CHANGES IN BODY COMPOSITION FROM ADMISSION TO DISCHARGE IN ADOLESCENT EATING DISORDER PATIENTS

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BY

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To the Dean of the Graduate School:

I am submitting herewith a thesis written by Kelsey Williams entitled "Changes in Body Composition from Admission to Discharge in Adolescent Eating Disorder Patients." I have examined this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Masters of Science in Nutrition.

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ABSTRACT

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DECEMBER 2015

Although weight repletion is important in the treatment of eating disorder-related malnutrition, the type of weight gained (fat mass versus lean mass) is unknown. This study used air displacement plethysmography (ADP/Bod Pod) to determine changes in body composition from admission to discharge in adolescent eating disorder patients and evaluated the acceptability of the Bod Pod. Females ages 12-18 years being treated for eating disorder-related malnutrition were recruited between July 2013 and January 2015. Bod Pod measurements were conducted during the first and last week of hospitalization. Written surveys were completed to determine acceptability. Despite body image concerns, participants found the Bod Pod to be acceptable. There was a significant increase in fat mass, body fat percentage, and lean mass from admission to discharge. The success of the treatment program was supported by the increase in fat and lean mass. Further eating disorder research using ADP/Bod Pod to assess body composition is warranted.

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CHAPTER I

INTRODUCTION

The prevalence of eating disorders in adolescents has increased from the 1950s onward with an estimated increase in incidence of 1.03 per 100,000 persons per year (Hoek &Van Hoeken, 2003). An eating disorder is characterized by severe disturbances in eating behaviors and an intense drive for thinness (DSM IV, 2000). Common physiological changes in this population are decreased body fat and bone density, amenorrhea, and loss of muscle mass (Bratland-Sanda, Martinsen, & Sundgot-Borgen, 2012). Weight restoration, and an adequate amount of calories is necessary for recovery and the return of a regular menstrual cycle in patients with eating disorders (Ghoch et al., 2012). In addition, a low percentage of body fat at discharge has been associated with poorer outcomes (Mayer et al., 2007). Therefore, assessing changes of body composition is imperative in the evaluation and treatment of an eating disorder patient, especially during the critical growth stages of adolescence.

Body fat percentage before and after inpatient refeeding has been evaluated in adults with eating disorders. There is a greater increase in fat mass versus lean mass throughout admission (Probst, Goris, Vandereycken & Coppenolle, 2001). The proportion of fat to lean mass gained is important to monitor due to the negative emotional implications of a greater proportion of fat mass to lean mass in this population. The weight gain associated with refeeding may also lead to abnormal fat redistribution although the precise locations of the fat distribution are still uncertain. Implementing

changes in inpatient treatment protocol, such as diet composition and/ or physical activity, could potentially lead to more beneficial distribution of body composition and subsequently better health outcomes.

Body composition tools are commonly used in this population to determine severity of malnutrition, bone age, and to monitor progress during treatment after admission. Among the adolescent eating disorder population, body composition using skinfold thickness, dual energy X-ray absorptiometry (DXA) and bioelectrical impedance measurements have been made. None, however, has used the method of air displacement plethysmography, commonly called the Bod Pod. Air displacement plethysmography (ADP/Bod Pod) is a densitometric technique that uses the inverse relationship between volume and pressure to calculate percent body fat and fat-free mass in subjects (Bod Pod, 2000). Only one study has used the Bod Pod in adult patients with an eating disorder (Pattyn et al., 2011). Thus, additional studies on the use of the Bod Pod with the adolescent eating disorder population are warranted.

Purpose of the Study

This study determined the change in body composition (fat mass versus lean body mass) from admission to discharge using air displacement plethysmography (ADP/Bod Pod) in females ages 12-18 years with an eating disorder who were undergoing inpatient refeeding treatment at Texas Children's Hospital. Additionally, this study determined patient acceptability of using ADP/ Bod POD in an inpatient adolescent eating disorder population.

Research Questions

1) Females in an inpatient adolescent eating disorder program will find the ADP/ Bod Pod an acceptable form of body composition.

2) Females ages 12-18 years with an eating disorder in an inpatient refeeding treatment program will have an increase in body fat, body fat percentage, and lean mass from admission to discharge.

CHAPTER II

REVIEW OF LITERATURE

Eating Disorders

An eating disorder is a type of mental illness that involves severe disturbances in feeding behaviors and body perception (American Psychiatric Association, 2013). It is characterized by abnormal feeding rituals, body image distortion, and extreme desire for thinness. The three main types of eating disorders are: anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED) (American Psychiatric Association, 2013). AN is characterized by restricting food intake that leads to significant low body weight, body distortion, and a fear of weight gain. BN is diagnosed when an individual uses binging and purging techniques to achieve weight loss. Lastly, BED is characterized by binging on large quantities of food in a short period of time. However, unlike those individuals with BN, people with BED do not purge afterwards (American Psychiatric Association, 2013). The prevalence of eating disorders has been estimated among women to be 0.9 percent and 0.3 percent in men of all ages (Hudson, Hiripi, Pope, & Kessler, 2007). Eating disorders are most common in adolescents with 95% of those individuals with an eating disorder being between the age of 12 and 25 years (SAMHSA).

Complications

Eating disorders result in mental and physical complications. Poor nutritional intake and malnutrition lead to complications in many organ systems including

cardiovascular (i.e. hypotension and cardiac arrhythmias), endocrine disorders (i.e. osteopenia and amenorrhea) and gastrointestinal problems (i.e. gastritis and constipation) (Marzola, Nasser, Hashim, Shih, & Kaye, 2013). In addition in both AN and BN, there are alterations in the brain structure and functionality resulting in problems with impulse control, cognitive function, energy metabolism, and the autonomic and hormonal systems (Klump, Bulik, Kaye, Treasure, & Tyson, 2009). Lastly, major depression and anxiety disorders have been shown to be present in 80% of those individuals with an eating disorder (Fichter & Quadflieg, 1997).

Treatment

Inpatient refeeding programs have been established to treat individuals with medically-compromised eating disorders. Individuals are admitted to an inpatient facility where they undergo cognitive behavorial therapy (CBT), weight restoration and nutritional rehabilitation. All of these approaches are necessary for proper treatment of eating disorders. When weight restoration has reached levels to stabilize health, patients can be discharged to an outpatient treatment program.

An initial concern during hospitalization is preventing refeeding syndrome. When a malnourished patient is fed after restricting food intake for a long period of time, major shifts of fluids and electrolytes can occur. Refeeding syndrome can be fatal and must be monitored closely. Historically, to prevent this metabolic process, caloric intake is started at very low calorie levels and then is advanced slowly (Leclerc, Turrini, Sherwood, & Katzman, 2013; Marzola et al., 2013). However, there has been recent evidence supporting a more aggressive feeding protocol and electrolyte supplementation for

abnormalities. For example, Garber et al. (2012) analyzed weight gain during a conservative refeeding protocol in 35 subjects with AN. 83% of patients lost weight during the first week of refeeding and not until day eight was weight gain observed. Overall, more aggressive refeeding in adolescents with AN will lead to faster weight gain and shorter hospital stays as long as monitoring and treating for refeeding syndrome. Despite differences in the advancement of calorie intake, there is general consensus that an adequate amount and proportion of carbohydrates, protein, and fat is essential for appropriate weight gain and a desired proportion of fat mass to lean mass.

Prognosis

The prognosis of an individual with an eating disorder is largely dependent on weight restoration and the effectiveness of behavioral therapy in the individual. Adequate weight restoration and therapy have been shown to improve mood and cognition, which reduces the risk of relapse (Bruch, 1982). In addition, adequate energy availability is necessary for the return of menses in malnourished eating disorder patients (Nattiv et al., 2007). On the other hand, poor weight gain or a low percentage of body fat at discharge has been associated with poorer outcomes (Mayer et al., 2007). Although substantial weight gain is needed for recovery, it can be emotionally difficult for an eating disorder patient due to their distorted body image and fear of gaining weight.

In addition to weight restoration, patients' level of physical activity at admission and during refeeding may have an effect on the success of treatment. Kostrzewa et al. (2013) found that individuals with a high level of physical activity at admission were shown to have a higher body fat percentage, higher leptin levels, and better psychological

outcome at one-year follow up compared to those individuals with low levels of physical activity. Adding physical activity to a refeeding program may lead to better outcomes. If physical activity is too rigorous during admission, however, weight gain may be slowed. Nevertheless, Fernandez de Valle et. al (2014) found that a refeeding program allowing for resistance exercise caused no significant difference in rate of weight gain compared to a program without exercise. Due to the benefits of resistance exercise on building lean body mass, adding strength training and cardiovascular exercise to the inpatient treatment protocol may help by creating a more balanced weight distribution and body composition at discharge. Overall, there is limited data on the outcomes of implementing an exercise program as part of an adolescent eating disorder treatment program.

Body Composition

Body composition is determined by the measurement of fat mass to fat free mass (or lean). Fat free mass consists of muscle, teeth, and bone. Due to minimal changes in the density of bone and teeth over short periods of time, body composition tools are able to use the fat free mass calculation as a way to monitor changes in lean muscle mass.

Measurement Methods

There are several primary types of body composition tools including: hydrostatic weighing (HW), dual-energy x-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA), and air displacement plethysmography (ADP/Bod Pod). HW is based on Archimedes principle that the amount of fluid displaced is directly related to its weight (Pintauro, 2015). Although it has been shown to be accurate, HW is time consuming, not easily accessible to the general population, and requires a subject be immersed in water.

DXA uses two intensities of body scanning x-rays that are able to distinguish amount and type of tissue by its elemental profile (Pietrobelli, Formica, Wang, & Heymsfield, 1996). For a DXA measurement, the subject must wear tight fitting clothing and the measurement takes approximately 10 minutes. The DXA is able to determine the location of body fat and fat free mass and provides an estimate of regional body composition in addition to total body composition (Coulson & Archer, 2015). DXA is commonly used in the medical setting because, unlike many other composition methods, it can measure bone mineral density as well as percentage of fat and lean mass and is considered the gold standard for body composition determination.

BIA is another commonly used body composition tool that sends electric current throughout the body, using the ability of lean mass and fat mass to conduct electricity, to estimate fat and fat free mass (Saladino, 2012). Lean mass is high in water and conducts electricity well while fat mass is lower in water and is a poor conductor. The subject lies down on a table and the right ankle and right wrist are fitted with four electrodes. As current passes through the subject, the rate of current depends on the amount of fat in the tissues. The disadvantages of using BIA include: preparation time, convenience, hydration status, and accuracy.

Air Displacement Plethysmography

One of the more recent body composition tools, which uses the same principles as HW, is air displacement plethysmography, also called ADP/Bod Pod. It is a densitometric technique that uses the inverse relationship between volume and pressure to calculate percent body fat and fat free mass in subjects (Bod Pod, 2000). First, body

mass is measured using a scale and then volume is measured by air displacement when the subject sits in the Bod Pod. Once these values are known, body density can be calculated by:

Density= Mass/Volume.

The relative proportions of fat mass to lean mass can then be calculated due to their differences in density (Dempster & Aitkens, 1995). Different equations to determine percent fat are available based on characteristics of the subject being measured. For example, the Brozek equation is used in populations that are extra lean or obese and the Siri equation is used in general population (Bod Pod, 2000). The volume of air in the lungs should be calculated for optimal accuracy. This can be done by choosing a predicted lung volume or by measuring the thoracic lung volume with the proper equipment. Since the test is based on volume displacement, control of food and beverage intake and exercise for 2 hours prior to the test procedure is necessary.

The Bod Pod is comparable to HW due to their similar methods of calculating body composition. The major difference is that the ADP/ Bod Pod uses air to measure body volume while HW uses water. The Bod Pod has been validated against HW in several studies with differences in body fat ranging from 0.3%- 1.1% (Fields, Goran, & McCrory, 2002; Bentznur, Kravitz, & Lockner, 2008). Secchiutti et al. (2007) sought to determine the sensitivity of ADP with small changes in body composition. The subjects were healthy adults who underwent a Bod Pod measurement with and without a bottle of oil or water in the chamber. Bod Pod could detect ~2 kg changes in fat or fat free mass (Secchiutti, Fagour, Perlemoine, Gin, Durrieu, & Rigalleau, 2007). Thus, the Bod Pod is

a reliable instrument in determining small changes in an individual's body composition. In addition to being reliable, the Bod Pod is efficient, non-invasive, and easy to operate making it easy to incorporate into a clinical setting (Fields et. al, 2002; Pattyn, Peeters, Balloey, Claessens, & Probst, 2011).

Body Composition and Eating Disorders

Historically, weight restoration in eating disorder patients has been considered the primary treatment strategy. More recent studies have shown that not only weight restoration is crucial but appropriate body composition change may play an integral part in the treatment outcome.

Percent Fat Mass to Lean Mass

Despite a balanced diet and light physical therapy, weight gained after refeeding is comprised of a higher percentage of fat mass than lean body mass. This relationship is expected in these individuals who are hospitalized for malnutrition due to their low percentage of body fat upon admission and the rate of weight gain during hospitalization. For example, weight gained, after refeeding a group of adolescent and young adult female AN patients, resulted in 55.5% increase in body fat versus lean body mass over time (Probst, Goris, Vandereycken, & Coppenolle, 2001). The increase in body fat was even greater in a study conducted by Orphanidou and colleagues (Orphanidou, McCarger, Birmingham, & Belzberg, 1997). Twenty-six malnourished adult females with AN gained an average of 5.3 kg ± 3.5 kg body fat versus 1.4 ± 2.9 kg lean body mass over a mean length of stay of 11 weeks. The high proportion of fat mass gained during refeeding may be counterproductive to the treatment of an individual with an eating

disorder due to their issues with body image. Body composition tests, such as ADP/Bod Pod and DXA, may be beneficial during treatment to ensure an optimal proportion of fat mass to lean mass is achieved.

Weight Distribution After Weight Gain

In addition to a higher increase in fat mass to lean mass, there is abnormal fat distribution after weight gain in the eating disorder population. Mayer et al. (2005) found that after weight gain in a group of AN patients, central adiposity represented by waist-to-hip circumference ratio, total trunk fat, visceral adipose tissue, and intramuscular adipose tissue was significantly greater when compared with control subjects. Ghoch et al. (2014) examined 33 adolescents with AN and 33 adults with AN compared with age-matched and BMI percentile matched controls and confirmed the previous findings. There was a central adiposity phenotype after short term restoration of body weight.

However, Orphanidou et al. (1997) found no preferential fat deposition after weight gain. Similarly, De Alvaro and colleagues (2007) found that after complete weight restoration over 24 months in 15 adolescent females there was adequately distributed fat mass and no sign of central adiposity. It is important to note that this study monitored weight gain over a longer period of time. The question remains as to whether or not fat may initially be centrally deposited but eventually redistributed throughout the body (Misra, Soyka, Miller, Grinspoon, Levitsky, & Klibanski, 2003). In addition, if it is initially centrally deposited, would a resistance training program during refeeding promote a more balanced ratio of fat mass to lean mass?

ADP and Eating Disorders

Skinfold thickness measurements, using DXA and BIA are prevalent in the adolescent eating disorder population. None, however, have used the ADP/Bod Pod. It appears that only one study has used the ADP/Bod Pod in adult patients with an eating disorder (Pattyn et al., 2011). Three different body composition assessment tools were tested for validity with a group of inpatient AN patients. BIA, skin fold measurements, and ADP/Bod Pod measurement were not interchangeable in these patients, confirming the concept that using one consistent method of body composition assessment throughout a patient's treatment is preferable. Thus, additional studies on the applicability of the ADP/Bod Pod with the adolescent eating disorder population are warranted.

ADP and Athletes

There is little evidence about the use of the ADP/Bod Pod in malnourished adolescent eating disorder patients, but the use of ADP/Bod Pod in other lean populations, such as collegiate track and field athletes have been used. Although adolescent athletes may not be the physiological equivalent to an eating disorder patient, body fat percentage of an athlete often is very comparable. Bentzur and colleagues reported that use of the ADP/Bod Pod in athletes was strongly correlated with HW (Bentzur, Kravitz & Lockner, 2008). In another study, DXA and ADP/Bod Pod were used in a group of adolescent athletes. ADP/Bod Pod was comparable to DXA and valid body composition tool in adolescent athletes (Silva, Minderico, Teixeira, Pierobelli, & Sardinha, 2006).

Ballard et. al (2004) compared the use of DXA and ADP/Bod Pod in 47 female collegiate athletes with a group of controls. ADP/Bod Pod was not different from DXA when measuring body fat in athletes (ADP = 22.5 ± 5.5%, DXA = 22.0 ±4.7% P = 1.0).

Determining body composition can be a useful tool in the treatment of adolescent eating disorder patients. No studies have used ADP/Bod Pod in the adolescent eating disorder population. Due to its comparability to HW and ease of use, ADP/Bod Pod may be an appropriate tool for use in this population if its acceptability can be determined. More research is warranted on ADP/Bod Pod's acceptability and whether changes in physical therapy protocols or diet therapy can better optimize body composition changes in this unique population.

CHAPTER III

METHODS

Participants

Participants were admitted to the inpatient eating disorder program at Texas Children's Hospital, Houston, Texas. Inclusion criteria were a diagnosis of malnutrition, $\leq$ 85% of ideal body weight (IBW), 12-18 years old, female, English or Spanish speaking, and an expected hospitalization for at least 3 weeks. Exclusion criteria were inclusion criteria not met, and/or both Bod Pod measurements were not completed. The study was approved by both Baylor College of Medicine and Texas Woman's University International Review Boards.

As part of the inpatient eating disorder program at Texas Children's Hospital, diet and exercise are monitored closely. Calories started at approximately 35 to 40 kcal/kg body weight (BW). This was previously increased from 30 kcal/kg BW to better reflect recent evidence supporting higher calories at admission. Electrolyte supplementation was provided to correct for any abnormalities. Calories were increased based on rate of weight gain and estimated energy needs for catch up growth. Calories were determined using TCH diet analysis program. Physical therapy was initiated once the patient was at 70 to 75% IBW and consisted of only stretching. Once the patient reached 80% IBW, the patient was allowed to start walking on the treadmill at a low speed.

The last phase of physical therapy occurred once the patient is between 80 to 85% IBW, with resistance training using two to five pound weights for 20 to 25 minutes initiated and limited to one to two times a week.

Study Design

Recruitment of Participants

The participants were recruited from the inpatient eating disorder facility at Texas Children's Hospital Houston, Texas. The eating disorder program is a part of Texas Children's Hospital Adolescent Medicine Service and is designed for patients ages 10-24 years old (BCM, 2013). Research personnel reviewed the patient census to identify potential participants for the study. Patients were approached between the 2nd and 7th day of admission. Preparation for the Bod Pod measurement, Bod Pod procedure, and confidentiality of results were discussed in detail. All questions by parent/guardian and/or the patient were addressed by research personnel.

Body Composition Measurements

Written informed consent was obtained from patients or parents/guardians, if the patient was under the age of 18 years. Between the 2nd through the 7th day of admission, participants were transported via wheelchair by study personnel to undergo a Bod Pod composition measurement in the Clinical Care Center of Texas Children's Hospital. A trained Bod Pod operator conducted the procedure (Bod Pod, 2000). Participants were fasting and had not exercised for two hours prior to the test. In addition, participants wore tight fitting clothing such as Spandex bike shorts, sports bra, and a swim cap provided by the study personnel. At the beginning of the procedure, height to the nearest cm was

measured with a floor stadiometer and appropriate subject identification numbers were entered into the Bod Pod's software.

Once prompted, the Brozek equation was selected, due to the lean population, and predicted lung volume was used. For each participant, the measurement required a two-part calibration with and without a 50 liter hollow cylinder, provided by the manufacturer. Lastly, weight to the nearest kg was obtained by a calibrated scale and the participant entered the Bod Pod chamber. The Bod Pod measurement takes two approximately 50 second measurements. Participants were asked to stay still and breathe normally during the measurements. Participants and their clinicians were blinded from the results of the test. A second Bod Pod measurement, using the same protocol, was conducted on all study patients within 7 days of discharge. Although the same ADP/ Bod Pod operator did not perform both measurements for each participant, technique had been verified to be very similar between operators. In addition, little variation typically exists between ADP/Bod Pod operators due to ease (automation) of the measurement.

Acceptability and Demographic Survey

At the first body composition assessment, participants were asked to complete a one page demographic form as well as a survey to evaluate the acceptability of the Bod Pod procedure. The acceptability survey included questions using both Likert scale and open ended questions. Surveys are located in Appendix A and B.

Biomedical Data

Participant's anthropometric measures (height, weight, body mass index, %IBW), age, kcal/kg BW intake per day, macronutrient composition, Intake/Output's,

medications, menarche, return of menses, Tanner stage, DXA results, and history of premorbid obesity were collected from the participant's medical record in an effort to control for potentially influencing factors in later analysis.

Statistics

SPSS version 23 was used to determine statistics. Based on our power analysis we needed 20 subjects to detect a significant result. In order to have 20 completed subjects (both pre and post tests) we anticipated a target recruitment sample of 30 subjects. A sample size of 15 achieves 95% power to detect a mean difference of 4% body fat between admission to discharge assuming a standard deviation of 4 and a significance level (alpha) of 0.05, using a 2-sided paired sample t-test (effect size 0.8). Descriptive statistics, including means and standard deviations, were used to characterize the patient population in terms of age, weight, height, BMI, %IBW, kcal/kg BW, macronutrient composition, Intake/Output's, length of stay, and body composition (ADP/ Bod Pod results). Ordinal variables were analyzed using frequencies to describe acceptability of the Bod Pod procedure to the patients. Percent change in body fat, body fat mass in kg and lean muscle mass in kg over time were calculated from admission to discharge. A paired t-test was used to determine whether the changes in body fat and/or lean body mass were significant between admission and discharge. The level of significance was set at $p < 0.05$. Analysis of covariance was used, as needed, to control for confounders.

CHAPTER IV

RESULTS

Demographics

The study population consisted of 30 females admitted to the inpatient eating disorder facility at Texas Children's Hospital. Of the 30 enrolled, 10 participants did not complete a discharge Bod Pod test because they were discharged before study staff could obtain a second measurement (n=8), refused the test (n=1), or left against medical advice (n=1). Body fat percentage of three participants was too low to be reliably measured, thus they were also excluded from the analysis. The final study sample size was 17 females. The participants who enrolled in the study were compared to those who completed the study to evaluate possible differences among the two groups. Demographic data for the participants is described in Table 1. Anthropometric data at baseline for the two groups is displayed in Table 2. There were no significant differences between the initial sample of participants compared to the final sample. Return of menses was noted in three participants during admission but it is important to note that menses resumed due to the start of estrogen therapy not kcal/kg BW.

Table 1.

Demographic Characteristics of the Initial and Final Participants Completing the Study

	Initial N (%) (N=30)	Final N (%)[1] (N=17)
Age		
12	3 (10%)	2 (12%)
13	2 (1%)	0 (0%)
14	11 (37%)	6 (35%)
15	6 (20%)	3 (18%)
16	5 (17%)	4 (24%)
17	3 (10%)	2 (12%)
Race/Ethnicity		
White	20 (67%)	11 (65%)
Hispanic	7 (23%)	6 (35%)
Other	2 (7%)	0 (0%)
Asian	1 (3%)	0 (0%)
Language		
English	24 (80%)	13 (76%)
Spanish	5 (17%)	4 (24%)
Other	1 (3%)	0 (0%)
People in Household		
3	6 (20%)	2 (12%)
4	7 (23%)	4 (24%)
5	10 (33%)	6 (35%)
6	3 (10%)	1 (1%)
7	4 (13%)	4 (24%)
Household Education Level		
Some High School	2 (7%)	1 (1%)
High School	5 (17%)	1 (1%)
Some College	3 (10%)	3 (18%)
Bachelors	11 (37%)	8 (47%)
Masters/PhD	9 (30%)	4 (24%)

[1]Completed Bod Pod test at admission and discharge with valid results.

Table 2.

Characteristics of the Initial and Final Participants Completing the Study[1]

Variables	Initial (n=30)	Final[2] (n=17)
Age (years)	14.6 ± 1.4	14.8 ± 1.5
Weight (kg)	40.2 ± 6.3	40.4 ± 6.6
% IBW	74.9 ± 6.4	76 ± 5.8
BMI	15.3 ± 1.4	15.5 ± 1.1
BMI %ile	4.6 ± 9.1	2.9 ± 4.6
Length of Stay (days)	36 ± 18	36 ± 14
Kcal/kg BW	41.2 ± 9.3	39.3 ± 7.1
% CHO	53.5 ± 5.9	52.5 ± 6.9
% PRO	16.9 ± 3.5	17.5 ± 3.6
% FAT	29.8 ± 5.6	29.7 ± 6.6

[1] *Mean ± SD* [2]Completed Bod Pod test at admission and discharge with a valid result

Acceptability

According to survey data, participants found the Bod Pod test to be acceptable (100%; n=30), comfortable (93%; n=30), and would be willing to repeat it (97%; n=30). As shown in Figure 1, participants were asked: "What, if anything, was uncomfortable about the measurement?" The top two reasons reported were "attire" and the "popping noise" the machine made during measurements. Table 4. lists responses to the open-ended questions on the survey.

Table 3.

Participant Acceptability of the Bod Pod Procedure[1,2]

Survey Parameter	N (%)
Acceptable	30 (100%)
Comfortable	28 (93%)
Willing to repeat	29 (97%)

[1]Total sample size n=30 [2]Answered 4 or 5 on a scale of 1-5 (1=not at all, 5=very)

Table 4.

Participant Acceptability Responses

Survey Open-Ended Questions	Qualitative comments
What part, if any, of the procedure was uncomfortable to you?	"The popping noise" "Clothing" "My ears were pounding." "I'm claustrophobic." "It was kinda cold." "The clothing I had to wear made me uncomfortable." "The bathing suit." "There wasn't any part of the procedure was uncomfortable to me." "A little pressure in my ears but not uncomfortable only after a few seconds of air pumping. I felt a little pressure on my ears." "One piece bathing suit." "There wasn't any comfortable part, but the balance spent a lot of time to take the weight." "At first I was afraid it would be stuffy inside, but it wasn't." "Just slight pressure on my ears."
Was there anything about the process that could have been explained better or changes? If so, please describe.	"I liked how it reminded me of a game that I play." "No, there wasn't anything that could've been explained better." "No, everything was good." "Attire" "No, all was explained well. I thought the pod was pretty cool."

Table 5.

Participant Acceptability Survey: Procedure Comfort (n=30)

	N (%)
Claustrophobic	1(3%)
Temperature	1 (3%)
Length of Measurement	1 (3%)
Attire	4 (13%)
Popping Noise	5 (17%)
None	9 (30%)
No response	9 (30%)

Biomedical Data

Paired t-tests (n=17) evaluating changes in body composition from admission to discharge revealed a significant (p<.001) increase in fat mass (3.7 kg), body fat percentage (6.6%), and lean mass (1.4 kg) (Table 5). The medication type did not significantly affect the amount/type of weight gained by the participants.

Table 6.

Change in Body Composition (n=17)

	Admission (mean)	Discharge (mean)	Change (mean)	t(df), p-value
Fat mass (kg)	5.7 ± 3.1	9.4 ± 2.6	3.7 ± 2	t(16)=-7.523, p<.001
Body fat (%)	13.4 ± 6.3	20 ± 3.9	6.6 ± 3.8	t(16)=-7.046, p<.001
Lean mass (kg)	35.6 ± 5	37 ± 5.1	1.4 ± 1.2	t(16)-4.988, p<.001

Rate of weight gain and fat mass gained in post pubertal females has been documented previously (Rogol, Roemmich, & Clark, 2002). In this study, differences in body composition of pre- and post-pubertal participants were assessed. Changes in diet composition, weight, and body composition were compared by dividing participants into two groups, 12-14 year olds and 15-17 year olds (Table 6.) Change in overall weight (p=.012), body fat percentage (p=.025), fat mass (p=.017), and lean mass (p=.332) based on age were significantly different. Older adolescents increased weight, percent body fat, and fat mass more than younger adolescents. There was no signifcant change in kcal/kg BW, % carbohydrate (CHO), % protein (PRO),% fat (FAT) between the two age groups.

Table 7.

Change in Diet Composition, Weight and Body Composition by Age

	Age		t(df),p-value
	12-14y (n=8)	15-17y (n=9)	
Kcal/kg BW change	22.3 ± 10.2	21.8 ± 11.9	t(15)=.101, p=.921
CHO change (%)	3.6 ± 9.4	1.9 ± 8.5	t(15)=.406, p=.691
PRO change (%)	-3.3 ± 3.7	-2.8 ± 3.8	t(15)=-2.56, p=.802
FAT change (%)	-.65 ± 7.3	1.9 ± 5.4	t(15)=-.827, p=.421
Weight change (kg)	4.6 ± 1.3	7.2 ± 2.3	t(15)=-2.852, p=.012
Body fat change (%)	4.4 ± 2.4	8.5 ± 4	t(15)=-2.493, p=.025
Fat mass change (kg)	2.5 ± 1.1	4.7 ± 2.1	t(15)=-2.697, p=.017
Lean mass change (kg)	1.1 ± 1.1	1.7 ± 1.3	t(15)=-1.002, p=.332

CHAPTER V

DISCUSSION

Body composition measurements should be an integral component of an inpatient refeeding protocol in the adolescent eating disorder population. Several body composition tools, including DXA, HW, and BIA, have been used with this population to monitor treatment progress but evidence is lacking on the use of ADP/Bod Pod in adolescent eating disorder patients. Furthermore, much of the evidence on body composition in the female eating disorder population combines data on adults and adolescents. This study was undertaken to fill a gap in the literature by determining the acceptability of ADP/Bod Pod in the malnourished adolescent eating disorder population. An additional goal of this study was to analyze the body composition of malnourished adolescent eating disorder patients before and after refeeding using ADP/Bod Pod. Both of the hypothesis were confirmed. ADP/Bod Pod was found to be acceptable by adolescent females with eating disorders and adolescents significantly increased the amount of fat mass, lean mass, and percent body fat from admission to discharge.

Acceptability

Due to significant body image concerns in the eating disorder population, it was important to determine whether or not ADP/Bod Pod was acceptable. No studies to date have looked at acceptability of the ADP/Bod Pod in patients with an eating disorder. The ADP/Bod Pod was acceptable (100%), comfortable (93%), and most of the participants

would be willing to repeat it again (97%). Bod Pod measurements would be acceptable for adolescents with an eating disorder. The fact that these results were so high was surprising to the faculty in the Section of Adolescent Medicine & Sports Medicine. Initially, they were concerned that body image disturbance would prohibit ADP/Bod Pods not only in future protocol, but thought the study might be cancelled because of it. Tight clothing and the popping noise from the Bod Pod were the two important reasons participants were uncomfortable in the Bod Pod. Tight clothing was necessary for the Bod Pod measurement, but letting the subject wear their own clothing, instead of the one piece bathing suit provided, may improve acceptance. Unfortunately, other participant complaints cannot be addressed by a revision of the procedure.

Changes in Body Composition Before and After Refeeding

The final study population was comprised of White and Hispanic females with an average age of 14 years. Participants were malnourished with an average IBW of 75.7% ± 4.2% and a percent body fat of 13.4 ± 6.3 at admission. Laurson and colleagues (2011) determined that a body fat percentage of 13.4 would be categorized as less than the 5th percentile for females between the ages of 12 and 17 years old. In accordance with previous findings, the current study confirmed that malnourished adolescents with an eating disorder were depleted in both body fat and lean mass (Kerruish et al., 2002). The primary finding was that adolescent eating disorder participants gained a greater amount of fat mass (3.7 ± 2 kg) compared to lean mass (1.4 ± 1.2 kg) during the refeeding period. These results were associated with the initial decreased amount of body fat at admission, the fast weight gained, and limited exercise during the refeeding period. Previous studies

have shown similar results, although in these studies weight gain was at a slower rate over a longer period of time (Probst et al., 2001; Orphanidou et al., 1997). For example, participants in this study gained approximately 3.7 kg body fat over an average length of stay of 35.4 ± 14.3 days , while Orphanidou et al. noted an increase in body fat of 5.3 kg ± 3.5 kg over an average length of stay of 77 days. An explanation for the faster weight gain in this study may be due to the age of the population (adolescents versus adults), severity of malnutrition at admission, shorter length of time with disease (newer onset in adolescents), or due to the use of a more aggressive feeding protocol resulting in a faster rate of weight gain. Until recently, inpatient eating disorder programs have taken a "low and slow" approach to refeeding, (Garber et al., 2012).

Differences in physical activity during admission may account for some of variability in fat mass to lean mass between similar studies. Patients in this study had limited involvement in physical activity until they were medically stable. Once medically stable, patients engaged in lifting light weights, stretching, and walking on the treadmill. Moderate physical activity during weight restoration may lead to improved body satisfaction and quality of life (Vancampfort, 2013; Fernandez de Valle et al., 2014). Fernandez de Valle et al. examined a 3 month low-moderate strength training program in young anorexic patients. BMI or weight was not affected by the strength training program and, according to a survey taken by the participants, it increased quality of life in the patients. A limitation of the Fernandez de Valle study was the use of body composition equations versus actual measurements to estimate lean mass and fat mass. The question remains as to whether or not a structured strength training program improves weight

distribution (fat mass to lean mass) during inpatient refeeding. To date, there is no research looking at the implementation of a strength training program and the changes of body composition using ADP/Bod Pod during inpatient refeeding in adolescents with eating disorders. It may be that a more intensive strength training program and/or a change in diet composition would help to increase lean mass gains and create a more desirable body composition. For example, a diet consistently positive in total calories but higher in protein and lower in carbohydrate, in conjunction with more intense strength training program, may lead to increased lean mass.

It was also important to look at the differences in body composition in pre-pubertal adolescents compared to post-pubertal adolescents. It is well known that fat mass is gained differently before and after puberty. Not surprisingly, findings showed a faster rate of weight gain and fat mass in the 15-17 year old group compared to the 12-14 year old group. Since older adolescents gained weight at a faster rate, changes in diet and physical therapy may need to be altered more quickly following admission to obtain optimal body composition. Tanner stage is often collected to determine stages of pubertal development during adolescence. Tanner stage was collected for some of the participants of the study but was not available for all participants. Complete Tanner stages would have helped to better correlate rate of weight gain and body composition at different stages of adolescence.

Diet composition is also important in determining potential influences on body composition. In this study, diet composition remained relatively constant from admission to discharge with 53% of calories from carbohydrates, 17% calories from protein, and

30% of calories from fat. It is important to note that there are no specific recommendations for macronutrient distribution in people with eating disorders. The Dietary Guidelines for Americans are typically used. According to the 2010 Dietary Guidelines for Americans, these would fall into the Acceptable Macronutrient Distribution Range (AMDR) for each macronutrient: 45 to 65% of calories from carbohydrate, 25 to 35% of calories from fat, and 10 to 35% of calories from protein. The question remains as to whether or not a diet higher in protein and lower in carbohydrate in combination with resistance exercise may be beneficial to gain a higher proportion of lean mass to fat mass. There is limited evidence comparing changes in diet composition to body composition in the adolescent eating disorder population. Forbes et al. (1984) looked at a group of adolescent and young adult females and males and found that a high protein diet did not result in a higher gain of lean body mass compared to fat mass. The limitations of this study was that it did not take into account the type of physical therapy the patients underwent, i.e. cardiovascular versus resistance, and the study also used a mixed sample of females and males, which assumes that males and females gain lean mass at the same rate. Studies looking at diet composition and changes in body composition are warranted.

Strengths

There were several strengths of this study that should be noted. First, all of the patients were admitted to the same inpatient eating disorder facility and had to follow the same inpatient protocol; thus, minimizing any confounding factors that may have affected body composition results. Secondly, we used ADP/Bod Pod, which has been shown to be

a reliable and valid body composition tool. Lastly, trained Bod Pod operators performed all the body composition measurements, ensuring an accurate measurement for all participants.

Limitations

Several limitations should be mentioned that may have impacted the results. The sample size was small. Participants were discharged without notification of research personnel. This was the primary reason participants enrolled in the study did not complete the study. Better communication between medical providers and research personnel was needed to prevent loss of study participants. Another limitation was the use of a predicted lung volume instead of an actual measured lung volume for each ADP/Bod Pod procedure. Measured lung volume involves the use of special equipment, such as a breathing tube, which was not feasible. However, measuring lung volume using the breathing tubes would have given a more accurate estimate of lung volume by correcting for the isothermal effect on body volume. Finally, ADP/Bod Pod measurements were not compared with another body composition tool. Some DXA measurements were collected but the data was not compared to the ADP/ Bod Pod results because of time differences between when ADP/Bod Pod and DXA were performed. In the future, obtaining the initial ADP/Bod Pod measurement on the same day as a DXA measurement would be beneficial.

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Many studies have used different body composition tools to assess weight gain and weight distribution before and after refeeding in eating disorder patients. This was the first study to use ADP/Bod Pod for the measurement of body composition before and after refeeding in the adolescent eating disorder population. The ADP/Bod Pod measurement was acceptable for this population, despite significant body image concerns. In addition, it was demonstrated that a higher amount of fat mass was gained compared to lean mass during inpatient refeeding of malnourished adolescents with eating disorders. The limited physical activity, low amount of body fat at admission, and fast rate of weight gain were associated with the higher gain of fat mass versus lean mass. Further research using the Bod Pod in this population is warranted to better understand these changes.

Although some accumulation of fat mass is necessary during weight restoration, a large amount of fat mass to lean mass may be counterproductive in the treatment of eating disorders due to body image concerns. In addition to an increased amount of fat mass, the question remains as to whether or not the fat is initially centrally deposited.

The implementation of a strength training program during inpatient refeeding may be beneficial to obtain a more optimal proportion of fat mass to lean mass, and result in a greater proportion of weight gained being more desirable lean mass. Studies looking at

the impact of an inpatient strength training program and/ or changes in diet composition on body composition of adolescents with an eating disorder are warranted.

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APPENDIX A

Demographic Survey

Bod Pod Demographic Survey

Please circle or fill in the answer that best describes you and your family.

1. What is your race/ethnicity?

   White Hispanic Asian African American

   Other_____

2. What is your primary language (the language you speak at home)?

   English Spanish Chinese

   Other: _____

3. What is the highest level of education in your household?

   - ☐ Some High School
   - ☐ High School
   - ☐ Some College
   - ☐ Graduated from a technical school (Associate's degree)
   - ☐ Graduated from a college (Bachelor's degree)
   - ☐ Graduated from a post college university (Master's degree or Doctorate degree)

4. How many people live in your household?

   1 2 3 4 5 6 7 or more

APPENDIX B

Acceptability Survey

Acceptability Survey

Please circle or fill in the answer that best describes your feelings about your the Bod Pod experience today.

1. On a scale of 1 to 5, how acceptable was the Bod Pod procedure to you?

1	2	3	4	5
not at all				very acceptable

2. On a scale of 1 to 5, how comfortable was the Bod Pod procedure for you?

1	2	3	4	5
not at all				very comfortable

What part, if any, of the procedure was uncomfortable to you and why?

_____

_____

3. On a scale of 1 to 5, how willing would you be to have another Bod Pod measurement done in the future?

1	2	3	4	5
not at all				very willing

4. Was there anything about the process that could have been explained better or changed? If so, please describe.

_____

_____

APPENDIX C

IRB Approval Letters

Office of Research
6700 Fannin Street
Houston. TX 77030-2343
713.794-2480 Fax 713-794-2488

October 2, 2013

Ms. Kelsey Clinch
Nutrition & Food Sciences
6700 Fannin Street
Houston, TX 77030

Dear Ms. Clinch:

Re: Changes in Body Composition from Admission to Discharge in Adolescent Ewing Disorder Patients (Protocol #: 17446)

Your application to the IRB *has* been reviewed and approved.

This approval lasts for one (I) year. The study may not continue after the approval period without additional 1RB review and approval for continuation. It is your responsibility to assure that this study is not conducted beyond the expiration date.

Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any unanticipated incidents. If you have any questions, please contact the TWU IRB.

The signed consent forms, as applicable, must be filed with the request to close a study file at the completion of the study.

Sincerely,

Jan Foster, PhD, A PRN, CNS
Institutional Review Board - Houston

cc. Dr. Rose Bush, Department of Nutrition & Food Sciences - Houston
Carolyn Moore, PhD, RD, Department of Nutrition & Food Sciences - Houston
Graduate School

July 17, 2013

Baylor College of Medicine

Baylor College of Medicine Office of Research
One Baylor Plaza, 6000 Houston, Texas 77030
Phone: (713) 798-6970
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Email: irbrii.hentmc.edu

ELISABETH SYMEONIDIS HASTINGS
BAYLOR COLLEGE OF MEDICINE
PEDIATRICS: ADOL. & SPORTS MED.

Hurnan 'Approval Letter

H-3 2 7 0 7 - CHANGES IN BODY COMPOSITION FROM ADMISSION TO DISCHARGE IN ADOLESCENT EATING DISORDER PATIENTS

APPROVAL VALID FROM 6/6/2 01 3 TO 5/28/2 01 4

Dear Dr. HASTINGS

The Institutional Review Board for Human Subject Research for Baylor College of Medicine and Affiliated Hospitals (BCM IRB) is pleased to inform you that the research protocol and consent form(s) named above were approved.

The study may not continue after the approval period without additional IRB review and approval for continuation. You will receive an email renewal reminder notice prior to study expiration; however, it is your responsibility to assure that this study is not conducted beyond the expiration date.

Please be aware that only IRB-approved informed consent forms may be used when written informed consent is required.

Any changes in study or informed consent procedure must receive review and approval prior to implementation unless the change is necessary for the safety of subjects. In addition, you must inform the IRB of adverse events encountered during the study or of any new and significant information that may impact a research participants' safety or willingness to continue in your study.

The BCM IRB is organized, operates, and is registered with the United States Office for Human Research Protections according to the regulations codified in the United States Code of Federal Regulations at 45 CFR 46 and 21 CFR 56. The BCM IRB operates under the BCM Federal Wide Assurance No. 00000286, as well as those of hospitals and institutions affiliated with the College.

Sincerely yours,

BAMBI JO GRILLEY, B.S.

Institutional Review Board for Baylor College of Medicine and Affiliated Hospitals