Bioelectrical Impedance Analysis as Compared with the Gold Standard in Terms of Validity and Reproducibility

Honors Project

In fulfillment of the Requirement for

The Esther G. Maynor Honors College

University of North Carolina at Pembroke

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December 5, 2015

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ABSTRACT

BIOELECTRICAL IMPEDANCE ANALYSIS AS COMPARED WITH THE GOLD STANDARD IN TERMS OF VALIDITY AND REPRODUCIBILITY

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May 4, 2013

Body composition, a term familiar to most Americans, is an important predictor of overall health. There are currently six common ways to assess an individual's body composition, and two of them can be done at home. Bioelectrical Impedance Analysis (BIA) is one of the most common in-home assessments and can be completed in just a few minutes with the use of an bathroom scale. Another popular assessment, the BodPod, is known as the "gold standard" and is found only in laboratory settings. Reliability is a concern for many when using an at-home assessment when compared to an expensive piece of laboratory equipment.

Thirty-seven UNCP students' body composition was measured using both BIA and the BodPod. The results were then analyzed using a paired sample T-test (p=0.05) for males, females and the cohort. Cohort results were then compared using a Pearson Product Moment Correlation. The T-test was not statistically significant for male subjects (0.07896), but was statistically significant for the females (0.03318). The Pearson correlation showed a .8486 strong, positive correlation between BIA. With outliers (those with greater than 9% difference between scales) removed, the correlation improved to .9111. For a general population, BIA is an acceptable method of obtaining body composition measurements.

Chapter 1

Introduction

For many Americans, body composition is a term they know only from media and possibly at their yearly check-ups at the doctor's office. However, many people may not be conscious of their personal body composition. It has been shown that body composition, along with other factors such as smoking and family history, can be a strong predictor of one's overall risk for chronic disease (Baumgartner, 1995). In fact, studies show that current trends in obesity predict that all adults will be obese by 2048 (Article Resource Association {ARA}, 2012). While this seems staggering, it's not hard to believe considering that, for adults, the Centers for Disease Control and Prevention (CDC) (2012) showed that the obesity rate in every state is at least 15%. Even worse, 69.2% of American adults are currently overweight or obese (CDC, 2012). Furthermore, 33% of all children and teenagers are currently overweight or obese (et al., 2012).

Many use the excuse that they can't achieve an optimal level of fitness because they lack necessary funds. What if it could be shown, though, that body composition, one of the five components of fitness, could be assessed with minimal costs to the subject? If proven to be reliable, the results of an in-home body composition test could equip people with some of the knowledge they need to make healthy, informed lifestyle choices.

Body composition is defined as the proportion of fat, muscle, and bone of an individual's body (Merriam-Webster, 2012). Interest in the function and health of

the human body is no new concept. In fact, Leonardo Da Vinci drew the Vitruvian Man in 1490 (Davinci, 1490). Modern body composition measurements, however, were first noted by Al Behnke in the early 1940s (Pierson, 2003). Behnke made his measurements on healthy sailors. Those measurements, however, in contrast to today's measurements were for anatomical reasons.

Today's measurements focus more on the physiology and function of the human body (Pierson, 2003). Frances Moore was the first person to take physiological measurements, also in the 1940s. The measurements taken and recorded by Moore lead to the discovery of a link between the charge of batteries and the charge of cells by focusing on the numerous ions found within the human body (et al., 2003). Body composition is assessed on people of all ages including both healthy individuals and those with chronic diseases, to establish a baseline of functional health and identify and minimize risk factors for chronic disease. (Lee, Blair, & Jackson, 1999). It is true that an individual could simply use waist circumference and body mass index as a measure of body composition (Zhu, 2004), but using an apparatus such as a BodPod or a Bioelectrial Impedance Analysis machine provides a direct measurement of one's actual physical makeup. An assessment with this amount of detail gives an individual a clear view of his/her personal body composition and specific needs. From these assessments, resting metabolic rate, total energy expenditure, and daily caloric needs can be closely estimated.

Two well-known methods of body composition are Bioelectrical Impedance Analysis (BIA) and air displacement plethysmography (BodPod). The foundational

principles upon which BIA was built were first discussed in 1871 (ESPEN, 2004). Thomasset first experimented with determining total body water (TBW) with the use of needles (et al., 2004). Body composition measurements using the principles of BIA were first used in the 1970s, and by the 1990s, the consumer market was booming with several at-home, easy-to-use models of BIA (et al., 2004). BIA has evolved from the early models of single frequency to the more modern models that utilize multi-frequency electrical current (et al., 2004).

BIA works on the principle of density (Liedtke, 1997). According to the laws of physics, density is equal to an objects mass divided by its volume. Density is common associated with a liquid, such as water. As discovered many years before, the body contains a large amount of water. Science has also shown that lean tissue mass contains a large amount of water and electrolytes, while fat and bone do not. Because of the high conducting properties of the electrolytes found in lean mass, current flow is high.

The conductive and resistive nature of the human body is at the very basis of anatomy of physiology (et al., 1997). Each cell within the body is surrounded by a protein-lipid-protein membrane layer. This layer is specifically designed to maintain a gradient between the inside and outside of the cell (et al., 1997). This layer allows the cell to react when stimulated by current. Fat and water, however do not react when stimulated because they do not contain the important membrane (et al., 1997). This is important in BIA, because it gives an overall view of the total amount of cells (minus fat) that are contained within an individual's body. The electrical properties of human tissue correlates to a geometric angle between 6 and 9 degrees

(et al., 1997) The higher the angle, the more reactive properties contained within the cell; thus the higher content of lean mass (et al., 1997).

While BIA has been used in both commercial and home body composition measurements for some time, the method of air displacement plethysmography (BodPod) is a newer method that is quickly rising as the preferred method for obtaining body composition measurement in research and laboratory settings (Dempster and Aitkens, 1995). Scientists first researched using air displacement as a measurement in the 1960s, but the measurements were far too deviated to consider them accurate or reliable (Dempster et al., 1995). However, in 1995, Life Measurement Instruments developed a chamber known as the BodPod that measures body composition with a mere 3% margin of error (Dempster, 1995). It is considered in many circles to be the new "gold standard" of body composition measurement (Dempster & Aitkens, 1995).

Whereas BIA works with the electrical current of body fluids and tissues, the BodPod measures pressure gradient differences. Boyle's law states that at a constant temperature, the product of pressure and volume is constant (Dempster., 1995). There is also an adaptation to this law known as Poisson's law, which accounts for a condition in which temperature cannot be held completely constant for a certain period of time. Dempster (1995) states "a quantity of air compressed under isothermal conditions will decrease its volume in proportion to the increasing pressure". The individual chambers within the BodPod are held at a constant volume. As the test runs, an oscillating diaphragm disturbs the volume of both chambers. The difference between the pressures in the two chambers is then used

to determine pressure amplitude (Dempster., 1995) From pressure amplitude measurements, total body mass can be calculated. Additional calculations must be made to account for residual lung volume and body surface area. The convenience of the BodPod is that these calculations are programmed in the computer, also attached to the BodPod (Dempster, 1995).

With the downward spiral of Americans' health and fitness in full view, and the nation on the cusp of healthcare reform, it's obvious that Americans need to be aware of their individual body compositions. Furthermore, it's never been more important that Americans focus on primary prevention, rather than the acute care healthcare model, the keys to prevention being through education and knowledge. A valid, in home, body composition analysis could be a catalyst for change in many Americans. The knowledge of their body composition state could inspire people to begin make healthier lifestyle choices all of which could reduce their risk for chronic disease and premature mortality.

With the American obesity epidemic at alarming levels, it's possible that a simple at home body composition assessment can be a catalyst for making better health choices. Therefore, the purpose of this study is to determine whether a simple comparison between a BIA bathroom scale and the BodPod, among a heterogeneous group of people, will justify the use of a BIA bathroom scale for accurate body composition monitoring in the home., -

Chapter 2

Review of literature

Look around and you'll undoubtedly see a handful of people who are overweight. In a nation surrounded by technology, fast food and comfort, fitness isn't on the top of many people's priority list. In fact, researchers have now released new information placing U.S. obesity rates at 40% by 2030 (Associated Press, 2012). Aside from apparent obesity rates, there's a misconception that "skinny" means "fit." This is not always true. For example, anorexics are not at all fit. They're skinny and at some moderate points in the disorder, many of them have a "desirable" body. Being underweight can pose just as many risks as someone who is overweight or obese. Weight issues on both ends, combined with an abundance chronic disease and tobacco only compound the issue of body composition. In modern America, the choice to improve body composition is easy for most. The thousands of retailers, fitness centers and grocery stores found in nearly every city make it easy for people to have access to the resources needed to positively impact their body composition.

Self-awareness of one's body composition could hold important implications for the health and fitness of future generations of Americans. With all of the information available to Americans today, there's no excuse for people to be in the dark on their body composition. Body composition testing, the very foundation of exercise physiology, gives the subject information on his/her fat to lean mass ratio, which can then be assessed to give the subject information on his/her individual exercise and

nutrition needs. There are currently six common ways to assess body composition. Two of the six common methods can be done at home

History

The history of body composition testing is rooted deep within the history of exercise physiology. Exercise physiology by definition is "The scientific study of the acute and chronic metabolic responses of the human body to exercise, including biochemical and physiologic changes in the heart and skeletal muscles." (Katch, McArdle, & Katch, 2011) The earliest recorded mention of exercise physiology is found in early Greece and Asia Minor (2011). Some of the earliest recorded civilizations were concerned with the overall health of their bodies (2011). Herodicus, a well-known physician greatly stressed nutrition and it's impact on the human body as early as 480 B.C (2011). It's no new thing for people to be concerned with how their bodies function, in turn affecting how they function as a member of society(2011).

Dr. Albert Behnke developed the first modern model of body composition in 1960. His work focused on gender differences in body composition and led him to create the reference man and reference woman (2011). The differences in these models account for a larger frame and heavier bone mass in a man, but a larger amount of sex-specific fat in a woman. This research model was breakthrough for that time because it provided a physical model for physiological differences in men and women. The model also implied that hormones and biological factors, not just lifestyle play an important role in determining the overall body composition of an individual person. (Katch et al., 2011).

Today, body composition is used in practically every realm of the health world. From exercise physiology to personal training, body composition testing is an effective means to establish a baseline level of health for a particular individual.

Comparison of Models

While there are many models of body composition assessment on the current market, (BIA) and the BodPod are among the most popular. The comparison drawn here will be among validity and reproducibility. The BodPod, considered to be the "gold standard," is said to be reliable, but accessibility is a concern for those who do not have access to a well-equipped human performance lab, such as those found in many universities.. BIA tools can be bought in Walmart, or ordered from a website such as Amazon.com, but reliability can be a concern.

The BodPod works on the premise of air displacement. When a subject is being evaluated through the BodPod, they are to wear tight, form-fitting clothing such as a bathing suit or compression shorts. Then, the subject sits inside a "pod." Inside this pod are two chambers, connected by an oscillating diaphragm. The diaphragm measures the pressure differences in the chambers. The pressure changes between the chambers increase or decrease in respect to each other to maintain equilibrium. A computer connected to the BodPod then uses a series of formulas to calculate body fat, fat free mass and lean mass of the individual based on the basic formula, density= mass/volume. While the accuracy is comparable to that of hydrostatic weighing, it is a safer and more comfortable method of obtaining body composition measurements (Florida Fitness Testing, n.d.). Hydrostatic weighing is a method of body composition analysis that is

derived from Archimedes principle, which states “the buoyant force is equal to the weight of the water displaced” (McGinnis, 2005). The process involves submersing the subject in a tank of water while weighing them on an underwater scale. Because fat is less dense than fat-free mass, the more fat a person contains, the more likely they are to float (Kennedy, Wilmore & Costill, 2012).

The premise of Bioelectrical Impedance Analysis (BIA) has been explored since the mid-1800s (ESPEN, 2004). BIA takes a simple concept and then correlates it to the complex human body. BIA works on the premise of electrical current and the density of the tissues (Liedtke, 1997). The theory of this method is that there is a difference in fat mass and fat free mass when analyzed through electrical current (deVries & Housh, 1994). For this analysis, subjects either hold a hand held device in their hands or they stand on a BIA platform. In their book, *Physiology of Exercise,* deVries and Housh (1994) stated, “Fat-free weight has a greater electrolyte content that adipose tissue and therefore more readily conducts electrical current.” This method, like hydrostatic weighing, works on the principle of body density (1994). One study noted, “BIA models may not be reliable for estimating body composition in a range of populations because the equations are specific to the group on which they were established.” (Peterson, Repovich, & Parascand, 2011)

Cheap BIA versus Expensive BIA: Does it matter?

The convenient thing about BIA devices is that they can be bought at any Walmart, Target, or similar store. BIA devices operate by one of two methods, depending on the grade and model of the device. The first method, most commonly

found in commercial grade BIA devices, is the use of electrodes. These are among the most expensive of BIA devices. They are generally over $100. In this method, electrodes are hooked to the wrist and ankle of the subject. The electrical current is measured throughout the entire body. Because the current flows through the entire body, the device is able to measure total body water and fat-free mass (2011). In contrast, the consumer scale models found in retail stores are known as “limb-to-limb” devices. They can be purchased for as little as $12. These devices measure low electrical current between fingers, hands or feet. After the current is measured, the device takes a pre-determined formula and figures the total amount of body fat. According to Peterson et al. (2011), the problem lies in that the particular formula used may not be accurate for a certain population of people. Though Peterson’s study suggests that BIA devices are not reliable for use on women, a separate study, performed on active women, indicated that a leg-to-leg BIA device was just as reliable as hydrostatic weighing when measured on active women (Civar, Aktop, Tercan, Ozdol, & Ozer, 2006).

Chapter 3

Methods and Procedures

Thirty-five healthy subjects (mean age 21.3 ± 0.5) were recruited through means of a flyer (see Appendix A) created by the PI, and all subjects participated out of their own free will. The study was approved through the UNCP Institutional Review Board under the protocol number 12-10-001. Subjects were contacted through email to schedule an individual time to have their body composition screened. For the actual testing day, they were instructed not to eat, drink or exercise two hours prior to the testing. Also, females were instructed to wear either a bathing suit or compression shorts and a sports bra and that the males were instructed to wear only compression shorts. No additional equipment was required of the subjects.

As each subject arrived for their scheduled time, they were taken into the human movement lab located on UNCP's campus where they were instructed to clean their feet with wipes provided and to step on a Tanita BIA scale that measure their weight and body fat percentage. After this procedure, the BodPod machine was calibrated for each individual person to establish a baseline measurement for each subject. Calibration involved a series of volumetric measurements taken by the BodPod to ensure the apparatus obtained accurate results for each person. Before starting the BodPod measurements, subjects were notified that if at any time they because panicked, they could push a release button that would stop the machine and allow them to exit. Next, subjects were given a swim cap to wear and were instructed to sit as still as possible inside the BodPod machine in order to obtain the

most accurate results, and a minimum of two measurements were recorded by standard BodPod procedures.

After the BodPod measurements were completed, subjects were instructed to gather any items, including clothes that they brought with them. Subjects were given the opportunity to take a copy of their individual results with them. Also, each subject was given an opportunity to ask questions about his or her individual results and what they could do to change their body composition, if needed. Weight and body fat percentage were recorded after each measurement and were kept on a password-protected laptop, inside a locked room. Initially, subjects were not required to give any more information or undergo anymore testing after their initial testing. However, upon evaluation of the results, a few discrepancies were detected. These discrepancies amounted to a greater than 9% difference between results from the BIA and results from the BodPod. The subjects in whom discrepancies were found (Five, in total) were contacted about retesting. Four subjects were retested, with a different setting enabled on the BIA scale. In addition, the subjects were tested by a third method, skinfold measurement, for which Jackson and Pollock's three site method was employed. The second set of data was analyzed and compared to the first to determine reliability and validity of each data set.

After all data was collected,it was analyzed using paired-samples t-Tests ($p = 0.05$) and Person Product Moment Correlations.

Chapter 4

Results

The statistical analysis of the body composition results, by BodPod and BIA, for males only, females only, and the entire cohort were analyzed through paired-samples t-Test with a p = 0.05. The males only comparison was not statistically significant (p = .70896). However, the women showed a statistical significance (p = 0.03318). The entire cohort was also not statistically significant (p = 0.06958).

A Pearson (r) correlation was performed on the cohort results, which showed a correlation of 0.84860. The cohort Pearson (r) correlation did not showed a strong, positive correlation with all reports tests (.8486). However, after removing proposed outliers to the test (those with greater than 9% difference between the two scales), the Pearson correlation showed a strong, positive trend of .9111correlation between the two scales (See Figure 3).

Figure 1.

Differences in Body Fat Percentage Among Females as Measured by BodPod and BIA.

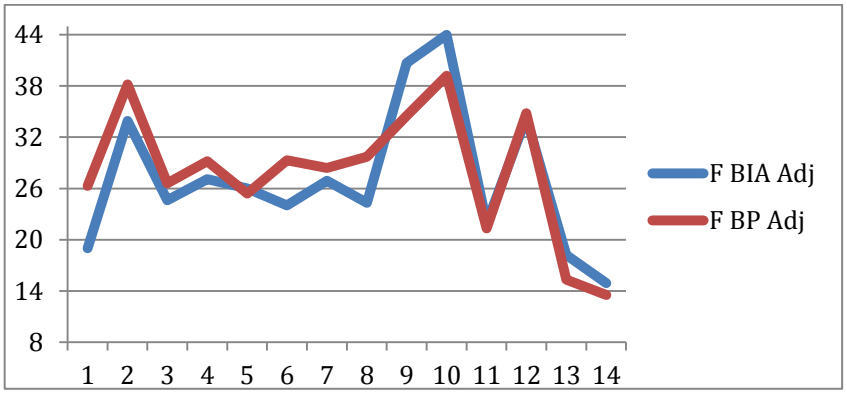
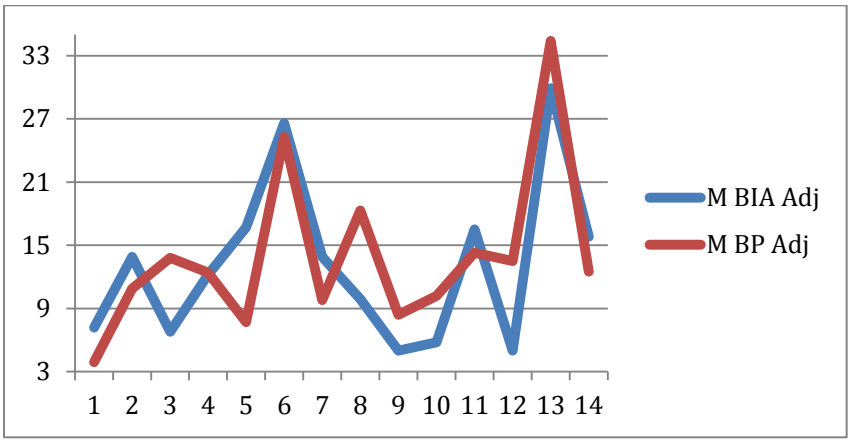


Figure 2.

Differences in Body Fat Percentage Among Males as measured by BodPod and BIA.



Chapter 5

Discussion

Based on statistical analysis from raw data, a strong correlation was found between the BodPod and BIA. Other studies, such as one completed by a collaborative effort between Eastern Washington University and Linfield College also found a moderate, positive correlation (r= .700) between 7 different BIA assessments and the BodPod (Peterson et al.,, 2011). In this study, the Pearson correlation boasted an .8486 correlation for the general population (2011). This strong correlation indicated that for the average person, BIA is an acceptable alternative to the BodPod in testing body composition. This may be due to the differential properties of fat and lean tissue. Whether using air displacement or electrical current, the different types of tissues will behave differently when a stress is applied to them. It should be noted that in the analysis of data, any outliers (those with a greater than 9% difference between the two scales) were removed after the first correlation to run an additional correlation. After the outliers were removed, the correlation improved from .8486 to .9111. This even further supports that for a general population of people, the BIA is in fact reliable.

A random sampling of the outlying subjects were retested and then tested using a skinfold caliper (SKF). This was done to see which method was more accurate for the sub-population. The results of the additional testing showed that the BIA is actually a better choice for those people, because though the measurements between the BodPod and BIA were greater than 9% difference, the measurements between BIA and SKF were almost identical. For the four people

retested using a skinfold caliper, the results of that test were within 1% of the body fat percentage calculated through BIA.

The reason for the differences between BIA and the BodPod lies in a cross comparison among those specific people. It can be theorized, upon analysis of the individuals, that all outliers were either endurance athletes or had compromised lung volume by way of pulmonary disfunction due to illness or smoking.

A study completed in the early '90s shows that pulmonary function is compromised in those who are current smokers (Xu, Dockery, Ware, Speizer, & Ferris, 1992). In opposition, endurance athletes' aerobic training improves their lung function. Specifically, the aerobic training endurance athletes endure increases their lung volume by increasing their maximum voluntary ventilation (Katch et al.,2011). Maximum voluntary ventilation (MVV) involves a process of taking a measurement of 15 seconds of deep breathing and estimating the capacity based on the volume breathed for one minute.

In one study, the United States Nordic Ski team members' MVV was measured to be as high as 239 L-min^{-1} as compared to a normal males MVV of 180 L-min^{-1}(et al., 2011). This would normally be helpful in a test such as the BodPod, which takes into account the subjects breathing. However, it can be proposed that in a resting state, endurance athletes, such as cross country runners or swimmers, are actually breathing shallowly because the body does not need as much air during rest as is does during prolonged aerobic exercise.

The secret to this lies in a physiological term known as VO_{2max}. VO_{2max} is defined as "maximum volume of oxygen that by the body can consume during

intense, whole-body exercise, while breathing air at sea." Aerobic training naturally increases VO_{2max}. Two things primarily increase oxygen consumption abilities: oxygen delivery capabilities and the efficiency of mitochondria. This is closely related to the cardiovascular system, which also improves due to aerobic training. As the cardiovascular system improves, the blood in circulation is better able to extract and deliver oxygen to the rest of the body. To this end, endurance training can increase VO_{2max} up to 25%. This increase correlates to improved lung function (Seiler, n.d.). It's also argued that the increase in lung volume is genetic, as is the number of type I muscle fibers found in endurance athletes. (et al., 2011). For the subjects with compromised lung volume, they may not be able to take in as much air, creating the same effect as with endurance athletes, but for an opposite reason. This theory suggests that the subjects were possibly breathing shallowly while in the BodPod, thus creating the skewed results. However, this cannot not be determined for sure.

Even more so for these people, BIA is a better alternative to the BodPod, while also cheaper and more accessible. When shallow breathing in the BodPod occurs, the BodPod reads it as a greater mass, which makes them seem more "fat." This is not an issue for BIA because BIA does not take into account a person's breathing. In addition, a thesis study completed by Phil Blaney showed the thoracic gas volume has a significant effect on BodPod results. He found that both those with greater than normal thoracic lung volume (endurance athletes) or those with smaller lung volumes (possibly compromised lung volume) will have greater variability in body composition testing (Blaney, 2008).

Another possible theory of the reasoning behind the proposed outliers is also found in the thoracic prediction made by the BodPod, but stems from a different perspective. "Manufacturers of the Bod Pod® have established predictive values of thoracic gas volume based on height and age" (Blaney, 2008). This theory suggests that the thoracic lung volume predicted by the BodPod is made from general characteristics of the subject. Three out of four outliers were conditioned endurance athletes. This insight into the physiological body structures of the subjects implies that they have a greater lung volume due to hypoxic training (Katch, McArdle & Katch, 2012). Also a common characteristic among these outliers was their small stature. This is an important piece of information in reference to this theory because their lung volume is large, especially when compared to their small statures. It is possible that because of their large lung volume, the BodPod incorrectly under-predicted their lung volume. If this was the case, the extra volume of their lungs is now being measured as mass. With a greater mass being read from their lungs, they're now being measured as more dense, which in turn lends itself to a higher content of body fat. The other one of the four outliers, however, was not an endurance athlete. However, this subject was not only tall, but was thin when weight was compared with height. Because of the contrast in body measurements, it's reasonable to assume that the BodPod again under-predicted the lung volume of the subject. This could be read from a perspective that the subject was actually more "broad" than the BodPod measure him/her as being.

Though several guidelines were in place throughout data collection, limitations may have affected the overall outcome of the study. The BIA scale used

for data collection was a Tanita BC-533 InnerScan Body Composition Monitor. Guidelines suggest that participants refrain from eating, drinking, or exercising three hours prior to being tested. While participants were informed of this guideline, their amount of adherence to the guideline could have affected the overall readings. Also, the sample size, which was 36 people, was a small cross-sectional area of a heterogeneous group of people found on a college campus. While the results stayed consistent with the hypothesis, a larger sample size may have given a more variable result.

Quite possibly one of the biggest limitations to the study lies in the settings of the BodPod. The BodPod allows the user to use a "predicted" body density/thoracic lung volume model already programmed within the system and based on gender and race or a "measured" body density/thoracic lung volume which involves the participant breathing in a tube connected to the BodPod. Because of time constraints and ease of testing, the "predicted" models were used, which could have created the outliers identified in the results. In fact, research has shown that there is a difference between predicted total gas volume and measured total gas volume. This could suggest that that BodPod incorrectly predicted the total gas volume of certain individuals (Blaney, 2008).

With all of the information gathered and interpreted in the study, it's apparent that steps should be taken to improve the health of US citizens. With every opportunity afforded to Americans, the life expectancy ranked only 27th out of 33 countries in a recent survey of well-being among countries. (Xu, Kochanek, Murphy, 2010). US Healthy People 2020 is a national initiative aimed at improving the health

of Americans through prevention and education. In their survey of Americans' health, they note that nearly 1 out of every 2 American adults had 1 of 6 reported chronic illnesses including cardiovascular disease, asthma, diabetes, COPD, cancer and arthritis (US Department of Health and Human Services, 2011). In an age of information, educating people on their individual body composition is a key component in the fight against unhealthy lifestyle choices. In the Healthy People 2020 "Nutrition and Weight Status" objectives, the US Department of Health and Human services identifies "knowledge and attitudes" as the top social determinant of diet. (US Department of Health and Human Services, 2011). When people are aware and educated, they're better equipped to make healthy lifestyle choices.

While knowledge is certainly important, it's only useful when used along with implementation. As stated above, national change must start at the personal level. One implementation strategy program that may be useful in targeting body composition change is a community-based wellness program capturing people who are at risk for chronic disease due to their body composition. Research in the efficacy of community-based wellness programs has shown positive results in not only the prevention of chronic disease and obesity, but also sustainability of such programs when compared to programs that are not community based (Ivester et al., 2010). From a health promotion standpoint, education and awareness would be a useful tool in garnering the participation of at-risk individuals. Educating them of their risks for chronic disease through inexpensive body composition assessment, such as BIA, maybe a catalyst for change in many people. Involving the community, including doctors offices and health departments would only further enforce the

feeling of total wellness. Creating a sense of community and family could be a positive encouragement to those resistant to change. Research finding such as these could also serve to include simple body composition testing for people at their regular check-ups with their primary care physician.

Chapter 6

Conclusions

Knowing that there is a positive correlation between BIA and the BodPod is an encouraging find to those concerned with their body composition. A .9111 correlation between the two scales is surely a promising find and one that can and should be promoted. The knowledge gained from this study can be used for future health promotion in children and adults. While initiatives such as Healthy People 2020 are federal initiatives, the choice to make lifestyle changes ultimately lies in the hands of the people. With proper education and self-awareness, people are one step closer to improving their quality of life and impacting the lives of those around them.

Future research towards this end could prove advantageous to the general public. For example, further study towards the thoracic lung volume of endurance athletes and those with compromised lung function in reference to the BodPod may identify the exact reasoning behind the theory of "outliers." Also, a cross comparison of BIA models would be helpful in advertising BIA as a cheaper, yet effective way to measure body composition. The Tanita used in the study sells for $90.00 retail. This may still be too expensive for many people to afford. However, there are several

models that retail for cheaper. The most reliable, yet cost effective models may be more likely to sell to the general public. For health in future years, prevention is a necessary action. Though people cannot be forced to make a change regarding their health, every effort to capitalize on the importance of healthy lifestyle choices should be taken. With an inexpensive, yet effective way to assess body composition at home, Americans can take one step closer to achieving total health.

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APPENDIX A

RECRUITING FLYER

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RECRUITING FLYER

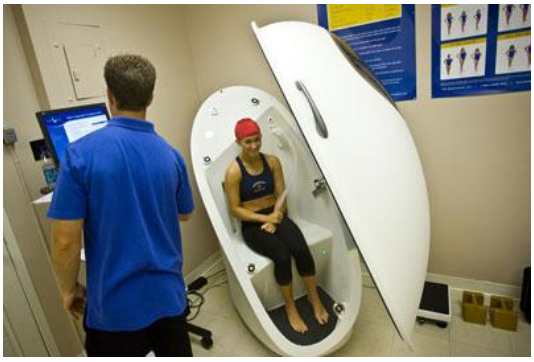
VOLUNTEERS NEEDED!

Healthy male and female students of all ages and races are needed to take place in an undergraduate research study. The study will look at two different measurements of body composition.

If you choose to take place in this study, only a few hours of your time will be required. Your body composition will be measured using the BodPod and Bioelectrical Impedance. Both are harmless, painless and extremely informative.

Bioelectrical Impedance

Interested? Questions? Contact Candace Langston or Dr. Jeff Bolles in the Jones Building



The BodPod

What to wear: In order to achieve maximum results, please wear either a bathing suit or form fitting clothing, as pictured to the left.