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Weight and Body Composition Change During the First Year of College: A Study of Traditional Residence Hall Freshmen

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WEIGHT AND BODY COMPOSITION CHANGE DURING THE FIRST YEAR OF COLLEGE: A STUDY OF TRADITIONAL RESIDENCE HALL FRESHMEN

by

Stephanie V. Christensen

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ABSTRACT

Weight and Body Composition Change During the First Year of College: A Study of Traditional Residence Hall Freshmen

by

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Overweight and obesity trends are on the rise, and young people are no exception. The popular phrase "Freshman 15" suggests that freshmen in college tend to gain weight faster than other populations. There is a growing body of literature that supports evidence of increased weight gain during the transition from high school to college. This study sought to examine not only weight changes among freshmen, but body composition, body mass index (BMI), and waist circumference (WC) changes as well. Body composition was measured using air displacement plethysmography (Bod Pod®). This study examined changes in both males (n = 45) and females (n = 43), as well as a subsample of Division I collegiate athletes (n = 19). The present study evaluated changes that occurred among a final group of 107 participants. Measurements were taken at the beginning of the semester in September, again in December, and at the end of the school year in April. Self-report questionnaires based on nutritional and physical activity were also evaluated.

Significant increases in weight (2.1 ± 2.6 kg), BMI (0.69 ± 0.87 kg/m^2), and WC (1.7 ± 2.7 cm) did occur during the freshman year. However, the change in body composition was not significant ($p > 0.05$). There was no relationship between the nutrition responses and the body composition changes that occurred with the exception of a weak relationship between change in "total caloric consumption during your freshman year" and change in body mass ($r = 0.25$, $p < 0.05$), change in BMI ($r = 0.24$, $p < 0.05$), and change in %BF ($r = 0.20$, $p < 0.05$). Regarding exercise, "total time spent doing physical activity during your freshman year" was inversely correlated to change in %BF ($r = 0.27$, $p < 0.01$). Finally, differences between non-athletes and athletes were not statistically significant ($p > 0.05$). These findings indicate that there are significant physical changes that occur during the freshman year of college. These changes may be a result of changes in environment, caloric consumption, and decreased physical activity. However, results did not indicate that these changes include a significant increase in percent body fat.

(88 pages)

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Stephanie Christensen

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CHAPTER I

INTRODUCTION

According to the 2003-2004 National Health and Nutrition Examination Survey (NHANES), the prevalence of overweight and obesity in the United States has climbed to 66% and 32%, respectively (Ogden et al., 2006). This trend is a concern because of the many health and social implications. Overall, in 2003-2006, 11.3% of children and adolescents aged 2-19 years were at or above the 97th percentile of the 2000 body mass index (BMI)-for-age growth charts, 16.3% were at or above the 95th percentile, and 31.9% were at or above the 85th percentile (Ogden, Carroll, & Flegal, 2008). Two of the *Healthy People 2010* national health objectives are (a) to reduce the prevalence of overweight and obesity among adults to less than 15%, and (b) to reduce the prevalence of obesity among children and adolescents to less than 5% (U.S. Department of Health and Human Services [USDHHS], 2006).

There has been much research to determine what causes obesity. Some have attributed the pandemic increase in obesity to technological change which in effect has reduced energy expenditure in the work place (Philipson, 2001). Others attribute it to increases in energy intake (Putnam & Allshouse, 1999), changes in eating patterns such as increased snacking (Nielsen & Popkin, 2003), and increased availability of fast food and full-service restaurants (Chou, Grossman, & Saffer, 2004). Whatever the cause may be, obesity is associated with many health problems.

There is a growing body of evidence that central obesity can independently and adversely affect health (Ho et al., 2008). Obesity is linked to an increased risk of metabolic diseases (Jebb et al., 2007). The metabolic syndrome is a constellation of risk factors associated with diabetes and cardiovascular disease. This syndrome consists of at least three of the following: central obesity, hypertension, high-density lipoprotein cholesterol, triglycerides, and impaired glucose metabolism (Ho et al.), with a large waist circumference (WC) being the most important predictor of this syndrome (Janssen, Katzmarzyk, & Ross, 2002). El-Serag (2008) has suggested that obesity is associated with a significant 1.5 to 2-fold increase in the risk of gastroesophageal reflux disease (GERD) symptoms and erosive esophagitis, and a 2- to 2.5-fold increase in the risk of esophageal adenocarcinoma compared to individuals with normal BMI. Obesity has been associated with numerous other health problems including hypertension (Marfunda et al., 2006), cardiovascular risk (Liu, Wade, & Tan, 2007); increased risks of colon cancer and gout for males, and risks of arthritis, hip fracture, and difficulty with activities of daily living are elevated for females (Must & Strauss, 1999).

Health problems are not the only consequences of the rise in obesity. The rapid increase in body weight in the population has been associated with a rise in obesity-related medical treatment and expenditures (Finkelstein, Ruhm, & Kosa, 2005). The average increase in annual medical expenditures associated with obesity is 37.4% ($732) and 26.1% ($125) for out-of-pocket expenses. Obesity is responsible for 5%- 7% of the total annual medical expenditures in the United States or $75 billion per year (Finkelstein, Fiebelkorn, & Wang, 2004).

A phenomenon known as the “Freshman 15” has become highly publicized by the media and is a prevalent phrase among college campuses. The name suggests that freshmen in college tend to gain weight faster than other populations. Universities often provide incoming freshmen with pamphlets, tips, and advice on how to avoid the unwanted weight gain.

The expected yearly weight gain for adults is 0.8 pounds (Kasparek, Corwin, Valois, Sargent, & Morris, 2008); however, many studies suggest that the yearly weight gain in college freshmen may in fact be much more (Anderson, Shapiro, & Lundgren, 2003; Levitsky, Halbmaier, & Mrdjenovic, 2004; Mihalopoulos, Auinger, & Klein, 2008). Some researchers have concluded that the "freshman 15" is myth rather than fact with no significant weight gain occurring during the freshman year of college (Graham & Jones, 2002; Hodge, Jackson, & Sullivan, 1993). Most others have reported significant, albeit modest, mean weight gains of much less than 15 pounds for the freshman year (Anderson et al.; Butler, Black, Blue, & Gretebeck, 2004; Hajhosseini et al., 2006; Hoffman, Policastro, Quick, & Lee, 2006; Levitsky et al.; Megel et al., 1994; Morrow et al., 2006; Racette, Deusinger, Strube, Highstein, & Deusinger, 2005).

Most of these "freshman 15" investigations have studied only females. Thus, there is a lack of research regarding the body composition changes that might occur in male first-year university students.

Also, most of these studies of college freshmen have only investigated weight gain rather than body composition or body fat percentage (%BF). This can be misleading as weight changes do not delineate changes in fat mass (FM) and fat-free mass (FFM). For example, there could be a substantial increase in FM and decrease in FFM without a large change in body weight. Furthermore, FM is a better indicator than body weight or BMI of cardiovascular disease risk (Segal et al., 1987) and all-cause mortality (Heitmann, Erikson, Ellsinger, Mikkelsen, & Larsson, 2000; Lahmann, Lissner, Gullberg, &

Berglund, 2002). Obesity is linked to an increased risk of metabolic diseases. The precise assessment of fat mass (FM) and its distribution is critical to study the association between adiposity and risk of metabolic diseases (Jebb et al., 2007). This evidence supports the idea of measuring body composition rather than, or in addition to, body mass changes.

Air displacement plethysmography (the Bod Pod®) uses densitometry to predict body fat and fat-free mass. When compared with other commonly used body composition assessment methods such as bioelectrical impedance analysis (BIA), hydrodensitometry or underwater weighing (UWW), and dual-energy X-ray absorptiometry (DXA), the Bod Pod® appears to be a reliable and valid measure (Ballard, Fafara, & Vukovich, 2004; Collins et al., 1999; Fields, Hunter, & Goran, 2000; Levenhagen et al., 1999; Maddalozzo, Cardinal, & Snow, 2002; McCrory, Gomez, Bernauer, & Mole, 1995). Furthermore, the Bod Pod® is equally capable compared to these other methods for accurately assessing the change in body composition over time (Elberg et al., 2004; Jebb et al., 2007; Kilduff, Lewis, Kingsley, Owen, & Dietzig, 2007). One study concluded that the Bod Pod® was actually more accurate than DXA for estimating body fat changes (Jebb et al., 2007).

Purpose of the Study

The purpose of this study was to use the laboratory method of air displacement plethysmography (Bod Pod®) to assess the change in body composition of both male and female traditional college freshmen, residing on-campus, over the course of the entire school year (two semesters). A subsample of freshmen athletes was studied in order to identify any differences in body composition changes between athletes and non-athletes during the first year of university life. Additional anthropometric measures of height, weight, BMI, and WC were tracked, and self-report data about diet and physical activity were obtained at the end of the study.

Research Questions

This was a longitudinal pre-post within-group comparison study with the purpose of answering the following research questions.

1. What is the prevalence of overweight and obesity of traditional freshmen upon entry to Utah State University?
2. What is the prevalence of overweight and obesity of traditional freshmen at the end of their first year at Utah State University?
3. What changes occurred to the body mass and body composition of traditional freshmen during their first year at Utah State University and were these changes significant?
4. Were the body mass and body composition changes of the freshmen athletes significantly different than the freshmen non-athletes?
5. Based on self-report data, how did diet and exercise habits change from the beginning of the freshmen year to the end?

Hypotheses

The following research hypotheses correspond to the research questions.

1. The prevalence of overweight and obese freshman in the sample population will be lower than the national average.
2. The number of overweight freshman will increase during the freshman year, but the number of obese freshman will remain the same.
3. Both body mass and body composition (body fat percentage) will increase significantly from the beginning to the end of the freshman year.
4. The body mass of athletes will increase; however, unlike freshman non-athletes, body composition will decrease.
5. Participants will report decreased physical activity and increased caloric consumption compared to pre-college life.

Definitions

1. Air displacement plethysmography (Bod Pod®): a laboratory method used to measure body volume and body density to assess body composition.
2. Bioelectrical Impedance Analysis (BIA): A procedure for assessing body composition in which an electrical current is passed through the body. The resistance to current flow through the tissues reflects the relative amount of fat present.
3. Body mass index (BMI): a measure derived from body mass and stature, to assess "norms" for body weight. BMI = Body mass (kg)/ stature (m^2).

4. Dual energy x-ray energy absorptiometry (DXA): Method used in clinical and research settings to estimate bone density and the bone mineral, fat, and mineral-free lean tissue of the body from x-ray attenuation.
5. Hydrodensitometry (HW or UWW): Body composition method used to estimate body volume via measurement of weight loss when the body is totally submerged under the water, also referred to as hydrostatic weighing or underwater weighing.
6. Near Infrared Interactance (NIR): Body composition method used to estimate percent body fat or total body density via measurement of the reflectance of near infrared light at the measurement site.
7. Obese: A BMI of 30.0 kg/m^2 or more.
8. Overweight: A BMI of 25.0-29.9 kg/m^2.
9. Skinfold: Measure the thickness of two layers of skin and the underlying subcutaneous fat.
10. Thoracic gas volume (TGV): Volume of air in the lungs and thorax.

CHAPTER II

REVIEW OF LITERATURE

Introduction

According to the 2003-2004 National Health and Nutrition Examination Survey (NHANES), the prevalence of overweight and obesity in the United States has climbed to 66% and 32%, respectively (Ogden et al., 2006). Based on self-report data (Behavioral Risk Factor Surveillance System) compiled by the Centers for Disease Control and Prevention, the prevalence of obesity in Utah is less than that of the country (United Health Foundation, 2005). However, close inspection of the data show that the rate of increase in obesity has been greater in Utah than the country as a whole with an increase of 109% in Utah since 1991 compared to a nationwide increase of 93%. This is a concern because obesity is an independent risk factor for coronary artery disease (American College of Sports Medicine [ACSM], 2006).

This review of the literature will examine (a) health risks associated with gaining weight and/or body fat, (b) studies specific to weight gain or body fat gain in freshmen and/or college students, (c) The Bod Pod® air displacement plethysmography (ADP) method, and (d) studies that have used the Bod Pod® to assess changes in body composition.

Health Risks Associated With Weight Gain

Even a modest increase in body weight is thought to result in a four-fold increase in the risk of cardiovascular disease in both men and women (Manisha & Abate, 2007).

In a study examining excess deaths associated with underweight, overweight, and obesity, overweight was associated significantly with increased diabetes and kidney disease. Obesity was associated with significantly increased mortality from CVD, from some cancers, and from diabetes and kidney disease. Obesity was also associated with increased mortality overall, due primarily to its association with CVD mortality (Flegal, Graubard, Williamson, & Gail, 2007).

Gelber and colleagues (2008) studied the association between different anthropometric measurements and the relative risk of CVD. After adjusting for confounding variables, they found that the relative risk for CVD was 0.58 (95% CI: 0.32 to 1.05) for men with the lowest weight-to-height ratio (WHtR) and 2.36 (95% CI: 1.61 to 3.47) for the highest WHtR. Among women, the relative risk was 0.65 (95% CI: 0.33 to 1.31) for those with the lowest WHtR and 2.33 (95% CI: 1.66 to 3.28) for the highest WHtR. Their findings emphasized that higher levels of adiposity, however measured, confer increased risk of CVD (Gelber et al., 2008).

A follow-up study of 230,000 Norwegian adults analyzed the association between BMI in adolescence and cause-specific mortality (Bjørge, Engeland, Tverdal, & Smith, 2008). The relative risks of death from endocrine, nutritional, and metabolic diseases and from diseases of the circulatory system were elevated in the two highest BMI groups of both males and females. The relative risks of death from diseases of the respiratory system and symptoms, signs, abnormal findings, and ill-defined causes were increased in the highest BMI group of both sexes. For both males and females, the risk of death from ischemic heart disease was increased in the two highest BMI categories (males: relative risk (RR) 1.8, 95% CI: 1.5 to 2.3 and RR 2.9, 95% CI: 2.3 to 3.6; females: RR 2.1, 95%

CI: 1.3 to 3.4 and RR 3.7, 95% CI: 2.3 to 5.7). The risk of death from diabetes mellitus was also increased for males with high BMIs. The relative risks of death for males were 1.8 (95% CI: 1.1 to 2.8) and 3.6 (95% CI: 2.4 to 5.5) and for females in the two highest BMI categories: 2.6 (95% CI: 1.4 to 4.7) and 5.6 (95% CI: 3.3 to 9.6). The relative risk of overall cancer death was also moderately increased in the highest BMI group. This study revealed an increased risk of death from diseases of the circulatory system, most strongly from ischemic heart disease, and from endocrine, nutritional, and metabolic diseases in those who had a high BMI. There was also increased risk of death from diseases of the respiratory system, colon cancer, and sudden death from adolescents whose BMI was very high (above the 85^{th} percentile in the US reference population) at baseline (Bjørge et al.).

Weight Gain or Body Fat Gain in Freshmen and/or College Students

The trend of increasing overweight and obesity has been ongoing for decades with some of the greatest increases occurring in persons 18 to 29 years of age (Ogden et al., 2006). The prevalence of overweight among incoming college freshman ranges from 18% to 26% (Butler et al., 2004; Hajhosseini et al., 2006; Huang et al., 2003; Li & Fu, 2005; Racette et al., 2005) with 35% of all college students exceeding the overweight criterion of a BMI ≥ 25 kg/m^2 (Lowry et al., 2000). Being overweight in early adulthood is positively related to cardiovascular disease (CVD) mortality in later life (Jeffreys, McCarron, Gunnell, McEwen, & Smith, 2003). Furthermore, this mortality risk associated with early adulthood obesity appears greater than that of mid-adulthood obesity.

Generally, people tend to gain weight gradually over many years. However, it has been suggested that there might be critical periods in the life span during which weight gain is more abrupt, and the freshman year of college might be one of these times (Anderson et al., 2003; Levitsky et al., 2004). Levitsky et al. proposed that the weight gain that occurs during the first semester of college is substantially greater than that observed in the general population. Additionally, this weight gain appears to be associated with the lifestyle changes that occur when transitioning to an "on-campus" environment. Hovell, Newborn, Randle, and Fowler-Johnson (1985) reported that freshman women living on campus gained significantly more weight and at a rate 36 times faster than age-matched community women.

Edmonds et al. (2008) studied changes in 116 females during their freshman year. They were tested the summer before entering the university and again in the fall and winter. Weight, height, body composition (BIA), and WC were all measured each time. Results indicated that there was an increase in body weight of 2.4 kg during the first 6-7 months of college. There were also significant changes in body composition and WC.

These studies add to the phenomenon that has become known as the "freshman 15". Most others have reported significant, albeit modest, mean weight gains of much less than 15 pounds for the freshman year (Anderson et al., 2003; Butler et al., 2004; Hajhosseini et al., 2006; Hoffman et al., 2006; Levitsky et al., 2004; Megel et al., 1994; Mihalopoulos et al., 2008; Morrow et al., 2006; Racette et al., 2005).

Anderson et al. (2003) completed a study of 145 college freshman. All of the participants' heights and weights were taken at the beginning of the study in September and the end of the study in December. Participants had an overall significant weight gain

(1.3 kg) from September to December (67.0 ± 0.9 kg vs. 68.2 ± 0.9 kg, $p < 0.01$). The amount of weight change ranged from -3.6 to 5.2 kg. The data were analyzed using both narrow and broad definitions of weight change to ensure that the observed weight change was not due to daily fluctuations of weight. Participants were also categorized according to their BMI. Fourteen percent of the participants were originally classified as normal weight (BMI < 25 kg/m^2) in September and were reclassified to either overweight or obese in December (BMI ≥ 25 kg/m^2 and 30 kg/m^2, respectively). Eighty-six percent of the participants remained in the normal weight category. They found that statistically significant, but modest, weight increases did occur for the majority of participants during their freshman year in college (Anderson et al., 2003).

Hoffman et al. (2006) measured changes in 67 freshmen, all residing in the university dormitories. Questionnaires were completed, height and weight were measured, and body fat was analyzed using a hand-held BIA. Results indicated that approximately 27% of the students lost weight and body fat during the study. For those participants who gained weight, there was an increase in all parameters of body composition, including BMI. The mean change in body weight was 2.86 pounds (1.3 ± 4.0 kg), and the mean change in percentage of body fat was 0.7 ± 4.0%. For those students who gained weight only, the mean increase in body weight was 6.82 pounds (3.1 ± 2.4 kg) and percentage of body fat was 0.9 ± 3.8%. Results confirm that the freshman year is a period in which weight gain occurs, but in this study, the weight gain was less than 15 pounds and was not universal.

A study on 125 freshmen students was conducted by Mihalopoulos et al. (2008). Changes in weight and BMI were observed and analyzed from the beginning of the freshman year to the time of the study (about 7 months). Participants' BMIs were calculated using self-reported height and weight. They observed a significant increase in weight (2.7 ± 6.2 lbs; 95% CI = 1.6-3.9 lbs). There was a wide variation with weight changes ranging from -5 to 20 pounds. About half (51.3%) of the students gained weight during the study. Results suggest that college freshman do gain weight; however, only 5% gained more than 15 pounds.

Levitsky et al. (2004) also quantified the change in body weight in freshmen during their first semester. The body weight of 60 participants was measured at the beginning and the end of the study. The mean weight gain, adjusted for clothing, was 1.9 ± 2.4 kg and was significant ($p < 0.01$). Mean BMI also increased significantly ($p < 0.01$) from 20.8 ± 2.1 to 21.5 ± 2.3 kg/m² over the 12 weeks with most of the students being in the normal range of BMI between 19.8 and 22.7 kg/m². Results show a significant weight gain during the first 3 months of college. While the average weight gain was not 15 pounds, the rate of weight gain observed in college freshmen is considerably greater than that observed in the population.

A large participant group of 290 students was studied and analyzed by Racette et al. (2005). This study included measurements of height, weight, and BMI calculations. The changes were observed from the beginning of the freshman year to the end of sophomore year. Results indicated that body weight increased in 70% of the 290 students. However, weight decreased in 26.7% of the students and remained the same in 3%. For those who gained weight, the mean increase was 4.1 ± 3.6 kg (~9 lbs, $p < 0.001$). BMI increased among 69% of the students. These findings demonstrate a potentially significant weight gain (~9 lbs) in 70% of the students during the first 2 years of college.

A study conducted by Butler et al. (2004) found that body weight was significantly higher after 5 months of college. Fifty-four college freshmen participated in the study, which consisted of measuring their height, weight, body composition (skin fold method), fat mass, fat-free mass, and BMI. These measurements were taken at the first of the school year and again 5 months later. Results indicated that the body weight was significantly higher (p = .014). However, other variables (BMI, body fat percentage, caloric intake, and predicted VO_2max), representing a more accurate estimate of epidemiologic risk and body composition indicated the effects of the selection bias were not significant. This study suggested that when freshman women move away to college, body weight increased. The authors attributed this increase in weight to a decrease in physical activity (Butler et al., 2004).

Morrow et al. (2006) investigated changes in body weight, BMI, body composition, and fat distribution among 137 freshman women during the 2004-2005 academic year. The baseline visit occurred during the first 6 weeks of the fall semester, with the follow-up visit occurring during the last 6 weeks of the spring semester. At each visit, height, weight, BMI, waist and hip circumferences, and body composition (by DXA) were obtained. There were significant ($p < 0.0001$) increases observed for body weight between the initial and final visits (58.6 vs. 59.6 kg), BMI (21.9 vs. 22.3 kg/m^2), percentage body fat (28.9 vs. 29.7%), total fat mass (16.9 vs. 17.7 kg), fat-free mass (38.1 vs. 38.4 kg), WC (69.4 vs. 70.3 cm), and hip circumference (97.4 vs. 98.6 cm), with no significant difference observed in the waist-to-hip ratio (0.71 vs. 0.71; p = 0.78).

Although the changes in body weight, body composition, and fat mass were statistically significant, the changes were modest and do not support the “freshman 15” weight gain publicized in the popular media.

Some researchers have concluded that the “freshman 15” is myth rather than fact with no significant weight gain occurring during the freshman year of college (Graham & Jones, 2002; Hodge et al., 1993; Jung, Bray, & Ginis, 2008).

Jung et al. (2008) collected anthropometric and body composition (BIA) from 101 freshman women living on campus at the beginning of their freshman year and again 12 months later. Results indicated that participants’ weight and BMI increased over the course of their freshman year ($p < 0.001$). The average weight gain for the sample was 3.08 ± 8.35 lb. When examining weight changes in individuals however, a substantial percentage of the sample lost weight; 34% of the sample lost weight over the first 12 months of college. The mean weight change for the 34 women who lost weight was -5.3 ± 5.3 lb ($p < 0.001$). Mean weight change in the 66 women who gained weight was 7.5 ± 6.0 lb ($p < 0.001$). Similar to changes in weight, the overall change in body fat percentage was relatively negligible (0.21% BF; $p = 0.53$). These results do not support the idea of an inevitable freshman weight gain. The average weight gain in this sample was a marginal 3 lb or 1.36 kg (Jung et al.).

In a study conducted by Graham and Jones (2002), 49 incoming freshman were given questionnaires that asked about eating attitudes and behaviors, body image, demographic data, exercise habits, and awareness of and concern about the Freshman 15. Height, weight, and body fat were measured at the beginning and end of the study. Weight change ranged from less than 15 pounds to more than 15 pounds, with the average change in weight a loss of 1.5 pounds. Body fat was measured using the skin fold method and changes were found ranging from a 4.6% decrease to a 2.9% increase in body fat, with the average a 0.36% loss. Graham and Jones conclude that this study provides additional evidence that the Freshman 15 is a myth. Although 59% of the participants gained weight, the average amount they gained was only 4.6 pounds (2.1 kg), and 36% of the sample actually lost weight during their first year of college. Body fat did not change during that year.

In a comparison of mean weight gain in freshman during the first 4 months of college, Levitsky et al. (2004) saw a mean increase of 1.9 kg. Anderson et al. (2003) revealed a 1.3 kg increase, Hovell et al. (1985) saw 1.3 kg increase, and Butler et al. (2004) and Matvienko, Lewis, and Schafer (2001) saw mean increases of 0.59 kg and 1.8 kg, respectively (Levitsky, Garay, Nausbaum, Neighbors, & DellaValle, 2006).

Pliner and Saunders (2008) acknowledge that the research on freshman weight gain is ambiguous, and states that it may be because some subset of individuals is particularly vulnerable to weight gain. They also agree that it may be due to the changes that occur in the lives of new students, one major change being the students' food environment. This change could include greater variety and choice, less parental influence on diet, and different social circumstances of eating. Their study assessed the weight changes in 113 college freshmen and found that the magnitude of increase for those students living on campus was substantially greater than that for any other group. The average increase in weight for participants not living on campus was 1.2 kg or less during the academic year. Those living on campus gained an average of 4.1 kg in the same period (Pliner & Saunders).

While there have been numerous studies on the subject, most of these studies have only investigated weight gain rather than body composition or body fat percentage (%BF). This can be misleading as weight changes do not reflect changes in fat mass (FM) and fat-free mass (FFM). For example, there could be a substantial increase in FM and decrease in FFM without a large change in body weight. Furthermore, FM is a better indicator than body weight or BMI of CVD risk (Segal et al., 1987) and all-cause mortality (Heitmann et al., 2000; Lahmann et al., 2002).

Of the literature reviewed, seven other studies measured body composition using skin-fold method, BIA, or DXA (Butler et al., 2004; Edmonds et al., 2008; Graham & Jones, 2002; Hajhosseini et al., 2006; Hoffman et al., 2006; Jung et al., 2008; Morrow et al., 2006). Two used skinfold measurements (Butler et al; Graham & Jones), four used bioelectrical impedance analysis (Edmonds et al.; Hajhosseini et al.; Hoffman et al.; Jung et al.), and one used DXA (Morrow et al.). A laboratory method such as hydrostatic weighing or the Bod Pod® would offer greater precision than the field methods used in these previous studies (Heyward & Wagner, 2004). Only the recent study by Morrow et al. used a laboratory method (DXA) to assess %BF change in first-year college students. However, Morrow et al. did not include males in their study. In fact, the focus of previous studies has been on only females; the total number of men included in these studies that assessed %BF change of freshmen combined is only 15 (Butler et al.; Graham & Jones; Hajhosseini et al.; Hoffman et al.; Morrow et al.). Furthermore, only three of the studies that measured %BF lasted an entire freshman year (Graham & Jones; Morrow et al.; Jung et al.).

The Bod Pod®

Laboratory methods of measuring body composition include dual-energy x-ray absorptiometry (DXA), hydrostatic weighing, and ADP. DXA involves using x-rays to measure bone mineral, fat, and lean soft-tissue mass. Hydrostatic or underwater weighing (UWW) and ADP (the Bod Pod®) use densitometry to predict body fat and fat-free mass. In densitometry methods, body mass (BM) and body volume (Vb) are measured, and body density (Db) is calculated (Db = BM/Vb). The Db is then used in a population-specific equation to estimate body composition (Noreen & Lemon, 2006). UWW has been the most widely used laboratory method for the past 30 years (Fields et al., 2000). The Bod Pod® and UWW differ in that UWW uses water displacement to find BV and the Bod Pod® uses air displacement to measure BV. UWW is time-consuming and requires that the subject be submerged in water, which is sometimes quite uncomfortable and unnerving for some people. The Bod Pod® is much less time consuming and not as physically demanding on the participants.

Although ADP methods were used to measure body composition in the past with varying degrees of success, the development of the Bod Pod® in 1995 made this method more practical. The Bod Pod® is a large, egg-shaped, fiberglass structure that is divided into two chambers, a front chamber for the person being measured and a rear reference chamber. A seat for the subject separates the two chambers. In between the chambers, a volume-perturbing element is present that oscillates under computer control, yielding complementary volume perturbations between the two chambers. The pressure fluctuations occur as a result of the volume perturbations and are used to determine the chamber air volume (Utter et al., 2002). The BV is equal to the volume of air in an empty chamber minus the volume of air remaining in the chamber after the subject enters the chamber (Wagner, Heyward, & Gibson, 1999). BV must be corrected for thoracic gas volume (TGV). While a predicted measure of TGV is often used, a measured TGV will yield more precise results. TGV can be measured with a simple puffing maneuver while in the chamber. It is an easier procedure than performing a forced expiratory volume underwater as is part of the UWW technique. The Bod Pod® procedure requires less participant and technician ability and is faster than UWW, thus considerable research has been done on the validity of the Bod Pod® as an accurate measurement tool of body composition.

Assessing Body Composition with the Bod Pod®

Reliability of the Bod Pod®

According to Noreen and Lemon (2006), the Bod Pod® can be safely used to measure virtually any adult subject population. The test-retest reliability for the Bod Pod® in assessing percentage body fat was 0.994 with a technical error of measurement of 0.448% (Collins et al., 1999).

Ballard et al. (2004) found that in 47 female collegiate athletes and 24 controls, the Bod Pod®, when compared with DXA, is reliable and valid. They found that the comparison of means indicated that the ADP and DXA are not different when measuring BF% in the athletes (ADP = 22.5 ± 5.5%BF, DXA = 22.0 ± 4.7%BF). Further, this study determined that ADP is a reliable measure of body fat in collegiate female athletes (r = 0.96, $p < 0.001$) and nonathletes (r = .97, $p < 0.001$), respectively.

Ball (2005) concluded that the inter-device variability of the Bod Pod® had minimal impact on %BF estimates, and showed good test-to-test reliability. In this study, duplicate body composition tests were performed in immediate succession on 50 adults using two Bod Pod® units located in the same body composition laboratory. Mean Db and %BF between the two units did not differ significantly for men (Db $p = 0.632$; %BF $p = 0.665$), while for women there were small but significant differences in Db and %BF between the two machines (Db $p = 0.001$; %BF $p = 0.001$).

McCrory et al. (1995) examined the test-retest reliability of the Bod Pod® on 68 subjects. The between-trial SD was 0.4% BF which suggests good test-retest reliability.

Noreen and Lemon (2006) did a study on a large heterogeneous sample of 980 healthy adults. They completed two body composition assessments separated by 15-30 minutes. A significant correlation ($r = 0.992$, $P = 0.001$) was found between the two body density measurements. A paired *t* test revealed no significant difference ($p = 0.935$). Therefore, the Bod Pod® appears to provide a reliable measure of %BF.

Validity of the Bod Pod®

Biaggi and colleagues (1999) compared measurements of %BF by ADP, UWW, and BIA in adults. The Bod Pod® was found to be an accurate method for assessing body composition in 23 men and 24 women. In the total group, %BF by the Bod Pod® was not significantly different from the %BF found in UWW or BIA, and %BF from the Bod Pod® was significantly correlated with %BF UWW ($r = 0.944$, $p < 0.001$) and with %BF BIA ($r = 0.859$, $p < 0.01$). Compared with UWW, the Bod Pod® underestimated %BF in men but overestimated %BF in women, indicating a significant sex effect ($p < 0.05$). The differences in estimation between the Bod Pod® and BIA and between BIA and UWW were not significantly different between the sexes. In another comparison with BIA, UWW, and DXA, the Bod Pod® appeared to be a valid measure (Levenhagen et al., 1999). Twenty healthy subjects within 20% of ideal body weight were measured using all four methods. The %BF measurements by the four methods were highly correlated ($r > 0.90$, $p < 0.0001$). This study further supports the utility of the Bod Pod® to estimate the %BF of healthy adults.

In a study testing 43 white college-age young women, Maddalozzo et al. (2002) found that there is generally good agreement (i.e., ±2 SD) between the Bod Pod® and DXA. They measured women's body composition using the Bod Pod® and DXA the same day and within 10 minutes of each other. Body fat percentage was estimated to be 24.3 ($SE = 1.1$) and 23.8 ($SE = 0.8$) using the Bod Pod® and DXA techniques, respectively.

Fields et al. (2000) support the use of Bod Pod® estimates of density as a substitute for underwater weighing (UWW). Their study involved 67 females whose %BF was measured in the Bod Pod® and by UWW. Body density in UWW was found to be higher ($p < 0.01$) than Bod Pod® density, corresponding to a difference of about 1.0% fat. They support the use of the Bod Pod® as it is quicker and less laborious than UWW. In addition, the Bod Pod® may be more desirable from the subject's point of view because it does not require submersion of the head in water.

Validity in Assessing Change

Kilduff et al. (2007) were interested in determining the reliability and the ability of various body composition techniques to detect acute increases in fat-free mass (FFM) following creatine supplementation. They were interested in establishing the limits of agreement between two test days, 7 days apart, for five different techniques and evaluate whether all five techniques detected similar changes in FFM following acute creatine supplementation. Fifty-five male university athletes were participants in the study. Height and weight were measured, and FFM was measured using 5 different techniques: HW, ADP, BIA, anthropometry, and near-infrared spectroscopy. The between-method differences did not present significant differences for this group ($p > 0.05$). Pearson product-moment correlation coefficients for FFM (kg) estimations between the two trials for all five methods were high, ranging from 0.983 to 0.998 ($p < 0.001$). The mean bias ranged between -0.1 and 0.3 kg for the various methods. The results are in agreement with previous studies testing reliability of ADP in various populations.

Fifty-eight adult women were participants in a study examining the validity of the leg-to-leg BIA device against a multi-compartment model during a period of weight loss and weight regain. All the participants had a BMI > 25 kg/m^2. The 12-month study consisted of an initial weight loss phase and a subsequent follow-up. Body composition was measured at weeks 0, 12, 24, and 52. Height and weight were measured, as was body composition using ADP, DXA, skinfold, and conventional tetrapolar BIA. Overall, the average bias was small for all methods with the exception of changes in FM (kg) measured by skinfold during the weight loss phase. In this study, the accuracy of the DXA to estimate body fat changes was lower than ADP (Jebb et al., 2007).

Elberg et al. (2004) examined estimates of body fatness at two different time points to assess estimates of change in %BF in normal-weight and overweight African American children and adolescents. Percentage body fat by ADP, BIA, and skinfold thickness was compared with estimates of %BF by DXA, the reference method. Eighty-six subjects, 52 girls and 34 boys, were studied two times. Results indicated that %BF measured by DXA was highly correlated with estimates of %BF by ADP-Siri ($p < 0.001$; $R^2 = 0.88$, $SEM = 0.10$; $R^2 = 0.84$, $SEM = 0.10$ for baseline and follow-up measurements, respectively), and ADP-Lohman ($p < 0.001$; $R^2 = 0.85$, $SEM = 0.10$; $R^2 = 0.81$, $SEM = 0.098$ for baseline and follow-up measurements, respectively). However, %BF by DXA was not as highly correlated with estimates of %BF by BIA. At each time point, ADP-Siri accurately estimated %BF compared with DXA in all subjects. Both ADP methods estimated the change in percentage body fat imperfectly, but acceptably, compared with DXA.

Summary

Much research has been done to determine if there is in fact a "freshman 15" weight gain. However, studies examining changes in body composition are few, as are studies lasting the entire school year. Males have not been studied in sufficient numbers. Further, a relatively new method of measuring body composition, the Bod Pod® has yet to be applied when measuring changes in freshmen. These reviewed studies generally support the use of the Bod Pod® when measuring body composition and changes in body composition, as it is more user-friendly, less time-consuming, and requires less effort on the part of the subject and technician than does UWW. It is important to successfully measure body composition among this population, both male and female, as there are many associated risks with an increase in body fat.

Few of the studies reviewed have used body composition, which is more related to disease, and none of these studies have used males as a part of their study with the use of a laboratory technique for measuring body composition.

The purpose of this study was to use the laboratory method of ADP (Bod Pod®) to assess the body composition, body mass, and WC changes of both male and female traditional college freshmen, residing on-campus, over the course of the entire school year (two semesters).

CHAPTER III

METHODOLOGY

This chapter will detail the research design, participants, procedures, and the statistical analyses. The purpose of this study was to was to use the laboratory method of ADP (Bod Pod®) to assess the body composition changes of both male and female traditional college freshmen, residing on-campus, over the course of the entire school year (two semesters).

Research Design

This was a longitudinal pre-post within-group comparison study with the purpose of answering the following research questions:

1. What is the body composition and prevalence of overweight and obesity of traditional freshmen upon entry to Utah State University?
2. What is the body composition and prevalence of overweight and obesity of traditional freshmen at the end of their first year at Utah State University?
3. What changes have occurred to the body composition of traditional freshmen during their first year at Utah State University?
4. Based on self-report data, how did diet and exercise habits change from the beginning of the freshmen year to the end?

There was also a between-group comparison component to this study with the purpose of identifying a difference between athletes and non-athletes in the change in body composition after the first year of attending a university.

Participants

One hundred and three (53 male, 50 female) traditional college freshman non-athletes, aged 17-19 years, were recruited for this study. Additionally, a similar subgroup of 21 (12 male & 9 female) freshman athletes were recruited for a total study sample of 124. Inclusion criteria were beginning university study (first semester), being a full-time student (minimum of 12 units), living in an on-campus residence hall, and being between 17-19 years of age. Students who indicated that they were not planning on completing the freshman year at Utah State University or who were planning on becoming pregnant during the freshman year were excluded from the study. Previous research suggests that the lifestyle changes and new-found independence associated with being an on-campus, resident freshman may be contributing factors to the freshman 15 phenomenon (Hovell et al., 1985). Thus, the goal for this first study was to limit the sample to this specific population.

Potential participants were identified from a list provided by university housing services. Students were sent an email regarding the purpose and design of the study. Those potential participants who replied to the email and expressed interest in participating were contacted by phone (Appendix A) during the first week of the fall semester and asked to participate in the study. This recruitment process continued until 50 female and 53 male non-athletes and 9 female and 12 male athletes agreed to participate. Upon agreeing to participate, an appointment for baseline data collection was made, pre-testing instructions were given (Appendix B), and informed consent (Appendix C) was obtained. This study was approved by the Institutional Review Board (IRB) of

Utah State University. In an effort to limit study attrition, students were paid $25 each if they completed all three trials of the study.

Procedures

Students received a phone call and an email reminder 1-2 days before their appointment for data collection. This reminder included directions to the Exercise Physiology Laboratory in the HPER building at USU as well as the following published pre-testing guidelines for the Bod Pod® (Heyward & Wagner, 2004):

1. Do not eat or engage in strenuous exercise for at least 4 hours prior to your appointment.
2. Avoid any gas-producing foods (e.g., baked beans and diet soda) for at least 12 hours prior to the test.
3. Bring a tight-fitting, lightweight swimsuit or non-padded compression shorts and jog bra.

Baseline data collection for the entire sample occurred during weeks 2 and 3 of the fall semester. A second assessment took place during the last 2 weeks of the fall semester prior to final exams, and a final assessment occurred during the last two weeks of the spring semester prior to final exam week.

Testing occurred in the Exercise Physiology Laboratory in the HPER building at USU. Upon entering the lab, the freshmen were asked to urinate and eliminate as much gas and feces as possible before changing into their swimsuits. Height (Ht) and body weight (Wt) were measured with the participant wearing only his or her swimsuit or compression shorts. Height was measured to the nearest 0.25 inch with a wall-mounted tape measure (Seca, Hamberg, Germany) and converted to centimeters. Weight was measured to the nearest 0.001 kg with a digital scale (Life Measurements, Inc., Concord, CA) as part of the Bod Pod® testing procedure. BMI, a commonly used index of obesity, was calculated from these data; BMI = Wt / Ht^2 (kg / m^2).

Clinical guidelines issued by the NIH recommend measuring WC along with BMI as a screening tool for increased health risk associated with obesity (Ardern, Katzmarzyk, Janssen, & Ross, 2003). Additionally, this rapid and easy-to-measure assessment might provide further insight into the body composition changes that occur during the first year in college. An anthropometric measuring tape was placed in a horizontal plane at the visible narrowing of the waist after a normal exhalation. If no visible narrowing was present, the measuring tape was placed at the level of the 12th rib. Measurements were taken to the nearest 0.1 cm, and an average of two measurements within ± 1.0 cm was used for subsequent analysis (Heyward & Wagner, 2004).

Body volume (Vb) and subsequently body density (Db; Db = Wt/Vb) were determined by the Bod Pod® (Life Measurements, Inc., Concord, CA), which is an ADP that estimates Vb with accuracy comparable to hydrostatic weighing (Fields et al., 2000). The Bod Pod® was calibrated at the beginning of each day's testing session according to the manufacturer's guidelines. To determine Vb, the subject sat motionless in the Bod Pod® chamber for two trials of approximately 20 s each. If the two tests disagreed by more than 150 mL, then additional trials were performed until there was agreement within 150 mL. The two trials were averaged to determine the Vb to be used in subsequent calculations. The Db was converted to %BF using the conversion formula of Siri (1961).

In order to maximize the precision of the Bod Pod® method, thoracic gas volume (TGV) was measured. This involved an additional trial in the Bod Pod® with the subject breathing normally through a hose followed by a brief "puffing" maneuver (3 short puffs similar in strength to cleaning eye glasses) against an occluded airway. If the subject could not perform the puffing maneuver after 5 attempts, the Bod Pod® predicted TGV was used instead of a measured TGV. TGV should not change appreciably over the course of a year; thus, it was not measured again and the same TGV was used during the subsequent testing sessions at the end of each semester.

Two one-page questionnaires were given to assess the student's perceived functional capacity (Appendix D) and physical activity rating (Appendix E). These were administered during the baseline testing in the fall and again at the final testing in the spring to help identify changes in functional capacity and physical activity participation as these could influence changes in body composition. These questionnaires were published by George, Stone, and Burkett (1997) for a study that was specific to college students.

The end of the semester testing sessions included measurements of Ht, Wt, WC, and Vb as described above. Additionally, a brief questionnaire modified from the research of Levitsky et al. (2004) (see Appendix F) was given during the end of the spring semester session in order to better understand changes that may have occurred in their dietary or exercise habits during the course of their freshman year in college. The test time for each participant was about 30 min for the initial fall session (consent form, Ht, Wt, WC, Bod Pod® with TGV, functional capacity and physical activity questionnaires), about 15 min for the end of the fall session (Ht, Wt, WC, Bod Pod®), and about 20 min for the spring session (Ht, Wt, WC, Bod Pod®, functional capacity and physical activity questionnaires, and nutritional and exercise habits questionnaire). Data were recorded each testing session on a data collection sheet (Appendix G).

Statistical Analyses

Data were analyzed using the Statistical Package of the Social Sciences (SPSS version 16.0 for Windows). The significance of the mean differences in Ht, Wt, BMI, WC, and %BF between the beginning of the fall semester, end of the fall semester, and end of the spring semester (freshman year) in college were determined by a repeated-measures ANOVA. If the mean difference was statistically significant, the percentage change was calculated and reported to determine the magnitude or practical significance of this difference. Between-group differences for changes in Wt and %BF between athletes and non-athletes were determined by an independent *t* test. The alpha level for statistical significance was set at $p < 0.05$ for all analyses.

CHAPTER IV

RESULTS

The purpose of this study was to use the laboratory method of ADP (Bod Pod®) to assess the body composition changes of both male and female traditional college freshmen, residing on-campus, over the course of the entire school year (two semesters). A subsample of freshman athletes was studied in order to identify any differences in body composition changes between athletes and non-athletes. Anthropometric measures of height, weight, BMI, and WC were tracked, and self-report data about diet and physical activity were obtained at the end of the study.

The sample consisted of a broad cross-section of 123 freshman students (64 males, 59 females) from 13 different residence halls across campus representing 42 different majors with 23.6% of the sample "undeclared." All of the participants were single, between the ages of 17-19 years (18.0 ± 0.3 years), and experiencing their first year at a university. Twenty-one of the 123 participants were athletes (12 males, 9 females). These athletes represented the basketball, football, and track teams for the men, and basketball, softball, soccer, and track for the women. The vast majority of the sample was Caucasian (88.6%), and 4.1% was African-American with the remaining 7.3% from other ethnic groups.

Maximal oxygen consumption (VO_2max) was not measured, but physical activity and perceived functional ability questionnaires were administered for the purpose of estimating the cardiorespiratory fitness of the sample. By using the George et al. (1997) non-exercise prediction equation for college students, the estimated VO_2max of the sample was 40.7 ± 5.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (males: 44.7 ± 4.4 $ml \cdot kg^{-1} \cdot min^{-1}$; females: 36.7 ± 3.6 $ml \cdot kg^{-1} \cdot min^{-1}$).

One hundred and twenty-three freshmen started the study in September, 112 were tested in December, and 108 finished the study in April. Thus, the overall attrition rate of this study was 12.2% (12.7% among non-athletes and 9.5% among athletes). Of the 15 people that did not complete the study, five moved home or were no longer living on campus, nine failed to respond to numerous phone calls or emails for the second or third trials, and one participant dropped out due to a medical problem. There were no significant differences ($p > 0.05$) between the 15 people that dropped out of the study and the 108 that completed it for the variables measured at the first trial in September (height, weight, BMI, WC, %BF, perceived functional ability, physical activity, & estimated VO_2max).

One participant who completed all three trials lost an extreme amount of weight (18.0 kg) and reduced body fat percentage and BMI by 13.7% and 6.45 kg/m^2, respectively. These losses exceeded the *z*-score limit of 3.29 that defines a statistical outlier (Tabachnick & Fidell, 1996); thus, this participant was removed from the data set for all subsequent analyses. The data analyses were done on the remaining 107 participants (45 male non-athletes, 43 female non-athletes, 11 male athletes, & 8 female athletes). Table 1 presents descriptive statistics for the entire sample at each trial.

For the freshmen that began the study ($N = 122$), 10 (8.2%) entered their freshman year underweight (BMI < 18.5 kg/m^2), and 21 (17.2%) were overweight (BMI ≥ 25 kg/m^2) with 2 of those (1.6%) being obese (BMI ≥ 30 kg/m^2). Among female non-athletes ($n = 50$), the average BMI at the beginning of the study was 21.6 ± 2.8 kg/m^2.

Table 1

Descriptive Statistics of Freshmen Who Started the Study (N=122), Completed Two Trials (N = 111), and Completed the Study (N = 107).

Variable	*N*	Minimum	Maximum	Mean ± SD
Age (y)	122	17	19	18.0 ± 0.3
Height (cm)				
Sept.	122	157.5	197.2	174.1 ± 8.6
Dec.	111	157.5	198.1	174.4 ± 8.7
April	107	157.5	198.1	174.3 ± 8.8
Weight (kg)				
Sept.	122	45.1	137.2	68.2 ± 13.3
Dec.	111	46.9	142.5	69.6 ± 13.4 [a]
April	107	47.3	138.3	70.7 ± 13.6 [a,b]
BMI (kg/m²)				
Sept.	122	17.6	38.8	22.4 ± 3.2
Dec.	111	17.8	40.3	22.8 ± 3.2 [a]
April	107	18.3	39.1	23.2 ± 3.3 [a,b]
Waist circumference (cm)				
Sept.	119	57.2	106.0	74.6 ± 8.2
Dec.	111	59.8	113.0	75.9 ± 8.0 [a]
April	107	59.3	110.0	76.6 ± 7.8 [a]

(table continues)

Variable	N	Minimum	Maximum	Mean ± SD
Body density (g/cc)				
Sept.	122	1.017	1.096	1.057 ± .019
Dec.	111	1.018	1.095	1.057 ± .019
April	107	1.021	1.093	1.057 ± .020
Body fat (%)				
Sept.	122	1.8	36.6	18.3 ± 8.5
Dec.	111	2.2	36.3	18.3 ± 8.6
April	107	2.8	34.9	18.3 ± 8.7

[a] $p < 0.05$ from trial 1

[b] $p < 0.05$ from trial 2

Among female non-athletes ($n = 50$), the average BMI at the beginning of the study was 21.6 ± 2.8 kg/m^2. The mean body fat percentage was 25.6 ± 5.4%. The mean BMI for male non-athletes ($n = 51$) at the beginning was 22.5 ± 2.5 kg/m^2, and the mean body fat percentage was 12.7 ± 6.2%. Among female athletes ($n = 9$), the mean BMI and body fat percentage was 21.8 ± 2.9 kg/m^2 and 18.9 ± 5.2%, respectively. The mean BMI and body fat percentage for male athletes ($n = 12$) was 25.3 ± 5.6 kg/m^2 and 11.9 ± 6.1%. From the first trial in September to the second trial in December, there was a significant increase in body mass ($p < 0.01$), WC ($p < 0.01$), and BMI ($p < 0.01$). From Trial 1 to Trial 2 there was no significant change in body fat percentage ($p = 0.41$).

At the end of the school year, only 1 (0.9%) of the 107 remaining participants had a BMI that would be classified as underweight (< 18.5 kg/m2), and 23 participants (21.5%) had a BMI of ≥ 25 kg/m^2 with still only 2 (1.9%) being over the obesity classification of ≥ 30 kg/m^2.

For female non-athletes ($n = 43$), the mean change in body mass from September to April was an increase of 2.1 ± 2.4 kg. BMI, %BF, and WC increased by 0.78 ± 0.92 kg/m^2, 0.2 ± 3.0%, and 1.6 ± 3.0 cm, respectively. These increases were all statistically significant ($p < 0.01$) with the exception of the change in %BF ($p > 0.05$). Among male non-athletes ($n = 45$), body mass increased an average of 2.1 ± 2.8 kg ($p < 0.01$), with an average change in BMI of 0.64 ± 0.87 kg/m^2 ($p < 0.05$). Waist circumference increased by 1.7 ± 2.2 cm ($p < 0.01$), but the change of %BF was non-significant (0.2 ± 3.2%, $p > 0.05$). There was a mean change in body mass among female athletes ($n = 8$) of 1.6 ± 2.6 kg, and a change in BMI of 0.59 ± 0.94 kg/m^2. Waist circumference went up by 0.5 ± 2.0 cm without a change in percent body fat (0.0 ± 2.0%). None of these changes were statistically significant ($p > 0.05$). For male athletes ($n = 11$), body mass increased by 2.0 ± 2.6 kg ($p < 0.05$) with a mean change in BMI of 0.61 ± 0.75 kg/m^2 ($p < 0.05$). The increase in WC (2.5 ± 3.5 cm) and %BF (0.2 ± 2.4%) were not significant ($p > 0.05$).

The change in %BF was significantly correlated with the changes in WC ($r = 0.42$, $p < 0.01$), body mass ($r = 0.69$, $p < 0.01$), and BMI ($r = 0.69$, $p < 0.01$). For the entire sample ($n = 107$), there were significant increases ($p < 0.01$) in weight (2.0 ± 2.6 kg; see Figure 1), BMI (0.69 ± 0.87 kg/m^2; see Figure 2), and WC (1.7 ± 2.7 cm; see Figure 3), however %BF remained unchanged (0.2 ± 2.9%, $p > 0.05$; see Figure 4).

Overall, both body weight and BMI increased from September to December ($p < 0.01$) and again from December to April ($p < 0.01$), but %BF remained stable ($p > 0.05$).

Changes in %BF, body mass, BMI, and WC were compared between athletes and non-athletes. The mean change in %BF among athletes was 0.1 ± 2.1%, and among non-athletes it was 0.2 ± 3.1%. Mean change in body mass for athletes and non-athletes was 1.8 ± 2.5 kg and 2.1 ± 2.6 kg, respectively. Mean change in BMI for athletes was 0.60 ± 0.81 kg/m^2, and for non-athletes it was 0.71 ± 0.89 kg/m^2. The change in WC between athletes and non-athletes was similar also (1.7 ± 3.1 cm for athletes and 1.7 ± 2.6 cm for non-athletes). None of these changes were significantly different ($p > 0.05$) when comparing athletes to non-athletes.

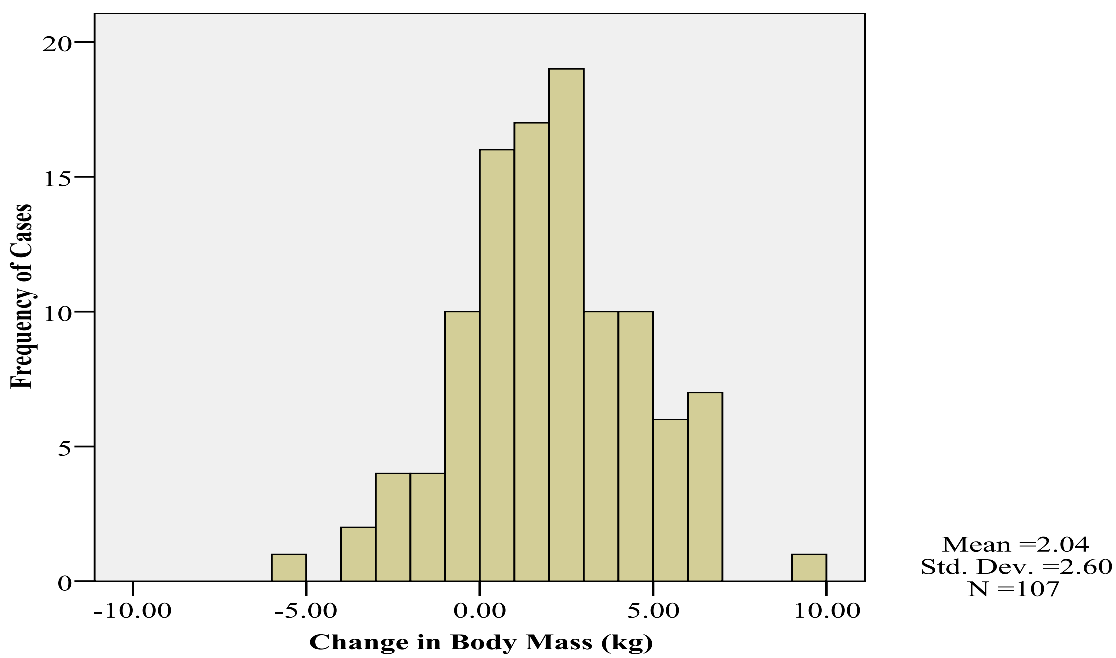

Figure 1. Change in body mass from September to April.

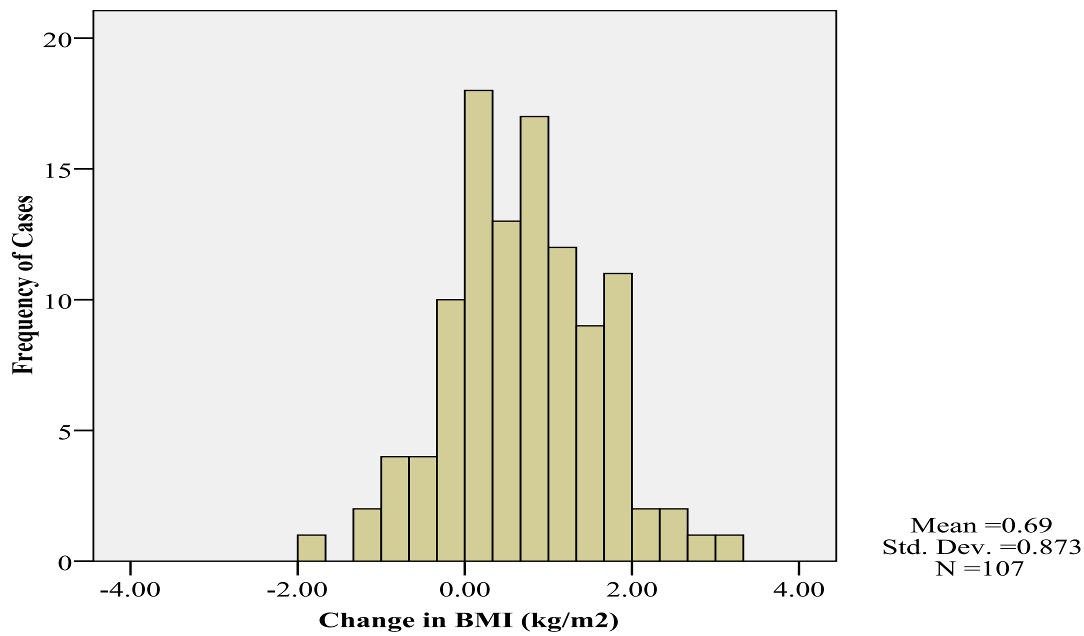

Figure 2. Change in body mass index from September to April.

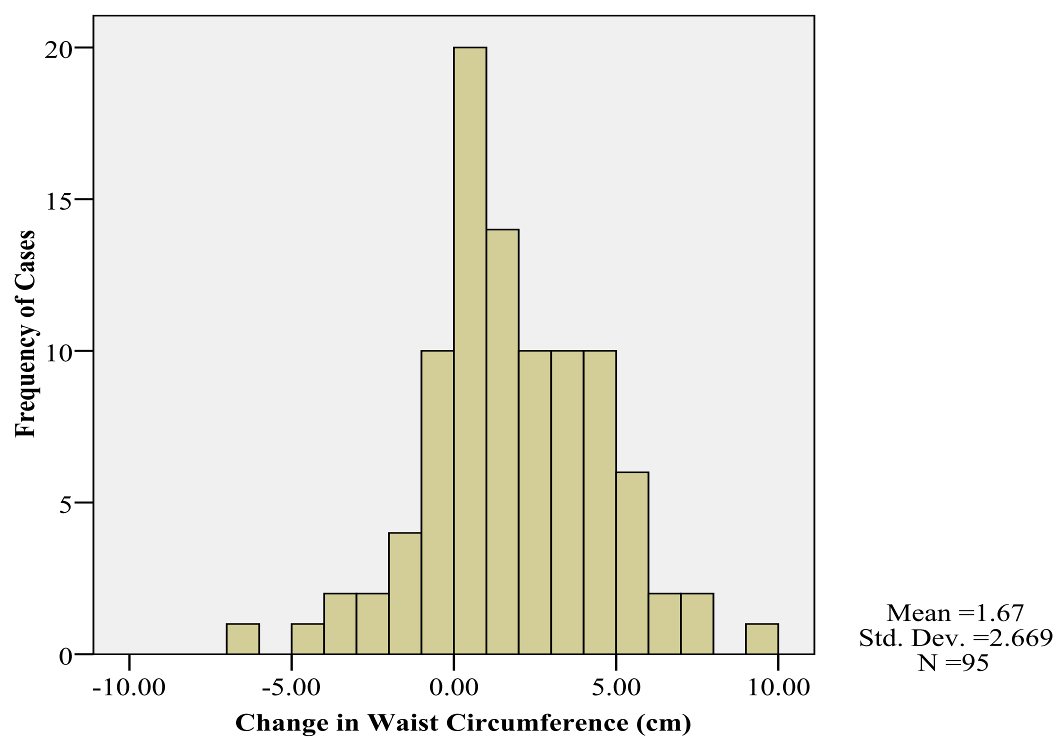

Figure 3. Change in waist circumference from September to April.

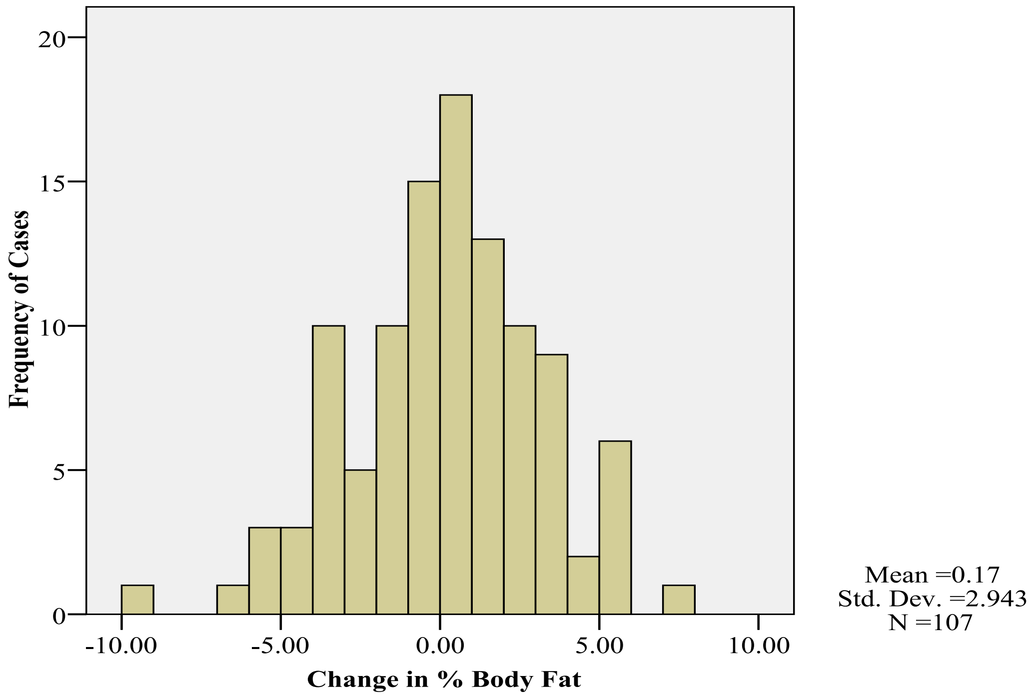

Figure 4. Change in body fat percent from September to April.

There was a significant ($p < 0.01$) but low correlation between the students' perceptions of their weight changes and the actual changes in body mass ($r = 0.33$), BMI $r = 0.33$), and WC ($r = 0.32$). There was no relationship between the nutrition questions and the body composition changes that occurred with the exception of a weak relationship between change in "total caloric consumption during your freshman year" and change in body mass ($r = 0.25$, $p < 0.05$), change in BMI ($r = 0.24$, $p < 0.05$), and change in %BF ($r = 0.20$, $p < 0.05$). Also, there was a weak inverse relationship between the change in the "consumption of fruits and vegetables during your freshman year" and the change in %BF ($r = -0.19$, $p < 0.05$). Regarding exercise, "total time spent doing physical activity during your freshman year" was inversely correlated to change in %BF

(r = -0.27, $p < 0.01$). The scores from similar nutrition questions and from similar exercise questions were summed to create a global nutrition score and global exercise score, respectively. However, these global scores were not significantly correlated to any of the changes in body composition.

CHAPTER V

DISCUSSION

A gain in body weight, albeit modest, is thought to result in a four-fold increase in the risk of cardiovascular disease for men and women (Manisha & Abate, 2007). Furthermore, fat mass, as measured by body composition methods, is a better indicator than body weight or BMI of cardiovascular disease risk (Segal et al., 1987) and all-cause mortality (Heitmann et al., 2000; Lahmann et al., 2002). As many of the studies in the literature have looked at weight gain and not body composition among first year college students, the purpose of this study was to use the ADP laboratory method (Bod Pod®) to assess the body composition changes of both male and female traditional college freshmen, residing on-campus, over the course of the entire school year (two semesters). Additional anthropometric measures of height, weight, BMI, and WC were tracked, and self-report data about diet and physical activity were obtained. This study was unique because it used a laboratory method to measure body composition, measured change over an entire school year, looked at change among male and female participants, and included a small sample of athletes.

The existing literature on freshman weight gain has indicated that the prevalence of overweight among incoming college freshman ranges from 18-26% (Butler et al., 2004; Hajhosseini et al., 2006; Huang et al., 2003; Li & Fu, 2005; Racette et al., 2005) with 35% of all college students exceeding the overweight criterion of a BMI $\geq$ 25 kg/m^2 (Lowry et al., 2000). The results of this study indicate a slightly lower prevalence of overweight freshmen upon entry to the university (17.2%). Thus, this sample was slightly leaner but close to the average freshman population. This could be due to the fact that like other studies, this one was voluntary, and may have attracted a more health-conscious population.

The George et al. (1997) non-exercise prediction equation for college students was used to estimate VO_2max to get an idea about the fitness level of the sample. The VO_2max estimates from this sample were similar, but slightly lower, than those reported by George et al. (1997) for college students, and they are near the 50^{th} percentile for adults aged 20-29 years (ACSM, 2006). Thus, the sample was considered "normal" with regard to physical fitness. However, due to the leanness of the study sample, it was surprising that the average VO_2max wasn't higher for the group. There was no difference between pre-study VO_2max and post-study VO_2max.

The prevalence of overweight among this sample at the end of the study was 22.4%, which is a 5.2% increase over the 7-month period. Butler et al. (2004) reported a prevalence of 14.6% overweight and 4.8% obese at the end of their study. The prevalence of overweight at the end of this study was 7.8% higher than the Butler et al. study. Anderson et al. (2003) found a large increase in overweight prevalence. Approximately 20% of their sample was overweight in September and by December, nearly 33% were overweight. Results from the present study indicate that this population was somewhere in the middle of these other groups.

The average weight gain among the sample was 2.1 ± 2.4 kg, which is much more than the expected yearly weight gain for adults, which is 0.8 pounds (Kasparek et al., 2008). While this increase in weight was generally not the 'freshman 15' pounds, it is consistent with much of the literature which reports significant, albeit modest weight gains (Anderson et al., 2003; Butler et al., 2004; Hajhosseini et al., 2006; Hoffman et al., 2006; Levitsky et al., 2004; Megel et al., 1994; Mihalopoulos et al., 2008; Morrow et al., 2006; Racette et al., 2005). Even though this and other studies do not support the idea of a universal 15 pound weight gain during the year, it is obvious that the weight gain during this critical period is more abrupt than at other times (Anderson et al.; Levitsky et al.). The mean weight gain in this study (2.1 kg) was slightly higher than that of Levitsky et al. (1.9 ± 2.4 kg). However, the Levitsky study only measured change from August to December. Hoffman et al. found that approximately 27% of their sample lost body weight and body fat from September to April. However, of those who gained weight, the mean weight gain was 3.1 kg, slightly higher than the present study. Yet, the average weight gain of those who gained weight (79%) in the present study, was 2.9 kg, which is similar to Hoffman et al. The average weight gain of the entire sample in this study is most similar to that of Edmonds et al. (2008). Their study was of a similar duration but included only females, and they found an average weight gain of 2.4 kg. The weight gain results of this study were also similar to Mihalopoulos et al. They also measured across a 7-month span and found a mean increase of 2.7 kg. Over half (51.3%) of their sample gained weight, and the average gain for students who did gain weight was 3.4 kg. One third experienced no weight change and 15% lost weight. Only 5% of their sample gained more than 15 lb, as compared to the 2.8% participants in the present study who gained at least 15 lb.

Results indicate that while the mean weight gain was 2.1 kg, 48.6% of participants gained more than that. Although the mean weight gain was 2.1 kg, 18% of the sample was 1 SD above this, gaining 4.6 kg or more, which is about 10 lb. This indicates that while the group as a whole did not gain 15 lb, there is a percentage of the freshman population that is gaining much more weight than is expected within 7 months. There were also participants who did actually lose weight (19.6%), which would decrease the mean weight gain for the group.

One factor that should be considered among this population is alcohol consumption. Alcohol consumption is often a large part of a university experience. Data collected from a national probability sample of American campuses indicates that 44% of undergraduates engage in heavy episodic drinking, which is defined as consuming 5 or more drinks (4 for women) on at least 1 occasion in the prior 2-week period (Wechsler et al., 2002). According to self-report data, only 14 participants (13%) stated that they drank any alcohol. This may be something that is unique to this campus and this sample in particular. Alcohol, with 7 kcal/g of empty calories, is often considered a potential reason for increased weight gain among freshmen. Lack of alcohol consumption on this campus might have attenuated some of the expected weight/fat gain. Of the 14 participants who reported alcohol consumption, 50% of them gained more than the average 2.1 kg, while 4 participants who reported alcohol consumption gained between 4.9 and 9.9 kg. However, there were no significant group differences ($p > 0.05$) in %BF change, body mass change, BMI change, or WC change between those who reported alcohol consumption and those who did not.

While there were significant changes in body mass, BMI, and WC, there was no significant change in body fat. This is consistent with some of the other previously reviewed studies which also found no significant changes in body fat (Butler et al., 2004; Graham & Jones, 2002; Jung et al., 2008). This suggests that the increases in fat mass and fat-free mass were equal among the majority of participants. However, at 18 years old, another possible contribution to weight gain without additional fat gain could be that growth and maturation are still occurring in some participants of this age group. It had been hypothesized that those non-athletes who gained weight, would also gain body fat. However, the changes in body fat were not significant, which was surprising. Although this was one of the longer studies of this kind, perhaps the change in body fat does not occur within 7 months. The weight gain trend obviously presents itself within that timeframe; however, it is hard to speculate if and when there would be a subsequent change in body fat. Although body fat increases among the population were not significant, of the 86 participants who gained weight, 56 (65%) did in fact increase in body fat. Eighteen of those participants gained more than 3%, with 7 participants gaining more than 5% body fat. Of those that gained the most weight (+ 1 SD or > 4.6 kg), all 19 increased %BF at least a small amount. Thirty participants decreased in body fat, and 8 of those lost more than 3%.

One surprising finding was that there was no difference between non-athletes and athletes. It had been hypothesized that both would gain body mass; however, athletes would decrease in body fat due to the vigorous training schedule of each team. Yet, there was almost no change in body fat among athletes. This could be attributed to the different sports and the time during their season. For example, the football players are in season in the fall. Therefore, they may have been in a maintenance stage in regards to a resistance training program. Perhaps the largest increases in muscle mass of football players occur during the high volume lifting season in late spring and summer. The same could be the case for track, soccer, softball, and basketball athletes. Another reason why there were no significant differences among the groups could be attributed to the healthy and physically active nature of the group of the non-athletes. In fact, the % BF of the non-athlete males at the beginning of the study was almost as low as the athletic males.

According to the self-report questionnaires, total caloric consumption during the first year at USU increased a little or increased greatly for 44% of the participants. Eighty-three percent of those who reported an increase in total caloric consumption gained weight during the study and 70% had an increase in WC. Of those who gained weight from increased caloric consumption, 61% gained more than the mean 2.1 kg, and almost half added an inch (2.54 cm) or more to their waistline. This is a concern because abdominal obesity, as measured by a large WC, is the key component of metabolic syndrome (ACSM, 2006).

Total physical activity decreased a little or greatly during the freshman year for 44% of the participants. Eight-one percent of those who decreased in physical activity gained weight, with 49% of those gaining more than 2.1 kg. Twenty-one percent of those who self-reported decreasing their physical activity gained more than 3% body fat.

Although the statistical correlations between self-report questions and changes in weight, body fat, BMI, and WC were not strong, it is suggested that weight gain can be attributed to the changes that occur in the lives of new students, one major change being the students' food environment. This change could include greater variety and choice, less parental influence on diet, and different social circumstances of eating (Pliner & Saunders, 2008). Several studies which have also reported higher than average weight gain among freshman, suggest that a decrease in moderate physical activity could also play a role in energy balance resulting in weight gain (Butler et al., 2004; Edmonds et al., 2008; Hoffman et al., 2006; Levitsky et al., 2004; Racette et al., 2005.)

Limitations

Some limitations existed within this study. These limitations will be addressed and considered.

The existing literature on freshman weight gain has indicated that the prevalence of overweight among incoming college freshman ranges from 18-26% (Butler et al., 2004; Hajhosseini et al., 2006; Huang et al., 2003; Li & Fu, 2005; Racette et al., 2005) with 35% of all college students exceeding the overweight criterion of a BMI ≥ 25 kg/m^2 (Lowry et al., 2000). The results of this study indicate a slightly lower prevalence of overweight freshmen upon entry to the university (17.2%). Therefore, this population may not have been representative of the entire freshman population. Potential participants were identified from a list provided by university housing services. Students were sent an email regarding the purpose and design of the study. Those potential participants who replied to the email and expressed interest in participating were contacted by phone during the first week of the fall semester and asked to participate in the study. This recruitment process continued until 50 female and 53 male non-athletes and 9 female and 12 male athletes agreed to participate. As this was a voluntary study, people who were overweight or obese, those most likely to be engaging in unhealthy nutrition and exercise behaviors, or those who would be more self-conscious about wearing the tight-fitting clothing necessary for testing in the Bod Pod®, may not have been as likely to participate in the study. People who are disinterested in health in general, and who in fact may be the population who would be most at risk for weight and body composition increases, may have not volunteered to participate in the study.

Another limitation with the subsample involved the recruitment process. A larger group of athletes would have been ideal; however, in attempts to recruit athletes from all different teams, there were some coaches who wouldn't allow their athletes to participate. There were also other athletes who were in the middle of a season and traveling a lot, therefore they expressed a lack of time to participate. There was not a large response from athletes so it turned out that a majority of the male athletes were football players, who are more likely to be overweight or obese than other athletes, depending on the position they play (Mathews & Wagner, 2008).

Based on the review of literature, it was assumed that the Bod Pod® would provide a reliable and valid measure of body composition and be able to identify small changes in fat mass. Previous researchers have reported between-test reliability coefficients of 0.96 to 0.99 (Ballard et al., 2004; Collins et al., 1999; Noreen & Lemon, 2006). The intra-class correlation coefficients for the test-retest and next-day reliability of the Bod Pod® used in the present study were 0.99 and 0.98, respectively. Also, the mean differences in %BF between test-retest and next-day measurements were not significant ($p > 0.05$). These are indicators that the Bod Pod® used in the present study was reliable. However, the SDs of the test-retest (1.4% BF) and next-day (1.8% BF) measurements were substantially greater than the test-retest reliability SD of 0.4% BF reported by McCrory et al. (1995). This suggests that the variability of the Bod Pod® used in the present study may be greater than previously thought. If this is the case, the precision of the Bod Pod® is placed into question limiting the ability to detect small but significant changes in %BF.

Compliance and honesty may also be limitations. Pretesting guidelines included instructions to refrain from eating or engaging in strenuous exercise for at least 4 hours prior to their appointment. They were also instructed to avoid any gas-producing foods (e.g., baked beans and diet soda) for at least 12 hours prior to the test. Participants were reminded of these instructions prior to each measurement and asked if they had complied. Thus, the results of body composition may have been distorted if pre-testing guidelines were not followed. Further, self-report data were based on the participant answering the questions honestly with the assurance that their names could not be tracked to their data. Especially with questions pertaining to alcohol consumption, as it would be illegal for this 18-year-old population to drink alcohol. Therefore, if questions were not answered honestly, alcohol consumption may have been underreported.

One of the strengths of the study is that the participants were not allowed to see their results until after the final measurement. Obviously, they would have been able to weigh themselves at will, yet few would have access to a laboratory method of measuring body composition. However, the fact that they were having their measurements taken 3 times throughout the year may have caused some participants to consciously try to avoid the weight and body fat increases.

One thing that perhaps would have been useful in trying to determine what factors are involved in the weight gain would have been to include questions about if and how often the participants ate at the university dining services or how often they cooked for themselves in the questionnaire. This may have been a factor, as the dining services usually offer unlimited food during meal times.

Implications

The results of this study indicate that the freshman year is definitely a period where many people experience a higher than normal weight increase in a short period of time. Similar to other studies, the gains in weight were less than the infamous 'Freshman 15', but higher than the average adult (Kasparek et al., 2008). As previous research has indicated, this weight gain may be of concern as even a modest increase in body weight is thought to result in a four-fold increase in the risk of cardiovascular disease in both men and women (Manisha & Abate, 2007). In a study examining excess deaths associated with underweight, overweight, and obesity, overweight was associated significantly with increased diabetes and kidney disease. Obesity was associated with significantly increased mortality from cardiovascular disease (CVD), from some cancers, and from diabetes and kidney disease. Obesity was also associated with increased mortality overall, due primarily to its association with CVD mortality (Flegal et al., 2007). Further, being overweight in early adulthood is positively related to CVD mortality in later life (Jeffreys et al., 2003). Therefore, if a population that is at increased risk for weight gain which may lead to overweight and obesity in later life can be targeted, appropriate prevention measures and education can be applied.

In addition to the weight gain, 70% of the sample increased their WC by at least a small amount with about 39% adding an inch (2.54 cm) or more. Only three people finished the study with a WC that would put them at high risk for metabolic syndrome and CVD according to the ACSM (2006). However, given the number of participants that added to their girth and the rate and magnitude of some of the increases (11 people gained 5 cm or about 2 inches in 7 months), it is likely that some of these students will be at increased risk for metabolic syndrome in the future if this trend continues.

Results of this study, along with other results reviewed in the literature, indicate that the weight gain that occurs during the first semester of college is substantially greater than that observed in the general population. Additionally, this weight gain appears to be associated with the lifestyle changes that occur when transitioning to an “on-campus” environment (Anderson et al., 2003; Levitsky et al., 2004). Results did not support a significant increase in body composition, and as this population tended to be more lean and fit than normal, perhaps the gains in fat-mass and fat-free mass for the majority of the participants were equal and do not represent an immediate health risk to these individuals. These results add to the literature on this subject in recommending that people who are in this population should be aware of the body changes that seem to be a result of a change in environment, and should implement healthy nutrition and physical activity behaviors to avoid unhealthy weight gain.

Future Research

Considering the limitations, this study leads to many recommendations for future research. Future research should be aimed at recruiting and studying a population with greater diversity as far as fitness levels, BMI, and body fat. This study used a good sample in that participants came from many different residence halls and a plethora of majors. However, the population was generally lean and healthy. If possible, it would be interesting to recruit healthy and unhealthy, fit and unfit individuals to have a more generalizable population. It would also be valuable to have a subsample of participants who are the same age group, but not attending the university. Further, it would be practical to have both students and non-students of this age, at different universities or regions across the country to include a more diverse population and compare results among different settings and regions of the country. Again, it would also be practical to include in the self-report data, questions about where the participants most often consume their meals. It would also be interesting to do follow-up measurements in the sophomore year and beyond to see if those participants who gained weight continue to gain weight, and if at a later time, they do in fact gain body fat. A larger, more diverse subsample of athletes would also be useful in identifying changes that occur in freshman athletes.

Conclusions

With regards to the original research questions, and within the limitations of this study, the following conclusions were made:

1. The prevalence of overweight and obese freshmen upon entry to USU was 17.2% overweight (BMI ≥ 25 kg/m^2) with 2 of those (1.6%) being obese (BMI ≥ 30 kg/m^2).
2. At the end of the freshman year, of the remaining 107 participants, 21.5% had a BMI of ≥ 25 kg/m^2 with still only 2 (1.9%) being over the obesity classification of BMI ≥ 30 kg/m^2.

3. For the entire sample ($N = 107$), there were significant increases ($p < 0.01$) in weight (2.0 ± 2.6 kg), BMI (0.69 ± 0.87 kg/m^2), and WC (1.7 ± 2.7 cm), however %BF remained unchanged ($0.2 \pm 2.9\%$, $p > 0.05$).
4. Body mass and body composition changes of the freshmen athletes were not significantly different than the freshmen non-athletes ($p > 0.05$).
5. Based on self-report data, there were many participants who reported an overall increase in total caloric consumption and a decrease in total physical activity; however, there were almost as many who reported a decrease in caloric consumption and an increase in total physical activity.

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APPENDICES

APPENDIX A. Phone Script

Phone Script

Hello. My name is Steph Christensen. I'm a researcher in the Physical Education Department.

We are doing a study to look at body composition changes in traditional Freshmen students during their first year in college. Your name was randomly selected from a list of freshmen students living in residence halls. We would like to invite you to participate in this study.

The study involves 3 testing sessions of approximately 30 minutes each. The testing will take place next week, at the end of the fall semester, and at the end of the spring semester. Your height, weight, waist circumference, and body composition will be measured. Additionally, you will be asked to answer a few questions about your exercise and nutritional habits.

If you participate in this study, you will get state-of-the-art testing for free. You will learn about your body composition and the changes that took place during your freshmen year. Additionally, you will be paid $25 if you complete the study in May.

Inclusion/Exclusion Verification

Must be:

1. 18-19 years old
2. This is their first full-year of university study.
3. Full-time student (12-credits or more)
4. Living in an on-campus residence hall

Exclusion (do not accept in study):

1. Currently pregnant or plan on becoming pregnant during their freshman year
2. Plan on not completing freshmen year (leaving for mission, etc.)

Additional:

1. Ask if they are on one of the USU NCAA athletic teams (we need 15 males & 15 females in this category).

APPENDIX B. Pre-testing Instructions

Pretesting Instructions

1. Do not eat or engage in exercise for at least 2 hours prior to your scheduled appointment.
2. Avoid eating gas-producing foods for at least 12 hours prior to the test.
3. Bring a tight-fitting swimsuit (Speedo-style) OR compression shorts (with sports bra for women).
4. Location: HPER building, room 147.
5. Please arrive on time. Your scheduled time is:____________

APPENDIX C. Informed Consent

Date Created: 10 July, 2006
Modified: 21 June, 2007

INFORMED CONSENT
Body Composition Change during the First Year of College: A Study of Traditional Residence Hall Freshman

Introduction/Purpose
The purpose of this research is to assess physical changes to include height, weight, waist circumference, and body fat percentage of both male and female traditional college freshmen as well as freshmen athletes residing on-campus over the course of the entire freshmen school year (two semesters). Drs. Dale Wagner and Ed Heath of the Health, Physical Education, and Recreation Department at Utah State University are conducting research to better understand and quantify these changes. There will be 100 nonathletes (50 female and 50 male) and 30 athletes (15 female and 15 male) in this study.

Procedures
If you agree to participate in this study, you will be asked to come to the Exercise Physiology Laboratory in the HPER building on the USU-Logan campus three separate times:

1) Once during weeks #2 or #3 of the fall semester: the purpose of this testing session is to obtain baseline information. The total time for this session should be less than 30 minutes. During this visit, the following procedures will occur:
   a) You will be asked to follow pre-testing guidelines:
      1. Do not eat or engage in strenuous exercise for 2 hours prior to your scheduled appointment.
      2. Avoid eating any gas-producing foods (e.g., baked beans, etc.) for 12 hours prior to test.
      3. Bring a tight-fitting, lightweight swimsuit (e.g. Speedo) or non-padded lycra compression shorts and a jog bra with you.
   b) You will be asked to urinate and eliminate as much gas and feces as possible before changing into your swimsuit.
   c) While wearing your swimsuit, your height and weight will be measured.
   d) While wearing your swimsuit, a measurement will be taken with a tape measure of your waist circumference.
   e) Your body volume will be measured by the Bod Pod. You will sit in a large egg-shaped chamber with a large window with the door closed for two 20-second trials. During this time you will be required to sit motionless and breathe normally. This measurement will be used for the estimation of your body fat.

INFORMED CONSENT
Body Composition Change during the First Year of College:
A Study of Traditional Residence Hall Freshman

f) A third Bod Pod trial will be done to measure your thoracic gas volume. This procedure involves wearing a nose clip and breathing normally into a plastic hose while inside the Bod Pod. You will be instructed to make 3 short "puffs" (similar to cleaning an eyeglass lens) at some point during your breathing cycle. This procedure is necessary to improve the accuracy of the Bod Pod test.
g) Two one-page questionnaires will be given to assess your perceived fitness and physical activity levels.

2) Once during weeks #14 or #15 of the fall semester: the purpose of this testing session is to quantify changes that have occurred during the fall semester. The total time for this session should be less than 15 minutes. Procedures "a-e" (described previously) will be repeated.

3) Once during weeks #14 or #15 of the spring semester: the purpose of this testing session is to quantify changes that have occurred during the spring semester. The total time for this session should be less than 20 minutes. Procedures "a-e" and "g" (described previously) will be repeated. Additionally, a brief questionnaire will be given in order to better understand changes that may have occurred in your dietary or exercise habits throughout the year.

Risks
There is minimal risk in participating in this study. Some people may feel claustrophobic inside the Bod Pod. However, the chamber door is closed for only about 30 seconds per trial. Also there is a very large window that allows you to see everything outside the chamber. Furthermore, there is an emergency button inside the chamber that will allow you to open the chamber door from the inside. There have been no reported incidences of injury associated with the Bod Pod since its inception in 1994. A technician will be available to assist you if needed. An office adjacent to the lab contains a phone for "911" emergencies.

Benefits
You will be given an estimate of your body fat percentage and an interpretation of this value at the end of the study. Knowledge of your body fat percentage can help you assess your health and fitness status. Furthermore, the information gained from this study may help researchers better understand the physical changes that take place during the freshman year of college.

Date Created: 10 July, 2006
Modified: 21 June, 2007

INFORMED CONSENT
Body Composition Change during the First Year of College:
A Study of Traditional Residence Hall Freshman

Explanation & Offer to Answer Questions
Dr. Wagner and/or his research associates have explained this research study to you. You have been given the opportunity and encouraged to ask questions. If you have other questions or research-related problems, you may reach Dr. Wagner at 797-8253 or by email at dale.wagner@usu.edu. Co-investigator, Dr. Ed Heath may be reached at 797-3306 or by email at edward.heath@usu.edu.

Extra Costs & Payments
There is no cost for your participation in this study. If you complete all three testing sessions, you will be paid $25.

Withdrawal due to Pregnancy
Should you become pregnant during the course of the study, it is your responsibility to inform the researchers. You will be withdrawn from the study without consequence or loss of benefits as pregnancy will create obvious changes in body composition that will confound the study.

Voluntary Participation & Right to Withdraw
Your participation in this research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence or loss of benefits; simply inform the researchers of your desire to withdraw from the study.

Confidentiality
Research records will be kept confidential, consistent with federal and state regulations. Your data will be identified by a number, not by your name. Your data and information about your identity will be kept in separate locked file cabinets in a locked room accessible by only Drs. Dale Wagner and Ed Heath and research assistant Stephanie Christensen. Any information linking you to your data will be destroyed following the final data analyses within a year of the completion of the study.

IRB Approval Statement
The Institutional Review Board (IRB) for the protection of human participants at USU has reviewed and approved this research study. If you have questions or concerns about your rights you may contact them at (435) 797-1821.

Date Created: 10 July, 2006
Modified: 21 June, 2007

INFORMED CONSENT
Body Composition Change during the First Year of College:
A Study of Traditional Residence Hall Freshman

Copy of Consent
You have been given two copies of this Informed Consent. Please sign both copies and retain one copy for your files.

Investigator Statement
"I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

______________________ __________ ______________________

Dr. Dale R. Wagner — Date
Principal Investigator
435-797-8253
dale.wagner@usu.edu

Dr. Ed Heath — Date
Co-Investigator
435-797-3306
edward.heath@usu.edu

______________________ __________

Stephanie Christensen — Date
Graduate Research Assist.
801-389-3882

Signature of Participant
By signing below, I agree to participate.

______________________________ ______________________

Participant's signature — Date

APPENDIX D. Perceived Functional Capacity Questionnaire

Suppose you were going to exercise continuously on an indoor track for 1 mile. Which exercise pace is just right for you--not too easy and not too hard?

Circle the appropriate number (any number, 1 to 13).

1 Walking at a *slow* pace (18 minutes per mile or more)
2
3 Walking at a *medium* pace (16 minutes per mile)
4
5 Walking at a *fast* pace (14 minutes per mile)
6
7 Jogging at a *slow* pace (12 minutes per mile)
8
9 Jogging at a *medium* pace (10 minutes per mile)
10
11 Jogging at a *fast* pace (8 minutes per mile)
12
13 Running at a *fast* pace (7 minutes per mile or less)

How fast could you cover a distance of 3-miles and NOT become breathless or overly fatigued? Be realistic.

Circle the appropriate number (any number, 1 to 13).

1 I could walk the entire distance at a *slow* pace (18 minutes per mile or more)
2
3 I could walk the entire distance at a *medium* pace (16 minutes per mile)
4
5 I could walk the entire distance at a *fast* pace (14 minutes per mile)
6
7 I could jog the entire distance at a *slow* pace (12 minutes per mile)
8
9 I could jog the entire distance at a *medium* pace (10 minutes per mile)
10
11 I could jog the entire distance at a *fast* pace (8 minutes per mile)
12
13 I could run the entire distance at a *fast* pace (7 minutes per mile or less)

APPENDIX E. Modified Physical Activity Rating Questionnaire

Select the number that <u>best describes</u> your overall level of physical activity for the previous 6 MONTHS:

0 = avoid walking or exertion; e.g., always use elevator, drive when possible instead of walking

1 = **light activity:** walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration

2 = **moderate activity:** 10 to 60 minutes per week of moderate activity; such as golf, horseback riding, calisthenics, table tennis, bowling, weight lifting, yard work, cleaning house, walking for exercise

3 = **moderate activity:** over 1 hour per week of moderate activity as described above

4 = **vigorous activity:** run less than 1 mile per week or spend less than 30 minutes per week in comparable activity such as running or jogging, lap swimming, cycling, rowing, aerobics, skipping rope, running in place, or engaging in vigorous aerobic-type activity such as soccer, basketball, tennis, racquetball, or handball

5 = **vigorous activity:** run 1 mile to less than 5 miles per week or spend 30 minutes to less than 60 minutes per week in comparable physical activity as described above

6 = **vigorous activity:** run 5 miles to less than 10 miles per week or spend 1 hour to less than 3 hours per week in comparable physical activity as described above

7 = **vigorous activity:** run 10 miles to less than 15 miles per week or spend 3 hours to less than 6 hours per week in comparable physical activity as described above

8 = **vigorous activity:** run 15 miles to less than 20 miles per week or spend 6 hours to less than 7 hours per week in comparable physical activity as described above

9 = **vigorous activity:** run 20 to 25 miles per week or spend 7 to 8 hours per week in comparable physical activity as described above

10 = **vigorous activity:** run over 25 miles per week or spend over 8 hours per week in comparable physical activity as described above

APPENDIX F. Body Composition, Nutrition, & Exercise Questionnaire

Questionnaire

Please answer the questions truthfully and to the best of your ability. Remember that your answers are confidential and can not be linked to you at a later time. Thank you for your participation in this study.

Body Composition:

1. Compared to last year when you were in high school, your body weight during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

2. Compared to last year when you were in high school, your body fat during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

3. Compared to last year when you were in high school, your muscle mass during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

4. If you think that you have experienced a change in either body weight or body composition (body fat or muscle mass) during your freshman year at USU, please explain why you think the change occurred?

____

____

____

5. Did you go on a diet or take other measures to lose weight (diet pills, laxatives, etc.) at any time during your freshman year?

____

6. What is your perception of your body weight?

Very underweight   slightly underweight   about right   slightly overweight   very overweight

Nutrition:

7. Compared to last year when you were in high school, your total caloric consumption during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

8. How many times do you eat in a typical *day* (include meals and snacks)?___________

9. Compared to last year when you were in high school, the number of times per day that you ate during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

10. Approximately how many servings of fruits and vegetables do you eat per *day*?_____

11. Compared to last year when you were in high school, your consumption of fruits and vegetables during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

12. Approximately how many times per *week* do you eat "fast food"?___________

13. Compared to last year when you were in high school, your consumption of "fast food" during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

14. Approximately how many alcoholic drinks did you have per *week*?__________
    (One drink is equal to a 1.5 oz cocktail or shot of hard liquor, 5 oz glass of wine, or 12 oz of beer)

15. Compared to last year when you were in high school, your consumption of alcohol during your freshman year at USU has:

Decreased greatly   decreased a little   about the same   increased a little   increased greatly

Exercise

16. How many days per week do you engage in at least 30 minutes of exercise or physical activity that results in sweating and heavy breathing (such as basketball, jogging, aerobic dance, or similar aerobic activities)?

____

17. How many days per week do you engage in exercises to strengthen or tone muscles (such as push-ups or weight lifting)?

____

18. How many days per week do you participate in a physical education activity course?

____

19. Compared to last year when you were in high school, your participation in organized sports (school athletic teams, intramurals, community leagues, etc.) during your freshman year at USU has:

Decreased greatly decreased a little about the same increased a little increased greatly

20. Compared to last year when you were in high school, your participation in leisure time physical activity (walking, bike riding, golfing, etc.) during your freshman year at USU has:

Decreased greatly decreased a little about the same increased a little increased greatly

21. Compared to last year when you were in high school, your occupational physical activity (physical exertion at work) during your freshman year at USU has:

Decreased greatly decreased a little about the same increased a little increased greatly

22. Compared to last year when you were in high school, your total time spent doing physical activity during your freshman year at USU has:

Decreased greatly decreased a little about the same increased a little increased greatly

APPENDIX G. Data Collection Sheet

______ Subject number Residence Hall_________________

Gender______ Age______ Ethnicity_____________ Marital Status_______

Major___________________ NCAA athlete Y N Sport_____________

Data Collection #1 (Fall 2007) Date______________

Thoracic volume (measured)_______ L Thoracic volume (predicted)_______ L

Height_______ cm Weight______ kg BMI________ kg/m^2 Waist______ cm

Body volume_______ L Body density_____________ g/cc %Body Fat_________

Data Collection #2 (Winter 2007) Date______________

Height_______ cm Weight______ kg BMI________ kg/m^2 Waist______ cm

Body volume_______ L Body density_____________ g/cc %Body Fat_________

Data Collection #3 (Spring 2008) Date______________

Height_______ cm Weight______ kg BMI________ kg/m^2 Waist______ cm

Body volume_______ L Body density_____________ g/cc %Body Fat_________