ABSTRACT

Comparison of Circumference-based Equation and Air Displacement Plethysmography to Assess Body Fat Percentage and Evaluation of Intervention for Army ROTC Cadets to Meet Body Composition Standards

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This study was designed to determine the correlation between manual anthropometric measurements used in the United States Army to determine body fat percentage and measurements taken using air displacement plethysmography (BOD POD). Additionally, this study investigated the effectiveness of a fitness and nutritional intervention program in reducing the number of cadets not meeting the Army standard for body fat percentage. Ten adults from Baylor University Army ROTC participated. Body fat percentage data were collected from the Army Physical Fitness Test Scorecard (DA Form 705) and the BOD POD. Diet and exercise journals were used in the intervention program. Finally, a post study survey was conducted. Body fat percentages calculated from manual anthropometric measurements were found to be significantly lower than those measured by the BOD POD. A downward trend was observed in body fat percentage for intervention cadets; however, more time would be needed to potentially meet body composition standards.

Comparison of Circumference-based Equation and Air Displacement Plethysmography to Assess Body Fat Percentage and Evaluation of Intervention for Army ROTC Cadets to Meet Body Composition Standards

by

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A Thesis

Approved by the Department of Family and Consumer Sciences

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Mary K. Weems, Ph.D., Chairperson

Submitted to the Graduate Faculty of
Baylor University in Partial Fulfillment of the
Requirements for the Degree
of

Master of Science

Approved by the Thesis Committee

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May 2015

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ACKNOWLEDGMENTS

A very special thanks goes out to Dr. Mary K. Weems and Dr. Janelle M. Walter, without whose motivation and encouragement I would not have considered a graduate career in nutrition science. It was through their persistence, understanding, and kindness that I was encouraged to apply for graduate school. I am forever grateful for the educational and professional developmental opportunities that you both have provided me during my graduate experience.

I would like to express my gratitude to Dr. Donna O. Burnett, whose expertise, understanding, and patience, added considerably to my graduate experience. I appreciate her vast knowledge and skill in many areas, and her assistance. She provided me with direction, technical support, and became more of a mentor and friend, than a professor.

I would also like to thank Dr. Paul M. LaBounty for all of the assistance and guidance provided at all levels of the research project.

I must also acknowledge Baylor University Army ROTC, “Bear Strong!”. Thanks for allowing me to include the cadets in my research and providing critical information concerning the ROTC program.

I would also like to thank my friends in the Nutrition Science program, particularly Chien-ming Chiang and Jordan Walker for our exchanges of knowledge, skills, and venting of frustration, which helped enrich the experience.

Lastly, I would like to thank my family for the support they have provided me throughout my entire life, and without whose love and encouragement, I would not be where I am today.

DEDICATION

To Ricky Hagood (SFC, U.S. Army, Retired) and
Darlene Hagood (CSM, U.S. Army, Retired).

CHAPTER ONE

Introduction

The United States Army is physically demanding for all soldiers. As a result, the Army strives to recruit the most physically fit persons. The Reserve Officer Training Corps (ROTC) recruits young men and women aspiring to be commissioned officers in the United States Army. Officers are considered to be the leaders in the Army, and are expected to lead by example. One of the Army standards is maintaining an acceptable percentage of body fat in their overall body composition, as described in Army Regulation 600-9. In recent years, the Army has expressed increased concern in increasing body weight and body fat percentages and "its effect on physical fitness, battlefield performance, and military appearance" (Crawford et al., 2011).

In the past, ROTC cadets have been denied scholarship and contract rewards due to failure to meet the body fat percentage standards. In some instances, cadets awarded a scholarship have been disenrolled from the program during their junior or senior academic years; on occasion, some cadets have been dropped post-graduation, prior to commissioning, solely as a result of not meeting the body fat percentage standard.

Statement of the Problem

This study was designed to (a) determine the correlation between manual anthropometric measurements that are used to determine body fat percentage and measurements taken using air displacement plethysmography (BOD POD), and (b) investigate the effectiveness of an individualized fitness and nutritional intervention

program focused on reducing the number of cadets not meeting the Army standard for body fat percentage.

Significance of the Study

Primarily, this study may provide support for reevaluating the body composition assessment techniques used by the Army. Secondarily, this study may provide a model of an effective intervention for cadets failing to meet the body fat percentage standard. Meeting the body fat percentage standard is important to cadets because it can be a determining factor in many ways. Cadets seeking a scholarship, and/or contract, will not be awarded these privileges without first meeting this standard. For cadets already having received a scholarship, failure to meet the body fat percentage standard can result in loss of scholarship and opportunity to commission, and simultaneous disenrollment from the Army ROTC program. When cadets lose their scholarships, thus forfeiting their contract to commission, they are required to pay back all financial rewards. If a cadet cannot pay back the financial rewards by a time decided by the higher commander, the cadet will be required to enlist in the Army.

For example, at Baylor University, contracted cadets are essentially given three semesters to meet the standard if it is found that they are outside the acceptable range. Upon the first infraction, cadets are counseled by the professor of military science (PMS), the commander, and advised to see a peer nutrition counselor at the Student Life Center. At this time, the cadet's benefits will be suspended until they are reassessed during the next semester. At the time of the second infraction, if cadets are in good standing, their benefits will continue to be suspended and will again be reassessed at the start of the next semester. If the cadets are not in good standing, this could qualify them for disenrollment

from the program. The third infraction semester is the cadet's final chance to meet the standard. At this time, if the standard is not met, the cadet will be disenrolled from the program. Most likely, the cadet will have to pay back their scholarship and other rewards. Special cases may arise when dealing with persons who have a medical condition that is preventing them from meeting the standard. Non-contracted cadets are given up to four semesters to meet the standard, which would typically be the beginning of their junior academic year. At this time, if the standard is not met, the cadet will be respectfully relieved from their participation in the Army ROTC program (J. Arroyo, personal communication, March 4, 2014).

This study has implications specifically targeting Army ROTC cadets; however, on a larger scale, this study could impact the United States Army and, furthermore, the security of the United States. Recent studies have shown that the obesity epidemic is affecting the number of persons fit to serve (McLaughlin, 2009). The Army needs to contract a predetermined number of people every year; with the decreased number of persons fit to serve, this goal is becoming difficult to meet (McLaughlin, 2009).

Definition of Terms

The following definitions serve to provide universal clarity and understanding for these terms through the entirety of this research.

1. Air displacement plethysmography (ADP) – a scientifically validated method for evaluating human body composition.
2. Army Body Composition Program (ABCP) – a program designed to enhance individual soldier readiness through the provision of healthy lifestyle choices

and by providing strategic policy oversight, interpretation, and guidance to the field that enhances readiness of the total force (AR 600-9)

3. Army Physical Fitness Test (APFT) – a test designed to measure muscular strength, muscular endurance, and cardiovascular respiratory fitness of soldiers. The events that make up this test are push-ups, sit ups, and a two mile run (FM 7-22).
4. Army Regulation (AR) 600-9 – an Army regulation that issues guidance and instruction for policies and procedures governing body composition and physical fitness standards.
5. BOD POD – a type of ADP tool that is used to measure body mass and volume. This technology is able to calculate body density, along with the amount of lean and fat tissue in one's body.
6. Cadet – a student or trainee attending a military school or program in order to become a commissioned military officer.
7. Cadre – a key group of officers and enlisted personnel that have been tasked with training the cadets.
8. Manual anthropometrics – manual measurements of the proportion, size and weight of the human body, carried out by a weight scale and tape measure.
9. Military Science (MS) Class – the classification within the ROTC program. From least to most experienced the classes are listed: MSI, MSII, MSIII, MSIV, and MSV. In most cases, one's military science class is reflective of their scholastic classification as a freshman, sophomore, junior, or senior, respectively.

10. Reserve Officer Training Corps (ROTC) (Army) – a college-based program responsible for training and preparing students to become commissioned officers.
11. Standard – an idea or thing used as a measure, norm, or model in comparative evaluations.
12. Taping – a form of evaluating body composition using a tape measure to measure the circumference of specific areas of the body for males and females.

Limitations

Participants may have consumed drugs that either conflicted with the expected outcomes or enhanced them. Furthermore, participants may have extremely limited their caloric intake, by way of crash dieting, bulimia or starvation. Likewise, subjects may have increased their exercise regimen beyond that which is described in the methods as a part of the intervention. In extreme cases, subjects may have undergone surgical treatment. Such approaches to weight loss may result in decreased performance and impose negative health consequences. Unrealistic body weights or body images can contribute to unhealthy weight loss approaches (Naghii, 2004).

Assumptions

The process of manual anthropometrics and BOD POD measurements may include human error. It is assumed that gender differences will not significantly impact the outcomes of the treatment. Similarly, it is assumed that classification (MSI, MSII, MSIII, and MSIV) will not significantly impact the outcomes of the treatment. Also, it is

assumed that all participants will answer all questions honestly and to the best of their ability.

CHAPTER TWO

Review of Literature

In efforts to provide appropriate management and control of human body fat percentage, it is vital that precise and accurate measures are taken, along with the development of successful treatments (Miyatake, 2005). This chapter will serve to provide relevant information from previous studies and related documents.

Army Standard

The Army has clearly defined standards for allowable body fat percentage. The standards are categorized by age groups and sex, as depicted in Table 1. The first age group is 17-20 years. Males in this age group are allowed 20% body fat, while women are allowed 30%. For each age group, following the first age group, the acceptable body fat percentage is increased by 2%. The second, third, and fourth age groups are 21-27, 28-39, and 40 and older, respectively (AR 600-9).

Table 1

Army Maximum Allowable Body Fat Percentages

Age Group	Male	Female
17 – 20	20%	30%
21 – 27	22%	32%
28 – 39	24%	34%
40 and older	26%	36%

Anthropometric Measurements

Throughout the context of this research anthropometric measurements will be limited to describing height, weight, and body circumference measures used to manually determine a soldier's height, weight, or body fat percentage.

Commonly among the literature, height and weight are used to assess one's body mass index (BMI). Specifically BMI is calculated by weight (kg)/ height (m^2). BMI is generally used as a preliminary assessment, or screening tool, when considering body composition. BMI does not take into consideration bone density, or fat free mass, which contribute to the body's composition.

Circumference measures are also used in efforts to better predict body fat composition manually. Measures such as waist circumference, neck circumference, and hip circumference are obtained (Miyatake, 2005). This numerical information is then entered into a gender specific formula to calculate a body fat percentage.

Body Composition Measurements

Numerous methods have been made available for the indirect measurement of body composition, and thus body fat percentage. The following are currently used methods for acquiring human body composition measurements: anthropometry, hydrodensitometry, measure of total potassium, air displacement plethysmography, dual X-ray absorptiometry (DEXA), bioelectrical impedance (BI), *in vivo* neutron activation analysis, and advanced imaging techniques (Miyatake, 2005). Due to the literature currently available in relation to the BOD POD the following discussion will address four methods in depth: BI, hydrodensitometry, DEXA, and BOD POD.

BI is a measurement approach that is based on applying an electric current to the human body. It is not as valid or reliable as the BOD POD; there are several common technical problems associated with this method (Miyatake, 1999). Different BI devices may use different equations to calculate body fat percentage, which can lead to a wide range of variability within this one measurement approach (Schifferli, Carrasco, & Inostroza, 2011). In a study by Miyatake (2005) using 11,833 Japanese subjects, BI underestimated body fat percentage compared to the BOD POD. Using DEXA as a reference technique, a study conducted by Schifferli, Carrasco, & Inostroza (2011), evaluating the manufacturer's equation, found that the manufacturer's equation used in the BI equipment underestimated fat mass by -2.5 ± 9.5%. Still, this method is safe, quick, non-invasive, and "requires minimal operator training" (Lintsi, Kaarma, & Kull, 2004). BI can provide accurate estimates of body composition. Contrastingly, problems associated with this method are due to the heavy influence of pulsatile blood flow, and total water volume in the body (Miyatake, 1999). Lintsi, Kaarma, and Kull (2004) found relatively long arms to significantly influence body fat calculations measured by BI. Therefore, BI is less reliable than other methods.

Hydrostatic weighing, also known as underwater weighing or hydrodensitometry, is a method in which one's weight in air is compared to their weight under water (Miyatake, 1999). Archimedes' principle is the basis of the hydrostatic weighing. Archimedes' principle states that the volume of an object submerged in water equals the volume of water displaced by the object (Francis, 1990). The procedures of this method are difficult to execute in obese, physically handicapped, and elderly populations (Miyatake, 1999).

DEXA measurements were originally used to evaluate bone diseases and disorders (Miyatake, 1999). It was later recognized that the same output data could be used to assess body composition to a degree of that comparable to hydrostatic weighing. Although the radiation emitted from this method is low, that could be discouraging to participants and their health. Additionally, the equipment is bulky and not suitable for conditions outside of the laboratory. Using a DEXA is also expensive (Miyatake, 1999).

The BOD POD is a relatively new air displacement plethysmograph (Miyatake, 1999). The BOD POD calculates body volume by measuring the decrease in volume caused by a subject entering the chamber, which has a fixed air volume. Next, whole body density is determined and body composition is calculated from prediction equations stored in the BOD POD software. This is similar to the process used in hydrostatic weighing (Miyatake, 2005). Research carried out by Miyatake and others has evaluated and confirmed the validity and reliability of this method through several tests. Findings of the Miyatake (2005) study concluded that there is high reliability of multiple tests completed in one single day, as well as over the course of three days. Bias caused by technicians responsible for operating the equipment was also accounted for. After five subjects were each measured by three different technicians, there were no significant differences found. A highly significant positive correlation was discovered between the DEXA and the BOD POD (Miyatake, 1999). Contrarily, a study that evaluated calorie restricted adults, normal weight adults, and overweight adults, based on BMI groups, found that the BOD POD tends to overestimate body fat percentage in participants with a lower body mass. In normal weight and overweight persons, the differences were not significant (Lowry & Tomiyama, 2015). Body composition can be determined with the BOD POD in two to five minutes on average. Minimum instructions are required for

persons being tested; high compliance has been observed (Miyatake, 1999). Additionally, because the assessment is software driven, the administration of the assessment takes minimal training. Furthermore, this equipment is mobile and not as costly financially as other methods. The BOD POD can be useful in weight control programs where simple and accurate body composition assessments are required (Miyatake, 2005); hydrostatic weighing and DEXA are impractical due to their large size, relatively high costs, and time consuming procedures. On the other hand, persons who have difficulties being in enclosed spaces, or consider themselves claustrophobic, may have difficulties using this method due to the design of the BOD POD.

Importance of Body Weight and Body Composition Management for Military Personnel

There is meaningful purpose behind the body composition standards in the military. All military branches strive to select persons who are most qualified to meet and exceed the physical demands of the job. It is assumed that an appropriate body weight and body composition will support good general health, physical readiness, and an acceptable military appearance (Naghii, 2006). Although it is controversial, military regulations tend to favor appearance. Excess amounts of abdominal fat are likely to attract more negative attention than the same amount of fat evenly distributed throughout the body (Naghii, 2006). In addition to increased abdominal circumference measures being associated with increased health risks, physical appearance provides basis for emphasis on abdominal circumference.

Excess body fat may have negative implications on the battlefield. Excess fat can negatively affect a soldier's ability to properly execute tactical movements, or cause the

soldier to execute tactical movements at a decreased speed, potentially increasing the time that the soldier is exposed to the enemy (Crawford et al., 2011).

Army Body Composition Program (ABCP)

In the Army, there is an established program to help soldiers meet the body fat percentage standard. Additionally, this program provides leaders a systematic approach to enforce these Army standards for all components (AR 600-9). This program is only made available to active duty and reserve component soldiers; there is not an established program for cadets.

All soldiers are weighed, at minimum, every six months to ensure compliance with regulations. The allowable weight is based on height and gender. When height and weight are being measured, the designated uniform is the authorized physical fitness t-shirt and trunks. Height is measured on a flat surface; the soldier looks directly forward, the head is held horizontal with the line of sight horizontal, and the chin parallel to the ground (AR 600-9). The body should be straight, but not rigid. When height is measured for the weight screening, the height is rounded to the nearest inch. When height is measured to determine body fat percentage, the height is measured to the nearest half-inch (AR 600-9). Weight is measured on scales used for weight measurements. These scales must be calibrated annually for accuracy (AR 600-9). Weight is rounded to the nearest pound: (a) if the fraction is less than one-half pound, round down, and (b) if the fraction is one-half pound or greater, round up.

If the screening weight is not met, soldiers are taped to assess body fat percentage. When being taped, soldiers will wear the authorized physical fitness uniform trunks and t-shirt. Spandex or girdle-like undergarments that may serve to bind or compress soft

tissue in the abdomen, hip, or thigh areas are prohibited. The tape measure will be made of nonstretchable material, preferably fiberglass (AR 600-9). The width of the tape measure will be one-quarter to one-half inch, with a minimum length of five feet. The selected tape measure will be calibrated using a yardstick. Unit commanders are responsible for designating personnel that have read the instructions, been properly trained, and obtained adequate practice. Two members of the unit are used to take circumference measurements. One soldier places the tape and takes measurements; the other soldier ensures proper placement and tension of the tape (AR 600-9). Soldiers should be measured by individuals of the same gender. Neck and waist circumferences are measured for males, and neck, waist, and hip circumferences are measured for females. All circumference measures are taken three times sequentially; and the average of these measures is used in body fat percentage calculations (AR 600-9).

Soldiers that exceed the allowable percent body fat standards are flagged and enrolled in the ABCP (AR 600-9). While enrolled in ABCP, soldiers will receive exercise guidance from their unit master fitness trainer or unit fitness training non-commissioned officer (NCO). A registered dietitian will provide nutrition counseling; a health care provider will provide nutrition counseling if a registered dietitian is not available (AR 600-9). Additional assistance in behavioral modification is provided as needed. About every 30 days the soldiers in the program are reassessed. Satisfactory progress in the program is measured by a monthly loss of three to eight pounds, or at least one percent decrease in body fat (AR 600-9). Soldiers must meet the body fat standard in order to be released from ABCP, regardless of passing the screening. Here lies a notable difference between ROTC and Army; a cadet is assumed to have met the standard and eligible for scholarship, contract, etc., upon passing the height and weight screening. A soldier has

failed the program when "he or she exhibits less than satisfactory progress on two consecutive monthly ABCP assessments," or if after six months the soldier has not met the body fat standards and exhibits unsatisfactory progress for three monthly assessments (AR 600-9). Failure of ABCP will lead to separation action, bar to reenlistment, or transfer to individual ready reserve, if there is no underlying medical condition (AR 600-9).

Nutrition Counseling and Physical Activity

In previous studies, diet has been shown to be more effective when considering initial weight loss. Contrastingly, exercise is the best predictor of preventing repeated weight gain (McInnis, 2003). A combination of both diet and exercise would potentially best promote and help sustain a healthy weight loss, or healthy body composition. A good weight loss program will include a weight loss phase and a maintenance phase (Naghii, 2006). Inappropriate weight reduction can lead to a decrease in lean tissue, as well a reduction in performance level.

Physical activity has been shown to favorably affect weight loss, total fat content, and body fat composition. Specifically, endurance exercises of an appropriate intensity, frequency, and duration are responsible for these affects (McInnis, 2003). For overweight or obese persons, it is critical to ensure that the exercise program is safe, effective, educational, and motivational (McInnis, 2003).

CHAPTER THREE

Methods

Population and Sample

The population addressed in this study is all Army ROTC cadets. The sample frame for this study consisted of 84 Baylor University Army ROTC cadets. The subjects selected for the study were acquired by systematic sampling. These cadets were selected on the basis that they failed the height and weight screening; and had to be taped to assess body fat percentage. Eighteen cadets were eligible to participate and 10 cadets agreed to participate in the study. This sample was composed of four females and six males. All participants signed an Institutional Review Board (IRB) consent form prior to participation. This study was approved by the Baylor University Committee for Protection of Human Subjects in Research, which is the official Baylor University Institutional Review Board [598403-3].

Phase One – Screening

Phase one was the screening phase. Initially, height and weight were used as screening parameters, with criteria used for cut scores presented in Figure 1. Cadets either passed or failed this assessment. It is important to note that the screening table used by the Army is not synonymous to a BMI table. For this phase, height was measured with a Komelon Tape Measure by an MSIV cadet; weight was measured with a Health O Meter Professional, Model 320KL digital scale, by an MSIV cadet. This weight scale is of 18 gauge steel construction with baked enamel finish. It has a 12 inch by 12 inch

platform and a capacity of 400 lbs (180 kg). The weight measured is displayed on a remote LCD display that is connected to the scale by a nine cord; the scale is battery operated. Features include tare, 30-second auto-off, and low battery indicator. Six different cadets carried out the height and weight measures obtained throughout the study. A two-person team performed these assessments. One cadet observed the measure and called it out to the other cadet, who recorded the measure on the Army Physical Fitness Test Scorecard (DA Form 705). The same equipment was used for each measurement. Although cadets who failed to meet the lower limits of the standards did not pass the screening, only those exceeding the upper limits were eligible for this study.

Table B–1
Weight for height table (screening table weight)

		Male weight in pounds, by age				Female weight in pounds, by age			
Height (inches)	**Minimum weight[1] (pounds)**	**17–20**	**21–27**	**28–39**	**40+**	**17–20**	**21–27**	**28–39**	**40+**
58	91	-	-	-	-	119	121	122	124
59	94	-	-	-	-	124	125	126	128
60	97	132	136	139	141	128	129	131	133
61	100	136	140	144	146	132	134	135	137
62	104	141	144	148	150	136	138	140	142
63	107	145	149	153	155	141	143	144	146
64	110	150	154	158	160	145	147	149	151
65	114	155	159	163	165	150	152	154	156
66	117	160	163	168	170	155	156	158	161
67	121	165	169	174	176	159	161	163	166
68	125	170	174	179	181	164	166	168	171
69	128	175	179	184	186	169	171	173	176
70	132	180	185	189	192	174	176	178	181
71	136	185	189	194	197	179	181	183	186
72	140	190	195	200	203	184	186	188	191
73	144	195	200	205	208	189	191	194	197
74	148	201	206	211	214	194	197	199	202
75	152	206	212	217	220	200	202	204	208
76	156	212	217	223	226	205	207	210	213
77	160	218	223	229	232	210	213	215	219
78	164	223	229	235	238	216	218	221	225
79	168	229	235	241	244	221	224	227	230
80[2]	173	234	240	247	250	227	230	233	236

Notes:
[1] Male and female Soldiers who fall below the minimum weights shown in table B–1 will be referred by the commander for immediate medical evaluation.
[2] Add 6 pounds per inch for males over 80 inches and 5 pounds per inch for females over 80 inches.

Figure 1. Weight for Height Table (Screening Table Weight) (AR 600-9)

When cadets did not pass the height and weight screening, they were taped to assess body composition, targeting body fat percentage. The circumference measures were inserted into a formula, developed by the Department of Defense (DOD), to determine body fat percentage. The formulas used to calculate body fat percentage for males and females are displayed in Table 2.

Table 2

Body Fat Percentage Calculation Equations

Sex	Formula
Male	% body fat=[86.010 x Log10 (waist – neck)] – [70.041 x Log10 (height)] + 36.76
Female	% body fat=[163.205 x Log10 (waist + hip – neck)] – [97.684 x Log10 (height)] – 78.387

For males, the neck and waist circumferences were measured, as illustrated in Figure 2. The neck circumference was measured by the same trained male cadre member for all measurements with a 60-inch tape from IKEA, just below the larynx and perpendicular to the long axis of the neck; the tape was placed as horizontally as anatomically possible (AR 600-9). The cadet looked straight ahead throughout the measurement. Shoulders were positioned down and not hunched as to alter the measurement. Care was taken to ensure that neck and shoulder muscles were not involved in altering the measurements. Neck measurements were rounded up to the nearest half-inch (AR 600-9). Waist circumference was measured with a 60-inch tape measure from IKEA by the same trained male cadre member for all measurements, against the skin at the navel level and parallel to the floor. Arms were positioned at the sides and the measurement was taken at the end of a normally relaxed exhalation. Waist measurements were rounded down to the nearest half-inch (AR 600-9). All measures

were taken sequentially three times; an average of the three measures was used to calculate the body fat percentage (AR 600-9).

Neck, waist, and hip circumferences were measured for women, as illustrated in Figure 2 (AR 600-9). The neck measurement procedures and equipment were the same as for males. The waist circumference was measured with a 60-inch tape from IKEA, against the skin at the narrowest point of the abdomen, typically halfway between the navel and xiphoid process. Arms were positioned at the sides and the measurement was taken at the end of a normally relaxed exhalation. Waist measurements were rounded down to the nearest half-inch (AR 600-9). Hip circumference measures were taken with the view of the person being measured from the side. The measure was taken over authorized physical fitness uniform trunks; the tape was drawn snuggly without compressing the underlying soft tissue. The tape was placed around the hips at the greatest protrusion of the gluteal muscles, keeping the tape in a horizontal plane, parallel to the floor (AR 600-9) Time 1 and 2 were measured by a trained female cadre member; Time 3 and 4 were measured by a trained MSIV cadet. All measures were taken sequentially three times; an average of the three measures was used to calculate the body fat percentage (AR 600-9).

Within two days of the anthropometric body fat percentage assessment these participants had their body fat percentage assessed using the BOD POD. The COSMED *Gold Standard* Body Composition Tracking System was used for this study. All BOD POD assessments were administered by the same trained individual at each data collection point. The testing environment was kept between 70 and 80 degrees Fahrenheit, with a relative humidity of 20-70%. All quality control procedures were performed on the BOD POD prior to use, and quality tests were conducted at the

beginning of each testing day. The quality control procedures used were as follows: system warm-up, analyze hardware, scale calibration, scale check, autorun, and volume (COSMED USA, Inc.).

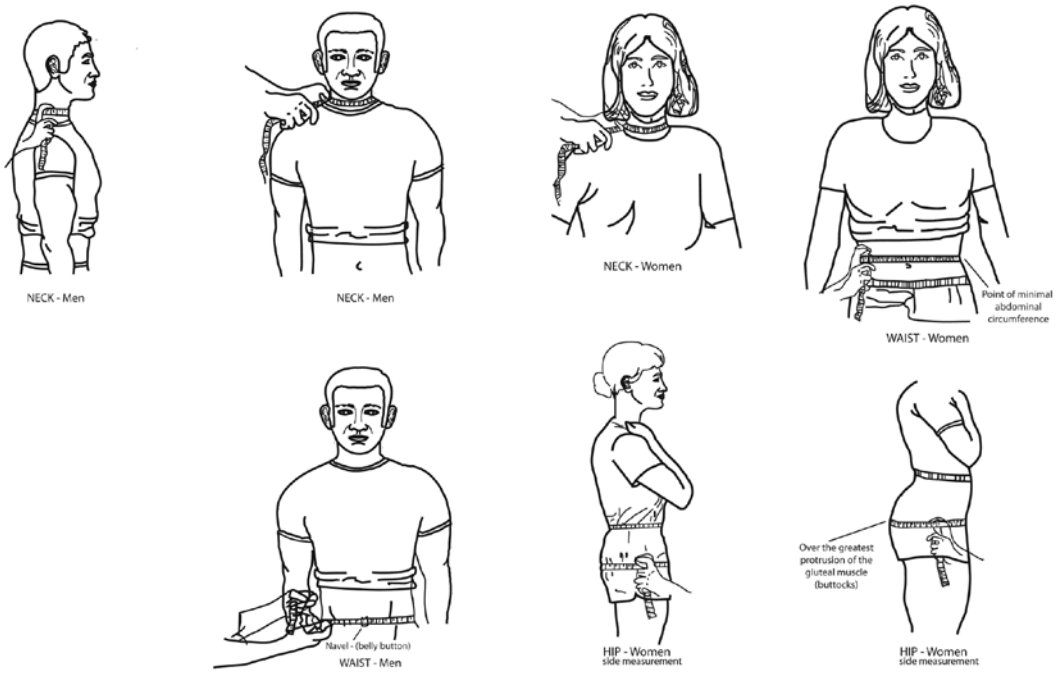

Figure 2. Male and female taping procedure illustration.

According to detailed specifications for operating the BOD POD, male subjects were required to wear spandex bottoms, while females were required to wear spandex bottoms and an unpadded sports bra. All participants wore a BOD POD swim cap, in order to completely cover and compress their hair. Prior to testing, participants abstained from food, drink, and exercise for two hours. The cadets were dry, relaxed, and at normal body temperature.

Before testing began, subject information was entered, including name, birth date, gender, and height. The same height measure recorded on the Army Physical Fitness Test Scorecard (DA Form 705) was used. Next, the subject's body mass was measured on the

calibrated electric scale used in conjunction with the BOD POD equipment. After that, the subject entered the BOD POD chamber for two or three volume measurements. Each volume measurement lasted for 50 seconds. In most cases, only two volume measurements were necessary; a third measure was only needed if the first two volume measurements were not consistent. Once the volume measurements were complete, the subject exited the BOD POD chamber. The thoracic gas volume (TGV) was predicted for each participant from BOD POD prediction equations. Body density (D_B) was calculated with the subject's mass (M_B) and volume (V_B), as depicted in Figure 3. Two different equations were used to calculate body composition, based on population; the equations are listed in Table 3 (COSMED USA, Inc.).

$$D_B = \frac{M_B}{V_B}$$

Figure 3. BOD POD body density calculation.

Table 3

BOD POD Software Equations

Name	Equation	Population
Siri	% fat = (4.95/D_B-4.50)*100	General Population
Ortiz	% fat = (4.83/D_B-4.37)*100	African American and Black Females

Phase Two – Intervention

Cadets who failed the anthropometric taping, thus exceeding the accepted body fat percentage, were eligible to participate in the intervention phase of this study. The intervention was delivered in two parts: nutrition counseling and exercise.

In the first part of the intervention, a graduate student in the Nutrition Sciences program at Baylor University provided peer nutrition counseling. The peer nutrition counseling began three days after entrance into the study, under the supervision of a doctoral-level registered dietitian. The nutrition counseling focused on nutrition education and making diet and exercise related behavior changes. Weight, body composition, nutrition, and physical activity goals were assessed. Nutrition education focused on healthy weight loss, keeping food records, balanced meals, portion control, physical activity, smart shopping, reading food labels, meal planning, food preparation, making better choices, and snack tips. Plans were made to reach healthy weight goals, using MyPlate nutrition education materials and healthy eating tips. Furthermore, a dietary analysis was completed using a three-day food journal at Time 1, Time 2, Time 3, and Time 4. Following the initial peer nutrition counseling session, nutrition counseling took place bi-weekly for each participant.

The second part of the intervention was an individually designed exercise program. Cadets were required to regularly participate in physical training (PT) three times a week. As a part of the intervention, two additional group exercise sessions were held on Mondays and Fridays to total five days of structured physical activity for the cadets in the intervention group. The two group exercise sessions lasted one hour each. Mondays consisted of long runs, while high intensity interval training exercises were completed on Fridays. Aside from two upper body circuit workouts, all workouts were derived from Army doctrine (FM 7-22).

Reassessment

Typically, four APFTs are administered during each semester, about four weeks apart. The initial height and weight screening occurred during APFT 1 (Time 1). All three of the reassessments were conducted during APFT 2 (Time 2), APFT 3 (Time 3), and APFT 4 (Time 4). At each reassessment, all subjects that participated in the initial assessment were required to repeat the screening, or phase one; no new participants were admitted to the study after the initial sample was formed. At any time the cadets were permitted to terminate participation in the intervention; however, all participants who had originally participated in the study were asked to complete phase one for each reassessment, pass or fail, in order to collect important data. Figure 4 depicts the methodology throughout the duration of the study.

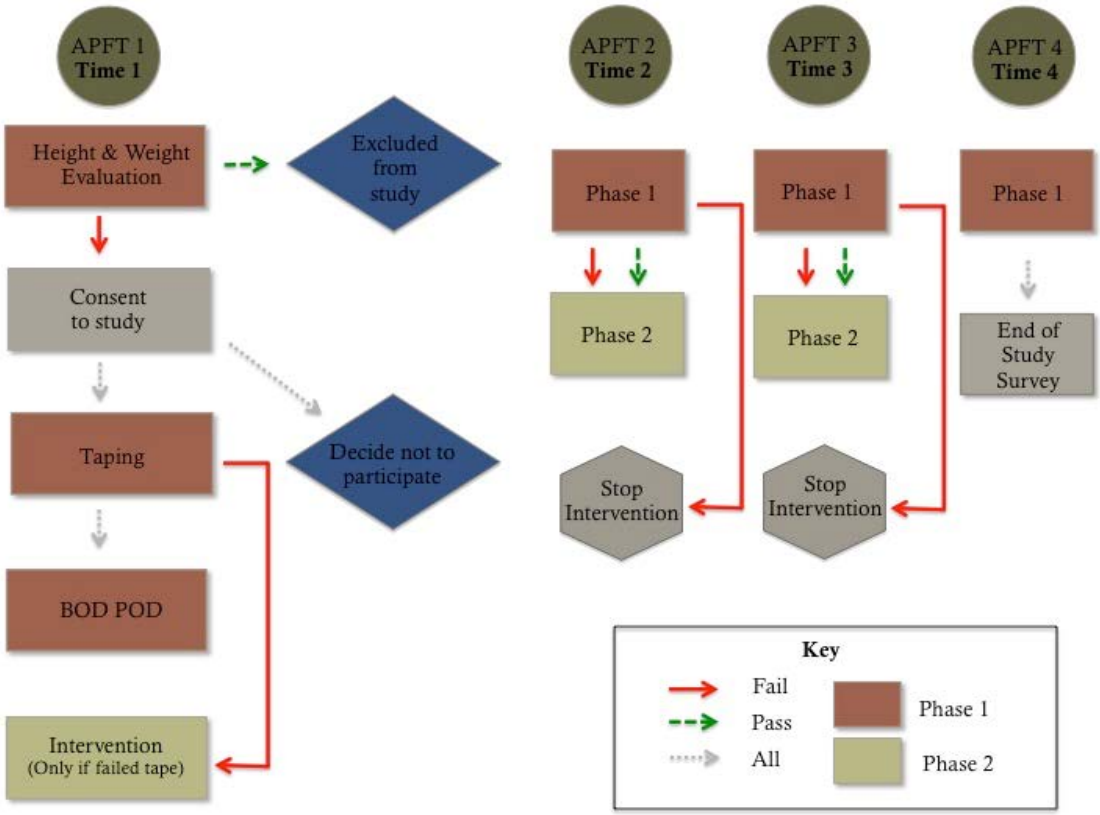

Figure 4. Methodology flow chart.

Statistics

Phase One - Screening

Data were analyzed using SPSS. Values were expressed as means ± SD. All assumptions were met before running paired *t* test: (a) only matched pairs can be used to perform the test, (b) the data are normally distributed, (c) the variance of the two samples is equal, and (d) the measurements must be independent of each other. The Pitman-Morgan test was used to test the assumption of homogeneity of variance prior to running paired *t* tests (Gardner, 2001). Multiple paired *t* tests were performed to compare means for the following data: (a) Times 1, 2, 3, and 4 body fat percentage calculated with anthropometric measures (Anthro%BF) and corresponding BOD POD body fat measures (BP%BF), (b) Time 1 and Time 4 body fat percentage calculated with anthropometric measures (Anthro%BF), (c) Time 1 and Time 4 body fat percentage measured by the BOD POD (BP%BF), (d) Time 1 and Time 4 weight measured with ROTC scales (ROTC Scales), (e) Time 1 and Time 4 weight measured with BOD POD scales (BP Scales), (f) Times 1, 2, 3, and 4 and averaged measurements for body weight taken with ROTC scales (ROTC scales) and those taken with the calibrated BOD POD scales (BP Scales), and (g) Time 1 and Time 4 APFT scores. For all tests, statistical significance was set at $p < 0.05$.

Phase Two - Intervention

A food and exercise journal was used to measure calorie consumption and activity. The diet information from these journals was entered into MyPlate SuperTracker to be converted into caloric intake data. MyPlate SuperTracker is an online software, developed by the United States Department of Agriculture, that allows one to "plan,

analyze, and track" one's diet and physical activity (USDA). The resulting quantitative data was used to assess calorie consumption, macronutrient distribution, and dietary trends.

CHAPTER FOUR

Results

Initially, all 84 Baylor Army ROTC cadets were screened, by MSIV cadets, using the height and weight screening table. The eighteen cadets who did not pass this screening were eligible to participate in this study; 10 cadets voluntarily participated in the study. The sample included six men and four women, for a total of 10 participants. Out of the 10 participants, three did not pass taping; they did not meet Army body fat percentage standards. Those three participants were eligible to participate in the intervention. Two of those three subjects participated in the intervention phase. Table 4 describes the general characteristics of the participants. As evidenced in Table 4, the participants were at various MS levels: four MSIs, two MSIIs, and four MSIVs. The average age was 19.9 years old. All participants were generally healthy throughout the duration of study.

Table 4

General Characteristics of Participants

Characteristic	Men	Women	All
Number	6	4	10
Age (years)	19.7	20.3	19.9
MS Level			
I	3	1	4
II	0	2	2
IV	3	1	4

Prior to running paired *t* tests to compare values, the Pitman-Morgan Test was run to evaluate the data for homogeneity of variance between dependent samples. The

Pitman-Morgan Test is used to test homogeneity of variance when there is a correlation between samples, such as are used in the paired *t* test. In all cases, except for two, there were no statistically significant differences detected between the variances in the variables used in the paired *t* tests. Table 5 displays the results of the Pitman-Morgan Test run to determine homogeneity of variance, noting that Pair 1 and Pair 5 differed significantly in terms of variance. The *t* test results for these pairs must be interpreted with caution due to this issue.

Paired *t* tests were run to compare means of variables with relationships of interest, particularly relationships between anthropometric measures and BOD POD measures. Results of the paired *t* tests are displayed in Table 6. Pair 5, comparing the Time 1 and Time 4 APFT scores, showed a statistically significant difference. Pair 9 depicts a statistically significant difference in Time 3 weight, comparing the ROTC scales and BP Scales. Pairs 11-14 compare Anthro%BF and BP%BP, at Time 1, Time 2, Time 3, and Time 4, respectively. There were highly significant differences at Time 1 and Time 2, while significant differences were observed at Time 3 and Time 4.

There was an insufficient number of subjects to perform statistical analyses for the intervention phase of the study. Therefore, observational data were considered in addition to the quantitative data. Due to the limited number of participants, these data are presented in the form of case studies. Table 7 shows caloric consumption of subjects throughout the duration of the study. Table 8 illustrates the macronutrient distribution of the calorie consumption. Subject 1 completed 17 out of 23 exercise sessions; Subject 2 completed 15 out of 23 exercise sessions.

Table 5

Results of Pitman-Morgan Test (Homogeneity of Variance)

Pair	Variable	Variance	*n*	*r*	*t* cal	*t* crit	*df*	Sig. (2-tailed)
1	Anthro BF							
	Time 1-	24.77	8	.959	-3.5935	±2.4469	6	.0115*
	Time 4	55.64						
2	BP%BF							
	Time 1-	48.612	9	.937	0.2043	±2.3646	7	.8439
	Time 4	46.059						
3	ROTC Scales							
	Time 1-	639.567	10	.954	0.3023	±2.3060	8	.7702
	Time 4	599.878						
4	BP Scales							
	Time 1-	551.475	9	.981	0.4935	±2.3646	7	.6368
	Time 4	512.982						
5	APFT							
	Time 1-	4330.678	10	.859	2.7117	±2.3060	8	.0266*
	Time 4	1681.556						
6	Avg Weight							
	ROTC Scales-	551.697	8	.994	0.0605	±2.4469	6	.9537
	BP Scales	548.722						
7	Weight Time 1							
	ROTC Scales-	639.567	10	.968	0.8359	±2.3069	8	.4275
	BP Scales	551.475						
8	Weight Time 2							
	ROTC Scales-	511.822	10	.986	-0.2767	±2.3069	8	.7890
	BP Scales	528.794						
9	Weight Time 3							
	ROTC Scales-	533.956	9	.982	0.0647	±2.3646	7	.9502
	BP Scales	529.046						
10	Weight Time 4							
	ROTC Scales-	599.878	9	.991	1.5480	±2.3646	7	.1655
	BP Scales	512.982						
11	%BF Time 1							
	Anthro-	24.767	10	.898	-2.2088	±2.3069	8	.0582
	BP	46.059						
12	%BF Time 2							
	Anthro-	29.905	7	.902	-0.4695	±2.5705	5	.6585
	BP	35.841						
13	%BF Time 3							
	Anthro-	38.268	7	.909	-0.8877	±2.5705	5	.4153
	BP	53.200						
14	%BF Time 4							
	Anthro-	55.643	7	.888	0.4603	±2.5705	5	.6646
	BP	46.059						

*Correlation is significant at the .05 level (2-tailed)

Table 6

Results of Paired t Test

Pair	Variable	*M*	*SD*	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	*t*	*df*	Sig. (2-tailed)
1	Anthro %BF Time 1-Time 4	-.2500	2.7124	.9590	-2.5176	2.0176	-.261	7	.802
2	BP%BF Time 1-Time 4	.96667	2.37697	.79232	-.86044	2.79377	1.220	8	.257
3	ROTC Scales Time 1-Time 4	-.20000	7.6274	2.4120	-5.6563	5.2563	-.083	9	.936
4	BP Scales Time 1-Time 4	1.10870	4.89628	1.63209	-2.65492	4.87232	.679	8	.516
5	APFT Time 1-Time 4	-47.3000	37.0946	11.7303	-73.8359	-20.7641	-4.032	9	.003*
6	Avg Weight ROTC Scales-BP Scales	-1.37392	2.58210	.91291	-3.53261	.78477	-1.505	7	.176
7	Weight Time 1 ROTC Scales-BP Scales	-.45907	6.42969	2.03325	-5.05859	4.14046	-.226	9	.826
8	Weight Time 2 ROTC Scales-BP Scales	.70096	3.80982	1.20477	-3.42634	2.02442	-.582	9	.575
9	Weight Time 3 ROTC Scales-BP Scales	-3.93442	4.33864	1.44621	-7.26940	-.599.45	-2.721	8	.026*
10	Weight Time 4 ROTC Scales-BP Scales	.04745	3.81722	1.27241	-2.88673	2.98163	.037	8	.971
11	%BF Time 1 Anthro-BP	-4.26000	3.32539	1.05158	-6.63884	-1.88116	-4.051	9	.003*
12	%BF Time 2 Anthro-BP	-4.58571	2.48155	.93794	-6.88077	-2.29066	-4.889	6	.003*
13	%BF Time 3 Anthro-BP	-4.11429	3.41781	1.29181	-7.27523	-.95334	-3.185	6	.019*
14	%BF Time 4 Anthro-BP	-3.65714	3.52224	1.33128	-6.91467	-.39961	-2.747	6	.033*

*Correlation is significant at the .05 level (2-tailed)

Table 7

Intervention Calorie Consumption

Subject	Time 1	Time 2	Time 3	Time 4
1	2,567 kcal	2,019 kcal	2,129 kcal	N/A
2	1,531 kcal	1,523 kcal	1,644 kcal	1,720 kcal

Table 8

Intervention Macronutrient Distribution

Macronutrients	Time 1	Time 2	Time 3	Time 4
Subject 1				
Carbohydrate	38%	43%	50%	N/A
Protein	17%	22%	18%	N/A
Fat	45%	35%	32%	N/A
Subject 2				
Carbohydrate	59%	62%	64%	67%
Protein	12%	18%	14%	12%
Fat	29%	22%	25%	23%

CHAPTER FIVE

Discussion

Weight

There were no significant changes overall between ROTC scale weights 1 and 4; neither were there significant changes overall between BOD POD weights 1 and 4. As observed in this study, one contributing factor could be the timing of weight 4, which is routinely conducted immediately following Thanksgiving break. Most cadets go home to spend time with family and friends, and enjoy an abundance of traditional holiday foods that may be high in fat and calories. A decrease in physical activity is also seen during this time. Furthermore, stress may be increased, as this marks the end of the academic semester; many students stress over grades and do not get as much sleep. Stress eaters will often consume more calories during this time, creating the possibility of a positive energy balance. The combination of these factors could lead to weight gain and potentially contribute to the findings of the study.

There were no significant differences between ROTC scales weight for Time 1 and BOD POD weight for Time 1, ROTC scales weight for Time 2 and BOD POD weight for Time 2, or ROTC scales weight for Time 4 and BOD POD weight for Time 4. By contrast, there were significant differences between ROTC scales weight for Time 3 and BOD POD weight for Time 3. This could reflect a calibration error with the ROTC scales used during third anthropometric weighing. It is also possible that the ROTC scales may have been read or recorded incorrectly. This significant difference, suggesting human or machine error, may have caused a false positive for failing to meet the

screening weight. Otherwise, the ROTC scale did not differ significantly from the BOD POD scale.

Body Fat Percentage

There were no significant changes overall between Anthro%BF 1 and 4, or BP%BF 1 and 4. The key findings were highly significant differences between (a) Anthro%BF 1 and BP%BF 1, and (b) Anthro%BF 2 and BP%BF 2, and significant differences between (c) Anthro%BF 3 and BP%BF 3, and (d) Anthro%BF 4 and BP%BF 4. The BOD POD consistently calculated the cadet's body fat percentage significantly higher (4-5%) than the anthropometric calculations.

Possible factors contributing to this the differences in Anthro%BF and BP%BF include validity and reliability, and human error. While research shows that the BOD POD generates valid and reliable data, there is no accessible evidence for the formula used by the Army. Furthermore, there are more chances for human error in generating Anthro%BF. Lack of training or deviating from the standard protocol can lead to error. This is especially important when the persons conducting the measurements are frequently rotating. Additionally, it is common practice among cadets and soldiers being taped to try to manipulate the measured outcome by intentionally increasing the girth of their neck. All BOD POD measures were conducted by the same certified researcher, using the same equipment and procedures throughout the study.

Intervention

Three subjects were eligible to participate in the intervention; only two subjects agreed to participate. The eligible participant who did not participate in the intervention indicated the reason was due to prior high school team sport experiences; this subject

relied on prior knowledge and experience to meet the Army body fat percentage standard. This individual showed the greatest decrease in BP%BF and Anthro%BF out of the three eligible subjects.

Initially, the two subjects in the intervention group were highly motivated. Throughout the intervention there was a lack of consistency in completing the additional physical activity. Food records were well kept and improved throughout the intervention.

Intervention Subject 1 was a non-contracted MSI male. Initially, he consumed about 2,567 kcals per day. He reported having very little time to eat; when he might have had more time, sleep was more important. He frequently consumed fried foods and soft drinks in large amounts; he was eating twice a day, maximum. This subject always skipped breakfast, and getting a nap between PT and class was more important to him than eating. He quickly decreased calorie consumption by eliminating soft drinks from his diet. He reduced fried foods to only three days a week. Over the course of the study, diet pattern changes were illustrated in macronutrient distribution. At Time 1 his diet consisted of 38% carbohydrate, 17% protein, and 45% fat. By Time 3, he had decreased fat consumption to 38%, while protein intake increased by 1% and carbohydrate intake increased by 12%. The majority of his meals were consumed in on-campus dining facilities. Seldom, he would eat foods from fast food restaurants. Prior to joining ROTC he did not participate in any physically demanding activities. At Time 3, he was consuming about 2,129 kcals per day, which was a 438 kcal difference from Time 1. At Time 3 Subject 1 also met the screening weight, and did not have to be taped. Subsequently, he decided to terminate his participation in the intervention, although it was highly discouraged.

Intervention Subject 2 was a non-contracted MSII female. Initially, she was only consuming about 1,531 kcals per day. Considering her height, weight, and activity level, she was already in consuming a relatively low number of calories. However, she has had these dietary patterns for almost two years. She preferred a vegetarian diet that included foods common to Hispanic culture. Rice, beans, corn, tortillas, and avocado were some commonly consumed ingredients. Initially, her diet patterns were relatively low in protein and high in fat and carbohydrates. Over the course of the study, diet pattern changes were illustrated in macronutrient distribution. At Time 1 her diet consisted of 59% carbohydrate, 12% protein, and 29% fat. By Time 4, she had decreased fat consumption to 7%, while carbohydrate intake increased by 7%, and protein intake remained consistent. Most of her food was prepared in an apartment. Convenience and time was important in food preparation, and limited finances may have influenced food selection. Initially, Subject 2 attended all workout sessions. Between Time 2 and Time 3, due to time restraints, Subject 2 did not participate in many group exercise sessions. Instead, she exercised on her own. Exercise journals revealed that she ran an additional seven miles per week during this time; however, the running was performed at a leisurely pace. At Time 4 her calorie consumption increased to 1,720 kcal, which was 189 kcal more than Time 1.

Though not significant, a downward trend was observed for both of the subjects participating in the intervention strategies, with an average body fat decrease of 2.4%. While this is considerable progress in the time allotted for the intervention, at this rate, more time would be needed to meet body composition standards. The intervention cadets showed a greater increase in APFT scores compared to non-intervention cadets; intervention cadets had an average improvement of 81 points, while non-intervention

cadets had an average improvement of 44 points. This suggests that the additional exercise may be beneficial to performance -- in addition to improving body fat percentage, the cadets may have been gaining lean tissue, thus affecting body weight. In time, both continued loss of body fat and gain of lean tissue could have resulted in meeting the body fat percentage standards.

Conclusion

Although convenience and ease of practice are influential factors when considering Army body fat percentage measure practices, the results suggest that the methods or regulations used by the Army may not be the most accurate approach for assessing individual body composition. Current practices may not identify all noncompliant persons. The findings of this study suggest a need for reviewing current Army regulations concerning body composition assessments. Although both techniques present limitations, it is possible that the BOD POD may present more accurate body fat percentages. Advantages of the BOD POD are validity and reliability, and relative ease of administration. Disadvantages of the BOD POD are cost and the closed chamber that may be not be ideal for persons with claustrophobia.

An intervention similar to the ABCP for cadets showed positive outcomes. However, enough data were not collected to evaluate the significance of these outcomes. This intervention should be implemented for a longer period of time, with a larger sample, to better evaluate the effectiveness.

Considerations for Future Studies

This study demonstrated a significant difference in the measures of body fat percentage calculated from manual anthropometric measurements and those calculated

with the BOD POD. Several issues may have complicated the data. First, manual anthropometrics require judgment on the part of the person taking the measurements and the provide cadets and cadre the ability to somewhat manipulate the measurements. Second, the BOD POD also uses estimated values. In this study, the researcher chose to use predicted thoracic gas volume rather than measuring the actual thoracic gas volume of each subject. In addition, the BOD POD also uses formulas to calculate percent body fat. It is possible that the difference in the results of the body fat percentage calculations was attributed in part to the difference in the formulas used. On the other hand, BOD POD data is more likely to be consistent over time and more valuable as an index of body fat percent changes in subjects due to the lack of human judgment in taking and recording measurements.

Collecting raw circumference measure data from the anthropometric measures would be useful in determining the possibility of cadets manipulating the process, through intentionally increasing the neck circumference. A urine specific gravity test could be used to assess hydration levels. Dehydration or drinking at least 1000 mL of fluids, within an hour of measurements, can alter anthropometric and BOD POD measures (Vukovich & Peeters, 2003). Furthermore, when assessing females, researchers should account for fluctuations during menstrual cycles, as these fluctuations may alter data significantly. Observing the time difference between conducting anthropometric and BOD POD measures could provide information regarding efficiency and practicality. The use of stress management tools may assist in achieving and maintaining weight loss, thus a subsequent reduction and maintenance of body fat percentage decreases.

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