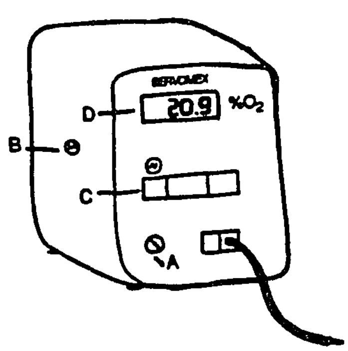
$CO_2$ analyzer

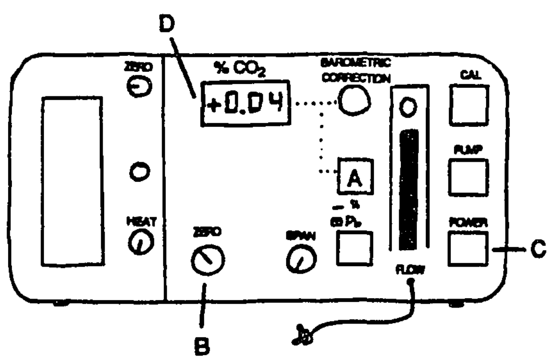
Cal Gas - 75% $O_2$, 5% $CO_2$

Sample Gas Bags

B. PROCEDURES

1. Turn the power on for both analyzers, and allow them to warm-up for 1/2 hour.
2. Vacuum out sample bags, and fill one bag with nitrogen ($N_2$) cal gas, and one with $O_2/CO_2$ mixture. (Fig.1)
3. Attach sample bag filled with $N_2$ to analyzer. The reading for both analyzers shuld be zero; if not, zero analyzer with the zero know on the machines by turning know slowly in a counterclockwise direction.
4. Calibrate the machines by introducing $O_2/CO_2$ cal gas. Adjust span knob to read percent of cal gas correctly, in this case, 75% $O_2$, 5% $CO_2$.

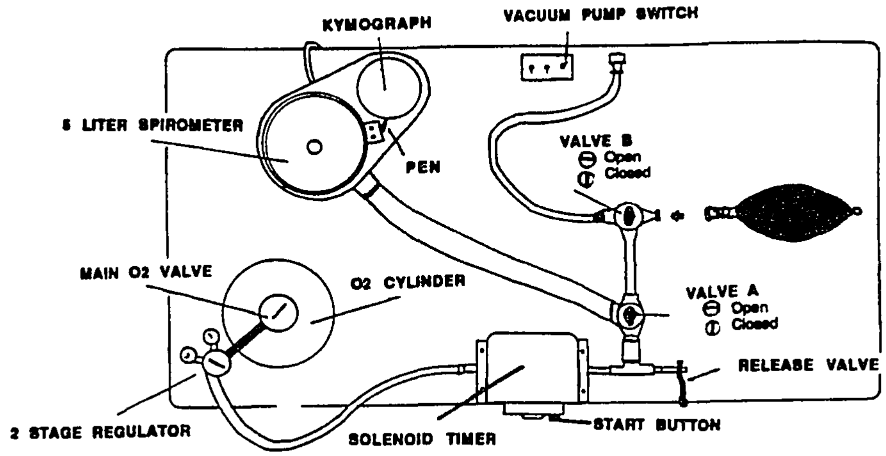



$O_2$ ANALYZER
A = Span Knob
B = Zero Knob
C = Power
D = Display %$O_2$

$CO_2$ ANALYZER
A = Pb/% $CO_2$ Knob
B = Zero Knob
C = Power
D = Display %$CO_2$

# RESIDUAL VOLUME SCHEMATIC




A. TO CALIBRATE SYSTEM:
1. Close the release valve
2. Open Valve A - so O2 goes to spirometer
3. Take pen cap off Kymograph pen and set pen to "zero liters"
4. Open Main O2 Valve by turning knob slightly counter-clockwise. 2 Stage Regulator should always be left open, thus, it needs only slight adjustments.
5. Press Start Button on the solenoid timer which delivers 5 liters of O2/5 seconds. Note reading on kymograph and
   a. If it is above 5 liters, slightly decrease the psi via the psi adjustment knob. If it is below, slightly increase psi adjustment knob
6. Open the release valve to flush O2 out of spirometer (spirometer bell should fall).
7. Repeat this procedure until the system is calibrated to deliver 5 liters of O2 in 5 seconds.

B. TO FILL BAGS:
1. Change valves to filling positions:
   Close the release valve
   Close Valve A
   Open Valve B
2. Flush entire system with O2 by pressing the start button (to relieve system of any mixed air).
3. Tightly attach black rebreathing bag to Opening #1 and open the rebreathing bag valve.
4. Press Start Button - 5 liters of O2 will be delivered to rebreathing bag.
5. Close Valve C. Turn on vacuum pump switch.
6. Repeat Step #4. Close rebreathing bag valve.
7. Attach rebreathing bag to hosing - you are now ready to begin collecting RV sample.

C. TO USE VACUUM:
1. Rebreathing Bags:
   a. Attach rebreathing bag to Opening #1 and open its valve.
   b. Close the release valve and open rebreathing bag valve
   c. Turn on pump switch until bag is completely vacuumed
   d. Turn off rebreathing bag valve
   e. Turn off pump switch
2. Sample Bags
   a. Insert rubber stopper (marked "sample bag vacuum") into opening #1
   b. Attach sample bag to tubing of rubber stopper
   c. Open sample bag stopcock as well as close Valve B
   d. Turn on pump switch
   e. Close sample bag stopcock and turn off pump

EXPERIMENTER INSTRUCTIONS
FOR THE DETERMINATION OF UNDERWATER WEIGHT

*Italized words are experimenter notes and are not instructions given to subjects.*

TANK ENTRY: (See Figure 1 for Tank Schematic)

1. Step down onto the gray stepping platform.
2. Step onto the bottom of the tank on the black painted feet. Be careful not to stand on the weighing scale. Remain standing while you are fitted with a weighted vest.
3. Sit down on the weighing scale in a cross-legged position, or you may place your legs in front of you as long as they are not touching the bottom or sides of the tank.
4. This weighted drape is to be placed over your knees or lap.
5. Now you will be fitted with the mouthpiece you tried on earlier. I will place this noseclip on your nose; make sure you can't breathe through your nose. Goggles are available if you would like them.
6. Grab onto the 2 handles on each side of the weighing scale.
7. *Experimenter verifies that subject is comfortable.*

PRACTICE TRIALS

1. To allow you to become comfortable breathing into the snorkel, I would like you to lean forward and just place your face in the water. Breathe comfortably a few times through the snorkel. *(Sit up and adjustments are made if necessary.)*
2. Now I would like you to lean forward to make sure that you can comfortably submerge your entire head and body underwater. If your head is still sticking out of the water, I will tap the top of your head so try to lean forward a little more. *(Sit up and adjustments are made if necessary. If the subject cannot comfortably submerge, alternative positions are made to allow for this.)*
3. *Once the experimenter and subject are comfortable with this procedure, the data collection can begin. Practice trials follow the instructions for below.*

UNDERWATER WEIGHT/RESIDUAL VOLUME DATA COLLECTION

1. *Experimenter gives entire data collection instructions prior to actual collection. The instructions are then repeated while the subject is performing the underwater weighing procedure.*
2. One trial will go something like this:
   a. Take a deep breath in and slowly lean forward. It's important to make sure the water remains smooth and still so the weighing scale doesn't move around.
   b. When you are completely submerged (remember that I will tap you on the head if your head is sticking out of the water) you will blow out all your air.
   c. Once you have blown out all your air, you need to give me a signal with your left hand. Your left hand will be holding on to the handles on the weighing scale, so there is no need to lift your whole hand out of the water. Just lift up one of your fingers, i.e., your left

index finger. This lets me know that all of your air is out of your lungs.

d. You will hold your breath and sit still for 3-4 seconds while I record your weight. You can hear the printer printing your weight (loud sound underwater).

e. Once I've gotten your weight, I will tell you when to breath. Once I've given you the signal to breathe, you can sit up and it doesn't matter if the water moves because I've already recorded your weight.

f. For the breathing part, you will breathe in and out at a rate of one cycle per 2 seconds. The breaths need to be fairly large because we want the air in your lungs to travel through this tube to the black bag that contains pure $O_2$. We have to make sure that the $O_2$ in the bag is adequately mixed with the air in your lungs.

g. I will count the breaths for you so you won't have to worry about the pace. So you'll breathe in and out, in and 2, in and 3, in and 4, in and 5, in and 6 then I will say "last one," and you will take a deep breath in and then blow out all your air just like you did a minute ago underwater.

h. So, one trial consists of slowly leaning forward, blowing out all your air, giving me a signal when you're are done, hold your breath 3-4 seconds, breathe in and out 7 times.

i. I need to have good trials, so we will do several practice trials, about 4 or 5.

I would like you to lean forward so that your entire head and body are underwater. Make sure you lean forward slowly so that the water remains smooth and still.

3. Any questions? Okay, let's practice.
4. *The trials are repeated with the following cues:*
   a. Whenever you are ready, you will take a deep breath, slowly lean forward, blow out all your air, give me the signal when you are finished blowing out, hold your breath for 3-4 seconds while I record your weight, and then you will breathe in and out 7 times.

MISCELLANEOUS INSTRUCTIONS

1. While you are underwater, you will be able to hear me. I'll be reminding you of what you are supposed to do, so you don't need to remember. I tell you the procedure first, so you know where we are going.
2. Remember, you can sit up while you are breathing in and out 7 times. I will place my hand on your forehead and gently guide you out of the water, so you'll know when it is okay to sit up. After you sit up, keep your eyes closed and I will wipe the water/chlorine out of your eyes.
3. *Subjects are constantly checked on as to how they are doing. They are given breaks between trials whenever they like. Subject is coached during all stages of testing to assure proper procedures.*
4. *For those individuals who can't hear they are told to lean forward, blow out all their air, give me a signal, then I would lift their forehead out of the water. When they feel my hand on their forehead, that is their cue to begin breathing. As with all subjects, experimenter uses hands as a visual cue for the breathing pace.*

# Appendix C

## Raw Data

| ID# | Age | HT cm | WT kg | SF Pec | SF Mid | SF Abd | SF Thigh | SF Subscap | SF Tri | SF Bi |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 65 | 173.4 | 69.28 | 4.5 | 8.5 | 8.5 | 7 | 12.5 | 8.5 | • |
| 2 | 65 | 177.8 | 77.56 | 7.5 | 13 | 12.5 | 6 | 14.5 | 10 | • |
| 3 | 72 | 174 | 78.15 | 7.5 | 14 | 12 | 8 | 17 | 8 | • |
| 5 | 73 | 169 | 69.2 | 13 | 16 | 15 | 9 | 17 | 9.5 | • |
| 7 | 65 | 172 | 58.67 | 6.5 | 9 | 10 | 10 | 13 | 10 | • |
| 9 | 68 | 174 | 95.28 | 11 | 25 | 18 | 7.5 | 19 | 7.5 | • |
| 10 | 70 | 176 | 85.27 | 12 | 15 | 14 | 10 | 17 | 11.5 | • |
| 11 | 63 | 168 | 75.85 | 16 | 19 | 22.5 | 21 | 12.5 | 17 | • |
| 12 | 67 | 173.5 | 82.73 | 10 | 13 | 25 | 26 | 17 | 19 | • |
| 13 | 69 | 180.5 | 122.23 | 30 | 37 | 40 | 26 | 40 | 26 | • |
| 14 | 60 | 174 | 82.91 | 17 | 21 | 21 | 15 | 24 | 14 | • |
| 15 | 60 | 172 | 75.13 | 16 | 20 | 29 | 25 | 15 | 19 | • |
| 17 | 63 | 172.5 | 69.95 | 19 | 16 | 24 | 27 | 16 | 17 | • |
| 18 | 62 | 167 | 81.97 | 17 | 19 | 27 | 17 | 23 | 18 | • |
| 19 | 66 | 167 | 64.89 | 17 | 17 | 17.5 | 13 | 21 | 14 | • |
| 20 | 64 | 166 | 80.5 | 15 | 24 | 20 | 21 | 19 | 19 | • |
| 22 | 66 | 175.5 | 85.92 | 19 | 39 | 34 | 27 | 40 | 32 | • |
| 23 | 66 | 177 | 100.58 | 27 | 40 | 34 | 28 | 25 | 29 | • |
| 24 | 67 | 182 | 88.16 | 13 | 12 | 24 | 20 | 15 | 15 | • |
| 25 | 68 | 170.5 | 82.19 | 15 | 26 | 19 | 22 | 17 | 13 | 13 |
| 26 | 68 | 178 | 77.56 | 13 | 16 | 21 | 11 | 8 | 13 | 6 |
| 27 | 61 | 176.5 | 70.43 | 7 | 12 | 18 | 10 | 16 | 16 | 12 |
| 28 | 70 | 167.5 | 59.61 | 6 | 10 | 11 | 18 | 11 | 10 | 8 |
| 29 | 60 | 173 | 65.86 | 17 | 18 | 25 | 7 | 15 | 11 | 5 |
| 30 | 63 | 170.5 | 88.03 | 21 | 24 | 25 | 20 | 29 | 12 | 16 |
| 31 | 63 | 189 | 83.12 | 17 | 13 | 27 | 11 | 15 | 13 | 8 |
| 32 | 63 | 176.5 | 90.47 | 21 | 28 | 32 | 19 | 25 | 22 | 18 |
| 33 | 71 | 176.5 | 81.84 | 16 | 20 | 22 | 15 | 28 | 14 | 8 |
| 34 | 69 | 182 | 88.39 | 15 | 22 | 24 | 13 | 23 | 18 | 15 |
| 35 | 68 | 182 | 96.52 | 23 | 26 | 30 | 21 | 27 | 21 | 18 |
| 36 | 62 | 182.5 | 84.15 | 19 | 30 | 26 | 23 | 23 | 18 | 13 |
| 37 | 65 | 176 | 73.8 | 14 | 17 | 18 | 12 | 11 | 9 | 8 |
| 40 | 62 | 173 | 69.27 | 14 | 15 | 18 | 15 | 12 | 12 | 4 |
| 41 | 74 | 172 | 60.82 | 5 | 8 | 9 | 12 | 11 | 8 | 3 |
| 42 | 68 | 179.5 | 98.13 | 15 | 23 | 30 | 20 | 33 | 18 | 12 |
| 43 | 61 | 174 | 95.65 | 7 | 19 | 17 | 10 | 21 | 12 | 7 |
| 44 | 69 | 172 | 88.22 | 10 | 27 | 23 | 18 | 15 | 15 | 13 |
| 45 | 63 | 171 | 77.25 | 20 | 20 | 30 | 15 | 22 | 17 | 8 |
| 46 | 72 | 180 | 80.29 | 17 | 20 | 21 | 15 | 17 | 12 | 5 |
| 48 | 67 | 178.5 | 66.09 | 8 | 8 | 15 | 12 | 13 | 11 | 8 |
| 49 | 65 | 173.5 | 61.68 | 7 | 10 | 24 | 20 | 13 | 12 | 4 |
| 51 | 62 | 180 | 90.02 | 18 | 15 | 28 | 37 | 22 | 16 | 11 |
| 52 | 68 | 173 | 75.77 | 16 | 16 | 20 | 22 | 17 | 20 | 8 |
| 53 | 63 | 175.5 | 91.86 | 24 | 23 | 41 | 35 | 21 | 16 | 11 |

| ID# | Age | HT cm | WT kg | SF Pec | SF Mid | SF Abd | SF Thigh | SF Subscap | SF Tri | SF Bi |
|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 73 | 168.5 | 78.59 | 18 | 30 | 29 | 17 | 20 | 17 | 9 |
| 47 | 69 | 177.5 | 108.08 | 21 | 24 | 35 | 35 | 32 | 20 | 8 |
| 55 | 60 | 176.5 | 80.53 | 9 | 14 | 26 | 22 | 16 | 14 | 5 |
| 56 | 69 | 187.5 | 93.22 | 15 | 20 | 25 | 17 | 19 | 15 | 6 |
| 57 | 60 | 176.5 | 74.68 | 10 | 17 | 17 | 14 | 20 | 12 | 7 |
| 58 | 67 | 167.8 | 78.14 | 19 | 22 | 17 | 8 | 34 | 17 | 17 |
| 59 | 69 | 176 | 91.39 | 23 | 23 | 24 | 19 | 28 | 22 | 12 |
| 60 | 60 | 179.5 | 73.89 | 10 | 15 | 16 | 8 | 15 | 10 | 6 |
| 61 | 62 | 191 | 102.14 | 17 | 28 | 30 | 16 | 18 | 17 | 10 |
| 62 | 67 | 165.5 | 72.7 | 15 | 14 | 17 | 12 | 22 | 13 | 11 |
| 63 | 60 | 175 | 81.47 | 19 | 29 | 24 | 20 | 22 | 14 | 12 |
| 64 | 65 | 175.5 | 89.78 | 20 | 24 | 24 | 8 | 18 | 15 | 14 |
| 65 | 66 | 170.5 | 76.86 | 15 | 16 | 18 | 9 | 18 | 8 | 8 |
| 66 | 62 | 181 | 65.99 | 9 | 9 | 18 | 6 | 11 | 7 | 5 |
| 67 | 76 | 166 | 95.32 | 18 | 31 | 34 | 8 | 32 | 14 | 13 |
| 68 | 65 | 172 | 72.33 | 15 | 17 | 32 | 14 | 18 | 14 | 8 |
| 69 | 71 | 177 | 93.48 | 15 | 28 | 19 | 11 | 24 | 15 | 9 |
| 70 | 66 | 159 | 69.82 | 11 | 24 | 30 | 16 | 17 | 15 | 14 |
| 71 | 60 | 171 | 71.15 | 12 | 18 | 27 | 20 | 14 | 14 | 8 |
| 72 | 60 | 174 | 74.46 | 18 | 20 | 26 | 27 | 25 | 21 | 15 |
| 73 | 71 | 175.5 | 91.36 | 18 | 21 | 27 | 11 | 28 | 15 | 16 |
| 74 | 62 | 178 | 95.76 | 18 | 32 | 32 | 15 | 24 | 17 | 9 |
| 75 | 77 | 174 | 66.95 | 11 | 14 | 13 | 11 | 17 | 11 | 9 |
| 76 | 75 | 175.5 | 66.22 | 9 | 14 | 12 | 9 | 12 | 9 | 5 |
| 77 | 61 | 169 | 66.38 | 11 | 15 | 17 | 21 | 13 | 12 | 9 |
| 78 | 62 | 181 | 89.96 | 22 | 25 | 34 | 16 | 24 | 15 | 10 |
| 79 | 62 | 172.5 | 80.32 | 14 | 27 | 20 | 21 | 18 | 17 | 12 |
| 80 | 75 | 171 | 90.11 | 22 | 35 | 26 | 16 | • | 15 | 18 |
| 81 | 72 | 177 | 73.84 | 14 | 22 | 19 | 10 | 20 | 13 | 5 |
| 82 | 75 | 173.5 | 65.89 | 9 | 9 | 13 | 10 | 11 | 13 | 6 |
| 83 | 63 | 186 | 92.66 | 17 | 19 | 20 | 14 | 24 | 17 | 15 |
| 84 | 65 | 174.5 | 87.59 | 12 | 18 | 26 | 15 | 24 | 13 | 8 |
| 85 | 69 | 164 | 74.47 | 22 | 32 | 36 | 16 | 26 | 16 | 11 |
| 86 | 65 | 181 | 87.21 | 17 | 17 | 28 | 22 | 27 | 19 | 11 |
| 87 | 68 | 183.5 | 86.49 | 15 | 16 | 25 | 24 | 14 | 15 | 12 |
| 88 | 65 | 166.5 | 65.32 | 12 | 21 | 18 | 5 | 25 | 8 | 5 |
| 89 | 70 | 171.5 | 74.95 | 20 | 21 | 21 | 10 | 27 | 10 | 10 |
| 90 | 69 | 177.5 | 89.6 | 20 | 30 | 30 | 25 | 23 | 18 | 16 |
| 91 | 63 | 166.5 | 63.31 | 11 | 14 | 21 | 11 | 14 | 13 | 8 |
| 92 | 68 | 164 | 123.6 | 28 | 43 | 60 | 24 | 45 | 20 | 11 |
| 93 | 60 | 175 | 62.02 | 5.5 | 7 | 14.5 | 9.5 | 10 | 6 | 5 |
| 94 | 80 | 175.3 | 68.51 | 21 | 25 | 24 | 22 | 19 | 19 | 16 |
| 95 | 69 | 178 | 74.38 | 14 | 21 | 26 | 10 | 22 | 12 | 10 |
| 96 | 70 | 179 | 80.05 | 12 | 16 | 20 | 8 | 11 | 7 | 4 |

| ID# | Age | HT cm | WT kg | SF Pec | SF Mid | SF Abd | SF Thigh | SF Subscap | SF Tri | SF Bi |
|---|---|---|---|---|---|---|---|---|---|---|
| 97 | 65 | 185 | 94.71 | 26 | 40 | 33 | 15 | 32 | 17 | 17 |
| 98 | 64 | 182.5 | 99.05 | 19 | 24 | 37 | 12 | 28 | 15 | 12 |
| 99 | 64 | 176.5 | 94.55 | 21 | 30 | 20 | 17 | 34 | 8 | 7 |
| 100 | 65 | 166 | 63.57 | 9 | 14 | 29 | 20 | 15 | 12 | 8 |
| 101 | 67 | 178 | 77.59 | 16 | 25 | 20 | 9 | 19 | 12 | 8 |
| 102 | 62 | 162.5 | 73.16 | 10 | 12 | 18 | 13 | 11 | 13 | 6 |
| 103 | 60 | 174 | 69.06 | 13.5 | 15 | 25 | 18 | 17 | 10 | 7 |
| 104 | 68 | 173 | 116.99 | 30 | 44 | 40 | 34 | 50 | 25 | 20 |
| 105 | 73 | 160.3 | 60.91 | 8 | 11 | 16 | 17 | 16 | 7 | 6 |

| ID# | DW%F | RV1 | RV1 Db | RV1 %F | RV2 | RV2 Db | RV2 %F | RV3 |
|---|---|---|---|---|---|---|---|---|
| 54 | 35.2185 | 2.214 | 1.0206 | 35.0267 | 1.7572 | 1.0186 | 35.9554 | • |
| 47 | 41.2947 | 2.7566 | 1.023 | 33.8491 | 2.1791 | 1.015 | 37.6691 | • |
| 55 | 31.8607 | 2.6392 | 1.0368 | 27.438 | 2.7432 | 1.0374 | 27.1386 | • |
| 56 | 33.5109 | 2.5562 | 1.0315 | 29.8838 | 2.7205 | 1.0314 | 29.9328 | • |
| 57 | 32.9823 | 2.0463 | 1.0351 | 28.1943 | 2.0548 | 1.0352 | 28.1541 | • |
| 58 | 39.5413 | 2.5538 | 1.0294 | 30.8826 | 1.4812 | 1.0165 | 36.9447 | • |
| 59 | 39.7098 | 1.9313 | 1.0094 | 40.3775 | 1.9003 | 1.004 | 43.0232 | • |
| 60 | 30.6406 | 2.0714 | 1.0278 | 31.6034 | 1.8402 | 1.0305 | 30.3566 | • |
| 61 | 35.8914 | 3.309 | 1.021 | 34.8162 | 3.3264 | 1.0196 | 35.4637 | • |
| 62 | 34.512 | 1.97 | 1.0403 | 25.8469 | 1.7321 | 1.0386 | 26.593 | 1.8135 |
| 63 | 36.1087 | 2.0321 | 1.0241 | 33.365 | 1.7667 | 1.0243 | 33.2659 | 1.8135 |
| 64 | 35.8914 | 2.3876 | 1.0261 | 32.3931 | 2.1081 | 1.0218 | 34.4337 | • |
| 65 | 31.8607 | 2.2192 | 1.0374 | 27.155 | 1.9158 | 1.0365 | 27.5692 | • |
| 66 | 27.4223 | 2.7776 | 1.0586 | 17.6169 | 2.478 | 1.0479 | 22.3556 | • |
| 67 | 39.3707 | 2.0105 | 1.0255 | 32.6717 | 2.1134 | 1.0258 | 32.5557 | • |
| 68 | 34.2683 | 1.79 | 1.0291 | 31.0037 | 1.8609 | 1.0269 | 32.0335 | • |
| 69 | 36.5336 | 2.1432 | 1.0181 | 36.1829 | 1.9358 | 1.0158 | 37.2812 | • |
| 70 | 36.9462 | 1.6573 | 1.0245 | 33.152 | 1.3753 | 1.0212 | 34.7353 | 1.579 |
| 71 | 33.5109 | 2.3377 | 1.0178 | 36.3516 | 2.5797 | 1.0219 | 34.4053 | • |
| 72 | 39.7098 | 1.7724 | 1.0113 | 39.4646 | 1.6298 | 1.0091 | 40.5125 | 1.6471 |
| 73 | 39.0235 | 3.2413 | 1.0294 | 30.8814 | 2.7064 | 1.0209 | 34.8509 | • |
| 74 | 37.5434 | 1.8922 | 1.0289 | 31.0929 | 1.7491 | 1.0259 | 32.4825 | • |
| 75 | 31.5656 | 2.2775 | 1.0416 | 25.2528 | 1.9643 | 1.04 | 25.9503 | 2.0338 |
| 76 | 28.2056 | 2.5666 | 1.0553 | 19.0638 | 2.3471 | 1.0503 | 21.2878 | • |
| 77 | 31.5656 | 2.4251 | 1.04 | 25.9542 | 2.0053 | 1.0332 | 29.0846 | 1.9561 |
| 78 | 37.1481 | 2.3115 | 0.9896 | 50.2212 | 2.0254 | 0.9878 | 51.0993 | 2.1349 |
| 79 | 35.6706 | 2.1349 | 1.0308 | 30.2304 | 2.1873 | 1.0289 | 31.1003 | 2.1739 |
| 80 | 33.5109 | 1.7399 | 1.0332 | 29.1019 | 1.7 | 1.0297 | 30.7298 | 1.7172 |
| 81 | 32.4328 | 3.1054 | 1.0327 | 29.3127 | 2.8757 | 1.0343 | 28.5772 | 3 |
| 82 | 28.9464 | 2.6642 | 1.0403 | 25.8459 | 2.4663 | 1.0413 | 25.3691 | 2.4801 |
| 83 | 37.1481 | 2.3433 | 1.0453 | 23.5658 | 2.5061 | 1.0423 | 24.9265 | 2.4331 |
| 84 | 35.4464 | 2.3402 | 1.0358 | 27.8914 | 2.3266 | 1.0324 | 29.4795 | 2.525 |
| 85 | 38.6676 | 2.735 | 1.0233 | 33.7379 | 2.2714 | 1.0157 | 37.3712 | 2.0351 |
| 86 | 39.1982 | 3.8181 | 1.0276 | 31.6967 | 3.3323 | 1.0227 | 33.9973 | 3.8086 |
| 87 | 33.768 | 3.3892 | 1.0241 | 33.3723 | 3.2337 | 1.0204 | 35.1121 | 2.8998 |
| 88 | 32.1497 | 1.8471 | 1.0449 | 23.7521 | 1.8752 | 1.0441 | 24.111 | 1.6583 |
| 89 | 37.1481 | 2.448 | 1.0315 | 29.8973 | 2.1049 | 1.0234 | 33.6759 | 1.9935 |
| 90 | 39.8764 | 2.0471 | 1.0133 | 38.517 | 1.7031 | 1.0112 | 39.5025 | 1.8362 |
| 91 | 32.9823 | 2.6829 | 1.0463 | 23.1105 | 2.5047 | 1.0452 | 23.5984 | 2.2352 |
| 92 | 43.8985 | 1.9406 | 1.0081 | 41.0471 | 1.8131 | 1.0055 | 42.313 | 2.0343 |
| 93 | 25.7062 | 2.144 | 1.0602 | 16.898 | 2.2983 | 1.0588 | 17.4937 | 2.1831 |
| 94 | 38.1166 | 2.4182 | 1.0268 | 32.1032 | 2.3237 | 1.0221 | 34.3119 | 2.3909 |
| 95 | 35.2185 | 1.9909 | 1.0224 | 34.1464 | 1.9391 | 1.021 | 34.8205 | 1.9026 |
| 96 | 28.2056 | 2.5681 | 1.0265 | 32.2137 | 2.5069 | 1.0262 | 32.3742 | 2.5069 |

| ID# | DW%F | RV1 | RV1 Db | RV1 %F | RV2 | RV2 Db | RV2 %F | RV3 |
|---|---|---|---|---|---|---|---|---|
| 97 | 40.9914 | 2.6082 | 1.0325 | 29.4026 | 2.4998 | 1.0308 | 30.1926 | 2.4083 |
| 98 | 39.8764 | 2.942 | 1.0142 | 38.0923 | 2.8314 | 1.0197 | 35.4396 | 2.6661 |
| 99 | 36.3228 | 1.8151 | 1.0182 | 36.1567 | 1.8337 | 1.0195 | 35.533 | • |
| 100 | 32.4328 | 2.1714 | 1.0402 | 25.8546 | 1.7487 | 1.0332 | 29.1064 | 2.204 |
| 101 | 32.9823 | 2.4424 | 1.0293 | 30.9193 | 2.174 | 1.0266 | 32.1656 | 2.2222 |
| 102 | 31.2641 | 1.9332 | 1.0384 | 26.7148 | 1.7061 | 1.0373 | 27.1957 | 1.7747 |
| 103 | 28.581 | 2.6375 | 1.0362 | 27.6909 | 1.918 | 1.0306 | 30.3045 | 2.0021 |
| 104 | 45.4453 | 3.3242 | 1.0124 | 38.9568 | 2.1415 | 1.0023 | 43.8647 | 1.9991 |
| 105 | 29.3024 | 2.519 | 1.0292 | 30.9694 | 1.7955 | 1.0371 | 27.2735 | 1.6471 |

| ID# | SF Ilium | Y S4 %F | Y S3 %F | JP Db7 | JPS7 %F | JPDb 3 | JPS3 %F | DW Db |
|---|---|---|---|---|---|---|---|---|
| 1 | 11.5 | 14.3026 | 15.4547 | 1.0737 | 11.0438 | 1.0768 | 9.7146 | 1.0486 |
| 2 | 12 | 15.577 | 17.4151 | 1.0693 | 12.9074 | 1.0722 | 11.6519 | 1.0443 |
| 3 | 15 | 17.314 | 18.6841 | 1.0648 | 14.8976 | 1.0693 | 12.9097 | 1.0437 |
| 5 | 11 | 17.8461 | 19.002 | 1.06 | 16.97 | 1.0622 | 16.0173 | 1.0421 |
| 7 | 8.5 | 15.0702 | 15.4547 | 1.0697 | 12.7472 | 1.0719 | 11.8119 | 1.0461 |
| 9 | 15.5 | 18.0394 | 19.9288 | 1.0584 | 17.6966 | 1.0638 | 15.2982 | 1.0421 |
| 10 | 15.5 | 18.9641 | 20.2457 | 1.0612 | 16.436 | 1.0637 | 15.368 | 1.0324 |
| 11 | 20 | 24.5553 | 24.4524 | 1.052 | 20.5234 | 1.0496 | 21.5905 | 1.0391 |
| 12 | 22 | 27.5653 | 26.7833 | 1.0493 | 21.7333 | 1.0477 | 22.4819 | 1.0197 |
| 13 | 38 | 34.7937 | 35.2463 | 1.0273 | 31.8327 | 1.027 | 31.9855 | 1.0033 |
| 14 | 23 | 22.459 | 23.5728 | 1.0526 | 20.276 | 1.0546 | 19.3655 | 1.0238 |
| 15 | 22 | 27.0543 | 26.6744 | 1.0475 | 22.5759 | 1.0439 | 24.1802 | 1.0222 |
| 17 | 20 | 26.12 | 24.8519 | 1.0469 | 22.8343 | 1.0431 | 24.5312 | 1.0249 |
| 18 | 27 | 26.1659 | 27.4789 | 1.0498 | 21.4963 | 1.0489 | 21.9022 | 1.0211 |
| 19 | 20 | 21.5046 | 22.7172 | 1.0555 | 18.9878 | 1.0567 | 18.4247 | 1.0282 |
| 20 | 29 | 26.4828 | 26.8123 | 1.0493 | 21.7554 | 1.0516 | 20.6984 | 1.0222 |
| 22 | 35 | 33.9906 | 34.2381 | 1.0311 | 30.0724 | 1.0365 | 27.5708 | 1.0046 |
| 23 | 36 | 33.8252 | 33.8723 | 1.032 | 29.6396 | 1.0315 | 29.8888 | 1.0115 |
| 24 | 15 | 23.7875 | 23.5809 | 1.0534 | 19.9086 | 1.0502 | 21.334 | 1.0306 |
| 25 | 19 | 23.7266 | 22.8915 | 1.0478 | 22.4107 | 1.0506 | 21.1597 | 1.0232 |
| 26 | 22 | 22.3893 | 24.2941 | 1.0611 | 16.4886 | 1.0579 | 17.9014 | 1.032 |
| 27 | 19 | 20.3686 | 22.3497 | 1.0656 | 14.5302 | 1.0667 | 14.0462 | 1.0187 |
| 28 | 13 | 19.2055 | 18.0468 | 1.0626 | 15.8191 | 1.0644 | 15.0562 | 1.0335 |
| 29 | 17 | 19.516 | 22.1912 | 1.0603 | 16.8284 | 1.0573 | 18.1872 | 1.0279 |
| 30 | 27 | 25.2925 | 25.6368 | 1.044 | 24.1368 | 1.0456 | 23.4254 | 1.0145 |
| 31 | 25 | 23.5895 | 25.8942 | 1.0578 | 17.9478 | 1.0525 | 20.293 | 1.0232 |
| 32 | 28 | 28.699 | 29.949 | 1.0426 | 24.7719 | 1.0419 | 25.0773 | 1.0079 |
| 33 | 17 | 23.09 | 23.9342 | 1.0485 | 22.114 | 1.0518 | 20.629 | 1.0153 |
| 34 | 35 | 27.4785 | 29.7701 | 1.0509 | 21.0176 | 1.053 | 20.1045 | 1.0141 |
| 35 | 26 | 28.9111 | 29.6117 | 1.0401 | 25.9309 | 1.0395 | 26.2076 | 1.0091 |
| 36 | 29 | 27.5686 | 27.7195 | 1.0429 | 24.6407 | 1.0446 | 23.8638 | 1.0157 |
| 37 | 18 | 19.6051 | 20.6637 | 1.0606 | 16.7149 | 1.0594 | 17.258 | 1.0313 |
| 40 | 20 | 20.9848 | 21.6539 | 1.0598 | 17.0823 | 1.0581 | 17.8194 | 1.0306 |
| 41 | 10 | 16.6233 | 16.3789 | 1.0677 | 13.6302 | 1.0699 | 12.6515 | 1.0416 |
| 42 | 27 | 28.3219 | 29.1451 | 1.042 | 25.0483 | 1.0449 | 23.729 | 1.0095 |
| 43 | 23 | 20.1382 | 22.067 | 1.0618 | 16.208 | 1.0674 | 13.7348 | 1.0216 |
| 44 | 27 | 26.0338 | 26.8449 | 1.0506 | 21.1581 | 1.0536 | 19.8092 | 1.0202 |
| 45 | 21 | 25.0831 | 26.6539 | 1.049 | 21.8973 | 1.0462 | 23.1462 | 1.0165 |
| 46 | 18 | 22.7967 | 23.5253 | 1.0516 | 20.6956 | 1.0515 | 20.7442 | 1.0279 |
| 48 | 11 | 18.003 | 18.5264 | 1.0657 | 14.505 | 1.0652 | 14.719 | 1.0313 |
| 49 | 16 | 23.0308 | 22.7008 | 1.0572 | 18.2029 | 1.0546 | 19.3505 | 1.032 |
| 51 | 26 | 29.6738 | 26.9914 | 1.0394 | 26.2402 | 1.0358 | 27.8788 | 1.017 |
| 52 | 24 | 26.5005 | 26.429 | 1.0503 | 21.3085 | 1.0493 | 21.7383 | 1.0197 |
| 53 | 41 | 34.3271 | 33.211 | 1.0336 | 28.9092 | 1.0265 | 32.2241 | 1.0157 |

| ID# | SF Ilium | Y S4 %F | Y S3 %F | JP Db7 | JPS7 %F | JPDb 3 | JPS3 %F | DW Db |
|---|---|---|---|---|---|---|---|---|
| 54 | 21 | 26.877 | 27.9872 | 1.0434 | 24.4052 | 1.0442 | 24.0314 | 1.0202 |
| 47 | 27 | 32.5917 | 30.8997 | 1.0312 | 30.0419 | 1.0296 | 30.7509 | 1.0075 |
| 55 | 24 | 25.2329 | 25.1614 | 1.0538 | 19.7174 | 1.052 | 20.5267 | 1.0273 |
| 56 | 24 | 25.6121 | 26.5875 | 1.05 | 21.4379 | 1.0497 | 21.5651 | 1.0238 |
| 57 | 19 | 19.9798 | 20.7571 | 1.0593 | 17.2718 | 1.0627 | 15.7811 | 1.0249 |
| 58 | 15 | 19.922 | 22.1573 | 1.0521 | 20.4774 | 1.0589 | 17.4852 | 1.0112 |
| 59 | 22 | 26.8653 | 27.6046 | 1.0431 | 24.536 | 1.044 | 24.1258 | 1.0108 |
| 60 | 12 | 16.1577 | 17.7314 | 1.0662 | 14.2498 | 1.0677 | 13.623 | 1.0299 |
| 61 | 18 | 24.5029 | 25.7357 | 1.0483 | 22.1715 | 1.0477 | 22.4682 | 1.0187 |
| 62 | 15 | 19.922 | 20.9806 | 1.0573 | 18.1636 | 1.0589 | 17.4852 | 1.0216 |
| 63 | 18 | 23.1141 | 23.0265 | 1.0463 | 23.0995 | 1.0482 | 22.2362 | 1.0183 |
| 64 | 19 | 21.6876 | 24.3651 | 1.0546 | 19.365 | 1.054 | 19.6453 | 1.0187 |
| 65 | 16 | 18.3303 | 19.9176 | 1.06 | 16.9924 | 1.0605 | 16.7642 | 1.0273 |
| 66 | 12 | 15.7295 | 17.7342 | 1.0704 | 12.4534 | 1.0679 | 13.5341 | 1.0368 |
| 67 | 22 | 26.0811 | 29.2097 | 1.0425 | 24.7987 | 1.046 | 23.2424 | 1.0115 |
| 68 | 18 | 24.3381 | 25.9537 | 1.0521 | 20.5014 | 1.0482 | 22.2499 | 1.0222 |
| 69 | 21 | 22.6383 | 24.4931 | 1.051 | 20.9935 | 1.0571 | 18.2431 | 1.0174 |
| 70 | 30 | 27.2055 | 28.8282 | 1.0505 | 21.189 | 1.0505 | 21.2185 | 1.0165 |
| 71 | 20 | 24.186 | 24.3766 | 1.0532 | 19.9975 | 1.0507 | 21.1009 | 1.0238 |
| 72 | 22 | 27.2517 | 26.4275 | 1.0437 | 24.2525 | 1.0433 | 24.4534 | 1.0108 |
| 73 | 25 | 25.2888 | 27.6703 | 1.0485 | 22.114 | 1.0498 | 21.5063 | 1.0122 |
| 74 | 30 | 27.1728 | 29.1191 | 1.0451 | 23.6198 | 1.0464 | 23.0298 | 1.0153 |
| 75 | 12 | 19.0977 | 19.7947 | 1.0596 | 17.1703 | 1.0626 | 15.8448 | 1.0279 |
| 76 | 11 | 17.2876 | 18.1919 | 1.0644 | 15.0377 | 1.0667 | 14.0419 | 1.0351 |
| 77 | 18 | 21.5055 | 20.6224 | 1.0571 | 18.2758 | 1.057 | 18.3013 | 1.0279 |
| 78 | 40 | 29.3 | 31.2838 | 1.0449 | 23.7489 | 1.0422 | 24.9599 | 1.0161 |
| 79 | 20 | 23.8628 | 23.6176 | 1.0495 | 21.6322 | 1.0528 | 20.178 | 1.0192 |
| 80 | 32 | 28.2258 | 29.7794 | 1.0476 | 22.4949 | 1.0437 | 24.2652 | 1.0238 |
| 81 | 14 | 20.4779 | 22.0702 | 1.0549 | 19.2455 | 1.0583 | 17.7501 | 1.026 |
| 82 | 8 | 18.0387 | 18.8391 | 1.0655 | 14.5596 | 1.0653 | 14.6757 | 1.0335 |
| 83 | 15 | 21.3707 | 22.3839 | 1.0533 | 19.9623 | 1.0552 | 19.1215 | 1.0161 |
| 84 | 20 | 23.4706 | 24.6351 | 1.0521 | 20.5014 | 1.0533 | 19.939 | 1.0197 |
| 85 | 26 | 28.282 | 30.0003 | 1.0398 | 26.0628 | 1.0392 | 26.3256 | 1.013 |
| 86 | 24 | 27.4488 | 27.7115 | 1.0451 | 23.6215 | 1.0444 | 23.9371 | 1.0119 |
| 87 | 24 | 26.9123 | 26.429 | 1.0487 | 22.0005 | 1.0455 | 23.4479 | 1.0232 |
| 88 | 11 | 15.9544 | 18.2095 | 1.0599 | 17.0156 | 1.0657 | 14.4946 | 1.0267 |
| 89 | 26 | 22.7062 | 24.8852 | 1.0509 | 21.0058 | 1.0534 | 19.924 | 1.0161 |
| 90 | 26 | 29.2639 | 29.0672 | 1.0384 | 26.6804 | 1.0386 | 26.5954 | 1.0105 |
| 91 | 20 | 21.1433 | 22.9471 | 1.0619 | 16.1594 | 1.0606 | 16.7284 | 1.0249 |
| 92 | 38 | 36.5178 | 37.3246 | 1.0226 | 34.0804 | 1.0194 | 35.6003 | 1.0022 |
| 93 | 9 | 14.405 | 14.9945 | 1.0721 | 11.7237 | 1.0709 | 12.2104 | 1.0406 |
| 94 | 20 | 28.1945 | 28.0709 | 1.0408 | 25.5891 | 1.0406 | 25.6956 | 1.0141 |
| 95 | 18.5 | 22.4347 | 24.5899 | 1.0531 | 20.0225 | 1.0543 | 19.5128 | 1.0202 |
| 96 | • | 18.9641 | 20.855 | 1.0623 | 15.9739 | 1.0609 | 16.6052 | 1.0351 |

| ID# | SF Ilium | Y S4 %F | Y S3 %F | JP Db7 | JPS7 %F | JPDb 3 | JPS3 %F | DW Db |
|---|---|---|---|---|---|---|---|---|
| 97 | 30 | 27.8466 | 29.8204 | 1.0375 | 27.1148 | 1.0402 | 25.8541 | 1.0082 |
| 98 | 31 | 27.6881 | 30.3271 | 1.0457 | 23.3599 | 1.0441 | 24.0974 | 1.0105 |
| 99 | 27 | 22.8724 | 23.384 | 1.0437 | 24.2677 | 1.0503 | 21.2759 | 1.0178 |
| 100 | 17 | 24.3381 | 24.3651 | 1.053 | 20.0783 | 1.0501 | 21.3914 | 1.026 |
| 101 | 17 | 20.1574 | 22.1573 | 1.0553 | 19.0433 | 1.0582 | 17.7875 | 1.0249 |
| 102 | 17 | 20.0653 | 21.074 | 1.0639 | 15.2717 | 1.0622 | 16.0069 | 1.0285 |
| 103 | 20 | 22.459 | 22.7501 | 1.0546 | 19.3651 | 1.0523 | 20.3825 | 1.0343 |
| 104 | 30 | 34.4719 | 33.4326 | 1.0211 | 34.779 | 1.0232 | 33.7737 | 0.9991 |
| 105 | 10 | 19.1971 | 18.1997 | 1.058 | 17.8831 | 1.0594 | 17.2524 | 1.0328 |

| ID# | DW%F | RV1 | RV1 Db | RV1 %F | RV2 | RV2 Db | RV2 %F | RV3 |
|---|---|---|---|---|---|---|---|---|
| 1 | 22.0504 | 2.0745 | 1.0543 | 19.5197 | 2.901 | 1.0673 | 13.794 | • |
| 2 | 24.0023 | 3.3824 | 1.0625 | 15.8851 | 4.0682 | 1.0569 | 18.3481 | • |
| 3 | 24.2593 | 2.6054 | 1.0412 | 25.4302 | 2.0893 | 1.0314 | 29.9105 | • |
| 5 | 25.0021 | 2.0246 | 1.0468 | 22.8571 | 2.0246 | 1.0425 | 24.8003 | • |
| 7 | 23.2003 | 2.1005 | 1.0521 | 20.4984 | 2.3925 | 1.0519 | 20.5608 | • |
| 9 | 25.0021 | 4.0519 | 1.057 | 18.3023 | 3.8132 | 1.0461 | 23.1755 | • |
| 10 | 29.4769 | 2.3134 | 1.042 | 25.0467 | 2.2727 | 1.0408 | 25.6044 | • |
| 11 | 26.3754 | 3.0164 | 1.0479 | 22.3572 | 1.9504 | 1.0323 | 29.511 | • |
| 12 | 35.4464 | 2.2445 | 1.0268 | 32.0573 | 2.1661 | 1.025 | 32.9456 | • |
| 13 | 43.3877 | 2.4484 | 0.9916 | 49.2051 | 2.4484 | 0.9908 | 49.5717 | • |
| 14 | 33.5109 | 2.0141 | 1.0349 | 28.329 | 1.9649 | 1.0343 | 28.5628 | • |
| 15 | 34.2683 | 1.9649 | 1.0202 | 35.1776 | 1.8685 | 1.0271 | 31.9188 | • |
| 17 | 32.9823 | 1.5264 | 1.0265 | 32.2222 | 1.6248 | 1.0262 | 32.3805 | • |
| 18 | 34.7514 | 2.5568 | 1.0386 | 26.6251 | 2.8698 | 1.0457 | 23.3681 | • |
| 19 | 31.4157 | 2.5141 | 1.0382 | 26.765 | 2.3752 | 1.0382 | 26.8077 | • |
| 20 | 34.2683 | • | • | • | 1.9512 | 1.0334 | 29.0095 | • |
| 22 | 42.723 | 2.0406 | 1.0128 | 38.7671 | 2.0656 | 1.0118 | 39.203 | • |
| 23 | 39.3707 | 2.9541 | 1.0023 | 43.8658 | 2.9382 | 1.0032 | 43.4239 | • |
| 24 | 30.3181 | 2.5047 | 1.0499 | 21.4822 | 2.5617 | 1.0509 | 21.0212 | • |
| 25 | 33.768 | 1.812 | 1.0153 | 37.5601 | 1.7657 | 1.0132 | 38.5354 | • |
| 26 | 29.6493 | 2.0907 | 1.0419 | 25.077 | 1.812 | 1.0392 | 26.3427 | • |
| 27 | 35.8914 | 2.7476 | 1.0556 | 18.908 | 2.7476 | 1.0556 | 18.908 | • |
| 28 | 28.9464 | 2.3211 | 1.033 | 29.2039 | 2.4026 | 1.0308 | 30.2185 | • |
| 29 | 31.5656 | 2.4579 | 1.0456 | 23.4165 | 1.9271 | 1.0431 | 24.5333 | • |
| 30 | 37.9281 | 2.444 | 1.0107 | 39.7572 | 2.0619 | 1.0074 | 41.3542 | • |
| 31 | 33.768 | 3.1263 | 1.0449 | 23.7387 | 2.98 | 1.0409 | 25.5384 | • |
| 32 | 41.1439 | 2.3481 | 1.0162 | 37.1029 | 2.3752 | 1.0189 | 35.7986 | • |
| 33 | 37.5434 | 2.3346 | 1.0283 | 31.3733 | 2.3481 | 1.0299 | 30.6071 | • |
| 34 | 38.1166 | 1.9512 | 1.0228 | 33.946 | 1.9031 | 1.0214 | 34.6519 | • |
| 35 | 40.524 | 2.1441 | 1.0213 | 34.6991 | 1.9561 | 1.0197 | 35.4568 | • |
| 36 | 37.3471 | 1.5864 | 1.0174 | 36.5216 | 1.8599 | 1.0246 | 33.0929 | • |
| 37 | 29.9877 | 2.6104 | 1.0237 | 33.5207 | 2.2222 | 1.0184 | 36.0735 | • |
| 40 | 30.3181 | 2.0196 | 1.046 | 23.2104 | 1.9332 | 1.0469 | 22.8031 | • |
| 41 | 25.2409 | 2.3327 | 1.0319 | 29.6923 | 2.5 | 1.0266 | 32.1795 | • |
| 42 | 40.3648 | 2.4248 | 1.0132 | 38.5743 | • | • | • | • |
| 43 | 34.512 | 1.9542 | 1.0295 | 30.8307 | 1.6836 | 1.0279 | 31.5807 | • |
| 44 | 35.2185 | 2.342 | 1.0263 | 32.3191 | 2.4388 | 1.0236 | 33.5958 | • |
| 45 | 36.9462 | 1.7678 | 1.0272 | 31.885 | 1.7869 | 1.0273 | 31.8266 | • |
| 46 | 31.5656 | 2.0708 | 1.0077 | 41.1959 | 2.0263 | 1.0141 | 38.1315 | • |
| 48 | 29.9877 | 2.7911 | 1.0705 | 12.3991 | 2.8643 | 1.0659 | 14.3944 | • |
| 49 | 29.6493 | 1.5304 | 1.0299 | 30.6135 | 1.708 | 1.035 | 28.2801 | • |
| 51 | 36.7414 | 3.1116 | 1.0223 | 34.197 | 2.6992 | 1.0146 | 37.8756 | • |
| 52 | 35.4464 | 1.9825 | 1.0245 | 33.1692 | 2.1712 | 1.0011 | 44.458 | • |
| 53 | 37.3471 | 2.1783 | 1.0145 | 37.9044 | 1.9531 | 1.0123 | 38.9819 | • |

| ID# | RV3 Db | RV3 %F | Mean RV | Mean RV Db | Mean RV %F |
|---|---|---|---|---|---|
| 1 | • | • | 2.4877 | 1.0608 | 16.6568 |
| 2 | • | • | 3.7253 | 1.0597 | 17.1166 |
| 3 | • | • | 2.3473 | 1.0363 | 27.6703 |
| 5 | • | • | 2.0246 | 1.0447 | 23.8287 |
| 7 | • | • | 2.2465 | 1.052 | 20.5296 |
| 9 | • | • | 2.0065 | 0.9989 | 20.7389 |
| 10 | • | • | 3.9326 | 1.0516 | 25.3256 |
| 11 | • | • | 2.2931 | 1.0414 | 25.9341 |
| 12 | • | • | 2.4834 | 1.0401 | 32.5014 |
| 13 | • | • | 2.2053 | 1.0259 | 49.3884 |
| 14 | • | • | 2.4484 | 0.9912 | 28.4459 |
| 15 | • | • | 1.9895 | 1.0346 | 33.5482 |
| 17 | • | • | 1.9167 | 1.0237 | 32.3013 |
| 18 | • | • | 1.5756 | 1.0263 | 24.9966 |
| 19 | • | • | 2.7133 | 1.0421 | 26.7864 |
| 20 | • | • | 2.4447 | 1.0382 | 29.0095 |
| 22 | • | • | 2.053 | 1.0334 | 38.9851 |
| 23 | • | • | 2.0531 | 1.0123 | 43.6448 |
| 24 | • | • | 2.9462 | 1.0027 | 21.2517 |
| 25 | • | • | 2.5332 | 1.0504 | 38.0477 |
| 26 | • | • | 1.7888 | 1.0142 | 25.7098 |
| 27 | • | • | 1.9514 | 1.0406 | 18.908 |
| 28 | • | • | 2.7476 | 1.0556 | 29.7112 |
| 29 | • | • | 2.3618 | 1.0319 | 23.9749 |
| 30 | • | • | 2.1925 | 1.0444 | 40.5557 |
| 31 | • | • | 2.253 | 1.0091 | 24.6386 |
| 32 | • | • | 3.0531 | 1.0429 | 36.4508 |
| 33 | • | • | 2.3616 | 1.0176 | 30.9902 |
| 34 | • | • | 2.3413 | 1.0291 | 34.2989 |
| 35 | • | • | 1.9272 | 1.0221 | 35.0779 |
| 36 | • | • | 2.0501 | 1.0205 | 34.8072 |
| 37 | • | • | 1.7231 | 1.021 | 34.7971 |
| 40 | • | • | 2.4163 | 1.0211 | 23.0067 |
| 41 | • | • | 1.9764 | 1.0465 | 30.9359 |
| 42 | • | • | 2.4164 | 1.0293 | 38.5743 |
| 43 | • | • | 2.4248 | 1.0132 | 31.2057 |
| 44 | • | • | 1.8189 | 1.0287 | 32.9574 |
| 45 | • | • | 2.3904 | 1.0249 | 31.8558 |
| 46 | • | • | 1.7774 | 1.0273 | 39.6637 |
| 48 | • | • | 2.0486 | 1.0109 | 13.3968 |
| 49 | • | • | 2.8277 | 1.0682 | 29.4468 |
| 51 | • | • | 1.6192 | 1.0324 | 36.0363 |
| 52 | • | • | 2.9054 | 1.0185 | 38.8136 |
| 53 | • | • | 2.0768 | 1.0128 | 38.4431 |

| ID# | RV3 Db | RV3 %F | Mean RV | Mean RV Db | Mean RV %F |
|---|---|---|---|---|---|
| 54 | • | • | 2.0657 | 1.0134 | 35.4911 |
| 47 | • | • | 1.9856 | 1.0196 | 35.7591 |
| 55 | • | • | 2.4678 | 1.019 | 27.2883 |
| 56 | • | • | 2.6912 | 1.0371 | 29.9083 |
| 57 | • | • | 2.6384 | 1.0314 | 28.1742 |
| 58 | • | • | 2.0506 | 1.0352 | 33.9136 |
| 59 | • | • | 2.0175 | 1.0229 | 41.7004 |
| 60 | • | • | 1.9158 | 1.0067 | 30.98 |
| 61 | • | • | 1.9558 | 1.0292 | 35.14 |
| 62 | 1.0417 | 25.2 | 3.3177 | 1.0203 | 25.8798 |
| 63 | 1.024 | 33.394 | 1.8385 | 1.0402 | 33.3418 |
| 64 | • | • | 1.8708 | 1.0241 | 33.4134 |
| 65 | • | • | 2.2479 | 1.024 | 27.3621 |
| 66 | • | • | 2.0675 | 1.0369 | 19.9863 |
| 67 | • | • | 2.6278 | 1.0532 | 32.6137 |
| 68 | • | • | 2.062 | 1.0257 | 31.5186 |
| 69 | • | • | 1.8254 | 1.028 | 36.732 |
| 70 | 1.0249 | 32.988 | 2.0395 | 1.017 | 33.6251 |
| 71 | • | • | 1.5372 | 1.0235 | 35.3785 |
| 72 | 1.0119 | 39.178 | 2.4587 | 1.0198 | 39.7184 |
| 73 | • | • | 1.6831 | 1.0108 | 32.8662 |
| 74 | • | • | 2.9739 | 1.0251 | 31.7877 |
| 75 | 1.0411 | 25.456 | 1.8206 | 1.0274 | 25.5529 |
| 76 | • | • | 2.0919 | 1.0409 | 20.1758 |
| 77 | 1.0361 | 27.745 | 2.4568 | 1.0528 | 27.5945 |
| 78 | 0.989 | 50.501 | 2.1288 | 1.0365 | 50.6072 |
| 79 | 1.0336 | 28.921 | 2.1572 | 0.9888 | 30.0838 |
| 80 | 1.031 | 30.097 | 2.1654 | 1.0311 | 29.9762 |
| 81 | 1.0325 | 29.413 | 1.719 | 1.0313 | 29.1008 |
| 82 | 1.0397 | 26.115 | 2.9937 | 1.0332 | 25.7766 |
| 83 | 1.0458 | 23.301 | 2.5369 | 1.0404 | 23.9312 |
| 84 | 1.0312 | 30.007 | 2.4275 | 1.0445 | 29.126 |
| 85 | 1.0166 | 36.902 | 2.3973 | 1.0331 | 36.0038 |
| 86 | 1.0274 | 31.822 | 2.3472 | 1.0185 | 32.5053 |
| 87 | 1.0227 | 33.999 | 3.653 | 1.0259 | 34.1612 |
| 88 | 1.0427 | 24.745 | 3.1742 | 1.0224 | 24.2027 |
| 89 | 1.0204 | 35.11 | 1.7935 | 1.0439 | 32.8943 |
| 90 | 1.0174 | 36.53 | 2.1821 | 1.0251 | 38.1831 |
| 91 | 1.0403 | 25.804 | 1.8621 | 1.014 | 24.171 |
| 92 | 1.0112 | 39.523 | 2.4743 | 1.0439 | 40.9611 |
| 93 | 1.0535 | 19.858 | 1.9293 | 1.0082 | 18.0834 |
| 94 | 1.0258 | 32.573 | 2.2085 | 1.0575 | 32.9959 |
| 95 | 1.0219 | 34.41 | 2.3776 | 1.0249 | 34.4591 |
| 96 | 1.0258 | 32.53 | 1.9442 | 1.0218 | 32.3725 |

| ID# | RV3 Db | RV3 %F | Mean RV | Mean RV Db | Mean RV %F |
|---|---|---|---|---|---|
| 97 | 1.0299 | 30.639 | 2.5273 | 1.0262 | 30.0781 |
| 98 | 1.0164 | 37.007 | 2.5054 | 1.0311 | 36.8463 |
| 99 | • | • | 2.8131 | 1.0168 | 35.8448 |
| 100 | 1.0391 | 26.383 | 1.8244 | 1.0188 | 27.1148 |
| 101 | 1.0247 | 33.062 | 2.0414 | 1.0375 | 32.049 |
| 102 | 1.038 | 26.867 | 2.2795 | 1.0269 | 26.9259 |
| 103 | 1.0319 | 29.684 | 1.8047 | 1.0379 | 29.2263 |
| 104 | 1.0018 | 44.095 | 2.1859 | 1.0329 | 42.3053 |
| 105 | 1.0189 | 35.805 | 2.4883 | 1.0055 | 31.3492 |

# Appendix D

<u>Results Packet</u>

- Results Letter
- Fitness for Seniors
- Exercise and Weight Control
- Eating for a Low-fat Lifestyle

<u>Subject Recruitment Materials</u>

## III. SKINFOLD VALUES

| | | | | | | |
|---|---|---|---|---|---|---|
| a. Chest: | 9.00 | mm | d. Leg: | 10.00 | mm | |
| b. Abdomen: | 13.00 | mm | e. Underarm: | 9.00 | mm | mm=millimeters |
| c. Back: | 11.00 | mm | f. Arm: | 13.00 | mm | |

Your percent body fat via skinfold measures was 18.04 %.

## IV. UNDERWATER WEIGHING VALUES

Your percent body fat via underwater weighing was 25.05 %.

As you can see, there is a considerable difference between these measures - which is precisely why we are doing this study!! From a preliminary standpoint, we believe these differences are due to the fact that the prediction equations used to predict percent body fat from skinfolds or bio-impedance have not been made with older men in mind. Rather, they were developed from studies on young college-aged males who will have different bone and muscle densities than their older counterparts.

Remember that percent body fat via underwater weighing is considered the "gold standard", thus, it is the value you should use.

## V. TARGET WEIGHT

Once percent body fat is known, a predicted desirable weight (target weight) can be calculated which gives what you would weigh at a specific percent body fat. This specific percent body fat, or ideal body fat will vary from individual to individual depending on the following: age, height, weight, body type, activity level, lifestyle habits, medical history, etc. Many experts believe that men below 30 years should be between 15-19% body fat; there is no research or guidelines for any other age groups. As you can see, there is no one ideal percent body fat, thus, the "ideal" percent body fat I've chosen for you is based on my opinion.

| | | | | |
|---|---|---|---|---|
| 144.96 | | 25.05 | | 36.32 |
| Current Weight | x | Percent Body Fat | = | Fat Weight |
| 144.96 | | 36.32 | | 108.64 |
| Current Weight | - | Fat Weight | = | Lean Body Weight |
| 108.64 | | 0.78 | | 139.29 |
| Lean Body Weight | + | Desired Percent Fat | = | Target Weight |

We are hoping this research project will shed some light on this situation! Thank you again for participating, we couldn't have done it without you! If you would be interested in participating in any future research projects with the lab, please phone Janice at 739-3767 and give her your name and phone number. Again, thank you for your participation and please phone us if you have any questions!!

Sincerely,

Beth Kelley

Dear (SAMPLE)

Enclosed are your results from the research study entitled "**VALIDATION OF BODY COMPOSITION PREDICTION EQUATIONS FOR MEN OVER 60 YEARS OF AGE**". As we will be collecting data until August, the results of the entire study are not enclosed. If you would like to receive a summary of our findings once the study has been completed, please phone us so we can mail you a copy.

Body Composition is a term which refers to the amount of lean body weight (muscle, bone, organs) and the fat weight, which together make up an individual's total body weight. It is considered unhealthy to have a high amount of a person's total body weight as fat weight. The measurement of body composition, specifically fat weight or percent body fat is important for a number of reasons. However, the most common reason is that people are just curious about how much body fat they have.

When individuals gain fat, much of this added adipose tissue (fancy name for fat) occurs in subcutaneous (surface) areas in certain parts of the body. Men usually carry their extra fat around the waist area and women carry it around their limbs. Many studies have shown that as individuals age, there is less subcutaneous fat, yet more internal fat.

There are a number of ways to determine what an individual's body composition is. The criterion method, commonly considered the "gold standard" is underwater weighing. This method involves the determination of an individual's weight under water. With this weight and the person's mass, density can be determined. Once we have density, we use estimation equations to predict percent body fat.

As you know from experience, underwater weighing takes time, practice, patience and expensive equipment. Since many facilities do not have these items, "field tests" were developed by collecting data on individuals and comparing the results to underwater weighing. Skinfold measurements are one of these field tests, their basis being that external fat can be pinched by the thumb and forefingers. With older men, skinfolds may not be valid because of the body fat shift from external to internal.

## I. PERSONAL DATA

| | |
|---|---|
| a. Height: 68.31 inches | 173.50 centimeters |
| b. Weight: 144.96 pounds | 65.89 kilograms |
| c. Age: 75 | |

## II. CIRCUMFERENCE VALUES

| | | | | | | |
|---|---|---|---|---|---|---|
| a. Bicep: | 26.50 | cm | d. Thigh: | 45.50 | cm | |
| b. Waist: | 81.00 | cm | e. Calf: | 34.50 | cm | 1 inch = 2.54 cm |
| c. Abdomen: | 83.00 | cm | | | | |

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# ATTENTION: ALL MEN OVER 60 YEARS!!

## LEARN YOUR PERCENT BODY FAT!!

Volunteers needed to participate in a study with the UNLV Exercise Physiology Laboratory.

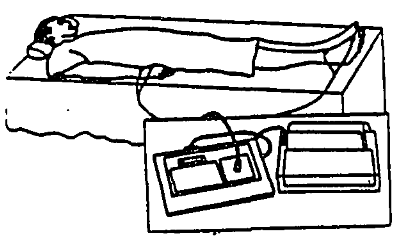
**WHO:** **Any man over 60 years of age**

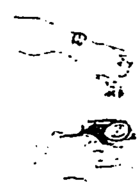
**WHERE:** **UNLV Exercise Physiology Lab in the McDermott Physical Education Complex, Room 206**

**WHEN:** **Testing to be scheduled at your convenience (for approximately 1- 1/2 hours) as well as an orientation meeting**

**HOW:** **Body fat will be determined via 3 methods; skinfold measurements, bio-impedance and underwater weighing**

PHONE BETH, DAHN OR JANICE AT THE LAB (739-3767) FOR YOUR ORIENTATION APPOINTMENT TODAY!!





PRESS RELEASE

**ATTENTION, ALL MEN OVER 60 YEARS!!!**

*Learn your percent body fat!*

UNLV's Exercise Physiology Lab is looking for males over 60 years of age to volunteer for a research project to be conducted this summer. The study focuses on body composition for men over 60, as there is little research among this age group.

Each participant will attend an orientation meeting where instructions will be given and questions will be answered. At the meeting, participants will be scheduled for a testing session (approximately 1- 1/2 hours) where the following measurements will be taken: height; weight; skinfold measurements; underwater weighing which involves sitting in a warm bath and submerging the face while breathing into a tube; and bio-impedance.

Each participant will receive personalized results indicating their percent body fat, and target weight (if currently involved in a weight loss program).

If you would like further information or would like to sign up for the next orientation, please phone Beth, Dahn or Janice at the laboratory (702) 739-3767 or Beth at 897-2474 in the evenings.

## Men needed for research at UNLV

UNLV's exercise physiology lab is looking for men over 60 years of age to volunteer for a study of body composition.

Each participant will be weighed and measured, including underwater weighing to determine body-fat percentages.

Everyone who takes part in the study will receive personalized results indicating their percentage of body fat and target weight.

Men over 60 who would like information about the study may call 739-3767.

# BIBLIOGRAPHY

Arnold, J.S., Bartley, M.H., Tont, S.A., Jenkins, D.P., (1965). Skeletal changes in aging and disease. Orthopedics, 49, 17-37.

Baker, P.T., & Angel, J.L., (1965). Old age changes in body density: Sex and race factors in the United States. Human Biology, 37, 104-119.

Baumgartner, R.N., Heymsfield, S.B., Lichtman, S., Wang, J., Pierson, R.N. Jr., (1991). Body composition on elderly people: Effect of criterion estimates on predicitive equations. American Journal of Clinical Nutrition, 53(6), 345-353.

Becque, M.D., Katch, V.L., and Moffatt, R.J., (1986). Time course of skin-plus-fat compression in males and females. Human Biology, 58, 33-42.

Behnke, A.R., (1942). The specific gravity of healthy men. Journal of the American Medical Association, 118(7), 495-501.

Blanchard, J., Conrad, K.A., Harrison, G.G., (1990). Comparison of methods for estimating body composition in young and elderly women. Journal of Gerontology, 45(4), 119-124.

Borkan, G.A., & Norris, A.H., (1977). Fat redistribution and the changing body dimensions of the adult male. Human Biology, 49(3), 495-514.

Borkan, G.A., Hults, D.E., Gerzof, S.G., & Robbins, A.H., (1985). Comparison of the body composition in middle aged and elderly males using computed tomography. American Journal of Physical Anthropology, 66, 289-295.

Brodie, D.A., (1988a). Techniques of measurement of body composition, Part 1. Sports Medicine, 5, 11-40.

Brodie, D.A., (1988b). Techniques of measurement of body composition, Part II. Sports Medicine, 5, 74-98.

Brozek, J., (1960). Age differences in residual lung volume and vital capacity of normal individuals. Journal of Gerontology, 15, 155-160.

Brozek, J., & Keys, A., (1953). Relative body weight, age and fatness. Geriatrics, 8, 70-75.

Brozek, J., & Kinsey, W., (1960). Age changes in skinfold compressibility. Journal of Gerontology, 15, 45-51.

Chumlea, W.C., Baumgartner, R.N., Vellas, B.P., (1991). Anthropometry and body composition in the perspective of nutritional status in the elderly. Nutrition, 7(1), 57-60.

Chumlea, W.C., Roche, A.F., & Rogers, E., (1984). Replicability for anthropometry in the elderly. Human Biology, 56, 329-337.

Chumlea, W.C., Roche, A.F., & Webb, P., (1984). Body size, subcutaneous fatness and total body fat in older adults. International Journal of Obesity, 6, 311-317.

Clarys, J.P., Martin, A.D., & Drinkwater, D.T., (1984). Gross tissue weights in the human body by cadaver dissection. Human Biology, 56, 459-473.

Craig, A.B., & Ware, D.B., (1967). Effect of immersion in water on vital capacity and residual volume of the lungs. Journal of Applied Physiology, 23, 423-425.

Donahue, J., Golding, L.A., & Cummings, L., (1988). Measuring percent body fat: Pros and cons of four methods. Perspective, December, 34-37.

Deurenberg, P., vander Kooij, K., Evers, P., Hulshof, T., (1990). Assessment of body composition by bioelectrical impedance in a population aged greater than 60. American Journal of Clinical Nutrition, 57(1), 3-6.

Deurenberg, P., Westrate, J.A., vander Kooy, K., (1989). Is an adaptation of Siri's formula for the calculation of body fat percentage from body density in the elderly necessary? European Journal of Clinical Nutrition, 43(8), 559-67.

Durnin, J.V., & Rahaman, M.M., (1967). The assessment of the amount of fat in the human body from measurements of skinfold techniques. British Journal of Nutrition, 32, 77-92.

Durnin, J.V., & Womersley, J., (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged 16-72 years. British Journal of Nutrition, 32, 77-97.

Fahey, T.D., & Schroeder, R., (1978). a load cell for hydrostatic weighing. Research Quarterly, 49(1), 85-87.

Flint, M.M., Drinkwater, B.L., Wells, C.L., & Horvath, S.M., (1977). Validity of estimating body fat of females: Effect of age and fitness. Human Biology, 49, 559-572.

Forbes, G.B., (1976). The adult decline in lean body mass. Human Biology, 48, 161-173.

Forbes, G.B., & Reina, J., (1970). Adult lean body mass declines with age - longitudinal studies. Metabolism, 19, 653-663.

Forsyth, R., Plyley, M.J., & Shephard, R.J., (1988). Residual volume as a tool in body fat prediction. Ann. Nutr. Metab., 32, 62-67.

Friedlaender, J.S., Costa, P.T., Bosse, R., Ellis, E., Rhoado, J.G., & Stoudt, H.W., (1977). Longitudinal physique changes among healthy white veterans at Boston. Human Biology, 49, 541-558.

Fryer, J.H., & Shock, N.W., (1962). Studies on body composition in men aged 60 and over. In J.H. Fryer & N.W. Shock (Eds.). Biological aspects of aging (pp.59-78). New York: Columbia University Press.

Garn, S.M., Sullivan, T.V., & Hawthorne, V.M., (1988). Persistence of relative fatness at different body sites. Human Biology, 60(1), 43-53.

Garrow, J.S., (1982). New approaches to body composition. American Journal of Clinical Nutrition, 35, 1152-1158.

Girandola, R.N., Wiswell, R.A., Mohler, J.G., Romero, G.T., and Barnes, W.S., (1977). Effects of water immersion on lung volumes: Implications for body composition analysis. Journal of Applied Physiology, 43(3), 276-279.

Golding, L.A., and Lindsay, A.R., (1989). Measuring body composition with attention to age and sex trends. Perspective, May, 30-33.

Golding, L.A., Myers, C.R., & Sinning, W.E. (Eds.), (1989). The Y's Way to Physical Fitness. Chicago: Human Kinetics.

Greaves, K.A., Puhl, J., Baranowski, T., Gruben, D., & Seale, D., (1989). Ethnic differences in anthropometric characteristics of young children and their parents. Human Biology, 61(3), 459-477.

Gruber, J.L., Pollock, M.L., Graves, J.E., Colvin, A.B., Braith, R.W., (1990). Comparison of Harpenden and Lange calipers in predicting body composition. Research Quarterly for Exercise and Sport, 61(2), 184-190.

Hattori, K., Numata, N., Ikoma, M., Matsuzaka, A., & Danielson, R.R., (1991). Sex differences in the distribution of subcutaneous and internal fat. Human Biology, 63(1), 53-63.

Jackson, A.S., (1984). Research design and analysis of data procedures for predicting body density. Medicine and Science in Sports and Exercise, 16(6), 616-620.

Jackson, A.S., & Pollock, M.L., (1977). Prediction accuracy of body density, lean body weight and total body volume equations. Medicine and Science in Sports and Exercise, 9, 197-201.

Jackson, A.S., & Pollock, M.L., (1978). Generalized equations for predicting body density of men. British Journal of Nutrition, 40, 497-504.

Jackson, A.S., & Pollock, M.L., (1982). Steps towards the development of generalized equations for predicting body composition of adults. Canadian Journal of Applied Sports Sciences, 7, 189-196.

Jackson, A.S., & Pollock, M.L., (1985). Practical assessment of body composition. Physician and Sportsmedicine, 13(5), 76-90.

Katch, F., (1969). Practice curves and errors of measurement in estimating underwater weight by hydrostatic weighing. Medicine and Science in Sport and Exercise, 1, 212-213.

Katch, F.I., & Katch, V.L., (1980). Measurement and prediction errors in body prediction assessment and the search for the perfect prediction equation. Research Quarterly for Exercise and Sport, 51, 249-260.

Kenney, P.A., (1985). Physiology of aging. Clinics in Geriatric Medicine, 1(1), 37-59.

Kelley, E.L., Golding, L.A., Tandy, R.D., (1991). Comparison of the Harpenden and the Lange skinfold calipers. International Journal of Sports Medicine, 12, 338.

Keys, A., & Brozek, J., (1953). Body fat in adult man. Physiological Reviews, 33, 245-325.

Krzywicki, H.J., & Chin, S.K., (1967). Human body density and fat of an adult male population as measured by water displacement. American Journal of Clinical Nutrition, 20(4), 305-310.

Latin, R.W., Johnson, S.C., & Ruhling, R.O., (1987). An anthropometric estimation of body composition of older men. Journal of Gerontology, 42(1), 24-28.

Latin, R.W., & Ruhling, R.O., (1986). Total lung capacity, residual volume and predicted residual volume in a densitometric study of older men. British Journal of Sports Medicine, 20(2), 1986.

Lohman, T.G., (1981). Skinfolds and body density and their relation to body fatness: A review. Human Biology, 53(2), 181-225.

Lohman, T.G., (1982). Body composition methodology in sports medicine. Physician and Sportsmedicine, 19(12), 47-58.

Lohman, T.G., (1984). Research progress in validation of laboratory methods of assessing body composition. Medicine and Science in Sport and Exercise, 16(6), 596-603.

Lohman, T.G., Roche, A.F., & Martorell, R., (1989). Anthropometric Standardization Manual. Champaign, Illinois: Human Kinetics.

Lukaski, H.C., (1987). Methods for the assessment of human body composition: Traditional and new. American Journal of Clinical Nutrition, 46, 537-556.

Martin, A.D., and Drinkwater, D.T., (1991). Variability of the measures of fat. Sports Medicine, 11(5), 277-288.

Masoro, E.J., (1981). Handbook of physiology of aging. CRC Press, Inc.

Masters, A.M., Lasser, R.P., & Beckman, G., (1960). Tables of average weight and height of Americans aged 65-94 years. Journal of the American Medical Association, 172(115), 658-662.

Montague, M.F., (1960). A handbook of anthropometry. IL: Charles C. Thomas.

Ostrove, S.M., & Vaccaro, P., (1982). Effect of immersion on residual volume in young women: Implications for measurement of body density. International Journal of Sports Medicine, 3, 220-223.

Roche, A.F., (1987). Some aspects of the criterion methods for the measurements of body composition. Human Biology, 59(2), 209-220.

Rossman, I., (1979). The anatomy of aging. In I. Rossman (Ed.) Clinical Geriatrics (7-22).

Schmidt, P.K., and Carter, J.E. Lindsay, (1991). Static and Dynamic Differences among five types of skinfold calipers. Human Biology, 62(1), 369-388.

Shephard, R.L., (1987). Physical activity in aging (2nd ed.). Rockeville, Aspen Pub.

Siri, W.E., (1961). Body composition from fluid spaces and density. In J. Brozek & A. Henschel (Eds), Techniques of measuring body composition. Washington D.C.: National Academy of Sciences National Research Council, 223-244.

Steen, B., (1979). Body composition at 70-75 years of age. Journal of Clinical and Experimental Gerontology, 1, 185-200.

Steen, B., Lundgren, B.K., & Isaksson, B. (1985). Body composition at age 70, 75, 79 and 81 years: A longitudinal population study. Nutrition, Immunity and Illness in the Elderly., New York, Pergamon Press.

Vir, S.C., & Love, A.H.G., (1980). Anthropometric measurements in the elderly. Gerontology, 26, 1-8.

Watson, R.R., (1985). Handbook of nutrition in the aged. CRC Press.

Welch, B.E., & Crisp, C.E., (1958). Effect of level of expiration on body density measurement. Journal of Applied Physiology, 12(5), 399-402.

Whitbourned, S., (1985). The aging body: Physiological changes and psychological consequences. New York: Springer-Verlag.

Wilmore, J.H., (1969). A simplified method for determination of residual lung volumes. Journal of Applied Physiology, 27, 96-100.

Wilmore, J.H., (1983). Body composition in sport and exercise: Directions for further research. Medicine and Science in Sport and Exercise, 15(1).

Wilmore, J.H., (1984). A reaction to the manuscripts of Roche and Buskirk. Medicine and Science in Sport and Exercise, 16(6), 594-595.

Wilmore, J.H., Vodak, P.A., Parr, R.B., Girandola, R.N., & Billing, J.E., (1980). Further simplification of a method for determination of residual lung volume. Medicine and Science in Sports and Exercise, 12(3), 216-218.

Withers, R.T., & Hamdorf, P.A., (1989). Effect of immersion on lung capacities and volumes: Implications for the densitometric estimation of relative body fat. Journal of Sport Sciences, 7, 21-30.

Womersley, J., Durnin, J.V.G.A., Boddy, K., & Mahaffy, M., (1976). Influence of muscular development, obesity, and age on the fat-free mass of adults. Journal of Applied Physiology, 2, 223-229.

Yearick, E.S., (1978). Nutritional status of the elderly: Anthropometric and clinical findings. Journal of Gerontology, 33(5), 657-662.

Young, E.A., Blondin, J., Tensuan, R., & Fryer, J.H., (1963). Body composition of "older" women. Journal of the American Dietetic Association, 43, 344-348.