European Scientific Journal September 2014 /SPECIAL/ edition Vol.3 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

THE DIFFERENCES IN OBESITY RATING BETWEEN BMI AND SKIN FOLD TESTING

Ezzeldin R. Aly, PhD
Assistant Prof., of Health and Movement Science & Sport Manageement,
Graceland University

Abstract

Obesity in the United States has grown and is becoming a deadly epidemic. Critics point out that BMI is not useful in the evaluation of health; while convenient; it is not an accurate indicator of true "obesity." BMI is not a direct measure of body composition, but it is rather an index related to height and weight. To evaluate the validity of body mass index (BMI) 13 college baseball players were used as a sample. We measured their BMI and compared this to their Skin Fold norms. The results showed that all the subjects were classified as overweight when using the BMI equation. On the other hand, the skin fold test results indicated only two baseball players were classified with a risk of obesity. Thus, BMI must be considered with other factors and should not be used as a sole measurement of obesity.

Keywords: Obesity, BMI, USA

Introduction

Over the past twenty years "obesity", as a classification of one's health, has grown dramatically in the US and is now measurably prevalent among children and young adults. According to the US Centers for Disease Control and Prevention (CDC), obesity is "common, serious, and costly" (Nihiser, 2007). In 2008, the CDC found that "from 1980 to 2008, the percentage of youth who were obese tripled from 7% to 19.6% in children (6-11years) and 5% to 18% in adolescents (12-19 years) (Nihiser, 2007). Because of this epidemic, educational efforts have been enacted to help people become aware of the negative effects of obesity.

Need for the Study

One component being used to make the public more aware of obesity is the application of the Body Mass Index (BMI) as an indicator of a person's "thinness" or "fatness". BMI is, simply stated, the ratio of weight to height squared. Any number over 25 is classified as obese. This measurement, developed in the 19th century by Adolphe Quetelet (Bagust, 2000), has become the standard of measurement for obesity for many health organizations. As an example, BMI indexing for adolescents is now widespread in schools across America. Arkansas, in 2003, was the first state to incorporate programs using BMI information. Since then, "about 30 states have implemented or considered BMI programs" (Wehrwein, 2009). BMI indexing has become so common that Harvard Medical School has stated that BMI "is sometimes called the fifth vital sign" (Wehrwein, 2009).

On the other hand, BMI has gathered its critics. According to the CDC, "little is known about the outcomes of BMI measuring programs" (Nihiser, 2007). While convenient, critics also point out that BMI is not useful in the evaluation of health; BMI is not an accurate indicator of true "obesity." BMI is not a direct measure of body composition, rather it is an

index related to height and weight.

Purpose of the Study

Is BMI a single, accurate indicator of health, or is BMI a better measure of physical fitness and health when used with other measurements to provide an overall assessment of an adolescent's "healthiness"? The purpose of this study is to examine whether BMI testing within a collegiate athletic environment is a justifiable standard as the sole indicator of a person's obesity.

Hypothesis

There will be a difference in obesity ratings among Graceland University baseball players when comparing BMI and the skin fold test results.

Basic Assumptions of the study

Participants will be volunteers from Graceland University's men's varsity baseball team. Height and weight measurements will be accurate. Measurements and calculations of body composition testing will be accurate.

Limitations

Only baseball players will be used.

Review of Literature

According to V.P. Wickramasinghe's research, the worldwide incidence of non-communicable disease is increasing. This is attributed to the increase in the prevalence of obesity (Wickramasinghe, 2009). But how is one classified as obese? There are many field tests and measurements to gain information that can distinguish someone as obese. BMI has been used frequently to determine whether a person can be recognized as obese. It has become the mainstream way to determine obesity because of the ease of obtaining measurements (height and weight) and the easy calculation without any prior training required.

History of the Body Mass Index (BMI)

The Body Mass Index, or BMI, was created by Adolphe Quetelet in the 19th century. It was, in his vision, a simple way to gauge a person's body weight. The components of the equation weighed an individual's height and overall body mass to generate an index number indicating whether a person was under, over or at the appropriate weight level based on those components. According to A. Bagust, "The BMI is based on Quetelet's original 19th century empirical observation that weight tends to vary with the square of standing height" (Bagust, 2000).

Over time, little has changed. The BMI has remained in effect as a primary metric to determine an individual's level of obesity, if any. Its simplicity and low expense have made it an attractive and consistent measure. To say it has become an almost universal tool would be an understatement in terms of its use for health organizations around the US and the world. Even the American Academy of Pediatrics recommends "that BMI should be calculated and plotted annually on all youth as part of normal health supervision with the child's medical home" (Nihiser, 2007). Also, in the "Childhood Body Composition in Relation to Body Mass Index", Maynard found that BMI values have become simple to use because the values can be "easily tracked over time" (Maynard, 2001).

The chart below illustrates the four major classes and the seven sub-groups that comprise the rating scale used with Body Mass Index.

Table 1The International Classification of Adult Underweight, Overweight and Obesity according to BMI

Classification	BMI(kg/m2)	
	Principal cut-off points	Additional cut-off points
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004.

As shown in the chart, the index offers a tiered set of diagnostic measures to classify an individual's weight status. The BMI measurements are divided into four categories ranging from "Underweight" to "Obese" based on scores obtained by dividing weight by the square of the individual's height (kg/m²). Within each category there are sub-classifications that address specific ranges of the index scores. In this way a person can determine where they are rated based on the BMI.

Before the adoption of BMI as a tool to gauge obesity, the United States used simple height/weight tables developed by insurance institutions. According to the 2009 Harvard Health Letter, "The old Metropolitan Life Insurance tables listed 'desirable' weight ranges for a given height" (Wehrwein, 2009). These charts included "an (elbow measurement) for medium frame to try to compensate for the differences between peoples body shapes and skeletal muscle mass" (Pai, 2000). It still was difficult for people to use, but this "desirable weight would indicate those persons with the lowest mortality rates" (Pai, 2000).

BMI is considered to be a screening tool to determine obesity levels for children, adolescents and adults. Is it an optimal tool? Probably not, but it is, at the very least, a good first indicator that something may not be right in terms of a person's weight. If used in conjunction with skinfold measurement or waist circumference measurement, BMI could be used as an additional factor to determine obesity, but should not be used alone.

Other ways to measure body composition

Waist circumference Waist circumference is the "metabolically active fat that collects around the organs in our abdomens" (Wehrwein, 2009). According to the *Harvard Health Letter*, the definition of waist circumference among many researchers is the measure using the top of the hipbone as a landmark with the tape measure going over the navel. Men with a circumference over 40 inches (102cm) and women over 35 inches (88 cm) are at a high health risk and considered obese.

Waist-to-hip ratio The waist-to-hip ratio is waist circumference divided by hip circumference. According to Harvard's definition the "hips are usually measured at the widest circumference, around the buttocks" (Wehrwein, 2009). There are increased health risks for men that have a ratio over 0.9-1.00 and women with the ratio over 0.85.

Skinfold Himes states in his "Screening for Obesity" research that "a skinfold thickness is the double layer of skin and subcutaneous fat (panniculus adiposus) lifted as a fold and measured with standardized calipers and methodology at specific sites on the body" (Himes, 2009). Also, the skinfold is measured with a caliper on males at three sites (triceps, subscapular, and abdominal) and females at four sites (triceps, subscapular, abdominal, and thigh) (Hetzler, 2006).

The question remains – Is the BMI measure the optimal way to gauge obesity or is it a measure of convenience? As with any discussion or review of a topic there are at least two arguments to be made on either a pro or con basis. The issue of BMI as the sole indicator of obesity is not any different. The use of BMI as the sole discriminator is an improper use of the measure. While it is likely an adequate indicator of obesity, BMI alone can unfairly cast an individual into an undeserved category that can impact their social imagery, self-esteem and future finances (health, life insurance coverage, etc.). The fact that "obese" is a multi-factored categorization of an individual must be recognized.

Several key groups feel that using BMI is an accurate measure as a sole indication of obesity. For example, in 2005, the US Preventive Services Task Force (USPSTF) found "BMI (calculated as weight in kilograms divided by height in meters squared) percentiles for age and gender is the preferred measure for detecting overweight children and adolescents. The index is feasible, reliable and is consistent with adult obesity standards" (USPSTF, 2010).

In addition, John Himes, a PhD from the University of Minnesota, Division of emiology, found in his 2009 research that "There is little evidence that other measures of body fat such as skin folds, waist circumference, or bioelectrical impedance are sufficiently practicable, or provide appreciable added information to be used in the identification of children and adolescents who are overweight or obese" (Himes, 2009).

Giovanna Turconi and several of her colleagues from the University of Pavia, in Pavia, Italy in a 2005 paper to the *European Journal of Health*, agree to the use of BMI in their research. They found that "correlations that emerged from their work show that BMI is a good adiposity index also in adolescents, it acts as an indicator of cardiovascular risk conditions" (Turconi, 2010).

Other researchers have found that BMI must be taken in consideration with other factors. According to a 2009 research study conducted by David Freedman and Bettylou Sherry for the Centers for Disease Control in Atlanta, GA, "BMI cannot distinguish between body fatness, muscle mass, and skeletal mass and its use can result in large errors in the estimation of body fatness" (Freedman, 2009). Further they find that BMI is "almost useless as an estimator of percentage of body fat in normal-weight children" (Freedman, 2009). The difference between lean muscle mass and bone from body fat are large determinants in classifying obesity. Another example illustrating how BMI is too vague a measure is noted by *Tufts University in their Health News Letter*. They have concluded that "BMI can definitely be left aside as a clinical and epidemiological measure of cardiovascular risk for both primary and secondary prevention BMI is not a good measure of visceral fat, the key determinant of metabolic abnormalities that contribute to cardiovascular risk" (Tufts, 2006).

Other factors that should be considered when measuring BMI are race and gender. According to Dr. Stephen Daniel's research centering on the utility of BMI and the consideration of race and gender, "When BMI is used in a research or clinical setting to evaluate body fatness, the maturation stage, race, gender, and distribution of fat should be considered in the interpretation of the results" (Daniels, 1997). This research found that BMI cannot be "used as an equivalent measure of fatness in girls and boys or in blacks and whites" (Daniels, 1997). The results of the study show there is a difference in gender body composition and race body composition. Gender and body composition should not be

considered similar in any way. Not everyone is the same**.** All bodies are not created equally and using the BMI equation as a sole measurement is saying everyone is the same. Similarly, Kerry Welch and Chris Craggs, from the University of Nottingham, submit in their abstract of the *Learning Disability Practice* magazine for nursing, that their research supports a multi-factor approach to measuring obesity. They have determined that "BMI should not be used exclusively but as a part of a range of methods that are designed to diagnose and predict conditions" (Welch, 2010). A third argument for the consideration of other factors is reflected in an article submitted by A. Bagust. In examining the article, "An Alternative to Body Mass Index for Standardizing Body Weight for Stature", Bagust found that "according to BMI, female predominance is strongly associated with height, whereas male prevalence were not" (Bagust, 2000).

Since all these factors are not included in the BMI equation, which only includes height and weight, the perception of the obesity epidemic has the potential to be skewed in a negative direction.

Critics are beginning to doubt that using BMI is the best gauge to predict health risks in children. One study done by Michael Schmidt in the *International Journal for Obesity* found "waist circumference was the best predictor of metabolic health," which included risk factors of "excess abdominal fat, plus high blood pressure, blood sugar and cholesterol, and can up the chances of diabetes and heart disease" (Schmidt, 2010). Agreeing with this study is a study done in 2004, which found that waist circumference explains obesity-related health risks, not BMI. This research, conducted by Ian Janssen, found that "for a given waist circumference value, overweight and obese persons have a health risk that is comparable with that of normal-weight persons. Such an expansion of waist circumference risk strata could have important implications" (Janssen, 2004).

Skinfold measurements are one of the most practical methods to use to "determine body fat" (Riebe, 1996). It has a standard error of 3% (Riebe, 1996) and training and practice are essential in obtaining accurate skinfold measurements. This emphasis on training and practice is important to ensure accurate results. A study done by Creighton University found results indicated "skinfold measurements most accurately estimated the percentage of body fat" (Riebe, 1996, p. 66-69). Whitehead's research in the *Physical Educator* agrees with the skinfold accuracy and even clarifies "the inexpensive plastic Fat Control calipers gave measurements that were not different than laboratory calipers" (Whitehead, 1993). This makes skinfold measurement inexpensive, but a qualified person is still necessary to obtain the results. One downfall is the caliper cannot measure the morbidly obese, but this is only a small percentage of the people.

The controversy remains. BMI is popular, simple, and touted as accurate in determining health and obesity rates (Mathews, 2008). Skin fold measurements, while requiring some simple equipment and a practiced person to perform the measurements, may more directly measure body fat. If both methods are accurate, then results for individual subjects should be the same.

Methodology

Subjects

Subject sample comprised of approximately 13 males, age 18-25, who are members of the Graceland University varsity baseball team.

Procedure

A meeting was held after an afternoon baseball practice to recruit volunteers. At the meeting, attendees were given and informed consent form (Appendix A) explaining the purpose of the study, what would be asked of them, and possible benefits and risks. Subjects

wishing to see their body composition data could do so by notifying the researcher at the start of the data collection process. Those agreeing to participate were asked to report one time for measurements. Volunteers met in the Multipurpose Room in the Hampton Center at 02:30PM on November 5, 2010 to fill out "Subject Profile Form" (Appendix B). Each subject was then assigned a subject number to be used on the Subject Profile Form (Appendix B). Only the researcher had access to the list of subject names as they correlate to subject numbers. (This will only be retained in order to provide each subject body composition data if desired.) All reporting of data will use only subject numbers. First, the researcher measured and recorded height and weight. These measurements were then entered into a BMI equation and equated to a body composition category. Next got assistant from (Men's Trainer) as a certify athletic trainer took skin fold measurements on each subject; up to three measurements at each of three sites (Thigh, Abdominal, and Chest sites) were taken. Measurements for each site were recorded on the data collection sheet (Appendix B). Later the researcher used those numbers with the equation to determine body composition (percent of fat). Once all subjects were measured and body composition has been calculated using each of the two tests, the Researcher did a comparative analysis of the results between methods for each subject. The equation is as follows:

Body Density = BD

B D = 1.1093800 - 0.0008267*(sum of three skinfolds) + 0.0000016*(sum of three skinfolds)^2 0.0002574*(age)

Results

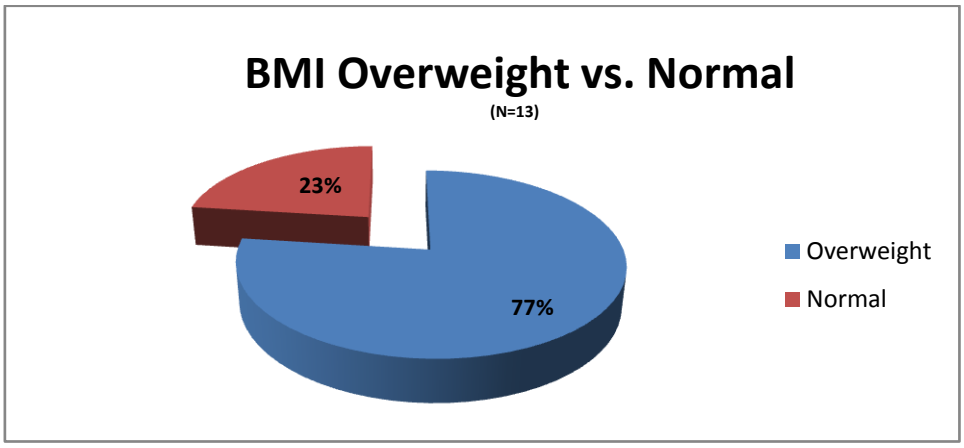
Table 2

STUDY RESULTS

						Subject Physical Traits			
Subject #	*BMI Index*	*BMI Classification*		*Skinfold Rating %*	*Skinfold Classification*	*Age*	*Height (inches)*	*Weight (lbs)*	*Gender*
MK 01	*28.6*	***Overweight***		*22.4*	***Moderate risk***	*20*	*72*	*211*	*MALE*
MK 02	*24.4*	*Normal*		*8.5*	*Lean*	*23*	*74*	*190*	*MALE*
MK 03	*26.2*	***Overweight***		*13.4*	*Fitness*	*22*	*77*	*221*	*MALE*
MK 04	*27.2*	***Overweight***		*9.8*	*Lean*	*20*	*68.5*	*182*	*MALE*
MK 05	*28.0*	***Overweight***		*18.5*	*Healthy*	*18*	*67*	*179*	*MALE*
MK 06	*27.6*	***Overweight***		*24.0*	***Moderate risk***	*21*	*73.5*	*212*	*MALE*
MK 07	*21.9*	*Normal*		*8.0*	*Lean*	*18*	*71*	*157*	*MALE*
MK 08	*27.2*	***Overweight***		*13.4*	*Fitness*	*21*	*65.5*	*167*	*MALE*
MK 09	*26.8*	***Overweight***		*12.5*	*Fitness*	*21*	*69*	*182*	*MALE*
MK 10	*26.0*	***Overweight***		*11.6*	*Fitness*	*21*	*65.5*	*159*	*MALE*
MK 11	*29.3*	***Overweight***		*19.0*	*Healthy*	*24*	*75*	*235*	*MALE*
MK 12	*25.7*	***Overweight***		*8.9*	*Lean*	*21*	*67*	*164*	*MALE*
MK 13	*24.2*	*Normal*		*8.9*	*Lean*	*19*	*74.5*	*191*	*MALE*

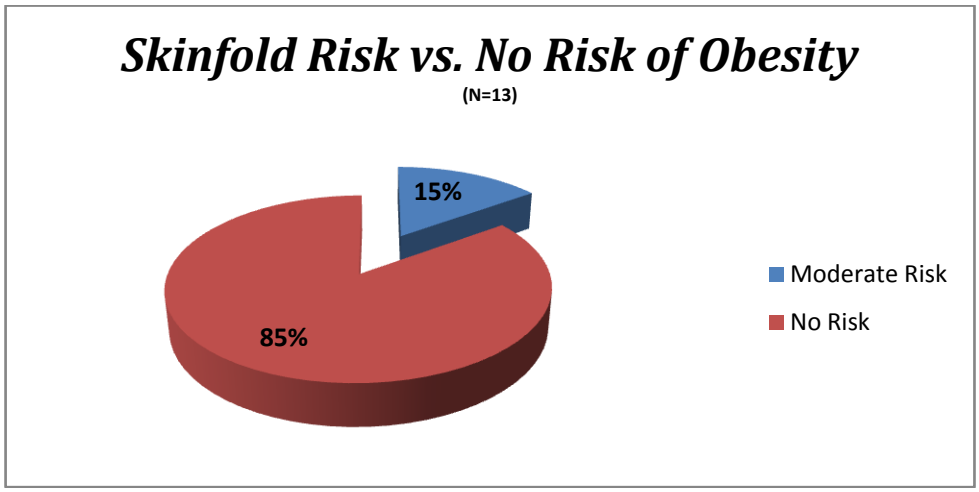
*This chart shows all of the 13 subjects and their measurements and classifications for both BMI and skin fold.

Table 3



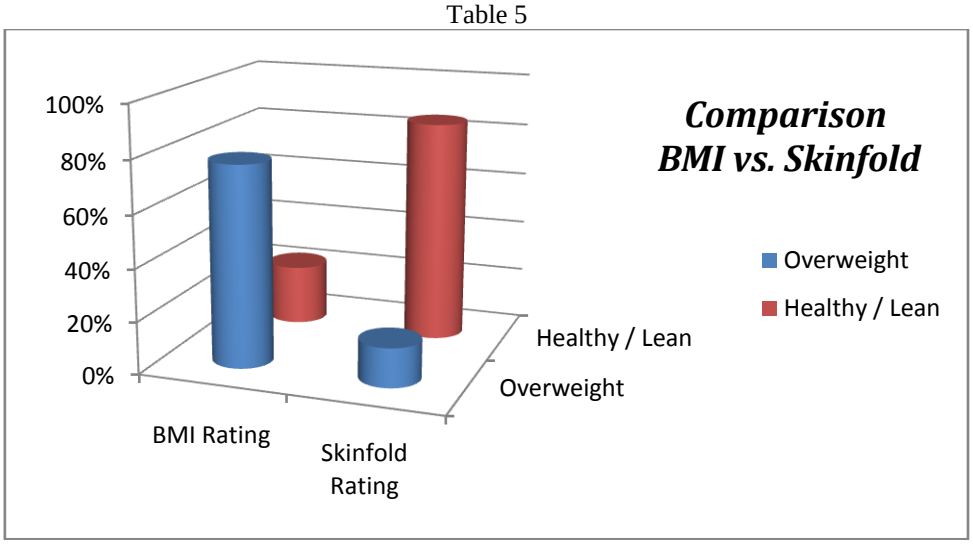
*The chart above illustrates all of the subjects classification of overweight vs. normal weight from the BMI norms.

Table 4



*The chart above illustrates all of the subjects classification of risk of obesity vs. no risk from the skin fold norms.

Table 5



*The chart above illustrates the comparison of BMI overweight vs. normal weight classifications and skin fold risk vs. no risk classifications of all subjects.

Conclusion

Out of all the study subjects using the BMI equation, ten of the fifteen were classified as overweight, compared to the skin fold test, where only two were classified with a risk of obesity. The margin of difference is very substantial when looking at these two tests. The results show the BMI equation should not be used as a single indicator of obesity and is not reliable enough when measuring body composition by itself. Knowing that the BMI equation may not be a reliable indicator when used alone could have implications on the classification of the overall population being obese or overweight. The results do not claim the entire population is wrongfully of being overweight or obese, but the numbers would be more accurate if other measurements or tests were applied. Time and precision would be a factor when "remeasuring" the population, but it would give true results without any false pretenses. Study in 2007, by The Department of Kinesiology, Epidemiology, and Physical Medicine and Rehabilitation, at Michigan State University, tested the relationship between BMI and percentage of fat to also determine the accuracy of BMI as a measure of percentage of fat in college athletes and non-college athletes. The results of their study showed that "BMI is not an accurate measure of fatness in college athletes and non-athletes" (Ode, 2007, p. 403-09). The results that they had gathered proved that "BMI misclassifies normal fat individuals a large percent of the time" (Ode, 2007). This study, on a much larger scale, supports the results the researcher have founded by showing that collegiate athletes, along with non-collegiate athletes do not conform to the BMI standards.

Another study in 2008, done by the Health, Physical Education, and Recreation Department at Utah State University, studied "Eighty-five National Collegiate Athletic Association (NCAA) Division 1 football players" (Mathews, 2008, p. 33-37), and their BMI classification of "overweightness" and/or obesity. The study they conducted also showed that "BMI alone is not a valid indicator of overweight and obesity in a strength-trained athletic population. However, some collegiate football players… meet multiple criteria for obesity" (Mathews, 2008, p. 33-37). This study, which was mainly focused on collegiate athletes, is fairly compareble to the study we had performed. In our study a fair number of subjects did not fit the BMI standards but were exceptional with the skin fold measurements. On a proportionate basis, the skin fold results in our study appear to provide a more accurate analysis of the athlete's health status. This would be confirmed even on a simple visual assessment of the test subjects versus the BMI judgments.

If there were to be a continuance of this study, we suggest adding two of three different ways to measure body fat and compare all of the different tests next to BMI and see which would ultimately be the "most accurate". Another recommendation for further research would be to test both male and female collegiate and non-collegiate athletes. Having a wide variety of subject would give a good perspective on the overall classification of obesity in the United States.

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Appendix A
Informed Consent

Dear Graceland University Participant:

You are being asked to participate in a study on **The differences in obesity rating between BMI and skin fold testing** by participating in the various body composition tests. You will be asked to report one time for approximately fifteen minutes to complete testing. Testing will be done on Friday at 11:00am.

Possible benefits of participation include improving the body of knowledge related to body composition testing and its accuracy among athletes. Additionally, you will be able to receive your body composition data for personal use. Please let the Researcher know if you would like to receive your individual results.

Possible risks of participation are not greater than activities of daily living. You may experience minor pinching from the skin fold calipers.

During the study you will be asked to participate in two body composition tests.

1. During the skin fold testing you may experience minor pinching from the calipers necessary for testing. You will be asked to not have participated in any sort of physical activity approximately 4 hours prior to testing.
2. For the BMI testing you will be asked to step on a scale to gain your weight and stand against the wall for accurate height measurement.

The results of testing will be kept confidential. Although the findings may be published, your name will not be used, and no one reading the results of the research will be able to identify you. Your participation in this study is voluntary. You may discontinue your participation at any point without penalty.

Attending and participating in testing indicates your understanding of this information and consent to participate.

Appendix B
Subject Profile Form

Last Name _____
First Name _____
Weight _____ pounds
Height _____inches5ft = 60 inches 6ft = 72 inches
Age _____
Gender M F (circle one)
Skin Fold Sites
Abdomen_____
Thigh_____
Chest_____
Subject testing number: _____