

Freshman versus Sophomore Year Changes in Body Weight and Composition

by

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Abstract

Objective: Differences in weight, body mass index (BMI), percent and absolute body fat and fat free mass, and waist circumference were investigated in males and females during the freshman and sophomore college years. **Methods:** Changes in height, weight, BMI, body composition (using bioelectrical impedance), and waist circumference (via body scans) were assessed over the freshman and sophomore years among 240 college students. **Results:** Weight (2.5 and 1.7 lbs) and BMI gains (0.3 and 0.3 kg/m²) did not significantly differ between the freshman and sophomore years, respectively. 69% of participants gained weight, which averaged 8.4 lbs. Significantly more percent body fat and fat mass were gained during the freshman (1.9% and 3.3 lbs, respectively) than the sophomore year (0.0% and 0.6 lbs, respectively). Females lost significantly more fat free mass during the freshman (-0.8 lbs) than the sophomore year (1.0 lbs). Changes in waist circumference and weight were significantly correlated. Increases the percentages of participants classified as overweight and with unhealthy body fat amounts and waist circumferences were observed. **Conclusions:** The freshman year is associated with weight gain and unhealthy body composition changes, and, while the sophomore year also is characterized by weight gain, overall healthier body composition changes were observed.

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Table of Contents

Abstract.....	ii
Acknowledgments.....	iii
List of Tables.....	v
Chapter 1. Introduction.....	1
Chapter 2. Literature Review.....	4
Chapter 3. Body Weight and Composition Changes: Freshman and Sophomore Year.....	36
Chapter 4. Summary.....	57
References.....	59
Appendices.....	68

List of Tables

Table 3.1 Selected demographic and anthropometric characteristics of the initial sample population.....	53
Table 3.2 Changes in body weight, body mass index (BMI), percent body fat, percent fat free mass, fat mass, fat free mass, and waist circumference of females and males over the freshman and sophomore years of college.....	54
Table 3.3 Changes in body weight, body mass index (BMI), percent body fat, percent fat free mass, fat free mass, and fat mass of females and males during each semester of the freshman and sophomore years of college.....	55
Table 3.4 Percent of participants' underweight, normal weight, overweight, and obese from the beginning of freshman year to the end of sophomore year.....	56
Appendix A Summary of studies examining body weight and composition in first year college students.....	68
Appendix B Summary of studies examining body weight and composition in second year college students.....	70
Appendix C Informed Consent.....	71

Chapter 1

Introduction

The rise in the prevalence of overweight and obesity the last few decades has led to a national epidemic. The World Health Organization estimates that 1 billion adults in the world are overweight, with 300 million of those adults considered obese (WHO 2006). The prevalence of obesity in adults (20 to 74 years of age) has more than doubled from 15.0% to 32.9% since the mid 70's and for adolescents/young adults (12 to 19 years of age) the prevalence of obesity has increased the most from 5.0% to 17.6% (CDC 2009a). The problem of overweight and obesity is of particular importance in Alabama since it is ranked the second most obese state in the nation with over 32% of residents classified as obese (CDC 2009a). Over 50% of young adults (18 to 24 years) in Alabama are considered overweight or obese indicating that this is a population group at risk (CDC 2009a).

The rise in overweight and obesity is of particular importance because of the consequences on Americans' health and the American economy. An increased risk of mortality and morbidity is associated with obesity including such problems as cardiovascular disease, stroke, type 2 diabetes, arthritis, reproductive complications, and some cancers (CDC 2009b, U.S. Surgeon General 2010). Also, the impaired mobility and decreased physical endurance caused by obesity and overweight may affect the quality of life a person lives (U.S. Surgeon General 2010). According to the World Health Organization, the economic cost in terms of medical expenses of overweight and obesity has been estimated at 78.5 billion dollars (WHO 2006).

Many studies over the past eight years have been published on weight and body composition changes among young adults during the freshman year of college (Anderson and others 2003, Butler and others 2004, Economos and others 2008, Edmonds and others 2008, Graham and Jones 2002, Gropper and others 2009, Hajhosseini and others 2006, Hodge and others 1993, Hoffman and others 2006, Holm-Denoma and others 2008, Hovell and others 1985, Jung and others 2008, Kasparek and others 2008, Levitsky and others 2004, Lloyd-Richardson and others 2008, Lowe and others 2006, Mifsud and others 2009, Morrow and others 2006, Provencher and others 2009, Pullman and others 2009, Wengreen and Moncur 2009). These studies have established that freshmen typically gain more weight during the first semester of their freshman year than the second semester, and the weight gain observed averages 4-5 lbs and not the commonly publicized 15 lbs. Moreover, body fat tends to increase on average greater than 1% during the freshman year indicating unhealthy changes in body composition during this time period. Only a few studies have examined weight and body composition changes beyond the freshman year of college (Hovell and others 1985, Hull and others 2007, Lloyd-Richardson and others 2009, Racette and others 2005, Racette and others 2008). These studies have determined that weight continues to increase throughout college but at a much slower rate than that seen the freshman year. Shifts in body composition also occur during the sophomore year in females. Specifically, the increases in percent body fat and fat mass that occurred during the freshman year in females decreased in the sophomore year and were accompanied by increased fat free mass (Hull and others 2007). Yet, missing from the literature is an examination of changes in body weight, composition, and shape both in males and females after the freshman year of college. The purpose of the present study was to examine changes in body weight, body mass index, percent body fat, percent fat free mass, fat mass, fat free mass, and waist

circumference in a group of male and female college students during their freshman and sophomore years of college.

Chapter 2

Literature Review

This section of the thesis will review the literature in the following areas: definitions of weight classifications, prevalence of obesity, health consequences of obesity, changes in body composition associated with weight gain, causes or factors associated with weight gain, and weight and body composition changes among college students during the freshman year and beyond the freshman year. Attention, when appropriate, will be directed in each section towards information related to young adults/college-aged students, the population that is the focus of the thesis research.

Definitions of Obesity and Overweight

Obesity and overweight describe adult weight classifications that are considered out of the norm and have been shown to increase risks for mortality and the development of health problems (CDC 2009b). Body mass index (BMI) is a common method of estimating total body mass. The Centers for Disease Control and Prevention (CDC) designate four BMI classifications for adults - underweight, normal weight, overweight, and obese. A BMI less than 18.5 kg/m^2 indicates underweight. The normal weight BMI classification ranges from 18.5 to 24.9 kg/m^2 . A BMI of 25 to 29.9 kg/m^2 is considered overweight, and a BMI of 30 kg/m^2 or higher is classified as obese (CDC 2009b). In children, growth charts have been developed by the CDC; percentiles on BMI-for-age growth charts are used to assess growth and size. Specifically, BMI is plotted on gender specific BMI-for-age growth charts in order to obtain a percentile ranking. The percentile approximates the relative position of the child's BMI-for-age against other

children of the same sex and age. Children at less than the 5th percentile are classified as underweight; children between the 5th and 85th percentile are classified as of a healthy weight; children between the 85th and 95th percentile are considered overweight; those in the 95th percentile or greater are considered obese (CDC 2010).

Prevalence of Obesity and Overweight

In the United States, overweight and obesity continue to increase in prevalence. For example, in adults 20 to 74 years of age, the prevalence of obesity has increased from 33.2% to 35.5% in females and 31.3% to 32.2% in males from 2004 to 2008 (Flegal and others 2010). Comparing data from two National Health and Nutrition Examination Surveys (NHANES), one from the mid 70s and another in 2003-4, reveals that among adults 20 to 74 years old the prevalence of obesity more than doubled from 15.0% to 32.9% (CDC 2009a). Data from the 1976-1980 and 2003-2006 NHANES surveys showed that the prevalence of obesity has increased for children aged 2 to 5 years from 5.0% to 12.4%, for children aged 6 to 11 years from 6.5% to 17.0%, and for adolescents/young adults aged 12 to 19 years, the prevalence of obesity increased the most from 5.0% to 17.6% (CDC 2009a). Another age bracket with large increases in the prevalence of overweight and obesity is the young adult group, aged 18 to 29 years, which is a common age bracket for college students (Mokdad and others 1999).

The rise in the prevalence of overweight and obesity the last few decades has led to a national obesity epidemic. The World Health Organization estimates that 1 billion adults in the world are overweight, with 300 million of those adults considered obese (WHO 2006). In percentage terms, the CDC estimates that greater than one-third of all Americans are obese, and over two-thirds are either obese or overweight (CDC 2009b, Ogden and others 2010). Further, another 18% of adolescents / young adults (12 to 19 years of age) in the United States are

overweight (CDC 2009a, Ogden and others 2010). According to the 2007-2008 National Health and Nutrition Examination Survey (NHANES), 12% of children and adolescents 2 to 19 years of age were at or above the 97th percentile, and 17% were at or above the 95th percentile. In the young adult age group (20 to 39 years), Flegal and colleagues (2010) determined that 27.5% of men and 34% of women were obese. Similarly, the 2007 National College Health Assessment found that 22.2% of college students were classified as overweight and 10.7% were considered obese. The 2008 Behavioral Risk Factor Surveillance System found that 26% of Alabama residents' aged 18 to 24 years are overweight and 27% are obese (CDC 2009a).

Health Consequences of Obesity

Each year 2.6 million adults will die because of overweight and obesity (WHO 2006). In addition to the increased mortality risk, the national obesity epidemic is associated with increased risks of several health problems including hypertension, cardiovascular disease, stroke, type 2 diabetes, sleep apnea, osteoarthritis, reproductive complications, and some cancers (CDC 2009b, U.S. Surgeon General 2010). Similar health problems (hyperlipidemia, nonalcoholic fatty liver disease, hypertension, sleep apnea, and menstrual abnormalities) may be found in children and adolescents who are overweight or obese (Daniels and others 2009, Dietz 1998). Also, the impaired mobility and decreased physical endurance caused by obesity and being overweight may affect the quality of life a person lives (U.S. Surgeon General 2010). According to the World Health Organization, the economic cost in terms of medical expenses of overweight and obesity has been estimated at 78.5 billion dollars (WHO 2006).

Changes in Body Composition Associated with Weight Gain

Weight gain results from an energy imbalance, intake greater than expenditure or expenditure less than intake. Weight gain in adults is associated primarily with increases in body

fat and to a lesser extent increases in fat free mass. For example, in a 70 kg male (age 25 years) who gains 30 kg of weight, 15.4 kg are from gains in fat mass (51%) with the remaining weight gained as body water and fat free mass, and in a 60 kg female (age 25 years) who gains 30 kg of weight, 18.7 kg are from gains in fat mass (62%) with the remaining weight gained as body water and fat free mass (Olesen 1965). Others estimate the composition of weight gain in adults at 62% to 75% fat mass and 25% to 38% fat free mass (Forbes 1988, Jequier and Tappy 1999).

Exact changes in body composition with weight gain and loss, however, depend in part on whether or not a person is exercising. For example, excess energy intake coupled with physical activity in adults results in weight gain that is associated with larger gains in fat free mass versus excess energy intake coupled with little exercise which results in weight gain with larger gains in fat mass (Forbes 2000).

The effects of exercise on body weight and composition appear to vary, but generally those who maintain their weight and exercise tend to gain lean mass and lose fat mass. Those who gain weight and exercise typically gain both fat and fat free mass. Weight cycling appears to be associated with decreases in muscle mass (Forbes 2000, Singh 2002).

The duration, frequency, and intensity of physical activity affect body composition changes. Generally, low intensity aerobic type exercise, such as walking less than 150 minutes per week, without dietary intervention, has minimal effects on body weight (Jakicic and others 1999, Ross and others 2000). Yet, while studies suggest that exercise alone does not promote weight loss, loss of fat mass has been reported when energy restriction is coupled with physical activity (Ross and others 2004). For example, high intensity and duration of exercise with dietary energy restriction in younger men who were not morbidly obese has been shown to promote weight loss and body fat loss (Brochu and others 2000). Similar findings have been reported in

middle-aged (40 to 65 years), overweight men and women; significantly more body weight and fat mass were lost with high amount/vigorous intensity exercise (20 mile jog per week) versus either low amount/moderate intensity exercise (walk 12 miles per week) or controls (Slentz and others 2004). In younger adults (18 to 34 years), high intensity exercise also has been shown to result in greater decreases in body fat, especially visceral, than low intensity or moderate intensity exercise (Bryner and others 1997).

In contrast with more aerobic types of exercise, resistance training alone without dietary modifications typically has little impact on overall body weight. However, some studies suggest that while overall body weight and fat mass are not affected, resistance training may selectively reduce intra-abdominal fat stores in older adults (Baumgartner and others 1998, Treuth and others 1995 and 1994). Other studies suggest that resistance exercise while also restricting energy intake helps to maintain fat free mass (Ballor and others 1988, Geliebter and others 1997). High protein energy restricted diets coupled with exercise (both walking and resistance training) have been associated with loss of body weight and body fat but only minimal loss of lean mass (Bopp and others 2008, Layman and others 2005). Physical activity with energy restriction, however, does not appear to be able to completely preserve fat free mass, especially when significant weight loss occurs (Cox and others 2003, Dengel and others 1998, Forbes 2000, Nieman and others 2002, Redman and others 2007, Stiegler and Cunliffe 2006, Wood and others 1991).

In summary, physical activity alone or with energy restriction affects body composition. The exact changes that occur in body composition depend on the type of exercise and its intensity, duration, and frequency. Desirable changes include increases or preservation of fat free mass and generally loss or maintenance of fat mass to a healthy level. Essential fat stores in

males and females are estimated at 2 to 5% and 12 to 15%, respectively. Body fat in excess of 20% for males and 30% for females, especially if body fat is predominately located in the abdominal region, is considered unhealthy and associated with increased health risks (Lee and Nieman 2007, Manore and Thompson 2000). This importance of body composition assessment and not just calculations of body mass index has been realized with emergence of “normal weight obesity” or being “skinny fat”. A cross-sectional study of 13,601 adults, aged 20 to 79.9 years, found that 43.9% of males and 52.3% of females who were considered to have a normal body weight based on body mass index exhibited high (unhealthy) body fat percentages (> 20% for males and > 30% for females) and metabolic disturbances (Romero-Corral and others 2008).

Causes or Factors Associated with Weight Gain

The transition from high school to college appears to be a critical time for young adults since new lifestyle and dietary habits are being developed and adaptation to a more independent lifestyle is required. Many students experience a weight gain while in college, especially the freshman year. This next section of the literature review will evaluate some of the dietary habits that may lead to an energy imbalance and thus weight gain in the college aged population.

Dietary Habits

Dietary habits can promote weight gain when energy intake exceeds energy expenditure. College students exhibit several dietary habits that may be associated with overconsumption of foods/beverages and thus energy. Some of these habits will be presented in this section and include (a) insufficient intakes of recommended food groups and nutrients, (b) junk food consumption, (c) alcohol consumption, and (d) fast-food/restaurant food consumption.

Insufficient Intakes of Recommended Food Groups and Nutrients. It has been well established that adolescents/young adults don't meet current recommended guidelines for intakes

of fruits and vegetables, whole grains, fiber, and dairy products. The 2005 Dietary Guidelines for Americans recommends 5-13 servings of fruits and vegetables, 6 servings of grains, 25 grams of fiber, and 3 cups of dairy per day (USDA 2005). The results of one national study as well as six smaller university-specific studies are reported.

Douglas and others (1997) determined that only 26.3% of the 4,609 college students polled for the 1995 National College Health Risk Behavior Survey consumed five or more servings of fruits and vegetables a day. Similar findings have been shown in other smaller studies conducted at various universities. Haberman and Luffey (1998) found that 80% of 301 college students consumed inadequate amounts of fruits and vegetables, grains, and dairy products.

DeBate and others (2001) assessed the dietary practices of 707 college students (226 males, 481 females) at a southeastern university. Results from a 24-hour recall indicated that 93.1% of participants did not consume the minimum recommendation of grain (6 servings), 98.7% did not consume the minimum recommendation of vegetables (3 servings), and 68.8% did not consume the minimum recommendation of fruits (2 servings). Only 53.2% of participants consumed the minimum recommendation of dairy products (DeBate and others 2001).

Huang and others (2003) examined 736 college students (382 males, 354 females) aged 18 to 27 years at the University of Kansas to determine dietary habits of college students. Sixty eight percent (n=370) of participants, 19 years of age and younger, consumed less than five servings of fruits and vegetables a day and 69.2% (n=377) of participants, 19 years of age and younger, consumed less than 20 grams of fiber a day. Seventy four percent (n=141) of participants, 20 years and older, consumed less than the recommended amount of fruits and vegetables and 61.3% (n=117) consumed less than 20 grams of fiber a day. Also, males

consumed on average significantly more fiber than females (19.9 ± 5.3 g/d vs. 16.1 ± 5.1 g/d fiber respectively) (Huang and others 2003).

Butler and others (2004) assessed the dietary habits of 54 students from a large Midwestern university. About 80% (n=43) of participants were deficient in grain consumption, 81.7% (n=44) were deficient in fruit and vegetable consumption, and 83.3% (n=45) of participants were deficient in dairy consumption (Butler 2004).

Racette and others (2005) reported that only 30% (n=230) of a sample of college freshman at Washington University consumed 5 or more servings of fruits and vegetables. A follow up study by Racette and others (2008) determined that 71% of participants, now seniors in college, still did not consume the recommended daily intake of fruits and vegetables.

Strong and others (2008) determined in a study of 43 first- and second-year college students at Virginia Tech that consumption of fruits (1 cup equivalent), vegetables (1.5 cup equivalent), and grains (1.4 oz. equivalent) was below recommendations. Daily fiber consumption by males (15 ± 6 g) and females (13 ± 5 g) was also lower than recommendations (Strong and others 2008).

Junk Food Consumption. The term “junk food” is a slang term that refers to any prepackaged food item that lacks in nutritional value and may contain undesirable characteristics in excess, like those of saturated fat, sugar, and salt. Consumption of salty snack foods has significantly increased over the last three decades. Energy intake from salty snack foods by adolescents has increased by 12%. Similarly, energy intake from salty snack foods by young adults increased 10%. Further, energy intake from soft drink consumption has increased about 5% and 7% in adolescents and young adults, respectively (Nielson and other 2002).

Studies linking junk food consumption and weight gain have been limited, but an association has been established in a study by Levitsky and others (2004). Factors associated with weight change in 60 freshmen (9 males, 51 females) at Cornell University were examined. Participants gained an average of 4.18 lbs the first semester of college. Junk food consumption accounted for 8% of weight variance, and 24% of weight variance when initial body weight was controlled. Also, 12% of total variance was associated with consumption of high fat foods (Levitsky and others 2004).

Alcohol Consumption. Alcohol consumption may be associated with weight gain in college students for two reasons. First, ingestion of alcohol provides the body directly with energy, and secondly, food consumption which also provides energy tends to occur with the alcohol ingestion. Several studies have documented the drinking habits of college students. In addition, a few studies have linked alcohol use with weight gain in college students.

In young adults, percent of total energy intake from alcohol consumption has increased from 2.6% in 1977 to 10.6% in 1996 (Neilsen and others 2002). Individuals aged 18 to 25 years have been reported to consume higher amounts of alcohol than any other age group (Kerr and others 2009). In a study of 71,860 college students only 18.6% reported having never had alcohol and 38.3% reported drinking 1 to 4 drinks the last time they partied (ACHA 2007). Also, over one third of all undergraduate college students in the National College Health Risk Behavior Survey reported episodic heavy drinking (≥ 5 drinks on one occasion) (Douglas and others 1997). Similarly, Pullman and coworkers (2009) followed 108 males from a Canadian university (University of Guelph). Over three quarters, 79% (n=85) of participants consumed alcohol regularly, and 55% (n=59) participated in binge drinking.

Three studies have linked alcohol consumption to weight gain in college students. Economos and colleagues (2008) investigated weight change in 369 freshmen (140 males, 256 females) at a private East Coast university over the freshman year. Participants gained an average of 5.3 lbs over the academic year. Weight gain occurred in 80% of the study population, and alcohol consumption was observed to have a positive effect on weight gain in males, accounting for a 4.2 lb increase in weight (Economos and others 2008).

Lloyd-Richardson and others (2008) examined 282 freshmen at a small northeastern university to determine drinking habits and first year weight change. During the first semester, moderate-risk drinkers or individuals that reported drinking four to five drinks per occasion on one to three days during the week had greater increases in BMI than low-risk drinkers or those that consumed alcohol one to two times per month. Also, moderate-risk drinkers were more like to consume junk food and high calorie foods after drinking episodes than low-risk drinkers (Lloyd-Richardson and others 2008).

Mifsud and coworkers (2009) assessed 29 freshmen (13 males, 16 females) from the University of Ottawa to determine changes in body weight and composition and alcohol consumption during the first year of college. Alcohol consumption was positively associated with changes in both weight and percent body fat (Mifsud and others 2009).

Fast Food and Restaurant Dining. A steady increase in the percentage of energy consumption from restaurant and fast food establishments has been documented in adolescents and young adults since 1977 (Nielson and others 2002, Jeffery and French 1998). The Nationwide Food Consumption Survey and the Continuing Surveys of Food Intake in Individuals reported that energy intake from restaurant/fast food has increased 12.8% in adolescents and 17.2% in young adults (Nielson and others 2002). The prevalence of eating away from home

three or more days a week has increased 40% since 1987 (Kant and Graubard 2004). College students have been reported to eat at fast food restaurants on average 6 to 8 times per week (Driskell and others 2005). Young adults aged 19 to 39 years consumed over half their total energy needs from foods obtained from restaurants and fast food locations (Nielsen and others 2002). Bowman and Vinyard (2004) noted that young adults aged 20 to 29 years were about four times more likely than adults 55 years of age or older to visit a fast food restaurant on a particular day.

Fast food restaurants are major competitors for residence hall dining establishments on college campuses. In a study of 630 college students (191 male, 439 female), only 27% of participants (n=170) reported not eating fast food regularly. About 32% (n=201) of students reported they ate fast food always/often, and 42% (n=264) ate fast food sometimes (Debate and others 2001). Similarly, Racette and others (2005) found that 56% of college women and 35% of college men consumed high-fat fast foods three or more times a week in a study of 764 freshmen at Washington University in St. Louis.

The rise in popularity of fast food dining is thought to be related to several factors. Rydell and others (2008), in a survey of 594 participants (241 males, 353 females) 16 years or older, found that 92.3% ate at fast food restaurants because they are quick, 80.1% because of convenience, and 63.6% because they are inexpensive. Also, 50% of adolescents and young adults reported eating at fast food establishments as a means of socialization (Rydell and others 2008).

Unfortunately, fast food consumption and restaurant dining have been linked to higher intakes of energy, fat, sodium, carbonated soft drinks, as well as lower intakes of milk, fruits, vegetables, dietary fiber, and vitamins (French and others 2000, McCrory and others 2002,

Paeratakul and others 2003). Eating away from home also has been associated with an increased risk for obesity (Duffey and others 2007, Levitsky and others 2004, Ma and others 2003, Nelson and others 2009, Niemeier and others 2006). The Coronary Artery Risk Development in Young Adults (CARDIA) study followed 3,394 individuals over a 7- and 10-year span to determine the effects of fast food consumption on weight change. At year 7 and 10, one unit of fast food consumption (1 time/week) was associated with 0.13 and 0.24 increase in body mass index, respectively (Duffey 2007). Similarly, Niemeier and others (2006) examined 9,919 participants in a longitudinal study and found that fast food consumption as an adolescent influenced weight status as a young adult. The availability of food on campus is one of the most common factors influencing weight and diet in college youths (Nelson and others 2009). An average weight gain of 4.18 lbs was observed in a study of 60 college freshmen at Cornell University and “all you can eat” breakfast and lunch facilities accounted for 20% of the total variance of weight gain (Levitsky and others 2004).

The results of these studies clearly suggest that college students/young adults are generally frequent consumers of fast foods and restaurant foods as well as other energy dense, nutrient poor “junk” foods. Further, they are not eating the recommended amounts of fruits and vegetables, and many also do not meet minimum recommendations for ingestion of dairy products and grain products.

Lifestyle Habits

Lifestyle habits also contribute to both energy intake and energy expenditure. Several habits that promote excessive energy intake will be presented, including social dining, residency, stress, and sleep habits. Another lifestyle habit that may promote inadequate energy expenditure and thus contribute to weight gain is physical inactivity.

Social Dining. Social facilitation, the altering of one's behavior due to the presence of others (Zajonc 1965), is associated with increased meal consumption (Herman and others 2003). Patel and others (2001) evaluated 78 women to determine the effects of mood and social situations on meal intake. Individuals exhibited higher energy intakes in social settings than alone regardless of mood.

Larger meal consumption was observed in individuals in a passive-negative mood, negative mood, or positive mood compared to those in a neutral mood. Higher intakes of protein and fat were both observed for individuals in social settings; however, carbohydrate intake was significantly less in social settings (Patel and others 2001). Larger meal size has also been reported in other studies of social dining (Clendenen and others 1994, deCastro and deCastro 1989).

Stroebele and deCastro (2006) investigated 133 undergraduate students (29 males, 104 females) to determine the effect of environment on food intake. Students consumed significantly more food as the number of people present increased (Stroebele and deCastro 2006). Similarly, a study of 37 students (21 males, 16 females) from the University of Liverpool determined that eating with two or more companions increased energy intake by 18%, and another study of 214 freshmen (141 females, 73 males) found that weight gain in those who dined at all-you-can-eat buffet style dining halls was significantly associated with the number of dining companions (Saunders 2008). This latter study also found that students who dined at all-you-can-eat campus dining halls with three or more companions gained significantly more weight than the students who dined at these facilities with two or fewer companions (Saunders 2008). Dining with companions has been shown to be associated with a significant increase in sweet, high fat foods (Hetherington and others 2006).

Pliner and colleagues (2006) assessed 132 individuals (70 males, 62 females) to determine the effect of group size and duration of a meal on the amount of food consumed at a meal. Males consumed significantly more than females and individuals consumed significantly more food when given more time for meal consumption. Participants did not, however, consume significantly more or less in regard to group size (Pliner and others 2006). This study illustrates that the amount of food consumed may not be dependent on the number of diners, but on the duration of a meal, which may be lengthened with the increase in diners.

Other studies have noted that meal consumption is not always increased; individuals may track or model the intake of their dining companions to determine how much to eat or eat depending on the impressions of others (Herman and others 2003).

Residency. The transition from high school to college usually results in the relocation of residence from living at home with a parent(s) to living in either on campus or off campus housing. While only examined in a few studies, living on campus appears to be associated with greater gains in body weight (Gropper and others 2010, Hovell and others 1985, Hull and others 2007).

Hovell and coworkers (1985) found that weight gain was significantly greater in females who lived on campus (8 lbs) and attended a four-year university versus another group of females who lived off campus and attended a community college (< 1 lb) over the academic year. Gropper and others (2010) examined weight gain of freshmen based on residency and found that females living on (n=203) campus gained significantly more weight, BMI, and fat free mass (3.6 ± 4.7 lbs, 0.6 ± 0.8 kg/m², 1.3 ± 3.7 lbs respectively) the first semester than females living off (n=98) campus (1.4 ± 6.0 lbs, 0.2 ± 1.0 kg/m², 0.0 ± 4.1 lbs respectively). In a study of weight gain over the freshman and sophomore year of college Hull and associates (2007) determined

that sophomore's living on campus gained weight (0.88 lbs) and body fat (0.22 lbs) while those living off campus tended to maintain their weight but lost body fat (-2.64 lbs) and increased fat free mass (2.42 lbs).

Multiple factors, that have yet to be identified, are likely associated with on campus residency and weight gain. Nelson and colleagues (2009) identified the availability of food on campus as a factor influencing unhealthy eating and overconsumption, which in turn leads to weight gain. But other factors, such as limited storage space for food, limited access to cooking facilities, and university meal plan requirements may also be influential.

Stress. The transition from high school to college and thus from adolescence to adulthood can be a stressful time for individuals. According to the College Chronic Life Stress Survey, first year college students report higher stress scores than upper-class undergraduates, with the highest scores seen for academic performance, studying, and time management (Towbes and Cohen 1996).

Stress appears to have a bi-directional relationship with appetite and weight change. A few studies are presented here after that have examined the effects of stress on appetite. Kandiah and colleagues (2006) followed 272 female college students (aged 17 to 26 years) to determine if stress influenced appetite. Eighty-one percent of the participants reported that under stress their appetite changed; specifically 63% reported an increase in appetite and 37% stated their appetite decreased (Kandiah and others 2006). Similarly, Oliver and Wardle (1999) found in a study of 212 participants that 42% reported increased appetite due to stress and 38% reported decreased appetite due to stress.

Two studies have reported the effects of stress on weight change. Serlachius and associates (2007) followed 268 students (100 males, 168 females) from a university in London to

determine the effects of stress on weight. An average weight gain of 3.4 lbs was observed in 55% of the students, whereas 12% lost weight and 33% remained stable. Stress was determined to be associated with the observed gains and losses in weight (Serlachius and others 2007). Economos and colleagues (2008) investigated the effects of stress on weight change in 369 freshmen (140 males, 256 females). Males, but not females, lost weight (9.7 lbs) in response to stress (Economos and others 2008). The results of these studies suggest that stress may promote both increases or decreases in appetite as well as increase or decreases on weight.

Sleep. The lack of sleep has been linked to irritability, depression, tension, and decreased satisfaction in life (Pilcher and Ott 1998) and may be associated with increased appetite and decreased energy expenditure (Knutson and others 2007, Patel and others 2006, Taheri and others 2004). College students often experience a change in the sleep cycle and in sleep habits during the transition from high school to college.

A few studies have examined the sleep habits of college students. The results of these studies are presented next followed by the findings of studies that have examined associations between sleep and body weight or BMI in college students. Pullman and others (2009), in a study of 108 male freshmen, determined that the amount of hours spent sleeping significantly decreased between high school and the end of freshmen year of college. Buboltz and colleagues (2001) found in a study of 191 undergraduates (95 males, 96 females) that 73% had occasional sleep problems; however, students averaged 8 hours 2 minutes of sleep a night during the week and 8 hours 27 minutes of sleep during the weekend. In a more recent study of 237 college students, males only averaged 6.4 hours of sleep a night and females averaged 6.35 hours of sleep a night (Tsai and Li 2004).

The National Longitudinal Study of Adolescent Health followed 4,489 adolescents (2,199 males, 2,287 females) to determine the risk of increased body mass index in relation to sleep habits (Knutson 2005). Forty-two percent of males and 46% of females reported less than eight hours of nightly sleep. Longer sleep duration was associated with lower BMI z-score and decreased risk for overweight for males, but not females (Knutson 2005).

Taheri and colleagues (2004) examined the effects of sleep duration on body mass index and hormone levels in the Wisconsin Sleep Cohort Study. The minimum BMI was associated with an average of 7.7 hours of sleep a night and increased BMI was proportional to decreasing nightly sleep. An increase in BMI from 31.3 to 32.4 kg/m² was observed when sleep was decreased from eight to five hours a night. Also, leptin levels decreased 15.5% and ghrelin levels increased 14.9% as nightly sleep decreased from eight to five hours (Taheri and others 2004).

Physical Inactivity. Some of the benefits of physical activity include weight increased bone and muscle strength and reduced risk of cardiovascular disease, type 2 diabetes, metabolic syndrome, and some cancers (CDC 2009c). According to the American College of Sports Medicine and the American Heart Association, adults (18 to 65 years of age) should get at least 30 minutes of moderate-intensity aerobic exercise at least 5 days a week. Also, muscular strength and endurance activities should be performed at least twice a week to promote health and physical independence (Haskell and others 2007). According to Centers for Disease Control and Prevention, 150 minutes of moderate-intensity aerobic exercise is recommended each week, as well as muscle strengthening at least two days a week (CDC 2009c). Adolescents and children require at least 60 minutes a day of physical activity with three of those days including some muscle- and bone-strengthening activities (USDA 2008).

Most college campuses offer activity centers and intramural sports for students. Yet, in spite of the opportunity, regular physical activity decreases as individuals' transition from adolescence to adulthood. Bray and Born (2004) found that the number of students involved in physical activity decreased from 66% during high school to 44% in the first two months of college.

Both national studies and some smaller university studies also demonstrate insufficient physical activity among college students. The National College Health Risk Behavior Survey reported that 37.6% of participants engaged in 20 minutes of vigorous physical activity at least three days a week and only 19.5% of participants engaged in 30 minutes of moderate physical activity five days a week (Douglas and others 1997). The National College Health Assessment reported that 42.8% of students engaged in 30 minutes of moderate exercise three days out of the week and 48.2% reported engaging in strength training on two days out of the week (ACHA 2007).

These national findings are echoed in the results of several smaller studies. For example, in a study by Racette and others (2008) at Washington University in St. Louis, 59% of the sample population of college students engaged in regular physical activity, while 29% of students did not exercise regularly their freshman year. Buckworth and Nigg (2004) determined that 30.6% of students engaged in moderately intense exercise five or more days a week and 53.2% of students engaged in vigorous activity three or more days a week. Males spent significantly more time watching television and playing video or computer games than females; however, males also reported significantly higher levels of exercise than females. Moreover, a negative correlation was observed between age and exercise in females (Buckworth and Nigg, 2004). In a study by Haberman and Luffey (1998), only 39% of 301 college students (140

males, 161 females) reported regular exercise three or more times per week, and 12.3% reported not exercising at all. Haung and others (2003), in a sample of 736 college students, found that only 16.1% engaged in regular physical activity.

Few studies have linked physical activity with weight change. Butler and others (2004) found a significant reduction in leisure, sport, occupational, and total physical activity in a group of females in which an average weight gain of 1.59 lbs was observed the first semester of college. Researchers suggested that diet alone was not responsible for the increased weight gain, but that decreased physical activity was mostly responsible (Butler and others 2004). Wengreen and Moncur (2009) followed 159 college freshmen (57 males, 102 females) to determine weight change during the first semester (16 weeks) of college; of those, 23% of participants (n=36) that gained greater than 5% of their baseline body weight, only 12.5% engaged in vigorous physical activity most days of the week and 60.7% participated in less physical activity than in high school (Wengreen and Moncur 2009).

In summary, less than half of college students engage in regular physical activity. While direct links between the reduction in physical activity and weight gain have not been firmly established in college students, it is clearly plausible that this physical inactivity coupled with the student's poor eating habits may be promoting a positive energy balance and weight gain. In the past decade, several studies have examined changes in weight and body composition during the college years. The next section of the literature review will focus on these studies.

Weight and Body Composition Changes among College Students: The Freshman Year

Twelve studies have examined either weight and/or body mass index changes among college students during the freshman year. These studies are presented first, followed by another

eight studies that have assessed both weight and body composition changes among college students during the freshman year.

Weight change studies

Hovell and others (1985) examined differences in weight change for women living on and off campus at a large private university in California. Sixty-five university women and 48 community comparison college women participated. All university women lived on campus while the comparison group lived off campus either at home or in private apartments. The university women group was divided into two cohorts with cohort 1 (n=43) completing measurements through the junior year of college and cohort 2 (n=22) completing measurements through the sophomore year of college. Height and weight of university women cohort 1 were obtained in October and March. Cohort 2 was also seen in March to measure height and weight, but previous measurements were gained from medical records. Height and weight were self-reported for 54% of cohort 1. On the follow up, cohort 1 participants were measured by an investigator, but cohort 2 participants self-reported weights. Participants in the community college group either provided self-reported initial height and weight or were measured by trained technicians. University women gained weight 36 times faster than the comparison women (0.73 lb/month vs. 0.02 lb/month, $p < 0.001$) with a statistically significant difference over time signifying that all groups gained weight. The university women's change in weight was significantly greater than the comparison (Hovell and others 1985).

Hodge and colleagues (1993) followed 61 females at Michigan State University to determine weight change during the first year of college. Participants were asked to attend two appointments 6 months apart in which their weight was measured. Height was recorded at the first visit. Eighteen females (29.5%) gained weight (≥ 4 lbs) and 11 females (11%) lost weight

(≥ 4 lbs). In those females that gained weight, the average gain was 7.0 lbs (Hodge and others 1993).

Lowe and coworkers (2006) examined 69 freshmen females from Drexel University in Philadelphia to determine weight gain in the first year college. Participant's height and weight were assessed at four different times: September, October (self-reported), January, and May. An average weight gain of 2 lbs was observed from September to October, 4.18 lbs from September to January, and 4.58 lbs from September to May. Eighty-three percent ($n = 57$) of the 69 females exhibited weight gain (Lowe and others 2006).

Economos and colleagues (2008) investigated weight change in 369 freshmen (140 males, 256 females) at a private east coast university over the freshman year. The study population was derived from four class years, 2000 to 2005. All participants self reported weight and height during August and again in April; however, in April height and weight were also measured by study staff. Participants gained an average of 5.3 lbs over the academic year with males gaining on average 5.0 lbs and females gaining on average 5.5 lbs. Weight gain occurred in 80% of the study population (Economos and others 2008).

Holm-Denoma and coworkers (2008) followed 606 freshmen (265 males, 341 females) at Dartmouth College to determine weight change during the first year of college. Self-reported weight and height were obtained from each participant's completed survey during the last semester of high school and nine months later. The males and females exhibited significant weight gain with males gaining on average 3.5 lbs and females gaining on average 4.0 lbs. Weight gain did not significantly differ between males and females (Holm-Denoma and others 2008).

Kasperek and colleagues (2008) assessed weight change in 193 freshmen (24 males, 169 females) from Winthrop University in South Carolina during the first year of college. An online survey was emailed to participating freshman during the third week of fall semester and at the end of spring semester. Heights and weights were self-reported. A mean weight gain of 2.5 lbs was reported. Participants with a baseline BMI of $<25 \text{ kg/m}^2$ who gained weight gained an average of 6.21 lbs. This gain was significantly less than participants with a baseline BMI of $\geq 25 \text{ kg/m}^2$ who gained weight (average 10.96 lbs) (Kasperek and others 2008).

Provencher and others (2009) followed 2,921 freshmen (1,294 males, 1,606 females) from six Canadian universities (University of Toronto, York University, University of Toronto at Mississauga, University of Guelph, Memorial University of Newfoundland, and Wilfrid Laurier University) to determine weight change among first year college students. Height and weight were self-reported prior to the first semester (T1), three months into the first semester (T2), and 7 months later (T3). Of the 2,921 participants, 1,326 participants (519 males, 807 females) reported measurements at all three time points. Weight significantly increased $0.9 \pm 3.6 \text{ kg}$ ($1.98 \pm 7.92 \text{ lbs}$) in males and $1.0 \pm 3.0 \text{ kg}$ ($2.2 \pm 6.6 \text{ lbs}$) in females from T1 to T2, and increased $1.6 \pm 4.4 \text{ kg}$ ($3.52 \pm 9.68 \text{ lbs}$) in males and $1.4 \pm 3.9 \text{ kg}$ ($3.08 \pm 9.68 \text{ lbs}$) in females from T1 to T3 (Provencher and others 2009).

Lloyd-Richardson and associates (2008) examined 382 freshmen at a small private university in Providence, Rhode Island to determine first year weight change. Participants were assessed in September, January, and May; 326 participants (117 males, 209 females) completed all three assessments. Males gained [3.2 kg (7.04 lbs)] significantly more weight than females [1.6 kg (3.52 lbs)] over the study period (Lloyd-Richardson and others 2008).

Wengreen and Moncur (2009) followed 186 college freshmen (68 males, 118 females) from Utah State University to determine weight change during the first semester of college. Weight and height were measured during the last two weeks of August and the first two weeks of December. Of the 186 freshmen, 159 (57 males, 102 females) completed the entire study. Weight significantly increased with an average weight gain of 1.5 ± 2.3 kg (3.3 ± 5.06 lbs); there was no significant difference in weight gain between men and women. Mean BMI significantly increased for men 0.33 ± 0.84 kg/m² and for women 0.60 ± 0.77 kg/m². Also, 23% (n=36) of participants gained greater than 5% of their baseline body weight during the 16-week period and 77% (n=123) maintained body weight to within 5% of their baseline body weight (Wengreen and Moncur 2009).

Graham and Jones (2002) followed 49 freshmen (10 males, 39 females) at a small liberal arts college in Iowa to determine actual and perceived weight change during the first year of college. Weight and height were collected from the student's medical records during the fall semester and participants were asked to return to the health services center in the spring semester to complete measurements again. The average change in weight was a loss of 1.5 lbs; however, most students thought they had gained an average of 4.1 lbs (Graham and Jones 2002).

Anderson and others (2003) investigated weight gain during the freshman year in 135 college freshmen (77 males, 58 females) in New York. Participants' height and weight were taken at the beginning of fall semester (September), the end of the fall semester (mid-December) and at the end of spring semester (May). An overall significant weight gain of 1.3 kg (2.86 lbs) was seen from September to December with 74% (n=100) of participants gaining weight when weight change was defined as ± 0.23 kg (0.5 lbs). One third of the sample was considered overweight by December. Forty-six participants (29 males, 17 females) returned in May for

reassessment. Weight gain averaged 1.7 kg (3.74 lbs) from September to May. There were no significant gender effects for either comparison. Again, using ± 0.23 kg as the definition of weight change, 74% of participants gained weight from September to May and 22% of the sample were classified as overweight/obese at the end of freshman year (Anderson and others 2003).

Levitsky and coworkers (2004) followed 60 freshmen (9 males, 51 females) at Cornell University to quantify weight changes during the first college semester. Weight was measured at the beginning of the freshman year (August 28 to September 1) and the end of the first semester (November 27 to December 1). Weight significantly increased 1.9 ± 2.4 kg (4.18 ± 5.28 lbs) during the first semester, as did BMI from 20.8 ± 2.1 to 21.5 ± 2.3 kg/m² (Levitsky and others 2004).

Weight and body composition change studies

Butler and associates (2004) assessed 54 females from a large midwestern university to determine changes in body weight and composition during the first semester of freshman year. Participants attended two appointments for weight, height, and skinfold (triceps, iliac, and thigh) determination, one at the beginning of the semester and one 20 weeks later. A significant weight gain was seen between appointments with the mean weight increasing 1.59 lbs. Significant increases in percent body fat (1.8%) and fat mass (2.95 lbs) and a significant decrease in fat-free mass (1.35 lbs) were observed after one semester (Butler and others 2004).

Morrow and colleagues (2006) tracked body weight and composition changes of 137 women at the University of Oklahoma over the freshman year of college. Height, weight, and body composition were measured during the first six weeks of fall 2004 semester and during the last six weeks of the spring 2005 semester. Body weight increased significantly by 1.1 ± 2.6 kg

(2.42 lbs) between fall and spring. Those who gained weight also showed a significant increase in BMI (0.4 kg/m^2), percentage body fat (0.8%), total fat (1.76 lbs), and fat-free mass (0.66 lbs) (Morrow and others 2006).

Edmonds and others (2008) followed 116 females from a Canadian university (University of Guelph) to determine weight, BMI, percent body fat, and waist circumference changes during the freshman year. Body weight and height were measured three times (September, November, and March) throughout the freshman year. A 2.4 kg (5.28 lb) increase in weight between September and March was seen and rate of weight gain was significantly greater during fall semester than winter semester. BMI did not change significantly during the study. Percent body fat significantly increased from $23.8 \pm 0.50\%$ (September) to $25.6 \pm 0.55\%$ (March). A significant increase in waist circumference from $76.9 \pm 0.75 \text{ cm}$ to $79.4 \pm 0.85 \text{ cm}$ was also observed from September to March (Edmonds and others 2008).

Pullman and coworkers (2009) followed 108 males from a Canadian university (University of Guelph) to determine weight, BMI, percent body fat, and waist circumference changes during the freshman year. Body weight, height, percent body fat, and circumferences were measured three times (September, November, and March) throughout the freshman year. A 3.0 kg (6.6 lbs) significant increase in weight was observed from September to March. BMI also significantly increased during the study from 23.5 to 24.3 kg/m^2 . Waist circumference significantly increased over the entire study period from $80.1 \pm 0.7 \text{ cm}$ to $83.1 \pm 0.8 \text{ cm}$. Also, percent body fat significantly increased from 12.6% to 13.4% and hip circumference significantly increased from $98.1 \pm 0.6 \text{ cm}$ to $99.4 \pm 0.7 \text{ cm}$ between November and March (Pullman and others 2009).

Mifsud and colleagues (2009) assessed 29 freshmen (13 males, 16 females) from the University of Ottawa to determine changes in body weight and composition during the first year of college. Participant's weight, height, waist circumference, and body composition were measured at three study sessions: mid September, early December, and late March/early April. A significant gender difference was observed the first semester with males gaining 3 lbs and females gaining 0.44 lbs. Similar results were observed at the end of the academic year with males gaining 4.18 lbs and females losing 0.22 lbs. Males also averaged a 2.9 cm increase in waist circumference and a total increase of 2.7 cm over the academic year. A significant gender difference was also observed for percent body fat. Percent body fat increased significantly in males the first semester (1.9%) and by the end of the academic year had increased 3.1%. Change in the female's percent body fat was 0.8% the first semester and 0.3% at the end of the academic year (Mifsud and others 2009).

Body weight and fat mass were evaluated in 67 college freshmen (32 males, 35 females) from Rutgers, the State University of New Jersey by Hoffman and others (2006). Participants were measured twice during the college year, once during the last three weeks of September and once during the last two weeks of April. Approximately 73% gained weight and significant increases were observed in weight (males 2.9 lbs; females 2.82 lbs), percent body fat (males 1.20%; females 0.20%), BMI (males 0.44 kg/m²; females 0.47 kg/m²), fat mass (males 2.38 lbs; females 0.95 lbs) and fat-free mass (males 0.22 lbs; females 1.87 lbs). No significant differences in any of the measurements were found between men and women (Hoffman and others 2006).

Hajhosseini and colleagues (2006) followed 22 females and 5 males from San Jose State University, California to determine body weight and composition changes in college freshman. Participants completed three clinical visits (0 weeks, 6-7 weeks, and 14-16 weeks) for height,

weight, and body composition (height was only measured at the initial visit). A significant increase in body weight was seen by the third visit and weight gain averaged 3.0 ± 0.7 lbs. There was also a significant increase in BMI from 23.5 ± 0.7 to 24.1 ± 0.8 kg/m² during the study period. Percent body fat significantly increased 2.1% and percent lean mass decreased proportionally 2.1% (Hajhosseini and others 2006).

Gropper and others (2009) examined 240 college freshmen (85 males, 155 females) from Auburn University to determine changes in body weight and composition among first year college students. Participants were assessed at the beginning of fall semester, at the end of fall semester, and at the end of spring semester with weight and body composition measured all three visits. Data were collected for 214 (73 males, 141 females) participants at the end of fall. First semester weight gain for participants averaged 1.7 ± 4.0 lbs for 141 females and 2.8 ± 4.4 lbs for 73 males. First semester also demonstrated a significant increase in percent body fat of $1.2\% \pm 1.7\%$ in males and of $0.7\% \pm 1.7\%$ in females: the difference was not significant between males and females. A significant difference in mean fat mass was seen between males and females with males gaining 2.1 ± 3.8 lbs and females gaining 1.4 ± 2.8 lbs. At the end of spring, 205 participants (73 males, 132 females) were reassessed; an average weight gain of 0.5 ± 5.3 lbs was observed from end of fall to the end of spring semester (males 0.6 ± 5.3 lbs; females 0.5 ± 5.3 lbs). No gender difference was seen for the spring study period. Significant increases in fat mass (1.0 ± 3.9 lbs) and percent body fat ($0.6\% \pm 2.1\%$) were observed with no differences between males and females. For the academic year, mean weight gain was 2.6 ± 5.3 lbs (3.4 ± 7.3 lbs for males; 2.1 ± 6.8 lbs for females) with no significant gender differences. Change in fat mass was significantly greater in males (3.7 ± 4.2 lbs) than females (2.3 ± 4.7 lbs) and change in percent body fat was also significantly greater in males ($1.9 \pm 1.9\%$) than females ($1.2 \pm 2.4\%$).

A significant increase in mean waist circumference (females 0.35 ± 1.84 and males 0.53 ± 1.47 inches) was observed over the academic year and a significant correlation ($r = 0.509$) was found between waist circumference change and weight change (Gropper and others 2009).

In summary, these studies clearly demonstrate that weight gain is a problem for most students during their freshman year of college, but not as much as the 15 lbs that is typically reported in the popular press. The observed weight gain appears to be greater the first (fall) semester versus the second (spring) semester of the freshman year. The average weight gain observed during the freshman year appears to be about 4 to 5 lbs, with weight gain in males averaging closer to 5 lbs and in females averaging closer to 4 lbs. Further, this weight gain is most often associated with greater than 1% gains in body fat suggesting students are adopting unhealthy diet and/or lifestyle habits as they transition to college and a more independent lifestyle. See Appendix A for a summary of the studies examining weight change in first year college students.

Weight and Body Composition Changes among College Students: Beyond the Freshman Year

Five studies have examined weight and/or BMI change in college students after the freshman year. Three of these studies focused on the first two years of college while a fourth study extended into the student's third (junior) year of college and a fifth study assessed students through to their senior year of college. The findings of these studies are presented hereafter. Only one of the five studies examined changes in body composition.

Racette and others (2005) examined 764 students (359 males, 405 females) from Washington University in St. Louis, Missouri to determine the changes in body weight, height, and BMI during the freshman and sophomore years. Participants were measured at the

beginning (fall semester) of the freshman year and the end (spring semester) of the sophomore year with 290 of the original 764 participants (38%) completing all measurements. About 70% (n=203) of participants gained weight (~ 4 lbs) and increased BMI. For those that gained weight an average increase of 4.1 ± 3.6 kg (9 lbs) was observed and BMI increased an average of 0.6 ± 1.8 kg/m² over the first two years of college (Racette and others 2005).

Lloyd-Richardson and coworkers (2009) followed 904 students (494 males, 410 females) from a public university in Indiana to determine weight change over the freshman and sophomore years. Body weight was measured at the beginning of the fall freshman semester (September 2002), the end of fall freshman semester (December 2002), the beginning of spring freshman semester (January 2003), the end of spring freshman semester (May 2003), and the end of spring sophomore semester (May 2004). Freshmen year mean weight change was significant with an average weight gain of 3.5 kg (7.7 lbs) for both males and females. About 54% participated at the first and last assessments and from the beginning of freshmen year to the end of sophomore year a significant weight gain was observed with males gaining 4.3 kg (9.46 lbs) and females gaining 4.2 kg (9.24 lbs) on average over the two-year period. From baseline, 63% (n=301) of the 492 participants at the end of spring sophomore semester (May 2004) gained weight with 46% (n=227) gaining 4 kg (8.8 lbs) or more weight (Lloyd-Richardson and others 2009).

A study by Hull and coworkers (2007) examined changes in body weight and composition in females during the sophomore year of college at the University of Oklahoma. Forty-eight females underwent height, weight, and body composition assessments during the first six weeks of the fall and during the last six weeks of spring semester during both the freshman and sophomore years. Weight gain averaged 2.64 lbs the freshmen year and was significantly

greater than the 0.44 lb weight gain observed for the sophomore year. Also, percent body fat and fat mass increased 0.7% and 1.76 lbs, respectively the freshman year and decreased 1% and 1.32 lbs, respectively the sophomore year. Between the beginning and end of the sophomore year, a significant decrease in percent body fat (-1%) and significant increase in fat free mass (1.54 lbs) were observed (Hull and others 2007).

Hovell and associates (1985) followed 43 university women attending a California university to determine weight change during the freshman, sophomore, and junior years of college. The women gained on average 0.69 lbs/month the freshman year and 0.18 lbs/month during the sophomore year, and lost 0.40 lbs/month during the junior year (Hovell and others 1985).

Racette and others (2008) followed the changes in weight and BMI from the beginning of the freshman year to the end of the senior year in 204 students (65 males, 139 females) at Washington University in St. Louis, Missouri. Significant increases in BMI and weight were observed over the four years. The average weight gain was 1.7 ± 4.5 kg (3.75 ± 9.92 lbs) in females and 4.2 ± 6.4 kg (9.26 ± 14.11 lbs) in males and the average increase in BMI was 0.5 ± 1.6 kg/m² in females and 1.1 ± 2.0 kg/m² in males (Racette and others 2008).

In summary, during the sophomore year of college, females appear to gain little weight. Based on the findings of just a few studies, this weight gain averages less than 1 lb in females and is significantly less than that gained during the freshman year. Shifts in body composition also occur during the sophomore year (as found in one study in only females). Specifically, the increases in percent body fat and fat mass that occurred during the freshman year in females decreased the sophomore year and were accompanied by increased fat free mass (Hull and others 2007). Studies examining the first two years of college report weight gains of 4 to 9 lbs in males

and females but do not separate the two years. Findings from a final study suggest that weight gain (about 4 lbs for females and 9 lbs for males) occurs between the freshman and the senior year of college but yearly changes are not reported. See Appendix B for a summary of the studies examining weight change beyond the freshman year.

Conclusions and Justification

Obesity is a national epidemic in the United States affecting all age, gender, racial, and ethnic groups. Obesity is particularly a major public health problem in the state of Alabama, which has the nation's *second* highest percentage of obese residents (26.2% of Alabamians are overweight and 27.1% are obese). Moreover, in the young adult age group, 18 to 24 years, 53.3% of Alabamians are either overweight or obese (CDC 2009a).

The college years and early years following college graduation appear to be critical time periods when weight gain is likely in young adults. Cross-sectional data from the Behavioral Risk Factor Surveillance System reported that the greatest magnitude of increase in the prevalence of obesity was among young adults 18 to 29 years of age (Mokdad and others 1999). Body weight and composition changes among college students during the freshman year have been well studied, especially the last 5 years. The results of these studies clearly demonstrate that the majority (typically 66% to 75%) of students gain weight and increase body fat their freshman year of college. The changes in body weight and fat appear to be especially high the first, that is fall, semester. But what happens after the freshman year?

Only a couple of studies to date have examined body weight and composition changes after the freshman year, and none of these studies has assessed changes in body shape. Of the five studies published to date, two studies only examined females and had sample sizes less than 50, another study included both males and females, but only reported total weight change over

the four year period (no body composition changes or yearly changes). The final two studies, while including both males and females, examined only weight and BMI, not body composition. Thus, missing from the literature is an examination changes in body weight, composition (especially percent body fat), and shape (especially waist circumference) both in males and females after the freshman year of college. Given the unhealthy weight and fat gains that occur during the freshman year of college and given the health consequences of true obesity as well as “normal weight obesity or being skinny fat”, assessments of college students during the sophomore or second year of college appear to be needed and of importance. The objective of the present study was to investigate changes in body weight, BMI, percent body fat, percent fat free mass, fat mass, fat free mass, and waist circumference of a group of male and female college students during the freshman and sophomore years of college.

Chapter 3

Body Weight and Composition Changes: Freshman and Sophomore Years

Abstract

Objective: Differences in weight, body mass index (BMI), percent and absolute body fat and fat free mass, and waist circumference were investigated in males and females during the freshman and sophomore college years. Methods: Changes in height, weight, BMI, body composition (using bioelectrical impedance), and waist circumference (via body scans) were assessed over the freshman and sophomore years among 240 college students.

Results: Weight (2.5 and 1.7 lbs) and BMI gains (0.3 and 0.3 kg/m²) did not significantly differ between the freshman and sophomore years, respectively. 69% of participants gained weight, which averaged 8.4 lbs. Significantly more percent body fat and fat mass were gained during the freshman (1.9% and 3.3 lbs, respectively) than the sophomore year (0.0% and 0.6 lbs, respectively). Females lost significantly more fat free mass during the freshman (-0.8 lbs) than the sophomore year (1.0 lbs). Changes in waist circumference and weight were significantly correlated. Increases the percentages of participants classified as overweight and with unhealthy body fat amounts and waist circumferences were observed.

Conclusions: The freshman year is associated with weight gain and unhealthy body composition changes, and, while the sophomore year also is characterized by weight gain, overall healthier body composition changes were observed.

Introduction

The rise in the prevalence of overweight and obesity the last few decades has led to a national epidemic. The World Health Organization estimates that 1 billion adults in the world are overweight, with 300 million of those adults considered obese (WHO 2006). The prevalence of obesity in adults (20 to 74 years of age) has more than doubled from 15.0% to 32.9% since the mid 70's and for adolescents/young adults (12 to 19 years of age) the prevalence of obesity has increased the most from 5.0% to 17.6% (CDC 2009a). The problem of overweight and obesity is of particular importance in Alabama since it is ranked the second most obese state in the nation with over 32% of residents classified as obese (CDC 2009a). Over 50% of young adults (18 to 24 years) in Alabama are considered overweight or obese indicating that this is a population group at risk (CDC 2009a).

The rise in overweight and obesity is of particular importance because of the consequences on Americans' health and the American economy. An increased risk of mortality and morbidity is associated with obesity including such problems as cardiovascular disease, stroke, type 2 diabetes, arthritis, reproductive complications, and some cancers (CDC 2009b, U.S. Surgeon General 2010). Also, the impaired mobility and decreased physical endurance caused by obesity and overweight may affect the quality of life a person lives (U.S. Surgeon General 2010). According to the World Health Organization, the economic cost in terms of medical expenses of overweight and obesity has been estimated at 78.5 billion dollars (WHO 2006).

Many studies over the past eight years have been published on weight and body composition changes among young adults during the freshman year of college (Anderson and others 2003, Butler and others 2004, Economos and others 2008, Edmonds and others 2008,

Graham and Jones 2002, Gropper and others 2009, Hajhosseini and others 2006, Hodge and others 1993, Hoffman and others 2006, Holm-Denoma and others 2008, Hovell and others 1985, Jung and others 2008, Kasparek and others 2008, Levitsky and others 2004, Lloyd-Richardson and others 2008, Lowe and others 2006, Mifsud and others 2009, Morrow and others 2006, Provencher and others 2009, Pullman and others 2009, Wengreen and Moncur 2009). These studies have established that freshmen typically gain more weight during the first semester of their freshman year than the second semester, and the weight gain observed averages 4-5 lbs and not the commonly publicized 15 lbs. Moreover, body fat tends to increase on average greater than 1% during the freshman year indicating unhealthy changes in body composition during this time period. Only a few studies have examined weight and body composition changes beyond the freshman year of college (Hovell and others 1985, Hull and others 2007, Lloyd-Richardson and others 2009, Racette and others 2005, Racette and others 2008). These studies have determined that weight continues to increase throughout college but at a much slower rate than that seen during the freshman year. Shifts in body composition also occur during the sophomore year in females. Specifically, the increases in percent body fat and fat mass that occurred during the freshman year in females decreased the sophomore year and were accompanied by increased fat free mass (Hull and others 2007). Yet, missing from the literature is an examination of changes in body weight, composition, and shape both in males and females after the freshman year of college. The purpose of the present study was to examine changes in body weight, body mass index, percent body fat, fat mass, fat free mass, and waist circumference in a group of male and female college students during their freshman and sophomore years of college.

Subjects, Study Design, and Methods

Subjects

Freshmen were recruited from Auburn University's incoming freshman class via email, fliers, and class announcements in introductory level courses typically taken by first year students at the beginning of fall semester 2007. Auburn University's 2007 incoming freshman class consisted of 4,191 students. The freshman class was 53% female and 47% male. The freshman class was mostly Caucasian (81.7%), followed by African American (11.3%), Hispanic (2.9%), Asian (1.9%), and Native American (0.8%) (Auburn University Office of Institutional Research and Assessment 2007). Most Auburn University freshmen had permanent residences in Alabama (57%), but about 43% had permanent residences elsewhere. Students from several states attend Auburn University including: 18.3% of students came from Georgia, 6.1% from Florida, 3.8% from Tennessee, and 2.7% of students were from Texas; the rest of the freshmen came from other states across the U.S. (Auburn University Office of Institutional Research and Assessment 2007).

Freshman volunteers were excluded from participation if they were under 17 years or older than 19 years of age, pregnant, married, had children, reported a diagnosed eating disorder, or enrolled at the university during the summer semester prior to fall semester freshman year. An informed consent from participants and from parents for subjects under 19 years was obtained prior to participation in the study. Participants received \$25 compensation at the first and third visits and \$20 at the second visit upon completion of requirements during the freshman year, and received \$30 at the first and third visits and \$25 at the second visit upon completion of requirements during the sophomore year. At the end of sophomore year, beginning of junior

year, participants received \$30 for their visit and completion of requirements.

Study Design and Methods

Participants were assessed during their freshman year: at the beginning (about the first four weeks) of fall semester (2007), at the end (about the last three weeks) of fall semester (2007), and at the end of spring semester (2008), and during their sophomore year: at the beginning (about the first four weeks) of fall semester (2008), at the end (about the last three weeks) of fall semester (2008), at the end of spring semester (2009), and at the end of the summer term (2009). Subjects' appointments for assessments were scheduled in advance.

A demographic questionnaire was used to obtain self-reported information from participants regarding sex, race/ethnicity, birth date, state of permanent residence, and residence location at college (e.g. on campus residence hall/dorm, off campus apartment, trailer, duplex, house, fraternity/sorority house, or at home with parents). This study was part of a larger four-year longitudinal study, which included additional questionnaires regarding environmental, behavioral, and lifestyle habits as well as body image and satisfaction, eating behavior regulation, stress, and depression.

Body weight and height were measured with a digital scale and an attached height rod (Healthometer, Pelstar, LLC, Model 500KL, Bridgeview, IL). Weight was measured to the nearest 0.2 lbs, and height was measured to the nearest one-quarter inch. Participants removed shoes, hats, belts, and outer garments, and emptied pockets before all measurements. Body mass index (BMI) was calculated for each participant by the standard formula, dividing weight by height squared (kg/m^2); BMI calculations were done with each assessment to account for changes in weight and, for some individuals, in height. Participants were classified based on BMI as underweight, normal weight, overweight, or obese using Centers for Disease Control and

Prevention (CDC) definitions (CDC 2009b). The adult BMI criteria for classification, according to the definition of CDC, instead of the BMI-for-age growth curves that end at age 20 years, were used since the college students are being followed longitudinally (CDC 2009b).

Body composition was measured using bioelectrical impedance analysis (BodyStat, BioVant Systems, Detroit, MI). Measurements using BodyStat varied by less than 0.5% with repeated measurements on the same subject. Since hydration status affects accuracy, subjects were instructed not to eat for 2-4 hours prior to assessment, not to drink caffeine or alcohol and not to engage in strenuous exercise for 12 hours prior to assessment (NIH 1996). To make it easier for subjects to meet these criteria, data were collected between 8 am and 11 am. Subjects' weight and body composition were measured at all assessments; height was measured at the beginning of the year assessments for all three years and end of the year assessments for the first two years.

Body shape was assessed using the NX16 three-dimensional body scanner ([TC]², Cary, NC). The scanner captures silhouette images and multiple body measurements of standing, stationary subjects. Using white light technology, the scanner obtains body measurements with a point accuracy of < 1 mm and a circumference accuracy of < 3 mm ([TC]² 2009). Subjects wear close-fitting scanwear to help maintain measurement accuracy. The body scanner software allows for the generation of body measurements at specific body sites to examine whole body silhouettes in a 360 degree space, and to retrieve planer slices of bodies at designated locations to evaluate the body shape and circumference measurements. Body shape was assessed at the beginning and end of each year. Only waist measurement data are reported in this study.

Approval

This study was approved by the Institutional Review Board for the Use of Human Subject

in Research at Auburn University (Appendix C).

Statistical Analyses

Statistical analyses were performed using InStat 3.0 (GraphPad Software, San Diego, CA), and SPSS Statistics 17.0 (SPSS Inc., Chicago, IL). Differences in ethnicity/race between the university freshman population and the study population were examined using the chi-square test. Repeated measures analysis of variance (ANOVA) was used to examine differences in body weight, BMI, percent body fat, percent fat free mass, fat mass, and fat free mass of the male and female participants among semesters/terms during the freshman and sophomore years. Statistically significant findings using ANOVA were followed by Tukey's multiple comparison tests. Paired t-tests were used to compare differences in body weight, BMI, percent body fat, percent fat free mass, fat mass, fat free mass, and waist circumference among the male and among the female participants for the freshman year versus the sophomore year, and rate of weight change for the freshman year versus the sophomore year. A student's t-test was used to compare the BMI of those who returned versus those who did not return for re-assessments. A Pearson's correlation was used to examine the relationship between weight change and waist circumference change over the freshman and sophomore years. A p value of < 0.05 was considered statistically significant. Data are reported as mean \pm standard deviation, unless noted differently.

Results

A total of 240 students, 155 females (65%) and 85 males (35%) volunteered for the study. This represents a convenience sample. Table 3.1 shows selected demographic and anthropometric information for this initial sample population. As noted in table 3.1, most students were Caucasian, from the state of Alabama, and lived on campus. Initial BMI of the

participants was $22.8 \pm 4.3 \text{ kg/m}^2$, range 15.2 to 50.7 kg/m^2 , with 12 subjects (5%) classified as underweight (10 females, 2 males); 181 subjects (75%) classified as normal weight (122 females, 59 males); 37 subjects (15%) classified as overweight (15 females, 22 males), and 10 subjects (4%) classified as obese (8 females, 2 males). Thirteen females and one male had $> 30\%$ body fat and $> 20\%$ body fat, respectively; each of these 14 participants was overweight or obese. Seven females and one male had a waist circumference greater than 35 inches and 40 inches, respectively.

Of the 240 initial volunteers, 120 participants (81 or 52% of the females and 39 or 46% of the males) returned for all assessments: 150 participants, 63%, (99 females and 51 males) returned for the end of summer sophomore year assessment. Twenty-four (10%) participants (7 males, 17 females) of the initial 240 were found to be no longer enrolled at the university and three females (1.2%) were not invited back to participate because of reported eating disorders.

The 150 participants seen at the beginning of fall freshman year and the end of the sophomore year had similar demographics as the initial sample population, that is 80.6% Caucasian, 14% African American, 1.3% Hispanic, 2% Asian, and 2% other. Over half ($n=101$) the participants held permanent residence in Alabama and the remainder of participants resided from Georgia (12%), Tennessee (5.3%), and Texas (3.3%). In addition, the BMI of those who returned ($23.0 \pm 4.7 \text{ kg/m}^2$) did not significantly differ from the BMI of non-returners ($22.5 \pm 3.5 \text{ kg/m}^2$). For the 150 participants, 26% lived on campus sophomore year, 65% lived off campus, 2% lived at home, 2% lived in a fraternity house, and 5% unknown.

Overall changes in body weight, BMI, percent body fat, percent fat free mass, fat free mass, fat mass, and waist circumference between the freshman year (beginning of fall semester to the end of summer term) versus the sophomore year (beginning of fall semester to the end of

summer term) for 46 male and 94 female participants are shown in Table 3.2. No significant differences were found between the two years for changes in body weight, BMI, or waist circumference; however, both females and males gained significantly more percent body fat and fat mass and lost significantly more percent fat free mass during the freshman year than the sophomore year. The females also lost significantly more fat free mass during the freshman year than the sophomore year. Fat free mass change among the males approached significance ($p=0.092$) with a loss occurring the freshman year and a gain occurring the sophomore year.

Changes in body weight, BMI, percent body fat, percent fat free mass, fat mass, and fat free mass for freshman year fall semester, freshman year spring semester, freshman year summer term, sophomore year fall semester, sophomore year spring semester, and sophomore year summer term for male ($n=39$) and female ($n=81$) participants are shown in Table 3.3. Significant differences were found among the females for changes in BMI, percent body fat, percent fat free mass, and fat mass between fall semester freshman year and spring semester sophomore year with the first semester freshman year characterized by significant loss of fat free mass and significantly greater increases in BMI, percent body fat and fat mass than for the spring semester sophomore year. In addition, for the females, change in body weight approached a significant difference ($p=0.057$) with greater gains the first semester than subsequent semesters. For the males, first semester freshman year was characterized by significantly greater increases in body weight and BMI than freshman year summer term. In addition, both percent body fat and percent fat free mass were significantly different between the fall semester freshman year and the spring semester sophomore year with greater gains in percent body fat and losses in percent fat free mass occurring initially versus spring semester sophomore year.

Most participants (37%) gained weight both years; 25% lost weight the freshman year

and gained weight the sophomore year and 24% of participants gained weight the freshman year and lost weight the sophomore year. Only 10% of participants lost weight both years. The rate of weight gain for the freshman and sophomore years was 0.21 ± 0.71 lbs/month and 0.14 ± 0.55 lbs/month, respectively and did not significantly differ.

Over the first two years of college, weight change for the 150 participants who were present for assessments at the beginning of the freshman year and the end of the sophomore year averaged a gain of 4.2 ± 9.3 lbs, range -23.6 to 40.2 lbs, and BMI increased 0.6 ± 1.5 kg/m². Females gained 3.6 ± 9.5 lbs and 0.5 ± 1.5 kg/m² and males gained 5.1 ± 8.8 lbs and 0.7 ± 1.3 kg/m² from the beginning of college to the end of the sophomore year (Table 3.2). Changes in body composition over the two year period also are shown in Table 3.2. About 69% (n=104) of this group gained weight; 19 participants (13%) gained ≥ 15 lbs, 11 participants (7%) gained ≥ 10 and < 15 lbs, and 35 participants (23%) gained between ≥ 5 and < 10 lbs. Weight gain of the 104 participants in this weight gain group was 8.4 ± 7.3 lbs. Percent body fat, fat mass, and fat free mass gains in the weight gain group were $2.8 \pm 2.9\%$, 6.1 ± 6.3 lbs, and 2.2 ± 3.6 lbs respectively. Waist circumference gain in this group was 0.74 ± 1.62 inches. About 31% (n=46) of participants lost weight with 10 students (7%) losing ≥ 10 lbs. Weight loss of the 31% of participants in this weight loss group was -5.5 ± 5.2 lbs.

Table 3.4 shows the change in percentages of participants classified as underweight, normal weight, overweight, and obese from the beginning to the end of the study period. Especially noteworthy is the increase in percent of participants classified as overweight by the end of the study period. Regarding overall percent body fat at the end of the study period, 17 females had $> 30\%$ body fat (one was classified as normal weight and the others were overweight or obese), and three males had $> 20\%$ body fat (one was overweight and the other

two were obese). At the end of the sophomore year, eleven females had a waist circumference > 35 inches, and one male had a waist circumference > 40 inches. Change in waist circumference and change in weight were significantly ($p < 0.0001$) correlated in the freshman ($r=0.6220$) and sophomore years ($r=0.7184$).

Discussion

This study examined changes in body weight, composition, and waist circumference in a group of male and female students during the freshman and sophomore years of college. The findings of this study are important, as few studies to date have investigated such changes beyond the freshman year in both males and females. Given the health consequences of obesity, the identification of critical periods of increased health risks are needed to allow for the development of health promotion and intervention strategies for at risk populations.

The results of this present study demonstrated that the freshman year (especially the first semester) is a critical time period for unhealthy changes in body weight and composition for college students. The largest gains in weight and BMI tended to occur the first semester freshman year and significantly greater gains in percent body fat and fat mass were found for the freshman year versus the sophomore year in both males and females. Hull and associates (2007) also found in a group of 48 females that gains in weight, percent body fat, and fat mass were significantly greater the freshman year than sophomore year.

Weight gain appears to be a problem for most college students not just during the freshman year but also during sophomore year. Over two-thirds (69%) of the participants in this study gained weight, and most gained weight both the freshman and sophomore year. This finding is similar to the 70% reported by Racette and others (2005) for a group of students attending a private university in Missouri but less than the 77% reported by Lloyd-Richardson

and others (2009) for a group of students attending a public university in Indiana.

In the present study, weight gain over the first two years (beginning of fall freshman year to end of summer sophomore year) averaged 4.2 lbs, with females gaining 3.6 lbs and males gaining 5.1 lbs. When only those who gained weight were considered, weight gain averaged 8.4 lbs. These findings are fairly consistent with those of Racette and coworkers (2005) who documented both a 4 lb weight gain between beginning of fall semester freshman year and end of spring semester sophomore year in a group of 290 students and a 9 lb gain among those who were classified as weight gainers. Lloyd-Richardson and coworkers (2009) reported higher gains of 9.2 lb and 9.5 lb for females and males, respectively from the beginning of the freshman year to the end of the sophomore year in a group of 492 students.

Over one-third of participants gained weight both the freshman and sophomore years of college. The rate of weight gain the freshman year was 0.21 lbs/month while that observed during the sophomore year was 0.14 lbs/month. Although, higher than the present findings, Hovell and others (1985) also reported a decrease in the rate of weight gain from 0.69 lbs/month in the freshman year to 0.18 lbs/month in the sophomore year.

BMI in the present study increased 0.6 kg/m^2 over the study period and was similar to the increase reported by Racette and others (2005) in a group of male and female students during the first two years of college. Moreover, in the present study between the start of college and the end of the sophomore year, fewer students were classified as normal weight (75% versus 67%, respectively), and more were classified as overweight (15% versus 23%, respectively) and obese (4% versus 5% respectively). This rise in the number of students classified as overweight and obese is consistent with the findings of Lloyd-Richardson and colleagues (2009); these researchers found the number of students who were overweight rose from 16% initially to 25.9%

overweight by end of sophomore year, and from 4.3% obese initially to 9.2% obese by the end of the sophomore year.

Yet, while BMI provides a good indicator of body fatness and risk for morbidity, health problems are associated with being “skinny fat” (that is having a normal BMI but a high/unhealthy percent body fat). In the present study, gains in weight and BMI were accompanied by unhealthy changes in body composition, especially the freshman year. Although the sophomore year was characterized by greater gains in fat free mass and lesser gains in fat, similar to the findings of Hull and coworkers (2007) in a group of sophomore female college students, small gains were none the less observed. More specifically, while not always statistically significantly different from semester to semester, percent body fat increased during the first four semesters of college for both males and females and absolute fat mass increased most semesters. Romero-Corral and coworkers (2008) in a cross-sectional study of 13,601 adults, aged 20 to 79.9 years, found that 43.9% of males and 52.3% of females who were considered to have a normal body weight based on body mass index exhibited high (unhealthy) body fat percentages (> 20% for males and > 30% for females) and metabolic disturbances. Using these same body fat percentages, the results of the present study are of concern. Initially, only one male and 13 females had unhealthy body fat percentages, yet by the end of the sophomore year, three males (one overweight and two obese) had > 20% body fat and 17 females had > 30% body fat with one being normal weight, 11 overweight and 5 obese. Further, changes in weight were significantly correlated with changes in waist circumference. Weight circumference is thought to be one of the best indicators of obesity-related health risks (Janssen and others 2004).

Limitations

The results of this study must be interpreted with caution since this study has limitations.

Participants of this study attended a public university, thus the results presented may not be appropriate for individuals who attend private universities or do not attend a university. Also, this study did not have a comparison group of young adults not seeking higher education, although a study by Georgiou and others (1997) found that young adult (18 to 24 years old) nonstudents were more often overweight than students. Self-selection bias is another limitation to this study if those individuals not returning after the initial visit did so because they were not comfortable or secure enough to be measured again.

Conclusions

The freshman year of college is associated with weight gain and unhealthy changes in body composition, and while the sophomore year also is characterized by weight gain, healthier changes in body composition were observed. It is likely these small yearly gains in weight and fat mass that, if continued throughout the college years, may be contributing to the high prevalence of obesity in the young adult population. Further studies are needed both to examine whether these changes continue into the junior and senior years of college and to identify dietary and lifestyle factors contributing to the unhealthy gains in body weight and fat in order to develop health promotion strategies for this population. In addition, studies examining seasonal influences on weight change are needed as are studies examining whether participant's knowledge of the study's purpose is affecting study findings.

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Table 3.1: Selected demographic and anthropometric characteristics of the initial sample population

	Beginning of Fall 2007 (n=240)
Gender ⁺	
Male	85 (35%)
Female	155 (65%)
Age (years)	
Male	18.2 ± 0.4
Female	18.1 ± 0.4
Height (inches)	
Male	70.0 ± 2.6
Female	64.7 ± 2.3
Weight (pounds)	
Male	163.5 ± 28.4
Female	133.5 ± 28.9
Body Mass Index (kg/m ²)	
Male	23.5 ± 3.9
Female	22.4 ± 4.4
Race ⁺	
Caucasian	196 (81.7%)
African American	29 (12.1%)
Hispanic	7 (2.9%)
Asian	4 (1.7%)
Other	4 (1.7%)
Permanent Residence ⁺	
Alabama	149 (62.1%)
Georgia	37 (15.4%)
Tennessee	11 (4.6%)
Texas	9 (3.8%)
North Carolina	7 (2.9%)
Florida	4 (1.7%)
Louisiana	2 (0.4%)
Arizona	2 (0.4%)
Maryland	2 (0.4%)
Illinois	2 (0.4%)
Mississippi	2 (0.4%)
Ohio	2 (0.4%)
Virginia	2 (0.4%)
Others (1 each)	9 (3.8%)
22 different states	
School Residence ⁺	
Campus dorm	147 (61.3%)
Off campus apartment, house, duplex, or trailer	90 (37.5%)
With parents	2 (1.2%)

⁺Data are presented as n (%) except for age, height, weight, and body mass index which are expressed as mean ± standard deviation

Table 3.2: Changes in body weight, body mass index (BMI), percent body fat, percent fat free mass, fat free mass, fat mass, and waist circumference of females and males over the freshman and sophomore years of college

	Freshman Year Changes	Sophomore Year Changes	Two Year Changes (Overall)
Weight (lbs)			
All	2.5 ± 8.7	1.7 ± 6.7	4.2 ± 9.3
Females	2.3 ± 8.1	1.4 ± 7.1	3.6 ± 9.5
Males	2.8 ± 9.9	2.4 ± 5.7	5.1 ± 8.8
BMI (kg/m²)			
All	0.3 ± 1.4	0.3 ± 1.1	0.6 ± 1.5
Females	0.3 ± 1.3	0.2 ± 1.2	0.5 ± 1.5
Males	0.3 ± 1.4	0.3 ± 0.8	0.7 ± 1.3
% Body Fat			
All	1.9 ± 3.0*	0.0 ± 2.4*	1.9 ± 3.1
Females	1.8 ± 3.2*	-0.1 ± 2.6*	1.7 ± 3.3
Males	2.2 ± 2.7*	0.3 ± 2.0*	2.3 ± 2.7
% FFM			
All	-1.9 ± 3.0*	0.0 ± 2.4*	-1.9 ± 3.1
Females	-1.8 ± 3.2*	0.1 ± 2.6*	-1.7 ± 3.3
Males	-2.2 ± 2.7*	-0.3 ± 2.0*	-2.3 ± 2.7
FFM (lbs)			
All	-0.9 ± 5.0*	1.2 ± 3.9*	0.3 ± 5.1
Females	-0.8 ± 4.5*	1.0 ± 3.5*	0.1 ± 4.9
Males	-0.9 ± 6.1	1.5 ± 4.7	0.7 ± 5.5
Fat Mass (lbs)			
All	3.3 ± 6.2*	0.6 ± 4.9*	3.9 ± 6.9
Females	3.1 ± 6.1*	0.4 ± 5.2*	3.5 ± 6.9
Males	3.8 ± 6.7*	1.8 ± 4.2*	5.3 ± 6.2
Waist (inches)			
All	0.02 ± 1.54	0.33 ± 1.26	0.35 ± 1.59
Females	-0.21 ± 1.67	0.29 ± 1.36	0.08 ± 1.71
Males	0.50 ± 1.23	0.43 ± 1.05	0.93 ± 1.12

*Values in rows are statistically significantly different $p < 0.05$

Table 3.3: Changes in body weight, body mass index (BMI), percent body fat, percent fat free mass (FFM), fat mass, and fat free mass of females and males during each semester of the freshman and sophomore years of college

	p value	Freshman Year			Sophomore Year		
		Fall	Spring	Summer	Fall	Spring	Summer
Weight (lbs)							
Females	0.057	1.9 ± 4.0	0.2 ± 5.7	0.1 ± 4.0	0.3 ± 4.6	0.0 ± 4.1	0.8 ± 4.4
Males	0.045	3.1 ± 4.5*	1.1 ± 5.6	-1.2 ± 8.2*	0.9 ± 5.6	1.6 ± 5.3	-0.7 ± 6.2
BMI (kg/m²)							
Females	0.025	0.3 ± 0.6*	0.0 ± 1.0	0.0 ± 0.7	0.0 ± 0.8	0.0 ± 0.7*	0.1 ± 0.7
Males	0.030	0.4 ± 0.6*	0.1 ± 0.8	-0.2 ± 1.2*	0.1 ± 0.8	0.2 ± 0.8	-0.1 ± 0.9
% Body Fat							
Females	0.018	0.7 ± 1.7*	0.5 ± 2.6	0.4 ± 2.3	0.2 ± 1.7	-0.4 ± 1.9*	0.1 ± 1.8
Males	0.046	1.3 ± 1.7*	0.8 ± 1.6	0.3 ± 2.4	0.3 ± 2.3	-0.1 ± 1.8*	-0.1 ± 2.2
% FFM							
Females	0.018	-0.7 ± 1.7*	-0.5 ± 2.6	-0.4 ± 2.3	-0.2 ± 1.7	0.4 ± 1.9*	-0.1 ± 1.8
Males	0.046	-1.3 ± 1.7*	-0.8 ± 1.6	-0.3 ± 2.4	-0.3 ± 2.3	0.1 ± 1.8*	0.1 ± 2.2
Fat Mass (lbs)							
Females	0.012	1.4 ± 2.9*	0.9 ± 4.7	0.5 ± 3.4	0.4 ± 3.2	-0.7 ± 3.3*	0.4 ± 3.2
Males	0.094	2.8 ± 3.7	1.6 ± 3.2	-0.3 ± 7.5	0.6 ± 4.8	0.1 ± 3.7	-0.1 ± 5.5
FFM (lbs)							
Females	0.124	0.4 ± 3.8	-0.7 ± 3.5	-0.5 ± 3.1	0.0 ± 3.1	0.5 ± 2.8	0.3 ± 3.2
Males	0.174	0.4 ± 4.7	-0.1 ± 4.5	-1.2 ± 4.2	0.4 ± 4.3	1.6 ± 4.1	-0.6 ± 4.1

*Values in rows are statistically significantly different (p<0.05)

Table 3.4: Percent of participants' underweight, normal weight, overweight, and obese from the beginning of freshman year to the end of sophomore year

	Beginning Freshman Year (n=240)	End Sophomore Year (n=150)
Underweight	5%	6%
Normal Weight	75%	67%
Overweight	15%	23%
Obese	4%	5%

Chapter 4

Summary

Weight, Body Mass Index, and Body Shape Findings

Weight gain averaged 2.5 ± 8.7 lbs and 1.7 ± 6.7 lbs in the freshman and sophomore years, respectively. Body mass index (BMI) gains averaged 0.3 ± 1.4 kg/m² and 0.3 ± 1.1 kg/m² in the freshman and sophomore years, respectively, of college. Over the first two years of college, a 4.2 ± 9.3 lb weight gain and a 0.6 ± 1.5 kg/m² BMI gain were observed. Females gained 3.6 ± 9.5 lbs and 0.5 ± 1.5 kg/m², and males gained 5.1 ± 8.8 lbs and 0.7 ± 1.3 kg/m². About 69% of participants gained weight; weight gain in this group was 8.4 ± 7.3 lbs.

Weight and BMI gains in males were significantly greater fall semester freshman year than summer semester freshman year. BMI gains in females were significantly greater fall semester freshman year than spring semester sophomore year. Change in weight and change in waist circumference were significantly correlated in both the freshman ($r=0.6220$) and sophomore ($r=0.7184$) years.

Body Composition Findings

Percent body fat gain averaged $1.9 \pm 3.1\%$ over the two year period ($1.9 \pm 3.0\%$ freshman year and $0.0 \pm 2.4\%$ sophomore year). Fat mass gain was 3.9 ± 6.9 lbs (3.3 ± 6.2 lb freshman year and 0.6 ± 4.9 lbs sophomore year). Fat free mass averaged 0.3 ± 5.1 lbs for the two years (-0.9 ± 5.0 lbs freshman year and 1.2 ± 3.9 lbs sophomore year). Percent body fat and fat mass gains were significantly greater for the freshman year versus the sophomore year, and percent fat free mass losses were significantly greater the freshman year versus the sophomore year. Fat

mass losses were significantly greater the freshman year than the sophomore year in females, and approached significance in males.

Percent body fat gains and percent fat free mass losses were significantly greater fall semester freshman year in both males and females than spring semester sophomore year. Fat mass gains in females were significantly greater fall semester freshman year than spring semester sophomore year.

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Appendix A

Summary of studies examining body weight and composition in first year college students

Author	Subjects (initial n)	Significant Weight Change Findings	Other Findings	Significant Body Composition Findings		
				% Body Fat	Fat Mass	Fat-Free Mass
Hovell and others 1985	158 females	0.73 lb gain/mo	projected 8.8 lb gain/yr			
Hodge and others 1993	61 females	7 lb gain over 6 mo wt gain group				
Lowe and others 2006	69 females	2 lb gain Sept to Oct 4.2 lb gain Sept to Jan 4.6 lb gain Sept to May				
Economos and others 2008	140 males 256 females	5.3 lb gain acad year				
Holm-Denoma and others 2008	265 males 341 females	3.5 lb gain over 9 mo 4.0 lb gain over 9 mo				
Kasperek and others 2008	24 males 169 females	2.5 lb gain acad year				
Provencher and others 2009	519 males 807 females	3.52 lb gain acad year 3.08 lb gain acad year				
Lloyd-Richardson and others 2008	117 males 209 females	7.04 lb gain acad year 3.52 lb gain acad year				
Wengreen and Moncur 2009	57 males 102 females	3.3 lb gain fall semester	0.3 kg/m ² increase BMI 0.6 kg/m ² increase BMI			
Graham and Jones 2002	10 males 39 females	1.5 lb loss acad year	4.1 lb gain perceived			
Anderson and others 2003	58 males 77 females	2.9 lb gain fall semester 3.7 lb gain acad year				

Summary of studies examining body weight and composition in first year college students						
Author	Subjects (initial n)	Significant Weight Change Findings	Other Findings	Significant Body Composition Findings		
				% Body Fat	Fat Mass	Fat-Free Mass
Levitsky and others 2004	9 males 51 females	4.18 lb gain fall semester	0.7 kg/m ² increase BMI			
Butler and others 2004	54 females	1.59 lb gain fall semester		1.8% increase	2.85 lb increase	1.35 lb decrease
Morrow and others 2006	137 females	2.42 lb gain acad yr		0.8% increase	1.76 lb increase	0.66 lb increase
Edmonds and others 2008	116 females	5.28 lb gain acad yr	2.5 cm increase waist circumference	1.8% increase		
Pullman and others 2009	108 males	6.6 lb gain acad yr	3.0 cm increase waist circumference	0.8% increase		
Mifsud and others 2009	13 males 16 females	4.18 lb gain acad yr 0.33 lb loss acad yr	2.7 cm increase waist circumference	3.1% increase 0.3% increase		
Hoffman and others 2006	32 males 35 females	2.9 lb gain acad yr 2.82 lb gain acad yr		1.2% increase 0.2% increase	2.38 lb increase 0.95 lb increase	0.22 lb increase 1.87 lb increase
Hajhosseini and others 2006	5 males 22 females	3.0 lb gain fall semester		2.1% increase		2.1% decrease
Gropper and others 2009	73 males 132 females	3.4 lb gain acad yr 2.1 lb gain acad yr		1.4% increase	2.8 lb increase	

Abbreviations: lbs=pounds, acad=academic, yr=year, mo=months

Appendix B

Summary of studies examining body weight and composition in second year college students

Author	Subjects (initial n)	Significant Weight Change Findings	Other Findings
Racette and others 2005	359 males 405 females	9.00 lb increase from beg Fr to end So yr	0.6 kg/m ² increase BMI
Lloyd-Richardson and others 2009	494 males 410 females	9.46 lb increase Fr & So 9.24 lb increase Fr & So	
Hovell and others 1985	117 females	1.0 lb increase So yr	
Hull and others 2007	48 females	0.44 lb increase So yr	1% decrease % body fat; 1.5 lb increase fat free mass
Racette and others 2008	64 males 139 females	9.26 ± 14.11 lb increase 3.75 ± 9.92 lb increase	1.1 ± 2.0 kg/m ² increase BMI (males); 0.5 ± 1.6 kg/m ² increase BMI (females)

Abbreviations: lb = pounds, So = Sophomore, Fr = Freshman, yr = year, beg = beginning

Appendix C

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July 10, 2009

MEMORANDUM TO: Dr. Sareen Gropper & Dr. Lenda Connell
Nutrition & Food Science

PROTOCOL TITLE: "Longitudinal Collegiate Study of Body Composition/Size and Related
Environmental, Behavioral and Psychological Factors"

IRB AUTHORIZATION NO.: 07-153 EP 0707

ORIGINAL APPROVAL DATE: July 9, 2007
RENEWAL DATE: July 2, 2009
EXPIRATION DATE: July 8, 2010

The renewal for the above referenced protocol was approved as Expedited by IRB procedure under 45 CFR 46.110 (Category #6 & #7):

"Collection of data from voice, video, digital, or image recordings made for research purposes.

Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies."

You should report to the IRB any proposed changes in the protocol or procedures and any unanticipated problems involving risk to subjects or others. Please reference the above authorization number in any future correspondence regarding this project.

If you will be unable to file a Final Report on your project before July 8, 2010, you must submit a request for an extension of approval to the IRB no later than June 22, 2010. If your IRB authorization expires and/or you have not received written notice that a request for an extension has been approved prior to July 8, 2010, you must suspend the project immediately and contact the Office of Human Subjects Research for assistance.

A Final Report will be required to close your IRB project file. Please note that the approval, stamped version of your informed consent should be provided to participants during the consent process. You are reminded that you must keep signed consents for three years after your study is completed.

If you have any questions concerning this Board action, please contact the Office of Human Subjects Research at 844-5966.

Sincerely,

Kathy Jo Ellison, RN, DSN, CIP
Chair of the Institutional Review Board
for the Use of Human Subjects in Research

cc: Dr. Doug White