

A VALIDATION OF A HANDHELD ULTRASOUND DEVICE TO ASSESS BODY
COMPOSITION IN COLLEGE-AGED ADULTS

A Thesis

Presented to

The Graduate Faculty of The University of Akron

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Kelly Eugene Johnson

May, 2013

A VALIDATION OF A HANDHELD ULTRASOUND DEVICE TO ASSESS BODY
COMPOSITION ON COLLEGE-AGED ADULTS

Kelly Eugene Johnson

Thesis

Approved:

Accepted:

Thesis Advisor/Chair
Dr. Judith A. Juvancic-Heltzel

Dean of the College
Dr. Susan Olson

Committee Member
Dr. Ron Otterstetter

Dean of the Graduate School
Dr. George Newkome

Committee Member
Mrs. Rachele Kappler

Date

Department Chair
Dr. Victor Pinheiro

TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES	vi
CHAPTER	
I. INTRODUCTION.....	1
II. REVIEW OF LITERATURE.....	5
III. METHODS.....	16
Participants	16
Research Design	16
Statistical Design	18
IV. RESULTS	19
V. SUMMARY	22
REFERENCES.....	37
APPENDICES.....	47
APPENDIX A. INFORMED CONSENT FORM	48
APPENDIX B. PAR-Q AND YOU QUESTIONNAIRE.....	52
APPENDIX C. GODIN LEISURE TIME PHYSICAL ACTIVITY QUESTIONNAIRE.....	54
APPENDIX D. MEDICAL HISTORY FOR.....	56
APPENDIX E. HUMAN SUBJECTS APPROVAL FORM.....	58

LIST OF TABLES

Table	Page
1. Participant Physical Characteristics	19
2. Estimates of %BF, FFM, & FM for DEXA,ADP, ULTRA.....	20

LIST OF FIGURES

Figure	Page
1. Percent body fat for DEXA vs ULTRA, DEXA vs ADP, or ULTRA vs ADP.....	20
2. Percent fat free mass for DEXA vs ULTRA, DEXA vs ADP, or ULTRA vs ADP..	21
3. Percent fat mass for DEXA vs ULTRA, DEXA vs ADP, or ULTRA vs ADP.....	21

CHAPTER I

INTRODUCTION

The prevalence of overweight and obese adults and children has dramatically escalated over the past century (Center for Disease Control and Prevention [CDC], 2007). Approximately 32 percent of the United States adult population and between 16 and 33 percent of children and adolescents are considered obese (American Academy of Child & Adolescent Psychiatry, 2008). Obesity is a risk factor for Type II diabetes, cardiovascular disease. (Johnson, Naccarto, Corder, & Repovich, 2012; Ball & Altena, 2004) Additionally, the risk of developing these chronic diseases increases with age and by adopting a sedentary lifestyle.

Body composition refers to the difference between fat mass (FM) and fat-free mass (FFM) which consists of bones, muscles, and tissues in the body. Research has demonstrated that some changes in body composition are due to a lack of physical activity and poor lifestyle decisions (Flegal, Carroll, Ogden, & Curtin, 2010; Wing et al., 2001). Some problems include loss of muscle mass and the inability to go about one's daily activity, which are shaped by a sedentary lifestyle. Currently, the Center for Disease Control and Prevention (CDC) and the World Health Organization (World Health Organization [WHO], 2007) use Body Mass Index (BMI) to assess an individual's risk of metabolic diseases such as cardiovascular disease, and Type II diabetes. However, BMI does not distinguish between an individual's FM and FFM. Current research suggests that overall body fatness, predominantly in the abdominal area, is more predictive of an

individual's relative health risk than BMI (Valdez, Seidell, Young, & Weiss, 1993).

Additionally, a study by Flegal, Kit, Orpana, & Graubard (2013), showed that individuals who are considered overweight by BMI were at a significantly lower mortality weight compared to normal individuals. This is because having a little extra fat may actually serve as a protective mechanism which helps fight off certain chronic diseases, and may aid in survival (Flegal, et. al, 2013).

The Center for Disease Control and Prevention and the World Health Organization have added waist circumference in an attempt to improve both the reliability and validity of BMI (CDC, 2007; WHO, 2007). Research has recently indicated that both visceral fat in the abdominal cavity and fat around the liver have shown to be an increased risk with and without high levels of subcutaneous fat (Kilpelainen et al., 2011, Taskinen et al., 2011). This supports the idea that waist circumference may be an excellent addition to the measurement of BMI to improve the validity of relative risk. When used without the waist circumference, BMI has been found to incorrectly classify an individual due to gender fat distribution, activity level, and age (Going, 2006). As obesity rates continue to increase, it is essential to monitor not only BMI as a measure of relative risk, but also body composition in order to identify changes in fat mass.

Therefore, it is essential to determine body composition and know the proportion of FM vs. FFM. Several methods are available to assess one's overall body composition including dual energy x-ray absorptiometry (DEXA), air displacement plethysmography (ADP), skinfold calipers, and hydrostatic weighing. Traditionally, hydrostatic weighing has long been considered the "gold standard" for body composition (Bentzur, Kravitz, &

Lockner, 2008; Nunez et al., 1999; Levenhagen et al., 1999). However, it is not without limitations. Hydrostatic weighing estimates a person's FM and FFM from a body density equation and thus it does not take into account potential differences in density of FFM. In addition, it also takes complete focus by the subject, because once submerged under water the subject must maximally exhale. This may be difficult and uncomfortable for subjects. As a result, ADP and DEXA have emerged as common methods to evaluate an individual's body composition. BOD POD[®] (Life Measurement Inc., Concord, CA) uses air displacement (ADP) rather than water displacement to estimate %BF. This method is quick, easy to administer, and requires minimal subject compliance. The DEXA has also shown to be an alternative method, which utilizes a three-compartment method of (bone mineral content, fat mass, lean mass, and body fat percentage). This method is quick and comfortable. Preparation for these tests require subjects to wear tight clothing, abstain from exercise and foodstuffs, or experience slight discomfort, and be exposed to minimal amounts of radiation.

While researchers in a laboratory setting can test the reliability and validity of these machines, body composition assessment is a valuable component for both fitness and wellness centers. Additionally, while these body composition assessment methods can identify percent body fat (%BF) by segmenting the abdomen or trunk, none are able to differentiate between subcutaneous and visceral fat in the abdomen. Very few are portable, which make them inconvenient for use in the field or clinical setting. This is important because current literature on risk of metabolic disease suggests that visceral fat is associated with the metabolic syndrome, insulin resistance, cardiovascular disease, and hypertension in both obese and normal weight individuals (Marceau, Biron, & Hould,

1999). Furthermore, measuring body composition in the field or clinical setting is beneficial to monitor both acute and chronic changes in managing of diseases that are associated with increased percent body fat.

More recently, the BodyMetrix[®] BX-2000 ultrasound system (IntelaMetrix, Concord, CA) has been developed which uses ultrasound waves that travel into body tissues. It not only estimates percent body fat, fat free mass, and fat mass, but also has the capacity to identify and measure both subcutaneous and visceral fat layers independently. This method is practical, portable, non-invasive, and is non-traumatizing to the individual. While current literature suggests that just measuring body composition is a better tool than just BMI to assess risk, it may not be the best tool to assess metabolic risk. Therefore, identifying the amount of visceral and subcutaneous fat may be the most vital when trying to identify an individual's metabolic risk.

Therefore, the purpose of this investigation was to validate the BodyMetrix[®] ultrasound machine and to compare it to dual energy x-ray absorptiometry (DEXA) and air displacement plethysmography (ADP) while estimating percent body fat (%BF), fat free mass (FFM), and fat mass (FM) in college-aged students.

Research Question #1: Is the BodyMetrix device a valid and accurate method for the assessment of body composition?

Research Question #2: What is the suitability of the BodyMetrix device for field testing?

Research Question #3: What is the accuracy between the BodyMetrix Ultrasound System, dual energy x-ray absorptiometry, and air displacement plethysmography when measuring FFM, FM, and %BF?

CHAPTER II

REVIEW OF LITERATURE

Overweight and obesity has become a worldwide problem being a major contributor to both cardiovascular disease and Type II diabetes. Excess body fat, particularly the distribution of body fat around the liver and in the abdominal cavity area, is associated with cardiovascular disease, type II diabetes, and gall bladder disease (Pi-Sunyer, 2009). In the United States approximately two-third of adults are overweight (BMI ≥ 25 – <30) or obese (BMI ≥ 30) (Flegal, Carroll, Ogden, & Curtin, 2010). Thirty-three percent of children in the U.S. are either overweight (≥ 85 th – <95 th Body Mass Index (BMI) percentile while 16.9% are considered obese (≥ 95 th BMI percentile) (Ogden, Carroll, Kit, & Flegal, 2012). The recent obesity epidemic may not be caused by changes in the gene pool alone, because research has recently shown that the number of fat cells in both thin and obese subjects is determined during childhood and adolescence. Fat cells remain constant during adulthood and only the volume or size of the fat cells change which causes weight to increase or decrease (Spalding et al., 2008). In addition, the obesity epidemic appears to be related to changes in society and behavioral patterns, which have resulted in a rise in consumption of dense foodstuffs and reduced physical activity (Crawford & Ball, 2002; WHO, 2007; CDC, 2007).

A surplus of body fat is commonly assessed in the general population and clinical setting by using a weight to height ratio also known as the Body Mass Index(BMI). Body mass index utilizes an individual's weight (in kilograms) divided by the square height (in

meters). This provides health professionals with a certain numerical value for an individual. A normal BMI for adults is between 18.5-24.9 kg/m², for overweight a BMI between 25-29.9 kg/m², and obese a BMI of ≥ 30 kg/m² (World Health Organization [WHO], 2007; Stevens et al., 1998). The World Health Organization (2007), use these ranges because research has demonstrated that an increase in risk of disease and mortality is associated with an increased BMI. Being overweight or obese has been linked with both increased morbidity and mortality, and risk factors for cardiovascular disease, Type II diabetes, osteoporosis, certain types of cancer and hypertension (Haslam & James, 2005; Valdez et al., 1993).

It is not body size that poses the greatest health risk associated with overweight and obesity; rather it is the distribution of adipose tissue predominantly in the abdominal area. Abdominal adipose tissue can be divided into two parts, subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT). Visceral adipose tissue is more metabolically active than SAT and has shown to be associated with an individual's increased relative risk of metabolic diseases (Bray 2004; Vague 1956; Despres & Krauss, 2004). Combining measurements of SAT via skinfold thickness, and anthropometric measurements of waist-to-hip (WHR) and waist-to-thigh ratio has been shown to increase validity and reliability of BMI (Filsom et al., 2000; CDC, 2007; WHO, 2007). Lahmann, Lissner, Gullberg, & Berglund, (2002) studied 26,000 cohorts and looked at central fat distribution and WHR. Lahmann et al. (2002) showed strong correlation between central fat distribution and WHR which was strengthened when total adiposity was measured via the DEXA. In addition, DEXA combined with WHR can predict visceral fat content, which has strengthened the value of DEXA for body composition analysis (Taylor,

Elsbeth, Gold, Williams, and Goulding, 1998). Body mass index is generally a great indicator of adiposity and disease risk. However, it does not distinguish between fat mass (FM) or fat free mass (FFM). Therefore, measuring body fat distribution with WHR in conjunction with DEXA, and BMI, while also measuring percent body fat (%BF) might be important to individuals who have a BMI of 25-29.9 kg/m². This is important because it could help to predict an individual's relative risk, while also assessing body composition in order to identify changes in fat mass.

The validity and reliability of measuring body composition depends on the precision of techniques, what body compartment model is used, and experience of the technician to analyze and interpret the results. The absolute amount of body fat is defined as fat mass, which includes all extractable lipids from adipose tissue. Fat-free mass consists of tissue including water, bone, muscle, connective tissue, and internal organs. Total body weight (BW) consists of the components FM and FFM. Relative body fat or %BF is FM expressed as a percentage of total body (BW) that is, $\%BF = FM/BW \times 100$. Normally, when measuring body composition body weight is divided into two or more components depending on which measurement devices are used.

The most common method to measure body composition utilizes a two-compartment technique which divides the body mass into FM and FFM. Hydrodensitometry and air displacement plethysmography (ADP) are among the most common assessments using a two-compartment model. Water, mineral, and protein that make up FFM are assumed to be constant in every individual (Heyward & Wagner, 2004; Wagner, Heyward, & Gibson, 2000). However, the two compartment models do not come without limitations. Evans, Arngrimsson, & Cureton (2001) indicated that age,

ethnicity, age, clothing, and subject compliance may introduce additional error in the prediction of FM and FFM when using a two-compartment model.

The precision of body composition assessments can be enhanced by other techniques such as magnetic resonance imaging, ultrasound, and dual-energy x-ray absorptiometry (DEXA). Many of these techniques for measuring multi-component models are not readily available or easily assessable in the clinical setting. Additionally, these methods are expensive and generally require technical skills to assure accurate results (Chumlea et al., 2002; Visockiene, Johnstone, Speakman, & Broom, 2007).

Plethysmography refers to the measurement of size, usually measured in volume (Dempster & Aitkens, 1995). In air displacement plethysmography, the volume of an object is measured indirectly by measuring the volume of air it displaces via an enclosed chamber (plethysmograph). Human body volume is measured while the subject sits in the enclosed chamber and then air displacement is calculated by displacing a volume of air equal to his or her body volume. Body volume is calculated indirectly by subtracting the volume of air remaining inside the chamber when the subject is inside from the volume of air in the chamber when it is empty (Dempster & Aitkens, 1995). Thus, the BodPod[®] utilizes basic gas laws to describe the inverse relationship between pressure and volume in two enclosed chambers, which results in being able to calculate both the body density and body composition. The BodPod[®] has been commercially available since the mid-1990's and includes an electric weighing scale, calibration weights, a cylinder computer, and computer software. Generally, air displacement plethysmography is of short duration taking around 5-8 minutes, necessitates a low degree of technical skill, and requires minimal compliance of the subject (Nunez et al., 1999; Higgins, Field, Hunter, & Gower,

2001; Anderson, 2007). The BodPod[®] has been shown to be a reliable instrument for estimating %BF across age group, ethnicity and gender (Higgins, Field, Hunter, & Gower, 2001; Dempster & Aitkens, 1995; Nunez et al., 1999). McCrory et al. (1995), used a population of healthy middle aged males and females in which ADP was compared to HW. Results revealed no significant differences in %BF when measured - throughout the day. Miyatake et al. (1999) study produced similar results, but demonstrated higher variation when measured by multiple technicians. Measurements with the ADP should be made under standard test conditions, i.e., subjects should wear minimal, preferably skin tight clothing (swimming suit for females, and spandex tight briefs for males), and refrain from exercise 2 hours prior to each test. Numerous studies have indicated that clothing (including cotton material) as well as increased body temperature and moisture can result in a 2% underestimation of %BF (Fields, Hunter, & Goran, 2000; Hull & Fields, 2005; Vescovi, Zimmerman, Miller, & Fernhall, 2002; Fields, Higgins, & Hunter, 2004). Therefore, the technical errors seen in previous studies may be due to researchers not following manufacturer's guidelines. Thus, careful adherence to manufacturer guidelines should be rigorously followed in order to limit measurement errors.

The assessment of body composition via the DEXA separates the body into three compartments while assuming a constant protein to mineral ratio in the FFM dry tissue. The DEXA method uses a multi-compartment method, thus making it advantageous over other methods such as ADP, skinfolds and bioelectrical impedance, which utilize a two-component model. Thus, the DEXA may provide a practical and reliable method for assessing body composition. Dual-energy x-ray absorptiometry measurement for body

composition has been validated using a three-compartment method (Norcross & Van Loan, 2004; Andreoli et al., 2001). Norcross & Van Loan (2004), reported that DEXA provides a valid assessment of %BF for healthy adults when compared to a two compartment models. Visser, Fuerst, Lang, Salamone, & Harris (1999) reported that the DEXA is also a valid measure of body composition when compared to a CAT scan, which is a 4-compartment model. A 4-compartment model divides the body into water, protein, fat and mineral content. Levenhagen et al. (1999) and Elberg et al. (2004) both used the DEXA as a reference method for comparing the accuracy of skinfolds, BIA, and ADP. Most importantly, both researchers showed that the DEXA is a valid criterion method when comparing other assessments of body composition methods.

Comparatively, the reliability of the DEXA on healthy adults for body composition has been shown to be precise, producing a CV 2-3% for %BF (Guglielmi et al., 1998).

Additionally, the DEXA has also been used to measure both long and short term change in body composition as a result of intervention (De Lorenzo et al., 1998; Gallagher et al., 2000; Houtkopper, Going, Sproul, Blew, & Lohman, 2000). This evidence substantiates the DEXA as an important tool in assessing both acute and chronic changes in body composition of both healthy and diseased populations.

Currently, conflicting opinions exist as to whether the DEXA is considered the “gold standard” in body composition assessment. Initially, DEXA was created to estimate bone mineral density, which it does accurately. It is still unclear whether the DEXA can account for differences in FFM due to hydration status (Rougbenoff, Kehayias, Dawson-Hughes, & Heymsfield, 1993). The DEXA assumes that hydration of FFM remains constant at 73%. If an individual is hyperhydrated, the DEXA may overestimate FM

which could result in a larger %BF (Kelly, Berger, & Richardson, 1998; Pietrobelli, et al., 1999). These results suggest that in order to get accurate estimates of %BF, individuals must continue their regular patterns of hydration or results may be affected.

Ultrasonography (ULTRA) uses ultrasound waves to penetrate the body tissue, in which reflections occur at different tissue boundaries allowing the device to detect true fat thickness at various areas on the body in addition to being able to measure %BF as well as SAT and VAT fat. Ultrasonography has been proposed as a possible alternative method for measuring body composition in obese, athletic, as well as the general population (Stolk et al. 2001, Pineau et al. 2010; Pineau, Fillard, & Bocquet, 2009; Fanelli & Kuczmarski, 1984). Pineau et al. (2010) found a strong correlation in both males and females for %BF when compared to the DEXA. Similarly, Stolk et al. (2001) also found that ULTRA was a reliable method of measurement and demonstrated moderate correlation of for Magnetic Resonance Imaging (MRI), and a strong correlation of for CT. Magnetic Resonance Imaging and research-grade ULTRA are the common clinical methods used to measure body composition. However, most of these methods are expensive and require technical skills to assure accurate results (Chumlea et al., 2002; Visockiene, Johnstone, Speakman, & Broom, 2007). The ULTRA used in this study was the BodyMetrix[®] BX-2000 ultrasound device (IntelaMetrix Inc., Livermore, CA). Like other ULTRA devices, it uses ultrasound waves to penetrate the body tissues, but the difference between this device and other devices is it utilizes skinfold (SF) site locations to measure %BF, FM, and FFM.

To our knowledge, only two studies have utilized the BodyMetrix[®] BX-2000 ultrasound device. Utter and Hager (2008) examined the accuracy of FFM while using

the BodyMetrix[®] BX-2000 device, and comparing it to HW and SF in high school wrestlers. Their results indicated that BodyMetrix[®] BX-2000 device was comparable to HW, but not to SF when estimating FFM. In the other study Johnson et al. (2012), examined the validity of the BodyMetrix[®] BX-2000 ultrasound device while estimating %BF and then comparing it to ADP and BIA in which no significant difference was observed in %BF when the three machines were compared. Therefore, it appears the BodyMetrix[®] BX-2000 device may be an alternative method to measure changes in FFM in athletes.

BodPod versus DEXA The majority of studies examining the reliability and the validity of the BodPod[®] have been compared to HW (Ball & Altona, 2004). Results have indicated an average variation of ~1%BF with a significant difference ranging from -4.0% to 1.9% between these two methods (Wells et al., 2000; Iwaoka et al., 2000; Nunez et al., 1999; Levenhagen et al. 1999; McCrory, Gomex, Bernauer, & Mole, 1995; Sardinha, Lohman, Teixeira, Guedes & Going, 1998). Although both methods use a 2-compartment model, potential differences arise when comparing results between these methods when measuring % BF due to subject compliance and residual volume for HW, as well as adhering to manufacturers' guidelines for ADP. This may suggest that HW may not be any more theoretically accurate than the BodPod[®], which complicates comparison of results between the two. The DEXA is slowly gaining acceptance as a different criterion method over HW due to its ability to measure FM, FFM, and bone mineral density (Ball & Altona, 2004; Kohrt, 1998, Kohrt, 1995). Currently thirteen studies using adults have compared the BodPod[®] to the DEXA (Collins et al., 1999; Fields et al., 2001; Frisard et al., 2005; Hemsfield et al., 2000; Koda et al., 2000;

Levengagen et al., 1999, Millard-Stafford et al., 2001; Minderico et al., 2006; Miyatake et al., 1999; Nunez et al., 1994; Sardinha et al., 1998; Wagner et al., 2000; Weyers et al., 2002). Most studies have included young to middle aged adults. Three studies compared both methods in examining changes in weight over time (Frisard et al., 2005; Minderico et al., 2006; Weyers et al., 2002). Minderico et al. (2006) studied 93 healthy females who completed a 16-month weight loss intervention in which both the DEXA and ADP were used to monitor pre and post body composition changes of FFM, FM, and %BF. Results from this study revealed no significant differences in % BF at pre and post, but significant differences were observed between methods for FM and FFM (Minderico et al., 2006). Similarly, Weyers et al. (2002) investigated overweight males and females who completed an 8-week weight loss program. Results revealed pre and post significant differences between APD and DEXA for FFM, FM, and %BF following a weight loss program of caloric restriction and moderate exercise. The mean differences for %BF measured between the DEXA and ADP for all other studies have varied (Fields et al., 2002; Ball & Altona, 2004). Eight studies to date have demonstrated significant differences in %BF when comparing DEXA and ADP (Ballard, Fafara, & Vukovich, 2004; Collins et al., 1999; Frisard et al., 2005; Levengagen et al., 1999, Millard-Stafford et al., 2001; Minderico et al., 2006; Sardinha et al., 1998; Wagner et al., 2000; Weyers et al.). These studies suggest that the DEXA and ADP when cross-validated may provide reliable results when performed on healthy individuals or individuals enrolled in a weight loss with exercise intervention. The results also indicate that either the DEXA or ADP may be excellent tools to monitor changes in body composition i.e. (FFM, FM, and %BF) in obese, overweight, or healthy individuals' overtime. However, more studies comparing

the DEXA to ADP are needed in order to further support this notion.

Few studies have compared ultrasonography and dual-energy x-ray absorptiometry. Currently, only three studies measuring % BF have compared the ULTRA to the DEXA (Pineau, Guihard-Costa, & Bocquet, 2007; Pineau, Filliard, & Bocquet, 2009; Pineau et al., 2009). Weight loss studies assessing %BF of adolescents revealed strong correlation between ULTRA and DEXA (Pineau, Guihard-Costa, & Bocquet, 2007; Pineau, Filliard, & Bocquet, 2009; Pineau et al., 2009). Strong correlations were also observed comparing both methods when investigating elite male and female athletes with no sex differences observed (Pineau et al., 2010). These studies indicate that ULTRA and DEXA provide high levels of accuracy and are in accordance with each other. Additionally, measuring FFM, FM, and %BF in athletes is beneficial to maximize performance and reduce injury risk while in the general population it is useful in the management of screening potential risk factors to improve medical monitoring.

Currently, no published data exists comparing ULTRA versus the BodPod[®] in measuring FFM, FM, and %BF. However, research comparing the accuracy of FFM, FM, and %BF for the BodPod[®] to the DEXA and ULTRA to the DEXA has shown strong correlation between each respectively (Ball & Altena, 2004; Koda et al., 2000; Pineau, Guihard-Costa, & Bocquet, 2007). As such, research comparing the Bod Pod[®] to the BodyMetrix[®] BX-2000 ultrasound device is warranted.

In summary, the current study is unique as no previous studies have performed a validation of the BodPod[®], BodyMetrix[®] BX-2000 ultrasound device, or the dual-energy x-ray absorptiometry in college aged subjects. Additionally, to our knowledge, only one study has validated the BodyMetrix[®] BX-2000 ultrasound device. However, only FFM of

high school wrestlers was measured and not FM or %BF (Utter & Hagger, 2007).

Although measurement of body composition in athletes is important to assure healthy weight and % BF, assessing these components is vital in the general population as well. Being able to have accurate and economical means to monitor %BF as well as FFM in overweight or obese individuals will not only help lower healthcare costs it can be a tremendous motivator to these individuals in assisting their adherence to a healthy diet and proper exercise programs. The BodyMetrix[®] BX-2000 ultrasound device appears to be promising and has the advantage of being less expensive, portable and non-invasive.

CHAPTER III

RESEARCH DESIGN AND METHODS

Study participants were recruited from The University of Akron campus via the use of email. This study consisted of 35 males and 49 females, ages 18 and 35. The study was approved by the Institutional Review Board from the Office of Research Services and Sponsored Programs at The University of Akron. Participants were excluded from the study if they are unable to come to the Exercise Physiology Laboratory in the morning and/or if they had physical impairments that prohibited them from lying on the DEXA table or sitting in the BodPod[®]. Upon arriving at the Exercise Physiology Laboratory, all assessments were completed within 90 minutes. Prior to participation an information orientation session was mandatory for eligible participants. During this time, participants received the informed consent (Appendix A), PAR-Q & YOU (Appendix B), (Canadian Society for Exercise Physiology, 2002), Godin Physical Activity questionnaire (Godin & Shephard, 1985), (Appendix C), Medical History form (Appendix D) and then participants were given instructions about the testing procedures as well as their ability to discontinue participation at any time. The orientation was held 48 hours before body composition measurements and performed by the Principal Investigator and qualified exercise physiologist to ensure that participants had ample time to read and complete the paperwork.

Body Metrix Ultrasound System

Ultrasound imaging using the BodyMetrix[®] BX2000 System, (IntelaMetrix,

Concord, CA, USA) was performed on all participants. The ultrasound technology utilizes high frequency sound waves, which penetrate the skin surface and travels into body tissues recording the reflected signal. Body composition was assessed using the Jackson-Pollock seven site formula, which includes the chest, midaxilla, suprailiac, abdomen, thigh, triceps, and subscapula (Jackson and Pollock, 1978). Ultrasound gel was applied to the top of the wand, and then placed perpendicular to the tissue interfaces at the seven sites indicated above. An angle of other than 90 degrees may result in a transmission parallax error also known as beam magnification (Donald and Brown, 1961). Once placed at the correct angle the wand was moved in a small circle and then slid back and forth along the skin surface (approximately ± 5 mm from the measurement site) over the location for about five seconds to provide local averaging of the measured signal.

BodPod

The Bodpod[®] (Life Measurement Instruments, Concord, CA, USA) uses air-displacement and pressure volume relationships to derive an individual's body volume. Body fat percentage was then estimated using the Siri equation, which is $(495/\text{Body Density} - 450)$ (Siri, 1961). All participants were asked to refrain from exercise, foodstuffs and drink, 2 hours prior to all testing. Participants were also required to wear tight fitting clothing or a bathing suit, such as spandex shorts for males and a sports bra and spandex shorts or a bathing suit for women. During testing, participants were asked to remove shoes, socks, jewelry, and then provided with a nylon swim cap during testing. At this time, participants' data were entered into the computer, in which each subject was weighed on a calibrated digital scale and asked to remain motionless in the chamber with

their hands in their lap, while breathing normally. Two, 50-second measurements were obtained. A minimum of two 50-second tests were conducted to ensure reliability of measures. If the body volume was not within 150 mL of each other a third test was completed.

DEXA

Whole body composition was estimated using a GE[®] Prodigy bone densitometer (GE/Lunar Corp, Madison, WI, USA). DEXA machines use tightly controlled x-ray beams to measure body composition. Bone mineral density, fat mass, lean body mass, and body fat percentage can all be measured via the DEXA. Percent body fat was calculated by dividing fat mass by total body tissue. After removing all jewelry and metals, participants were asked to lay quietly, arms at their sides, on the scanning bed while the scanning began at the head and moved slowly to the feet. Assessment was completed in 10-20 minutes. Prior to testing, anthropometric measurements of height was measured using a Detecto digital stadiometer while (Dectecto Cardinal Scale Manufacturing Co., Webb City, MO) while weight was taken using a Dectecto beam scale (Dectecto Physician Scale, Cardinal Scale Manufacturing Co., Webb City, MO).

Statistical Design

A one-way repeated measures analysis of variance was used to compare differences in %BF, FFM and FM between DEXA ADP, and US. Also statistical analysis was performed using SPSS V. 19.0 software. Post-hoc Bonferroni analysis, when appropriate, was then performed to determine where differences occurred. Statistical significance was set *a priori* at $p < 0.05$.

CHAPTER IV

RESULTS

The purpose of this investigation was to validate the BodyMetrix[®] Ultrasound machine and to compare it to dual energy x-ray absorptiometry (DEXA) and air displacement plethysmography (ADP) while estimating percent body fat (%BF), fat free mass (FFM), and fat mass (FM) in college-aged students. Upon providing written consent and completing medical history, Godin questionnaire, and a PAR-Q & YOU form (Appendices A,B, C, & D), 84 participants completed one visit to the Exercise Physiology laboratory at the University of Akron. Participant characteristics are presented in Table 1.

Table 1

Participant Physical Characteristics

Sex	Age (Years)	Height (Inches)	Weight (lbs)
Female <i>N</i> = 49	22.0 ± 5.6	64.1 ± 3.7	128.0 ± 22.7
Male <i>N</i> = 35	22.0 ± 3.2	71.3 ± 3.1	186.0 ± 26.0

Total Body Fat %, Fat Free Mass, Fat Mass

Table 2 depicts the means and standard deviations for %BF, FFM, and FM comparing the three machines.

Table 2

Estimates of %BF, FFM, & FM for DEXA,ADP, ULTRA

Estimates	DEXA	ADP	ULTRA
%BF	25.6 ± 8.5	19.5 ± 7.5	21.6 ± 6.3
FFM (lbs)	118.6 ± 33.0	122.2 ± 34.0	123.2 ± 35.0
FM (lbs)	37.4 ± 15.0	30.5 ± 16.2	30.4 ± 12.0

Note. Values are presented as mean ± *SD*.DEXA = dual-energy x-ray absorptiometry, ADP = air displacement plethysmography, ULTRA = ultrasound, %BF = percent fat, FFM= fat free mass, FM = fat mass.

A repeated measure ANOVA revealed significant differences in %BF for (DEXA vs ADP), (DEXA vs ULTRA), and (ULTRA vs ADP), ($p = 0.000$) as presented in Figure 1. There was no significant difference for FFM observed for (DEXA vs ADP, $p = .240$), (DEXA vs ULTRA, $p = .246$), and (ULTRA vs ADP, $p = 1.000$) as shown in Figure 2. Figure 3 depicts a significant difference in FM for (DEXA vs ADP) and (DEXA vs ULTRA), ($p = 0.000$). However, no significant difference in FM was observed for (ULTRA vs ADP) ($p = 1.000$).

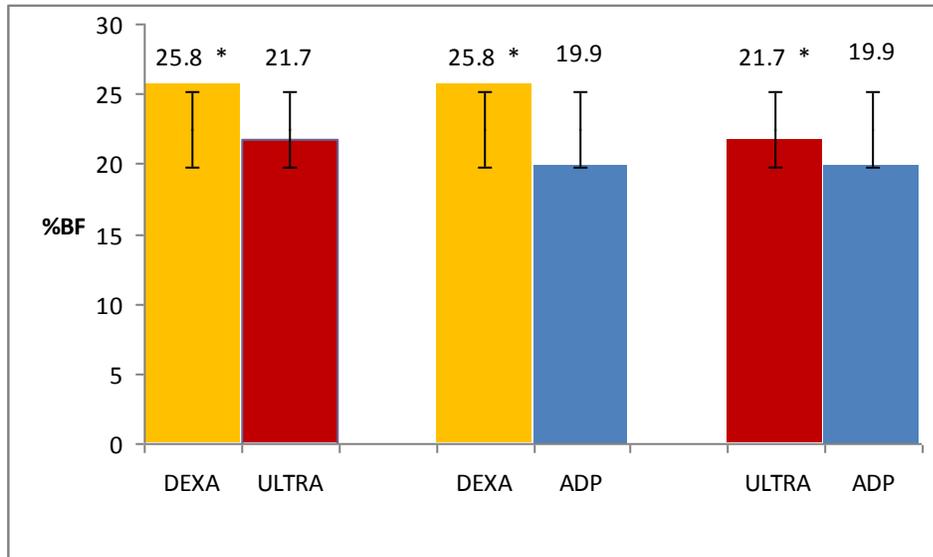


Figure 1. Percent body fat for DEXA vs ULTRA, DEXA vs ADP, or ULTRA vs ADP * $p < 0.05$.

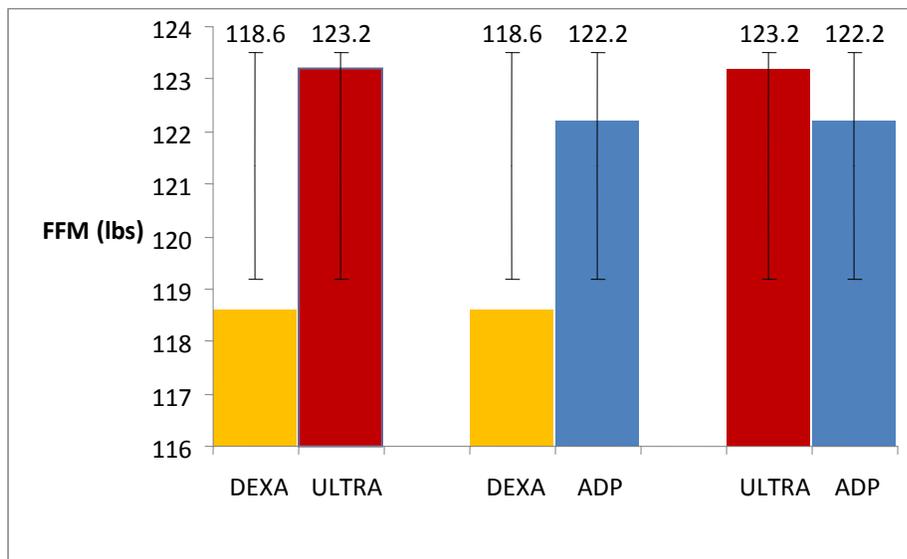


Figure 2. Fat free mass for DEXA vs ULTRA, DEXA vs ADP, or ULTRA vs ADP.

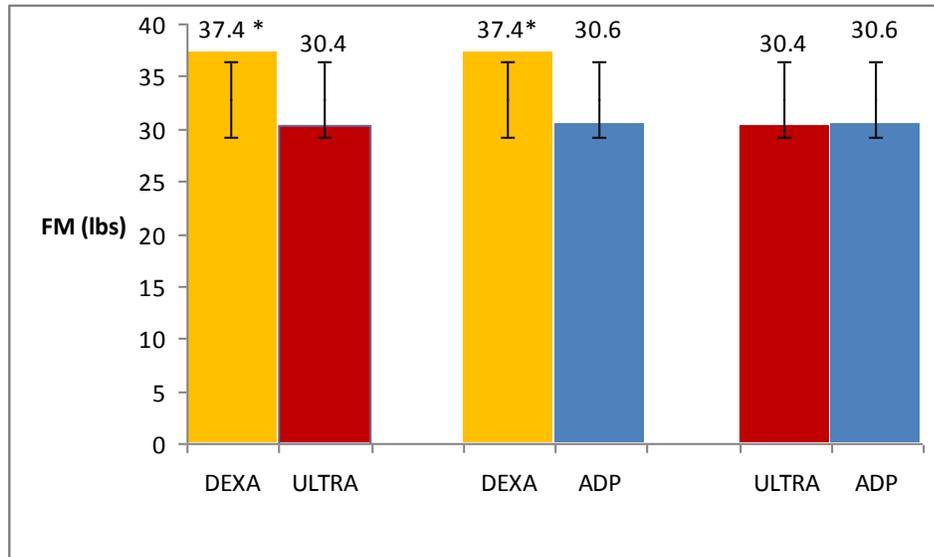


Figure 3. Fat mass DEXA vs ULTRA, DEXA vs ADP, $*p < 0.05$

CHAPTER V

DISCUSSION

Measuring body composition can be an important marker of an individual's relative risk for CVD, hypertension, and type II diabetes (Levenhagen, et al., 1999). The increased risk of these diseases is partly due to a lack of physical activity, diets high in fat, and sodium, which all contribute to the present obesity epidemic. Additionally, this increased risk is also linked to high levels of visceral fat primarily located in the abdominal cavity (Bray 2004; Haslam & James, 2005). Therefore, the purpose of the present study was to examine the validity of a new ultrasound machine while comparing it to the DEXA and ADP to estimate %BF, FFM, and FM in college-aged subjects.

With obesity rates still on the rise it is important to have valid ways to estimate an individual's body composition while measuring %BF, FFM, and FM. Additionally, body composition machines vary in cost, transportability, and sophistication of use. To our knowledge this is the first study to objectively compare the BodyMetrix[®] ultrasound machine to the DEXA and ADP, while measuring %BF, FFM, and FM in a healthy population of college students.

In the present study a significant difference was observed in %BF between the DEXA vs ADP. Levenhagen et al. (1999) used a smaller sample of healthy participants in which their study revealed a significantly higher % BF when compared to ADP which is

in agreement with our study. The ADP procedure uses a density measurement to estimate %BF, FFM, and FM, which assumes that both FFM and FM are additive and proportions other than fat are constant from person to person. Fat free mass is composed of water, muscle, bone, as well as internal organs, and disproportional alterations in any of these components could result in ADP underestimating %BF. However, the present study examined %BF acutely, and subjects adhered to manufactures instructions prior to all testing, which suggests there are other underlying factors for the difference between the DEXA and ADP when measuring %BF. Bone mineral content could possibly be the underlying factor as the density of FFM can strongly influence FM and %BF, possibly resulting in an underestimation of %BF and an overestimation in FFM via ADP. This present study used college aged subjects in which bone mineral content was assumed to be normal. Bone density is measured indirectly by the DEXA, but was not a measurement examined in this study.

Sardinha et al. (1999) utilized a healthy population of only middle-aged men, in which their results demonstrated a significant difference between the DEXA and ADP, and a higher estimated mean of %BF which is consistent with the current study. Similarly our results are also consistent with Ballard, Fafara, and Vukovich (2004) who found significant difference for %BF, for ADP and for DEXA when non-athletes were studied. However, these studies cannot be directly compared to the present or Levenhagen et al. (1999) study because one study used a pencil beam mode (QDR 1500 DEXA) and the other study used a fan beam (Hologic QDR 4500/A) DEXA model. Current research has demonstrated that the pencil beam vs fan beam provides different estimates of %BF as a result of the machine's calibration and software algorithms (Plank,

2005; Oates et al., 2006).

Previous research has demonstrated significant differences in %BF when estimated between scanners on the same subject from both GE Lunar and Hologic DEXA machines (Soriano et al., 2004; Plank, 2005). Therefore, these results suggest that the differences observed in previous studies when using the DEXA to estimate %BF seem to be system dependent, which may be influenced by gender, age, body size, and whether pencil or fan beams DEXA machines are used.

The present investigation revealed no significant differences in FFM when comparing DEXA to ADP. Previous studies examining DEXA vs ADP studied changes in FFM before and after weight loss rather than evaluating it concurrently. In support of the current results, Weyer et al. (2002) examined FFM in females following an 8 week weight loss program. Their results demonstrated that no significant differences were observed between methods following weight loss when measuring FFM. Therefore our results support previous research that both ADP and DEXA are valid methods to measure FFM.

Contrary to these findings, when comparing DEXA and ADP, Minderio et al. (2006) demonstrated significant differences in FFM at baseline and following a 16 month weight loss intervention. The authors concluded that ADP is a valid method to track changes FM and FFM in females over time, due to its ability to accommodate larger subjects and other clinical populations (Minderio et al, 2006). It is well acknowledged that females have higher amounts of body fat, and lower amounts of FFM. A small change in overall FM could alter FFM, which could explain the possible difference observed. Additional research supports the notion that ADP underestimates FFM and

over estimates FM in females (Fields et al., 2001; Vescovi et al., 2002; Wager, Heyward, & Gibson, 2000). In the present study FFM was lower in pounds when estimated by the DEXA compared to ADP . Our results are also in agreement with other studies which demonstrate the DEXA to be lower and ADP to be higher when measuring FFM (Minderio et al., 2006, Weyers et al., 2002; Vescovi et al., 2002). Fields et al. (2001) demonstrated that ADP significantly overestimated FFM in females when compared to a four-compartment model. A four-compartment model divides the body into four compartments which consists of fat mass, bone, total body of water and protein, and non-bone minerals.

Previous research has demonstrated that adding additional compartments does not result in higher %BF, FFM, or FM (Withers et al., 1999). The DEXA is a three-compartment model where ADP is a two-compartment model. In the present study thoracic gas volume was predicted instead of measured, which could explain the higher difference in FFM by ADP compared to DEXA. Previous studies have demonstrated that the differences are small when comparing actual to predicted values (Fields et al., 2001; Fields et al., 2002). However, in this current investigation no significant differences in FFM between methods were observed so this is unlikely but further research is warranted.

In the present investigation, significant differences in FM were found between DEXA and ADP. To date, numerous studies have found ADP to underestimate FM when compared to the DEXA. In support of these current findings, Levenhagen et al. (1999), found that ADP underreported FM compared with DEXA. Furthermore, Minderio et al. (2006), demonstrated significant differences in FM when comparing DEXA and ADP,

while Weyers et al. (2002) also found the DEXA to be higher in FM compared to ADP in overweight men and women. Contrary to these findings, Frisard, Greenway, & Delany, (2005) reported the DEXA to be lower in FM and FFM but was greater when compared to ADP. In the Frisard et al. (2005) study, a fan beam 2000 Hologic machine was used, which could explain the differences between observations in the current and previous studies. The DEXA measures the ratio of attenuation of two photon energies of both FM and FFM where no bone is present. Algorithms are then used to extrapolate soft tissue not containing bone, in which FM and FFM is determined (Andreoli et al., 2009). Therefore, when different algorithms are utilized this alters the reading of FM, and other values such as FFM, which can affect the DEXA's body composition measurement of %BF, FFM, and FM. Previous research has indicated that having more clothing could result in an underestimation of %BF resulting in a lower FM by ADP (Fields, Hunter, & Goran, 2000; Hull & Fields, 2001; Vescovi et al., 2002). In this present study each subject wore a nylon swim cap, while females either wore a swimsuit or spandex shorts and sports bra, while males wore spandex shorts with no shirt. Since manufactures guidelines were followed it is unlikely that clothing could have resulted in a lower variation of FM observed in ADP compared to the DEXA in the present study.

Possible explanations of large variations observed in FM between DEXA to ADP in the current investigation could be hydration. A primary assumption of the DEXA is that soft tissue is normally hydrated, thusly so FM and FFM can be accurately divided into partitioning fractions (Andreoli et al., 2009; Plank, 2005). Dual-energy x-ray absorptiometry machines assume that hydration of FFM remains constant at 73% however; hydration status fluctuates between individuals. Therefore, if an individual

body contains more than 73% water the DEXA can overestimate FM resulting in an overestimation of %BF (Andreoli et al., 2009). Whether hydration status can explain the significant differences observed in the current investigation between DEXA vs ADP in estimating FM is unknown. Another potential explanation of the significant differences and higher amount of FM by the DEXA vs ADP for FM is scanning of body thickness. Previous literature has defined this predicament as the “beam hardening effect” (Nana et al 2012). This study used college aged subjects and none of them were athletes or obese subjects where thicker body thickness is often observed. Therefore, this potential reason appears unlikely.

The present study used a GE Lunar Prodigy DEXA machine where previous research demonstrated this model to overestimate %BF and FM. In support of the current findings Williams, Wells and Wilson (2006) study demonstrated the GE Lunar Prodigy to overestimate the mean of FM and %BF when compared to a 4-compartment model performed on non-obese males and females. Likewise, previous research has shown that GE Lunar Prodigy DEXA machines measure higher amounts of fat in trunk compared to fat content in arms and legs (Norcross & Van Loan, 2004; Plank, 2005. Whether this notion is present in the current investigation it is unknown. Therefore, future research should investigate this proposition.

%BF- DEXA vs ULTRA. Results from this study demonstrated significant differences in %BF between the DEXA to ULTRA. To date little research exists comparing the ULTRA to DEXA when estimating %BF. A study by Pineau, Guihard-Costa, and Bocquet, (2007) used middle-aged males and females and compared an ULTRA that scanned the intra-abdominal area or lower back level with the umbilical

region and mid-thigh on both the left and right sides to the DEXA. The lower back region was chosen because this region is associated with co-morbidities (Pineau et al., 2007). Their results demonstrated that no significant differences in %BF between US vs DEXA. Similarly, Pineau, Fillard, and Bocquet (2009) examined US vs DEXA in athletes and found no significant difference in %BF between methods. These findings are contrary to observations in the present study. The present study utilized a BodyMetrix[®] BX-2000 ultrasound machine manufactured by (IntelaMetrix Inc.). This ULTRA machine assesses %BF using a Jackson-Pollock seven site formula, where the ultrasound in the Pineau (2007 & 2009) studies utilized only the mid-thigh and lower back region. Both studies used different propriety formulas and different regions of the body to estimate %BF, which could explain the possible discrepancies of %BF observed in the present and previous studies. Additionally, the ultrasound utilized by Pineau (2007) & 2009 studies had higher sonographic capabilities which could also explain the potential differences. To date only one study has validated the BodyMetrix[®] BX-2000 device against other known body composition methods such as ADP, BIA, SF, and DEXA (Johnson, et al, 2012). Additionally, further research on the BodyMetrix[®] BX-2000 ultrasound device is also warranted.

FFM and FM - DEXA vs ULTRA. This current study demonstrated no significant differences between DEXA and ULTRA for FFM. However, there was a significant difference in FM between the DEXA vs ULTRA. The ultrasound used in the present study is relatively new, and the device produced some promising results. Our study suggests that the ULTRA used may be a reliable alternative method to measure FFM. When the DEXA vs ULTRA were compared a significant difference was observed

between methods as well as a large variation in FM in pounds between machines. These findings of FM are mostly likely due to the advantages of three-compartment model vs a two-compartment model. Therefore, more studies should be carried out to examine if variations exist in FM. More studies are warranted examining populations such as older, obese, overweight, and athletes to see if similar results are yielded as in the present study.

Our investigation revealed a significant difference between ULTRA vs ADP, when measuring %BF. A study by Johnson et al. (2012), examined the validity of the BodyMetrix[®] ultrasound device while estimating only %BF comparing it to ADP and BIA machines. College aged subjects were used which is consistent with the present study, however no significant differences between ADP vs ULTRA were observed. A smaller sample size, lower body fat percentage, with the majority of the participants being males in the Johnson et al. (2012) could explain the lack of non-significant differences between methods for %BF. Additionally, this present study used a Jackson-Pollock seven site formula, while the Johnson et al. (2012) study used a Jackson-Pollock three site formula. Whether there is a difference in estimation %BF between a 3 site vs 7 site provided by the BodyMetrix[®] BX-2000 ultrasound device is unknown and warrants further investigation.

In the present study no significant differences were observed for FFM between the ADP and ULTRA which is in agreement with Utter and Hager (2008) study. To our knowledge this is the first investigation to examine estimates of FFM and FM comparing BodyMetrix[®] BX-2000 ultrasound device to ADP, and only the second to assess the validity of the BodyMetrix BX-2000[®] ultrasound device. Air displacement plethysmography has emerged as a valid and sophisticated tool to assess an individual's

%BF, FFM, and FM (Ballard and Altona, 2004). These results suggest that BodyMetrix[®] BX-2000 ultrasound device when compared to another two-compartment model such as ADP produce very similar readings of FFM and FM, however future research should be performed to further validate the BX-2000 ultrasound device against other two-compartment models such as hydrostatic weighing and three-compartment methods such as the DEXA.

Conclusions

Measuring body composition to estimate %BF, FFM, and FM is useful in all populations from healthy to athletic to overweight and obese individuals. Examining these changes is imperative in order to further our understanding of energy metabolism and its relationship to metabolic disease. Additionally, having accurate body composition measurement devices is crucial for monitoring the reduction of fat mass and maintenance of fat-free mass during periods of weight loss for both athletes and the general population. In this present study both ADP and the BodyMetrix[®] BX-2000 ultrasound device were utilized which are both two-compartment models. Two-compartment models exhibit inherent errors due the assumptions of FFM components, such as bone mineral content (Wang et al., 1999). Furthermore, hydration status can therefore affect body density values assumed by 2-compartment tests such as ADP and ULTRA and any body composition method that assumes a constant density of the fat-free mass must be considered inferior as a reference. The DEXA has also been known to produce significant error based on the assumption of hydration (Rougbenoff, Kehayias, Dawson- Hughes, & Heymsfield, 1993; Kelly, Berger, & Richardson, 1998; Pietrobelli, et al., 1999).

. Additionally, all of these methods are subject to error because none of the proposed

methods have been directly measured against cadavers (Brunton, Bayley, & Atkinson, 1993; Toombs, Ducher, Shepherd, & De Souza, 2012).

This was the first study to validate the BodyMetrix[®] BX-2000 ultrasound in college-aged students against other known valid tools including ADP and the DEXA to estimate %BF, FFM, and FM concurrently. Previous literature reveals conflicting results when comparing % BF between DEXA, ADP and ULTRA (Fields et al., 2001; Johnson et al., 2012; Levenhagen et al., 1999; Maddalozzo, Cardinal, & Snow 2002; Vescovi et al., 2002). Our study found significant differences in %BF measurements between methods. Additionally, this study also demonstrated that significant differences exist for FM for DEXA when compared to both ADP and ULTRA. However, when ADP vs ULTRA were compared to each other no significant differences were observed for FM. Limitations of the current investigation include not measuring hydration status. It is well acknowledged that hydration can alter readings of both %BF and FM in for both the DEXA and ADP however, whether hydration alters readings of the BodyMetrix[®] BX-2000 ultrasound device is unknown. Additionally, the results of %BF, FFM, and FM provided by the DEXA should not be generalized to other scan modes or different manufactures such as Hologic (Hologic Inc, Waltham,USA).

Furthermore, this study only used healthy college aged students, so the results found may be only generalized to a young, relatively healthy population. The results of this study suggest that the BodyMetrix[®] BX-2000 ultrasound device may be an accurate device when compared to ADP and DEXA, while estimating %BF and FFM. However, when FM was measured there was a large variation in FM between the DEXA vs ULTRA, as well as DEXA vs ADP. The BodyMetrix[®] BX-2000 ultrasound device is

portable and non-invasive and appears to be a promising valid and cost-effective method for assessment of body composition, but future research with other populations is warranted.

Future Directions

1. Further research should include different healthy age groups of both males and females, to see if estimates by that of ULTRA, ADP, and DEXA of %BF, FFM, FM yield similar results.

2. Future research should compare the Bodymetrix[®] BX-2000 ultrasound device to more than two different valid measurements of body composition.

3. Future research should compare the three site Jackson-Pollock equation vs seven site Jackson-Pollock equation both provided by the Bodymetrix[®] BX-2000 ultrasound device to examine whether differences in %BF, FFM, and FM exist.

4. Further research should include both general and broader populations, i.e. lean vs overweight vs obese adults and other individuals that present multiple co-morbidities.

5. Further research should include comparing athletic to non-athletic populations and also different types of athletes via the Bodymetrix[®] BX-2000 ultrasound device to examine whether differences in %BF, FFM, and FM exist.

REFERENCES

- American Academy of Child and Adolescent Psychiatry. (2008). Facts for Families. Retrieved from http://www.aacap.org/galleries/FactsForFamilies/79_obesity_in_children_and_teens.pdf
- Andreoli, A., Monteleone, M., Van Loan, M., Promenzio, L., Tarantino, U., & De Lorenzo, A. (2001). Effects of different sports on bone density and muscle mass in highly trained athletes. *Journal of Medicine and Science in Sports and Exercise*, 33(4):507–511.
- Ball, S. D. & Altena, T. S. (2004). Comparison of the Bodpod and dual energy x-ray absorptiometry in men. *Physiological Measurement*, 25, 671-678.
- Ballard, T. P., Fafara, L., & Vukovich, M. D. (2004). Comparison of BodPod and DXA in female collegiate athletes. *Journal of Medicine & Science in Sports and Exercise*, 36(4), 731-735.
- Biaggi, R. R., Vollman, M. W., Nies, M. A., Brener, C. E., Flakoll, P. J., Levenhagen, D. K., ... Chen, K. Y. (1999). Comparison of air-displacement plethysmography with hydrostatic weighing and bioelectrical impedance analysis for the assessment of body composition in healthy adults. *American Journal of Clinical Nutrition*, 69(5): 898-903.
- Brunton, J. A., Bayley, H. S., & Atkinson, S. A. (1993). Validation and application of dual-energy x-ray absorptiometry to measure bone mass and body composition in small infants. *American Journal of Clinical Nutrition*, 58, 839–845.
- Bentzur, K. M., Kravitz, L., & Lockner, D. W. (2008). Evaluation of the Bod Pod for estimating percent body fat in collegiate track and field female athletes: A comparison of four methods. *Journal of Strength and Conditioning*, 22(6), 1985-1991.
- Bray, G.A. (2004). Medical consequences of obesity. *The Journal of Clinical Endocrinology & Metabolism*, 89(9), 2583-2589.
- CDC Home, Healthy weight – it’s not a diet, it’s a lifestyle! (2007). Retrieved from <http://www.cdc.gov/healthyweight/index.html>
- Collins, M. A., Millard-Stafford, M. L., Sparling, P. B., Snow, T. K., Roszkopf, L. B., Webb, S. A., Omer, J. (1999). Evaluation of the BOD POD for assessing body fat in collegiate football players. *Journal of Medicine and Science in Sports and Exercise*, 31, 350–356.

- Chumlea, W. C., Guo, S. S., Kuczmarski, R. J., Flegal, K. M., Johnson, C. L., Heymsfield, S. B., . . . Hubbard, V. S. (2002). Body composition estimates from NHANES III bioelectrical impedance data. *International Journal of Obesity*, 26(12), 1596-1609.
- Crawford, D., & Ball, K. (2002). Behavioural determinants of the obesity epidemic. *Asia-Pacific Journal of Clinical Nutrition*, 11, S718–S721.
- De Lorenzo, A., Bertini, I., Candeloro, N., Lacopino, L., Andreoli, A., & Van Loan, M. D. (1998). Comparison of different techniques to measure body composition in moderately active adolescents. *British Journal of Sports Medicine*, 32, 215–219.
- Dempster, P., & Aitkens, S. (1995). A new air displacement method for the determination of human body composition. *Journal of Medicine and Science in Sports and Exercise*, 27, 1692-1697.
- Despres, J. P., & Krauss, R. M. (2004). Obesity and lipoprotein metabolism. In: Bray GA, Bouchard C, James WP, eds. *Handbook of obesity: etiology and pathophysiology*. 2nd ed. New York: Marcel Dekker; 845–871.
- Donald, I., & Brown, T.G. (1961). Demonstration of tissue interfaces within the body by ultrasonic echo sounding. *British Journal of Radiology*, 34, 539-550.
- Elberg, J., McDuffie, J. R., Sebring, N. G., Salaita, C., Keil, M., Robotham, D., . . . Yanovski, J. A. (2004). Comparison of methods to assess change in children's body composition. *American Journal of Clinical Nutrition*, 80(1), 64-69.
- Evans, EM., Arngrimsson, S. A., & Cureton, K. J. (2001). Body composition estimates from multicomponent models using BIA to determine body water. *Journal of Medicine and Science in Sports and Exercise*, 33(5), 839-845.
- Fanelli, M. T. Kuczmarski, J. (1984). Ultrasound as an approach to assessing body composition. *American Journal of Clinical Nutrition*, 39, 703-709.
- Fields, D. A., Hunter, G. R., & Goran, M. I. (2000). Validation of the BODPOD with hydrostatic weighing: Influence of body clothing. *International Journal of Obesity*, 24, 200-205.
- Fields, D.A., Wilson, G. D., Gladden, L. B., Hunter, G. R., Pascoe, D. D., & Goran, M.I. (2001). Comparison of the BOD POD with the four-compartment model in adult females. *Journal of Medicine and Science in Sports and Exercise*, 33, 1605-1610.
- Fields, D. A., Higgins, P. B., Hunter, G. R. (2004). Assessment of body composition by air displacement: influence of body temperature and moisture. *Dynamic Medicine*, 3(3), 1-7.
- Flegal, K. M., Carroll, M. D., Ogden, C. L., & Curtin, L. R. (2010). Prevalence and

- Trends in Obesity Among US adults, 1999–2008. *Journal of the American Medical Association*, 303(3), 235-241.
- Folsom, A. R., Kushi, L. H., Anderson, K. E., Mink, P. J., Olson, J. E., Hong, C. P., ... Prineas, R. J. (2000). Associations of general and abdominal obesity with multiple health outcomes in older women. *Archives of Internal Medicine*, 160, 2117-2128.
- Frisard, M. I., Greenway, F. L., & Delany, J. P. (2005). Comparison of methods to assess body composition changes during a period of weight loss. *Obesity Research*, 13(5), 845-854.
- Gallagher, D., Ruts, E., Visser, M., Heska, S., Baumgartner, R. N., Wang, J., ... Heymsfield, S. B. (2000). Weight stability masks sarcopenia in elderly men and women. *American Journal of Physiology and Endocrinology Metabolism*, 279, 366-375.
- Godin, G., & Shephard, R. J. (1985) A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Sciences*, 10, 141–146.
- Going, S. (2006). Optimizing techniques for determining body composition. *Gatorade Sports Science Institute, Sports Science Exchange*. 19(2), 1-6.
- Guglielmi, G., Passariello, R., & Genant H. K. (1997). Bone densitometry: an update. *European Radiology*, 7,1-56.
- Haslam, D.W., & James, W. P. (2005). *Obesity*, 366(9492), 1197-1209.
- Heymsfield, S. B., Segal, K. R., Hauptman, J., Lucas, C. P., Boldrin, M. N., Rissanen, A., ... Sjostrom, L. (2000). Effects of weight loss with orlistat on glucose tolerance and progression to type 2 diabetes in obese adults. *Archives of Internal Medicine*, 160, 1321-1326.
- Heyward V.H., & Wagner D.R. eds. *Applied Body Composition Assessment*. 2nd ed. Champaign, IL: Human Kinetics 2004.
- Higgins, P. B., Fields, D. A., Gower, B. A., & Hunter, G. R. (2001). The effect of scalp and facial hair on body fat estimates by the BOD POD. *Obesity Research*, 9:326-330.
- Houtkooper, L. B., Going, S. B., Sproul, J., Blew, R. M., & Lohman, T.G. (2000). Comparison of methods for assessing body-composition changes over 1 y in postmenopausal women. *American Journal of Clinical Nutrition*, 72,401-496.
- Hull, H. R., & Fields, D. A. (2005). Effect of short schemes on body composition measurements using air-displacement plethysmography. *Dynamic Medicine*, 4(5), 1-8.
- Iwaoka, H., Yokoyama, T., Nakayama, T., Matsumura, Y., Yoshitake, Y., Fuchi, T., . . . Tanaka, H. (1998). Determination of percent body fat by the newly developed

- sulfur hexafluoride dilution method and air displacement plethysmography. *Journal of Nutritional Science and Vitaminology*, 44, 561-568.
- Jackson, A.S., & Pollock, M. L. (1978). Generalized equations for predicting body density. *British Journal of Nutrition*, 40, 497-504.
- Johnson, K. E., Naccarto, I. A., Corder, M. A., Repovich, W. E. S. (2012). Validation of three body composition techniques with a comparison of ultrasound abdominal fat depths against an octopolar bio electrical impedance device. *International Journal of Exercise Science*, 5(3), 205-213.
- Kelly, T. L., Berger, N., & Richardson T. L. (1998). DXA body composition: theory and practice. *Applied Radiation and Isotopes*, 49,511-513.
- Kilpelainen, T. O. et al. (2011). Genetic variation near IRS1 associates with reduced adiposity and an impaired metabolic profile. *Nature Genetics*,43, 753-760.
- Koda, M., Tsuzuku, S., Ando, F., Niino, N., & Shimokata, H. (2000). Body composition by air displacement plethysmography in middle-aged and elderly Japanese: comparison with dual-energy X-ray absorptiometry. *Annals of the New York Academy of Sciences*, 904, 484-488.
- Kohrt, W. M. (1998). Preliminary evidence that DEXA provides an accurate assessment of body composition. *Journal of Applied Physiology*, 84, 372-377.
- Kohrt, W. M. (1995). Body composition by DXA: tried and true? *Journal of Medicine and Science in Sports and Exercise*,27, 1349-1353.
- Lahmann, P. H., Lissner, L., Gullberg, B., & Berglund, G. (2002). A prospective study of adiposity and all cause mortality: The malmo diet and cancer study. *Obesity Research*,10(5), 361-369.
- Laskey, M.A. (1996). Dual-energy X-ray absorptiometry and body composition. *Nutrition*, 12(1), 45-51.
- Levenhagen D. K., Borel M. J., Welch D. C., Piasecki J. H., Piasecki D. P., Chen K. Y., & Flakoll P. J. (2011). A comparison of air displacement plethysmography with three other techniques to determine body fat in healthy adults. *Journal of Parenteral Enteral Nutrition*, 23, 293-299.
- Maddalozzo, G. F., Cardinal, B. J. & Snow, C. M. (2002). Concurrent validity of the BOD POD and dual energy x-ray absorptiometry techniques for assessing body composition in young women. *Journal of the American Dietetic Association* 102(11),1677-1679.
- Marceau, P., Biron, S., & Hould F. S. (1999). Liver pathology and the metabolic syndrome X in severe obesity. *Journal of Clinical Endocrinology and Metabolism*, 84(5), 1513-1517.

- McCrory, M.A., Mole, P. A., Gomez, T., Dewey, K. G., & Berneauer, E. M. (1998). *Body composition by air-displacement plethysmography by using predicted and measured thoracic gas volumes. Journal of Applied Physiology*, 84(4),1475-1479.
- Millard-Stafford, M. L., Collins, M. A., Evans, E. M., Snow, T. K., Cureton, K. J., Roskopf, L. B. (2001). Use of air displacement plethysmography for estimating body fat in a four-component model. *Journal of Medicine and Science in Sports and Exercise*,33,1311-1317.
- Minderico, C. S., Silva, A. M., Teixeira, P. J., Sardinha, L. B., Hull, H. R., & Fields, D. A. (2006) Validity of air-displacement plethysmography in the assessment of body composition changes in a 16-month weight loss program. *Nutrition & Metabolism*, 3(32), 1-8.
- Miyatake, N., Nonaka, K., & Fujii, M. (1999). A new air displacement plethymograph for the determination of Japanese body composition. *Diabetes, Obesity, and Metabolism*, 1, 347-351.
- Nana, A., Slater, G. J., Hopkins, W. G., & Burke, L.M. (2012). Techniques for undertaking dual-energy x-ray absorptiometry whole body scans to estimate body composition in tall and/ or broad subjects. *International Journal of Sport Nutrition and Exercise Metabolism*, 22, 313-322.
- Norcross, J. & Van Loan, M. D. (2004). Validation of a fan beam dual energy x ray absorptiometry for body composition assessment in adults aged 18-35. *British Journal of Sports Medicine*, 38(4), 472-476.
- Nunez, C., Kovera, A. J., Pietrobelli, A., Heshka, S., Horlick, M., Kehayias, J.J., . . . Heymsfield, S. B. (1999). Body Composition in children and adults by air displacement plethysmography. *European Journal of Clinical Nutrition*, 53, 382-387.
- Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999–2010. *Journal of the American Medical Association*. 2012; 307(5):483–90.
- PAR-Q and You. Canadian Society for Exercise Physiology. Revised 2002.
- Pietrobelli, A., Wang, Z., Formica, C., & Heymsfield, S. B. (1998) Dual-energy X-ray absorptiometry: fat estimation errors due to variation in soft tissue hydration. *American Journal of Physiology*, 274, E808–E816.
- Pineau, J.C., Guihard-Costa, A.M., and M. Bocquet. (2007). Validation of ultrasound techniques applied to body fat measurement. A comparison between ultrasound techniques, air displacement plethysmography and bioelectrical impedance vs. dual-energy X-ray absorptiometry. *Annals of Nutrition and Metabolism*,51(5),421-427.89.
- Pineau, J.C., Filliard, A. M., & Bocquet, M. (2009). Ultrasound techniques applied to

- body fat measurement in male and female athletes. *Journal of Athletic Training*, 44(2), 142-147.
- Pineau, J.C., Lalys, L., Bocquet, M., Guihard- Costa, A.M., Polak, Frelut, M. L.,... Dabba-Tyan, M. (2010). Ultrasound measurement of total body fat in obese adolescents. *Annals of Nutrition & Metabolism*, 56, 36-44.
- Pi-Sunyer, X. (2009). The medical risks of obesity. *Postgraduate Medicine*, 121(6), 21-33.
- Plank, L. D. (2005). Dual-energy X-ray absorptiometry and body composition. *Current Opinion in Clinical Nutrition & Metabolic Care*, 8, 305-309.
- Roubenoff, R., Kehayias J J., Dawson-Hughes, B. , Heymsfield, S. B. (1993). Use of dual-energy X-ray absorptiometry in body composition studies: not yet a “gold standard. *American Journal of Clinical Nutrition*, 58, 589–591.
- Sardinha, L. B., Lohman, T. G., Teixeira, P. J., Guedes, D. P., & Going, S. B. (1998). Comparison of air displacement plethysmography with dual-energy X-ray absorptiometry and 3 field methods for estimating body composition in middle-aged men. *American Journal of Clinical Nutrition*, 68, 786-793.
- Siri, W. R. (1961). Body composition from fluid spaces and density; analysis of methods. In: Techniques for measuring body composition Ed. Brozek, J. and Henschel, A., pp 223-244. National Academy of Science. Washington D.C.
- Soriano, J. M. P., Ioannidou, E., Wang, J., Thornton, J. C., Horlick, M. N., Gallagher, D., & Pierson Jr, R. N. (2004). Pencil-beam vs fan-beam dual-energy x-ray absorptiometry comparisons across four systems: body composition and bone mineral. *Journal of Clinical Densitometry*, 7(3), 281-289.
- Spalding, K. L., Arner, E., Westermarck, P. O., Bernard, S., Buchholz, B.A., Bergmann, O., ... Arner, P. (2008). Dynamics of fat cell turnover in humans. *Nature*, 453(7196).
- Stevens, J., Cai, J., Pamuk, E. R., Williamson, D. F., Thun, M. J., Wood, J. L. The effect of age on the association between body mass index and mortality. *The New England Journal of Medicine*, 1998; 338:1-7.
- Stolk, R. P., Wink, O., Zelissen, P. M. J., Meijer, R., Van Gils, A. P. G., Grobbee, D. E. (2001). Validity and reproducibility of ultrasonography for the measurement of intra-abdominal adipose tissue. *International Journal of Obesity*, 25, 1346-1351.
- Taskinen, M. R., Adiels, M., Westerbacka, J., Soderlund, S., Kahri, J., Lundbom, N., ... Boren J. (2011). Dual metabolic defects are required to produce hypertriglyceridemia in obese subjects. *American Heart Journal*, 9: 2144-2150.
- Toombs, R. J., Ducher, G. Shepherd, J. A., De Souza, M. J. (2012). The impact of recent technological advances on trueness and precision of DXA to assess body

- composition. *Obesity*, 20(1), 30-39.
- Utter, A. C. & Hager, M. (2008). Evaluation of ultrasound in assessing body composition of high school wrestlers. *Medicine & Science in Sports & Exercise*, 40(5), 943-949.
- Vague, J. (1956) The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout and uric calculus disease. *American Journal of Clinical Nutrition*, 34, 416–422.
- Valdez, R., Seidell, J. C., Agn, Y. I. Weiss, K. M. A new *A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross population study. International Journal of Obesity and related Metabolic Disorders*. 17(2), 77-82.
- Vescovi, J. D., Zimmerman, S. L., Miller W. C., Fernhall, B. (2002). Effects of clothing on accuracy and reliability of air displacement plethysmography. *Journal of Medicine and Science in Sports and Exercise*, 34, 282-285
- Visser, M., Fuers,t T., Lang ,T., Salamone, L., Harris, T. B. (1999.) Validity of fan-beam dual-energy X-ray absorptiometry for measuring fat-free mass and leg muscle mass. *Journal of Applied Physiology*,
- Visockiene, Z., Johnstone, A. M., Speakman, R. J., Broom, I .J. (2007) Body composition measurement in obese patients with and without type 2 diabetes: comparison of methods. *Acta Med Lituanica*. 14(4): 301-308.
- Wagner, D. R., Heyward, V. H., Gibson, A.L. (2000). Validation of air displacement plethysmography for assessing body composition. *Journal of Medicine and Science in Sports and Exercise*, 32, 1339-1344.
- Wang , Z., Deurenberg, P., Wang, W., Pietrobelli, A., Baumgartner, R. N., Heymsfield, S. B. (1999). Hydration of fat-free body mass: review and critique of a classic body-composition constant. *American Journal of Clinical Nutrition*, 69(5), 833-841.
- Wells, J. C. K., Douros, I., Fuller, N. J., Elia, M., Dekker, L.(2000). Assessment of body volume using three-dimensional photonic scanning. *Annals New York Academy of Sciences*. 904, 247–254.
- Weyers, A. M., Mazzetti, S. A., Love, D. M., Gomez, A. L., Kraemer, W. J., Volek J. S. (2002). Comparison of methods for assessing body composition changes during weight loss. *Journal of Medicine and Science in Sports and Exercise*, 34(3):497-502.
- Wing, R R., Goldstein, M. G., Acton, K. J., Birch, L. L., Jakicic, J. M. Sallis, J. M. ... Surwit, R. S. (2001). Lifestyle changes related to obesity, eating behavior, and physical activity. *Diabetes Care*, 24(1), 117-123.

- Williams, J. E., Wells, J. C., & Wilson, C. M. (2006). Evaluation of Lunar Prodigy dual-energy X-ray absorptiometry for assessing body composition in healthy persons and patients by comparison with the criterion 4-component model. *American Journal of Clinical Nutrition*, 83,1047–1054.
- Withers, R., Laforgia, J., Pillans, R., Shipp, N, Chatterton, B, Schultz, C., & Leaney, F. (1998).Comparisons of two-, three-, and four-compartment models of body composition analysis in men and women. *Journal of Applied Physiology*, 85(1), 238-245.
- World Health Organization. (2007). WHO STEPS Surveillance Manual, Retrieved from <http://www.who.int/chp/steps/manual/en/index.html>

APPENDICES

APPENDIX A
INFORMED CONSENT FORM



Department of Sport Science and Wellness Education
College of Education
Akron, OH. 44325-5103
330-972-7738 Office
330-972-5293

PROTOCOL TITLE: A Comparison of Body Composition Assessment Techniques in Adults

Informed Consent Form

For Prospective Collection of Data/Information

DESCRIPTION: You are invited to participate in a research study that evaluates the accuracy of the BodyMetrix ultrasound device. This device will be compared to four other validated methods to determine accuracy, including the Dual-Energy X-Ray Absorptiometry (DEXA), Air displacement plethymography (Bodpod®), Bioelectric Impedance (InBody 520 body fat analyzer), and skin fold calipers. From the information collected we hope to learn how results from the BodyMetrix Ultrasound BX2000 device (IntelaMetrix, CA) compare to the other body composition methods.

PROCEDURES: You will be asked to refrain from exercise, food and drink, 2 hours prior to all testing. We will measure your height, weight, and body composition (muscle mass, fat mass, and body fat percentage). Additionally, you will be asked to complete Medical History and Godin Leisure Time Physical Activity questionnaires. The purpose of collecting the medical history and Godin questionnaires is to gather information about your health status and physical activity habits. This information will be confidential and used in comparing the various methods of body composition determination used in the study. You will not be required to do any physical activity for this study. Excess body fat and the distribution of the body fat may be correlated with the prevalence and/or risk factors for certain metabolic diseases such as diabetes, cardiovascular disease and obesity. You will then come into the Exercise Physiology laboratory one time for all testing. Age, height, and weight will be measured first, followed by waist, hip, and neck circumference (using a Baseline® Circumference tape measure).

Next, measurements will be taken using the InBody 520® body fat analyzer. This device measures the conduction of an electrical current traveling through your legs, arms, and trunk. Substances such as water, blood and muscle provide little resistance to the current, whereas adipose (fat) tissue is resistant to the current. Your height and age will be entered manually into the InBody 520® machine where you will step barefoot onto the metal surface footpads and your body weight will be measured. Full feet contact with the metal footpads must be maintained. You will grab the handheld pads with your hands, having your arms relaxed by your side and the above variables will be measured. You will not feel the current as it is being measured. Skin folds using a Lange skin fold caliper will be performed next where we will measure skinfold thickness in several areas of your body: chest, side of your body under your armpit, top of your hip, near your belly button, mid-thigh, the back of your arm and near your shoulder blade. Bodpod® testing will be performed next; you will be asked to remove shoes, socks, jewelry, and then provided with a nylon swim cap to cover your hair during testing. Your age, gender and height will be entered into the computer and you will be weighed on a calibrated digital scale. You will then enter the Bodpod® sitting still in the chamber with your hands in your lap, and instructed to breathe normally while two; 50-second measurements are obtained. Next, Dual Energy X-Ray Absorptiometry (DEXA) measurement will be performed. You will be asked to remove all jewelry and metals, and lay quietly, arms at your sides, on the scanning table. Scans begin at the head and move slowly to the feet. This assessment will be completed in 10-20 minutes. Finally, the BodyMetrix BX2000 Ultrasound device will be used. Ultrasound gel will be applied to the top of the wand where measurements will be taken in the same areas that the skinfolds were

performed. Once the wand is placed vertically, the wand will move in a small circle and then slid back and forth along the skin surface where the fat mass, muscle mass and percent body fat will be recorded.

RISKS: The possible risks associated with this study include the DEXA scans utilizing a small dose of radiation (1/10th of a typical medical X-ray and much less than a CAT scan); and each of you will be asked to take part in one scan. However, it must be noted that DEXA scans are common in research and clinical settings and pose minimal risk (any radiation exposure theoretically carries some risk) and but no discomfort. Additionally, some patients while enclosed in the Bod Pod may feel claustrophobic. Skinfold assessment using the Lange calipers may cause slight discomfort as the skin folds are being pinched.

BENEFITS: The benefits of this study are that you will learn your body composition: body fat percentage, fat mass and lean body mass as well as the distribution of these components in your body.

This information was explained to me by one, or both, of the following:

Kelly Johnson

Dr. Judith A. Juvancic-Heltzel

I understand that the investigators will answer any questions I may have concerning this investigation at any time by calling the phone numbers listed below. I understand that all of the information collected is confidential and for research purposes. The information will only be available to the investigators and will be kept in the locked office Room 307E. I also understand that my participation in this study is entirely voluntary, that I must be 18 years of age or older, and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the investigator may terminate my participation in the study at any time.

Contact information:

Dr. Judith A. Juvancic-Heltzel (330) 972-6273 jaj52@uakron.edu

Kelly Johnson (541) 490-702 kej20@ziips.uakron.edu

Dr. Otterstetter (330) 972-7738 ro5@uakron.edu

I understand I am not receiving any compensation for participating in this study, other than my individual data from the testing procedures.

Signature of Research Participant/Date

Witness/Date

APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Being more active is very safe for most people. However, some people should check with their physician before they start becoming more physically active. Please complete this form as accurately and completely as possible.

PAR-Q FORM Please mark YES or No to the following: YES NO

Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity? ____ ____

Do you frequently have pains in your chest when you perform physical activity? ____ ____

Have you had chest pain when you were not doing physical activity? ____ ____

Have you had a stroke? ____ ____

Do you lose your balance due to dizziness or do you ever lose consciousness? ____ ____

Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed when developing an exercise program (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, etc.)? ____ ____

Are you pregnant now or have given birth within the last 6 months? ____ ____

Do you have asthma or exercise induced asthma? ____ ____

Do you have low blood sugar levels (hypoglycemia)? ____ ____

Do you have diabetes? ____ ____

Have you had a recent surgery? ____ ____

If you have marked YES to any of the above, please elaborate below:

Do you take any medications, either prescription or non-prescription, on a regular basis? Yes/No
What is the medication for?

How does this medication affect your ability to exercise or achieve your fitness goals?

Please note: If your health changes such that you could then answer YES to any of the above questions, tell your trainer/coach. Ask whether you should change your physical activity plan.

I have read, understood, and completed the questionnaire. Any questions I had were answered to my full satisfaction.

Name: _____

Date: _____

APPENDIX C

GODIN LEISURE TIME PHYSICAL ACTIVITY QUESTIONNAIRE

Godin Leisure Time Physical Activity Questionnaire

Considering a 7-Day Period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time? (write on each line the approximate number)

Times Per Week

1. Strenuous Exercise _____
 - a. (Heart beats rapidly)
 - b. Examples: running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling

2. Moderate Exercise _____
 - a. (Not Exhausting)
 - b. Examples: fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing

3. Mild Exercise _____
 - a. (Minimal Effort)
 - b. Examples: yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking

4. Considering a 7-Day period, during your leisure-time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?
 - a. Often
 - b. Sometimes
 - c. Never/Rarely

APPENDIX D
MEDICAL HISTORY FORM

MEDICAL HISTORY - ADULT

Participant ID # _____ Date ___/___/___
Major (if college student) _____
Age _____ DOB ___/___/___ Sex m f
Height _____ in Wt _____ lbs
Height _____ cm (inches *2.54) Wt _____ kg (lbs/2.2)
BMI _____ kg/m² Weight percentile _____

Which ethnic group do you most identify with (circle response):
American Indian or Alaskan Native Asian or Pacific Islander Black, not of Hispanic Origin
Hispanic White, not of Hispanic Origin
Other _____

Y/N
____ Has a doctor ever said that your blood pressure was too high or too low?
____ Do you ever have pain in their heart or chest?
____ Do you ever notice extra heart beats, skipped beats or a racing heart?
____ Has a doctor ever said that you have heart trouble, an abnormal electrocardiogram (ECG or EKG),
heart attack, or coronary?
____ Do you often have trouble breathing?
____ Have you ever been diagnosed with asthma?
____ Have you ever been diagnosed with diabetes?
____ Do you have any orthopedic limitations to physical activity?

Do you have any other medical conditions that affect your ability to safely participate in physical activity?
If yes, explain.

Are you currently taking any medication(s)? Y N
If yes, please describe the
medication(s) _____

Are you involved in any club or school sport teams? Y N

If yes, what sport(s) and how frequently each week ? _____

Do you have any questions?

Does the participant seem eligible?

APPENDIX E
HUMAN SUBJECTS APPROVAL FORM



NOTICE OF APPROVAL

January 19, 2012

Kelly Johnson
200 West South Street
Akron, Ohio 44311

From: Sharon McWhorter, IRB Administrator

Re: IRB Number 20120108 "A Comparison of Body Composition Assessment Techniques in Adults"

Thank you for submitting an IRB Application for Review of Research Involving Human Subjects for the referenced project. Your protocol represents minimal risk to subjects and has been approved under Expedited Categories 4 & 7.

Approval Date: January 19, 2012
Expiration Date: January 19, 2013
Continuation Application Due: January 5, 2013

In addition, the following is/are approved:

- Waiver of documentation of consent
- Waiver or alteration of consent
- Research involving children
- Research involving prisoners

Please adhere to the following IRB policies:

- IRB approval is given for not more than 12 months. If your project will be active for longer than one year, it is your responsibility to submit a continuation application prior to the expiration date. We request submission two weeks prior to expiration to insure sufficient time for review.
- A copy of the approved consent form must be submitted with any continuation application.
- If you plan to make any changes to the approved protocol you must submit a continuation application for change and it must be approved by the IRB before being implemented.
- Any adverse reactions/incidents must be reported immediately to the IRB.
- If this research is being conducted for a master's thesis or doctoral dissertation, you must file a copy of this letter with the thesis or dissertation.
- When your project terminates you must submit a Final Report Form in order to close your IRB file.

Additional information and all IRB forms can be accessed on the IRB web site at:
<http://www.uakron.edu/research/orssp/compliance/IRBHome.php>

Cc: Ronald Otterstetter – Advisor
Cc: Judith Juvancic-Heltzel – Co PI
Cc: Stephanie Woods – IRB Chair

Approved consent form/s enclosed

Office of Research Services and Sponsored Programs
Akron, OH 44325-2102
330-972-7666 • 330-972-6281 Fax

The University of Akron is an Equal Education and Employment Institution