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Changes in body weight, RMR, and body composition in college freshman students

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CHANGES IN BODY WEIGHT, RMR, AND BODY COMPOSITION IN COLLEGE
FRESHMEN STUDENTS

A Thesis

Presented to

The Faculty of the Department of Nutrition and Food Science

San Jose State University

In Partial Fulfillment

Of the Requirements for the Degree

Masters of Science

By

Danielle Lauren Cook

May 2006

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ABSTRACT

CHANGES IN BODY WEIGHT, RMR, AND BODY COMPOSITION IN COLLEGE

FRESHMEN STUDENTS

by Danielle L. Cook

The purpose of the present thesis was to investigate changes that occurred in body weight, body composition and RMR, the influence of lifestyle, and whether or not weight gain is long-lasting or transient in college freshmen. In addition, four commonly used methods of estimating RMR were compared.

The present study demonstrates that a significant amount of weight is gained upon entering the first year of college. Overall, weight gain appeared to be variable and transient in nature. The data in this study demonstrates that weight gain in some individuals can be substantial; however, a small amount of exercise may be protective against initial weight gain in this population.

Measurements of RMR by BIA and O_2 , as well as calculated estimates of RMR by metabolic body size, Harris-Benedict, and Mifflin/St.Jeor equations were compared. Results from the present study indicate that all five methods provide reasonably similar estimates.

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PREFACE

Journal article one contained in Chapter 2 was prepared according to the publication guidelines for *The Journal of the American Dietetic Association*. Journal article two contained in Chapter 2 was prepared according to the publication guidelines of *The New England Journal of Medicine*. The remainder of the thesis is written according to the *Publication Manual of the American Psychological Association* (6th edition, 2002).

Table of Contents	Page
List of Tables.	x
List of Figures.....	xi
CHAPTER 1 Introduction and Review of Literature	1
Introduction.....	2
Review of Literature.....	3
Overweight and Obesity.....	3
Characteristics of Weight Gain.....	5
Energy Balance.....	7
Weight Gain in College Freshmen.....	13
Lifestyle Practices of Freshmen Students.....	14
Previous Studies Showing Freshman Weight Gain.....	15
Summary and Conclusions.....	16
CHAPTER 2 Journal Articles.....	18
Journal Article 1.....	19
Author's Title Page.....	20
Abstract.....	21
Introduction.....	23
Methods and Procedures.....	24
Results.....	27
Discussion.....	27

Acknowledgements.....	30
References.....	31
Journal Article 2.....	41
Author's Title Page.....	42
Abstract.....	43
Introduction.....	45
Methods and Procedures.....	46
Results.....	50
Discussion.....	54
Conclusions.....	57
Acknowledgements.....	59
References.....	60
CHAPTER 3 Summary and Recommendations.....	72
Summary and Recommendations.....	73
References.....	75
Appendixes.....	81
Appendix A IRB Approval.....	82
Appendix B Consent Form.....	83
Appendix C Exercise Surveys.....	85

List of Tables

<u>Tables</u>	<u>Page</u>
Journal Article 1	
1. Clinical and Demographic Characteristics of 62 Young Healthy Men and Women Undergoing Testing for Resting Metabolic Rates.....	34
2. Estimated Resting Metabolic Rate for Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict (HB-BEE), and Mifflin / St. Jeor (MSJ) Equations.....	35
3. Correlation Coefficients Between Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict (HB-BEE), and Mifflin / St. Jeor (MSJ) Equations.....	36
Journal Article 2	
1. Clinical Characteristics of the 63 Study Subjects Studied for 16 Weeks and the Sub-Group of 29 Followed for 1 Year.....	63
2. Changes in Body Weight, Body Composition, RMR, Total Energy Intake, and Macronutrient Composition in Diets of 63 College Freshmen.....	64
3. Correlation Coefficients between Changes in Body Weight, Body Composition, RMR, and Total Energy Intake of College Freshmen Participants During the 16 - Week Study Period.....	65
4. Exercise Patterns Among 36 First Semester Freshmen Students.....	66
5. Changes in Weight, Fat Mass, and RMR in College Freshmen Who Followed the American College of Sports Medicine (ACSM) Recommendations for Exercise and Those Who Did Not.....	67
6. Changes in Body Weight in 29 Freshmen Students at 16-Weeks, and at 1 Year Follow-up.....	68

List of Figures

<u>Figure</u>	<u>Page</u>
Journal Article 1	
Correlations Between Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict (HB-BEE), and Mifflin / St. Jeor (MSJ) Equations RMR.....	37
Journal Article 2	
1. Individual Changes in Body Weight in 63 First Semester Freshmen.....	69
2. Changes in Body Weight in 29 Freshmen Students at 16 Weeks (a), between 16 Weeks and 1 Year (b), and at the End of 1 Year (c).....	70

CHAPTER 1
INTRODUCTION AND REVIEW OF LITERATURE

Introduction

Overweight and obesity has increased dramatically in the United States in the past 30 years. According to the 1999-2000 National Health Nutrition Examination Survey (NHANES IV) an estimated 64% of adults and 15% of children and adolescents ages 6-19 years old in the United States are either overweight or obese (Center for Disease Control (CDC), 2004).

Obesity is a serious health risk, which has created considerable concern among clinicians and health care providers. Approximately 300,000 annual deaths are attributed to obesity (Allison, Fontaine, Manson, Stevens, & VanItallie, 1999). Studies have linked excess weight to an increased risk of chronic health conditions such as cardiovascular disease, hypertension, and type 2 diabetes (US Department of Health and Human Services, 1996; Stein and Colditz, 2004; Bray, 2004).

Weight loss of as little as 10% of a person's initial body weight, or 5 kg, has been shown to greatly decrease a person's risk of developing weight related diseases (Eckel and Krauss, 1998; Colditz, Willett, Rotnitzky, Manson, 1995; Huang et al., 1998). Although weight loss is often achieved, maintaining weight loss is far less common (Davey, 2004). Because current weight loss programs have little long-term success, identifying the causes of weight gain and developing prevention strategies is critical in weight control (Matvienko, Lewis, Schafer, 2001).

Research has shown that weight gain begins early in life (US Department of Health and Human Services, 1996). There are several periods throughout life when weight gain is common and the freshmen year of college appears to be a particularly

important one. There is a well-known belief that freshmen gain approximately 15 pounds during their first year of college. This notion is commonly referred to as “The Freshman 15”. Previous studies that investigated freshman weight gain found that the average weight gain was far less than 15 pounds and may be closer to approximately 5 pounds; however, weight gain was highly variable between individuals (Graham and Jones, 2002; Hodge et al., 1993; Hojhosseini et al., 2003; Levitsky, Halbmaier, & Mrdjenovic, 2004). Because the first year of college appears to be a time when accelerated weight gain occurs, studying freshman weight gain may not only aid in developing prevention strategies for weight gain in this population, but it may also enhance our understanding of weight gain in the general population. The purpose of the present study is to add to the existing literature on college freshman weight gain, assess how this weight is gained, investigate if changes in RMR occur, how specific dietary and exercise practices influence weight gain in college freshmen, and whether or not this weight gain is transient or long lasting.

Review of Literature

Overweight and Obesity

Definition The CDC defines obesity as having an extremely high amount of body fat in relation to lean body mass, or having a Body Mass Index (BMI) of 30 or higher (CDC, 2004). High body fat (over 25% in men and 32% in women) and a BMI of over 25 are highly correlated with the development of weight related diseases (CDC, 2004). BMI is calculated by dividing a person’s weight in kg by a person’s height in meters squared (kg/m^2). BMI is an accurate tool for classifying overweight and obesity in the

majority of the population; however, it does have limitations. For example, an athlete who is very lean and muscular may weigh more than someone who is the same height, but sedentary. Using BMI to assess their weight may qualify them as overweight, although they clearly are not over fat. Thus, using BMI to assess a healthy weight fails to accurately distinguish a person's body composition. In an ideal setting, both BMI and body composition measurements should be employed to more accurately assess healthy body weight.

Prevalence and Trends According to the 1999-2000 NHANES IV an estimated 64.5% of adults are overweight ($\text{BMI} \geq 25$) and 30.5% of adults are obese ($\text{BMI} \geq 30$) in the United States (CDC, 2004). This is an 8% increase from the age-adjusted overweight estimates gathered from NHANES III (1988-1994). Obesity trends are not only increasing in adults, but also in children. Results from the 1999-2000 NHANES indicate that approximately 15% of children and adolescents ages 6-19 years old are overweight. This is a 4% increase from the overweight estimates of the NHANES III (1988-1994) (CDC, 2004). These data suggest that overweight and obesity is beginning at a younger age. This notion is supported by a prospective cohort study, which observed that men and women born in 1964 became obese at a younger age than men and women who were born in 1957. In addition, >25% of the participants born in 1964 were obese by their mid-30s (McTigue et al., 2002).

Obesity and Chronic Disease Obesity is of great concern to clinicians and health experts. It is not only psychologically damaging, but it is also a great threat to one's health. Approximately 300,000 annual deaths are attributed to obesity (Allison et al.,

1999). A large study performed in the United States found that a high BMI is associated with higher rates of death among both men and women in all age groups (Calle, Thun, Petrelli, Rodriguez, & Heath, 1999). Several studies have linked excess weight to an increased risk of weight related health conditions, including cardiovascular disease, insulin resistance, metabolic syndrome, nonalcoholic fatty liver disease and nonalcoholic steatohepatitis, type 2 diabetes, cancer, premature death, hypertension, cerebrovascular disease, gallstones, osteoarthritis, sleep apnea, asthma, dyslipidemia, menstrual irregularities, pregnancy complications, endocrine changes, depression, and social discrimination (US Department of Health and Human Services, 1996; Stein and Colditz, 2004; Bray, 2004).

Characteristics of Weight Gain

Difficulty of Weight Loss and the Importance of Prevention Solving the obesity epidemic has become a major focus in the United States and throughout the world. This has led to the development of several weight loss programs and diets. It has been estimated that approximately 75% of women and 47% of men have attempted weight loss at some time in their life (Jeffery et al., 2000). Successful weight loss can often be achieved; however, weight maintenance is much more difficult. Increasing trends of overweight and obesity suggest that long-term weight loss may be unsuccessful (Jeffery et al., 2000). A meta-analysis of 29 studies, which examined the success of maintaining weight loss after 5 years, found that individuals who lost weight were only able to maintain a 3 kg weight loss below their initial weights (Davey, 2004). It has been estimated that 90 to 95% of persons who lose weight regain their weight (Rosenbaum et

al., 1997). Studies have shown that weight gained is rarely reversed and chronic weight cycling can make weight loss harder and slower each time weight is gained (Blackburn et al., 1989). McTigue et al., 2002 observed that >80% of participants who were obese at age 20 to 22 years were still obese at age 35 to 37 years. Because current weight loss programs have little long-term success and weight is rarely reversed, prevention of weight gain is critical in weight control.

Time in Life Span Targeting when weight is gained throughout the lifespan and who is at the greatest risk for becoming obese are important factors in slowing the rate of obesity in the United States. Weight gain often begins between 18 and 34 years of age; however, overweight and obesity is developing at an earlier and earlier age (Matvienko et al., 2001). The average yearly weight gain observed in adulthood is 0.2 to 0.8 kg (0.44 to 1.76 lbs.) and an average of 9.1 kg (20 lb.) is gained between the ages of 25 and 55 years (Matvienko et al., 2001; Rosenbaum et al., 1997). There are several periods throughout life when weight gain is common, such as, adolescence, pregnancy, midlife in women and the period after marriage in men (Yanovski et al., 2000). As people grow older they typically gain weight. Cross-sectional studies have demonstrated that a 1%-2% decrease in resting metabolic rate (RMR) occurs approximately every decade as a person ages, beginning somewhere in their mid-twenties (Gilliat-Wimberly, Manore, Woolf, Swan, Carrol, 2001). These changes occur primarily as a result of decreasing physical activity, which leads to a loss of muscle and a lower 24-hour energy expenditure. The first year of college also appears to be a time when an accelerated amount of weight is gained. This period of weight gain will be discussed in greater detail later in the paper.

Factors Leading to Weight Gain There is constant debate among health care providers and researchers as to why weight is gained. Understanding why weight is gained is critical to slowing or halting the increase in obesity that has been observed over the last 30 years. Overweight and obesity are the result of a culmination of factors, which include genetic, metabolic, behavioral, and environmental influences (Stein and Colditz, 2004). All of these factors impact body weight; however, the prevalence of overweight has increased by 40% and the prevalence of obesity has grown 110% in the last 25 years (CDC, 2004). This sudden increase in obesity suggests that behavioral and environmental influences, not genetics, have had the greatest influence on weight gain in the United States. Leading experts contribute weight gain to an energy imbalance (CDC, 2004). The first law of thermodynamics states that the amount of stored energy (stored as fat) is equal to the difference between energy intake and energy expenditure (Rosenbaum et. al, 1997). An important question exists: How has energy balance shifted towards a positive balance? Although there is no clear explanation, it is evident that in the United States food options, portion sizes, and the amount of convenience foods have increased, while the growing use of technology has greatly diminished energy expenditure. When calorie consumption exceeds calorie expenditure, the result is a positive energy balance and weight gain. We will examine each side of the energy equation in more detail.

Energy Balance

Diet The 1999-2000 Healthy Eating Index concluded that only 10% of Americans ate a “good diet,” 16% ate a “poor diet,” and 74% “needs improvement” (Putnam, Allshouse, Kantor, 2002). This data suggests poor eating habits. It only

requires a small amount of extra energy daily to result in weight gain. For example, a positive energy balance of 9 kcals daily (such as a stick of sugar free gum) will result in approximately 1 pound of weight gained yearly. As pointed out previously, the average yearly weight gain in American adults is approximately 1 pound (Matvienko et al., 2001). Our society has created an environment where food is inexpensive, highly palatable and easily accessible, which has made eating a convenience rather than a necessity. Portion sizes have increased substantially. For example, Coca Cola individual serving bottles have increased from 6.5 ounces to 20 or 32 ounces (Davey, 2004). Data from NHANES I, NHANES II and NHANES III, which analyzed diets in the United States from 1971-2000, indicate an increase in mean energy intake (kcals) (CDC, 2004). The average reported increase in daily energy intake for men was from 2,450 kcals to 2,618 kcals. In women it increased from 1,542 kcals to 1,877 kcals (CDC, 2004). Diet composition and location where foods were consumed also changed. Between 1977 and 1996 the number of meals consumed at restaurants and fast-food establishments compared to meals eaten at home increased from 9.6% to 23.5%, and the greatest increase was observed in people ages 19-39 years (Nielson, Siega-Riz, Popkin, 2002). Changes in dietary composition included an increase in percentage of carbohydrate and a decrease in percentage of fat consumed. Despite popular belief, research has shown that dietary composition has little to do with the development of obesity (Rosenbaum et al., 1997; Roust, Hammel, Jensen, 1994; Golay et al., 1996). Consumption of sugared beverages, French-fries, hamburgers, cheeseburgers, pizza, and Mexican food, which could potentially increase energy intake

has increased (Nielson et al., 2002). Unlike macronutrient composition, these trends in food choices suggest a general increase in energy intake.

Total Energy Expenditure Dietary intake plays a large role in energy balance; however, experts suggest that the recent increase in obesity is mainly due to a decrease in energy expenditure (Mayo Clinic, 2002; Pescatello and VanHeest, 2000). Total daily energy expenditure (TEE) is dependent on the following three variables: Resting metabolic rate (RMR), thermic effect of food (TEF) and physical activity (Matvienko et al., 2001). TEF accounts for approximately 10-15% of 24-hour energy expenditure (EE) and varies depending on diet (Mifflin et al., 1990). Physical activity is also highly variable between individuals and may contribute between 20-30% of TEE. Because TEF and physical activity between individuals is so variable from day to day, RMR is most frequently used as a predictor of 24-hour EE. RMR accounts for approximately 65-70% of TEE, and is best predicted by lean body mass (LBM) (Mifflin et al., 1990; Foster et al., 1988; Owen et al., 1987; Brooks, Fahey, White, Baldwin (2000).

There is no clear definition or consistent protocol for measuring RMR. Nieman, Trone and Austin (2003) defined RMR in their study as metabolic measurements taken at least 4 hours postprandial and a minimum of 4 hours post exercise, with subjects in a seated position after ten minutes of rest in the late afternoon. Case, Braehler and Heiss (1997) defined RMR as the amount of energy used by the body in a rested (no exercise for a minimum of 24 hours), fasted state (12 hours postprandial) at a thermoneutral temperature (21-22° C). Brooks et al. (2000) defined RMR as the energy required in a fully conscious person at rest and 8-12 hours after exercise or a meal (Brooks, et al.,

2000). Although no consistent protocol has been determined, Owen et al. (1986) determined that the coefficient of variation for measuring 8 fasted subjects at 20 different times over an 8 hour period was $\pm 4.7\%$. This data suggests that as long as subjects are fasting, have not exercised, and are resting quietly while measured, the time of day when RMR is measured will result in only slight variations in estimating RMR.

Measuring RMR The “Gold Standard” for determining resting metabolic rate (RMR) is direct calorimetry. However, this procedure is expensive and requires specialized facilities for proper determination. As a result, indirect methods that allow reasonably accurate estimates of RMR have been developed. Several indirect methods for measuring and predicting RMR exist. Two widely used methods for estimating RMR are the measurement of ventilated oxygen consumption (O_2) and estimates of lean body mass and body cell mass using bioelectrical impedance (BIA). All energy-releasing reactions in the body depend on biological oxidation; therefore, measuring oxygen consumption provides a reliable estimate of energy expenditure.

Measuring Lean Body Mass If LBM is used in estimating RMR it is important that accurate methods of assessing LBM are employed. Hydrodensitometry (underwater weighing) and Dual-energy x-ray absorptiometry (DEXA) are the “Gold Standard” for estimating body fat (Willett, Dietz, Colditz, 1999). Because both of these methods are expensive and require skilled technicians, they are used primarily in research settings and to validate less complicated, inexpensive methods such as body circumference (waist to hip ratio), skin-fold thickness, and bioelectrical impedance (BIA).

BIA passes a low frequency electrical current through extremity (e.g., arm) and the impedance to the electrical flow is measured through the other extremity (e.g., leg) on the same side of the body. Measurement of BIA is based on the assumption that lean tissue is a better conductor of electricity, and therefore, will conduct current better than fat mass. Resistance is then combined with height and weight into an equation to derive an estimate of body composition. Most studies have found that BIA is equally as accurate as skin fold technique; however, it has been found to be less accurate in estimating body composition in very lean and very obese people (Brooks et al., 2000).

Physical Activity Because exercise will potentially help build muscle, it may also increase RMR (Brooks et al., 2000; Gilliat-Wimberly et al., 2001). In addition to increasing RMR, exercise is also important for expending calories. Approximately 5 kcal are utilized for every liter of oxygen consumed during exercise (Brooks, 2000). If a person expends 300 calories per exercise session and performs this 3 or 4 times every week, they would lose 13 to 23 pounds of fat in 1 year (assuming that they are on an isocaloric diet) (Brooks, 2000). A 15-50% elevation in energy expenditure above RMR during the recovery period from exercise, commonly referred to as excess post-exercise oxygen consumption (EPOC), has also been observed (Binzen, Swan, Manore, 2001; Brooks, 2000). Research has shown that strength training and aerobic exercise performed at the same intensity both cause a similar increase in 24-hour energy expenditure in men (Melanson et al., 2002).

Although physical activity is critical to successful weight control and good health, research shows that few Americans are physically active. According to the Behavioral

Risk Factor Surveillance System in 2000, less than 1/3 of adults performed the recommended amount of physical activity and 40% of adults in the United States are completely sedentary (National Institute of Health (NIH), 2004). Youth in the United States was also found to be inactive. Only 25% of 12-21 year olds engage in light to moderate activity on a daily basis and only approximately 50% participate regularly in vigorous physical activity (NIH, 2004).

Recommendations for physical activity have been suggested in an attempt to increase the level of physical activity in the United States. The U.S. Department of Health and Human Services recommends that Americans engage in a minimum of 30 minutes (adults) or 60 minutes (children) of light or moderate physical activity 5 or more days of the week and/or vigorous activity 3 times or more per week for 20 minutes or more each time (U.S. Department of Health and Human Services, 1996). Moderate physical activity includes activities such as brisk walking or dancing. Examples of vigorous activities include running or playing basketball.

The American College of Sports Medicine (ACSM) recommends that healthy people should perform aerobic exercise 3 to 5 days a week at 40% or 50% to 85% of their maximum oxygen uptake reserve (moderate to vigorous physical activity, respectively) for 20 to 60 minutes (ACSM, 2004). Exercise can be performed in 10-minute bouts for an accumulation of 20 to 60 minutes throughout the day. ACSM also recommends that people younger than 50 years old should perform resistance training 2-3 days per week. They recommend performing one exercise of 8 to 12 repetitions for all major muscle groups (chest, back, legs, biceps, triceps, and abdominals) (ACSM, 2004).

Weight Gain in College Freshmen

There is a well established belief that freshmen gain approximately 15 pounds during their first year of college. This notion is commonly referred to as “The Freshman 15.” Although this notion is well known and feared, freshmen still continue to gain weight upon entering college (Graham and Jones, 2002; Hodge et al., 1993; Hojhosseini et al., 2003). Previous studies that investigated freshman weight gain found that the average weight gain was far less than 15 pounds (Graham and Jones, 2002; Hodge et al., 1993; Hojhosseini et al., 2003). Graham and Jones (2002) reported an average weight gain of 4.6 pounds in a small sample of college freshmen; however, it is important to note that 10 subjects gained between 5-9.5 pounds and 3 subjects gained between 10-15 lbs. in the nine-month study. Over half of the subjects gained weight (Graham and Jones, 2002). In another study, eighteen of the 61 subjects gained 4 pounds or more in their first year of college (Hodge et al., 1993). These findings are similar to a small, 16 week study performed at a large, ethnically diverse university, which reported a weight gain of ≥ 3 pounds in 16 of the 26 subjects (Hajhosseini et al., 2003). Hodge et al. (1993) found that the average weight gain in college women in their first 6 months of college was 7 pounds. Although the reported weight gain in these four studies was not fifteen pounds, it is important to note that there was a relatively large increase in weight. It is imperative to remember that the weight gain observed in these studies occurs within only nine months or less, and that this weight gain far exceeds the average yearly weight gain.

Lifestyle Practices of Freshmen Students

The first year of college is an important time in a young adult's life. As a result of a newfound independence and a necessity to make dietary choices on their own, the freshman year is often a time that students begin to form life-long eating behaviors (Sax, 1997). Deciphering what to eat and how to maintain or achieve a healthy weight requires a basic understanding of nutrition and human physiology. Most freshmen students were not provided with this knowledge in high school and, therefore, have a difficult time dealing with weight gain that commonly occurs with age (Matvienko, 2001). Much of the nutrition information that students learn is derived from home economics classes, television, parents, coaches, friends, labels on food packages, radio, non-scientific books, newspapers and magazines. These sources contain simplified nutritional concepts and lack the necessary information on how biology and nutrition interact and control weight (Matvienko, 2001); therefore, most college freshmen do not have the appropriate knowledge to safely maintain or achieve a healthy weight.

Unarmed and ill prepared, college freshmen commonly practice unhealthy lifestyle habits. Surveys conducted on college freshmen and college students indicate that most college students don't eat the recommended servings of fruits and vegetables and often replace these low calorie nutritious foods with high-calorie, non-nutritive foods (Debate, 2001; Sax, 1997). These dietary choices may increase energy intake and contribute to weight gain. In addition to poor eating habits, many college freshmen also fail to meet the recommended daily physical activity requirement. A study on college freshmen's health trends showed that less than half of the female freshmen surveyed

exercised six or more hours per week (Sax, 1997). Enrollment in daily physical education classes decreased from 42% in 1991 to 25% in 1995, and only 19% of all high school students are physically active for 20 minutes or more in physical education classes on all days of the school week (US Department of Health and Human Services, 1996). This data suggests that many of the freshmen students entering college are unaccustomed to exercising on a regular basis.

Previous Studies showing Freshman Weight Gain

There are only a few studies that have been done to assess freshmen weight gain, and most of the studies have important limitations. The majority of the subjects were female and several of the studies had return rates far below 100% (Graham and Jones, 2002; Hodge et al., 1993; Debate, 2001; Hojhosseini et al., 2003). Those that didn't return may have gained weight, which may have increased the mean weight gain among that sample population. Graham and Jones (2002) reported that the students who were most preoccupied with body image and weight gain were the students who participated in the entire study. The methods of assessing weight gain and body composition varied between studies. In one study subjects' heights and weights were self-reported (Debate, 2001). The data in this study may be inaccurate, because men tend to overestimate their height, females tend to underestimate their weight, and there was no standard method of measurement (e.g., the same scale). There is currently little data on the nature of how weight is gained in freshmen students. The only study that previously reported changes in body composition used skin-fold calipers; however, the site(s) measured were not specified (Graham and Jones, 2002). Because the methods used in this study were

incomplete, the data are difficult to interpret. In addition, as with any study where subjects are being periodically tested for changes in weight and body composition, subjects may have been more aware of diet and changes in weight (Graham and Jones, 2002; Hojhosseini et al., 2003). In addition to changes in body weight and composition, few studies have looked at the amount of daily energy consumed and specific exercise habits of college freshmen. Levitsky et al. (2004) surveyed freshmen about eating habits (e.g., snacking, meals per day, whether or not they ate breakfast, average size of meals, and alcohol consumption); however, specific daily food consumption was not assessed. Levitsky et al. (2004) also queried freshmen about the number of times per week they exercised, but did not investigate their specific exercise practices (e.g., duration, intensity and type of exercise performed). Lastly, past freshmen weight gain studies only lasted 1 to 2 semesters; therefore, it is unclear whether this weight gain is long-term or transient (Graham and Jones, 2002; Hojhosseini et al., 2003; Hodge et al., 1993; Levitsky et al., 2004). Due to the above-mentioned limitations, weight gain among college freshmen remains poorly understood.

Summary and Conclusions

Weight gain in the United States is a growing problem in all age groups and the first year of college represents one specific time throughout a person's lifespan when an accelerated amount of weight is gained. Although presently there is no clear answer as to the exact amount of weight that is gained in the first year of college, it is clear that a noticeable amount of weight is gained and that this weight gain is highly variable. What is not clear is how this weight is gained, how lifestyle practices may "protect" or

contribute to weight gain in this population, and whether or not this weight gain is long-lasting or transient. For example, it is not clear from existing research whether changes in body composition and resting metabolic rate (RMR) take place as a result of changes in body weight. Moreover, previous studies on freshman weight gain have not clearly documented diet or physical activity. Both exercise and diet have been shown to effect weight loss and gain; therefore, these may be important factors in both assessing risk and developing prevention strategies. Therefore, the purpose of the present study is multifaceted. First, it will add to the existing literature on the amount of weight that is gained by college freshman and whether or not this weight gain is maintained into participants' sophomore year. Second, it will fill in the gaps on how weight is gained, assess changes in RMR, and document how dietary and exercise practices influence weight gain in this population.

CHAPTER 2
JOURNAL ARTICLES

Journal Article 1

A COMPARISON OF RESTING METABOLIC RATE (RMR) USING
MEASUREMENTS OF VENTILATED OXYGEN CONSUMPTION (O₂),
BIOELECTRICAL IMPEDENCE (BIA), METABOLIC BODY SIZE (Kg^{0.75}),
HARRIS-BENIDICT (HB-BEE), AND MIFFLIN / ST. JEOR (MSJ) EQUATIONS

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Abstract

Objective: The purpose of this study was to compare five commonly used methods of measuring RMR in a sample size of young, healthy, college age males and females.

Design. The present study was a cross-sectional observational study.

Subjects/setting. A convenience sample of sixty-two young men and women with a mean age of 18.1 ± 0.7 yrs participated in these studies.

Main outcome measures. RMR was measured by ventilated O_2 consumption and compared to estimates by BIA and three prediction equation calculations, metabolic body size ($kg^{0.75}$), HB-BEE, and MSJ.

Statistical analyses. Descriptive statistics and t-test for paired comparisons adjusted for multiplicity were used to compare different methods of measuring RMR. Pearson correlations were used to explore associative relationships among methods.

Results. $Kg^{0.75}$ gave the highest prediction of RMR ($1606 \pm 16kcal$) followed by O_2 ($1580 \pm 19kcal$), HB-BEE (1558 ± 19), MSJ ($1506 \pm 22kcal$) and BIA ($1463 \pm 14kcal$). Although these methods yield significantly different estimates of RMR ($p < 0.001$), the quantitative differences were small and ranged from 1.6 % to 8.9%. Pearson correlations between O_2 and $Kg^{0.75}$ ($r = 0.828$; $p < 0.001$), O_2 and BIA ($r = 0.681$; $p < 0.001$), and MSJ and BIA ($r = 0.841$; $p < 0.001$) were statistically significant and very strong.

Conclusion. $Kg^{0.75}$, HB-BEE, and MSJ and BIA all closely predicts RMR estimated by O_2

Application. The equations for measurement of RMR, which only require a scale, stadiometer and a calculator, can provide reasonable estimates of RMR when performed in a less structured setting.

Introduction

Overweight and obesity has increased dramatically in the United States in the past 30 years. According to the 1999-2000 National Health Nutrition Examination Survey (NHANES) an estimated 64% of adults and 15% of children ages 6-19 years old in the United States are either overweight or obese (1). Body Mass Index (BMI), which is a measure of weight in kg compared to height in meters squared (kg/m^2), was used to classify overweight and obesity. Overweight is identified as a BMI of 25 to 29.9 kg/m^2 and obesity is defined as a BMI of 30 kg/m^2 and above.

Obesity is a serious health risk, which has created considerable concern among clinicians and health experts. Approximately 300,000 annual deaths are attributed to obesity (2). Studies have linked excess weight to an increased risk of numerous health conditions such as cardiovascular disease and type 2 diabetes (3,4,5).

Weight loss of as little as 5-15% of a person's initial body weight can decrease an overweight person's risk of developing weight related diseases (6). An important factor in weight loss is creating a negative energy balance. In order to successfully and safely achieve this, an accurate assessment of total daily energy expenditure must be determined. Total daily energy expenditure (TEE) is dependent on the following three variables: resting metabolic rate (RMR), thermic effect of food (TEF) and physical activity (7). TEF accounts for approximately 10-15% of 24-hour energy expenditure (EE) and varies depending on diet (8). Physical activity is also highly variable between individuals and may contribute between 20-30% of TEE (8). Because TEF and physical activity between individuals is so variable from day to day, RMR is most frequently used

as a predictor of 24-hour EE. RMR accounts for approximately 65-70% of TEE, and is best predicted by lean body mass (LBM) (8-13).

The “Gold Standard” for determining resting metabolic rate (RMR) is direct calorimetry. However, this procedure is expensive and requires specialized facilities for proper determination. As a result, indirect methods that allow reasonably accurate estimates of RMR have been developed. Several indirect methods for measuring and predicting RMR exist. Two widely used methods for estimating RMR are the measurement of ventilated oxygen consumption (O_2) and estimates of lean body mass and body cell mass using bioelectrical impedance (BIA). Several prediction equations for estimating RMR have also been developed (8-10). Most equations only require age, weight, height and gender in the calculation. Although these methods do not require expensive equipment and trained technicians, studies have suggested that these equations are inaccurate when compared to measured estimates of RMR (11,12,14-17). The purpose of this study was to compare four different, easily performed, less expensive, commonly used methods of measuring RMR in a sample size of young, healthy, males and females.

Methods and Procedures

Subjects and Study Design

A convenience sample of sixty-two young men ($n = 23$) and women ($n = 39$) with a mean age of 18.1 ± 0.7 yrs participated in these studies. Their clinical and demographic characteristics are presented in Table 1. The study population was ethnically diverse and similar to that ethnic composition of San Jose State University. Their mean BMI ($23.1 \pm$

3.7 kg/m²) was well within the normal, healthy range. The study was designed as a longitudinal study completed over the course of one 16-week semester. Participants reported to the Nutrition and Metabolic Laboratory at San Jose State University between 8:00 am and 5:00 pm every 5-6 weeks (total of 3 visits) in a post absorptive state (> 2hr from last meal), rested (> 2 hrs since exercising) and well hydrated. Individuals were weighed without shoes and in light clothing using a laboratory stadiometer at each visit. Measurements of RMR were estimated by ventilated O₂ consumption (Body Gem Health Tech Inc.) on the first and the last visit (16 weeks apart). The BodyGem is a small handheld device fitted with a SCUBA type mouthpiece. The subject sits in a seated position and breathes through the apparatus for 12-15 minutes. Oxygen is captured in the device and the BodyGem uses this data to compute a RMR.

In addition, 35 of the individuals also had RMR determined by BIA (BIA; Physiological Event Analyzer (PEA), RJL Systems) on all three days of testing. BIA requires 2 EKG-type electrodes to be placed 2-3 cm apart on one hand and one foot on the same side of the body. Subjects lie supine on a table during measurements. Resistance to flow of a small electrical current is measured by the BIA, and this data is used to estimate total body water and lean body mass. The BIA uses height, weight, and body composition to compute a RMR. Finally, three prediction equations for estimating RMR were used: Metabolic body size ($\text{RMR} = \text{Kg}^{0.75} \times 70$) (9), Harris-Benedict (Females: $655 + 9.56 \text{ W kg} + 1.85 \text{ H cm} - 4.68\text{A}$; Males: $66.5 + 13.75 \text{ W} + 5.0 \text{ H} - 6.78 \text{ A}$) (10), and Mifflin / St Jeor (Females: $655 + 9.56 \text{ W kg} + 1.85 \text{ H cm} - 4.68\text{A}$; Males: $66.5 + 13.75 \text{ W} + 5.0 \text{ H} - 6.78 \text{ A}$) (8). Subjects volunteered to participate in the study

and provided informed written consent. Approval for the study was obtained from the Human Subjects Committee at San Jose State University.

Variability of BIA and RMR Measurements

BIA measurements were repeated ten times, one minute apart in nine individuals to determine an intra-assay coefficient of variation (repeated measurement within an individual) for body composition. This same method was repeated one week later in the same nine individuals to assess inter-assay coefficient of variation for body composition (repeated measurements between different days). Inter-assay variation for BIA was $1.1 \pm 0.9\%$, while inter-assay variation was $0.3 \pm 0.2\%$.

Measurements of RMR were performed three times during the same visit in 13 individuals to determine an intra-assay coefficient of variation in RMR. Intra-assay coefficient of variability in RMR was $4.6 \pm 2.5\%$. Fasting RMR was repeated in 8 individuals on a stable diet at three intervals over a period of two weeks, on day 1, 5 and 14 for the determination of inter-assay variability (repeated measurements on different days). The inter-assay coefficient of variability was $2.3 \pm 0.7\%$.

Statistical Analysis

Descriptive statistics were used to describe subjects. A t-test for paired comparisons adjusted for multiplicity was used to compare different methods of measuring RMR. Pearson correlations were used to explore associative relationships between methods. All analyses were performed using a SPSS software version 10.0 for Macintosh. Data are expressed as mean $\pm$ standard deviation and statistical significance was set at $p < 0.05$.

Results

The results (Table 2) indicated that $\text{Kg}^{0.75}$ gave the highest prediction of RMR ($1606 \pm 16\text{kcal}$) followed by O_2 ($1580 \pm 19\text{kcal}$), Harris-Benedict (1558 ± 19), Mifflin/St. Jeor ($1506 \pm 22\text{kcal}$) and BIA ($1463 \pm 14\text{kcal}$). Although these methods yield significantly different estimates of RMR ($p < 0.001$), the quantitative differences were very small and ranged from 1.6 % (O_2 vs. $\text{Kg}^{0.75}$) to 8.9% ($\text{Kg}^{0.75}$ vs. BIA). Pearson correlations (Table 3 and Figure 1) between O_2 and $\text{Kg}^{0.75}$ ($r = 0.828$; $p < 0.001$), O_2 and BIA ($r = 0.681$; $p < 0.001$), and MSJ and BIA ($r = 0.841$; $p < 0.001$) were statistically significant and very strong.

Discussion

Results from the present study indicate that all three methods provide reasonably similar estimates, with strong significant correlations among the 5 techniques. It is important to note that there is no clear, consistent protocol or definition among scientific literature for measuring RMR. For example, Frankenfield et al., Case et al., Heymsfield et al., Owen et al., required subjects to fast for 12 hours, abstain from exercise for 12-24 hours, and performed RMR measurements in the morning (12-17). Foster et al. required subjects to fast for only 6 hours and measured subjects in the early afternoon (11). Trone et al. measured RMRs in the late afternoon and required subjects to fast for 4 hours and abstain from exercise for at least 4 hours (18).

The thermic effect of food in healthy lean women is highest at 30 and 90 minutes and is completed by 210 minutes on average (16). Data from our laboratory define peak rise in energy expenditure between 40 – 75 minutes with return to baseline RMR by 105

minutes post challenge. Subjects in the present study fasted for 2 or more hours, thus, the TEF would be expected to have had little effect on RMR in these individuals. In addition to the thermic effect of food, exercise may have also positively affected subjects RMR. A 15-50% elevation in energy expenditure above RMR during the recovery period post exercise, commonly referred to as excess post exercise oxygen consumption (EPOC), has been observed (19,13). Data from a small study of trained females demonstrated that RMR remained significantly elevated above resting levels for 1 hour, which resulted in an additional expenditure of approximately 25 extra calories (19). Melanson et al. observed similar findings in EPOC in men (20). Subjects in the present study were asked to abstain from exercise for a minimum of 2 hours; therefore, RMR was also probably not substantially affected by exercise in our study population. Nevertheless, since the present study only required subjects to fast for 2 hours and abstain from exercise for 2 hours, and the measured values for RMR may have been slightly overestimated.

The study design used in this research has important applications. The two methods we used to measure RMR do not require a highly trained technician to use and are therefore suitable for use outside of a research setting (20). Many health clubs and dietitians use these methods informally in practice daily. These methods both require that specific protocols be followed in order to assure accuracy; however, these protocols are rarely followed. The protocol used in the present study more closely mimics the metabolic state of most subjects measured outside of a research setting. In addition, although the BodyGem and BIA are less expensive methods than more widely accepted clinically research methods, they still require a relatively substantial financial investment.

Our data suggests that $Kg^{0.75}$, Harris-Benedict, and Mifflin / St. Jeor, which only require a scale, a stadiometer and a calculator, closely predicts RMR estimated by O_2 when performed in a less structured setting. Although the present study does not allow these methods to be compared with “true” RMR, the results indicate that all five methods provide reasonably similar estimates, with strong significant correlations among the techniques and, thus, provide useful tools for estimating caloric recommendations to healthy, young adults. These estimates can then be used to prescribe appropriate caloric recommendations for young healthy persons seeking weight loss. Finally, additional comparisons among these methods are required to better assess the reliability of these calculations in other age groups, obese individuals, and critically ill patients.

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Table 1 Clinical and Demographic Characteristics of 62 Young Healthy Men and Women Undergoing Testing for Resting Metabolic Rates

<u>Clinical Characteristics</u>	<u>n = 62</u>	<u>n = 35</u>
Age (Year)	18.1 ± 0.7	17.9 ± 0.4
Gender	23 M / 39 F	19 M / 16 F
Weight (kg)	65.1 ± 14.2	66.0 ± 13.2
Height (cm)	167.2 ± 9.3	168.6 ± 9.8
Body Mass Index (kg/m ²)	23.1 ± 3.7	23.1 ± 3.4
 <u>Demographic Characteristics</u>		
Asian and Pacific Islander	44%	51%
Caucasian	30%	28%
African American	11%	4%
Hispanic	11%	26%
Other	4%	0%

Table 2 Estimated Resting Metabolic Rate for Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict Equations (HB-BEE), and Mifflin / St. Jeor (MSJ)

Method	RMR (kcal)
O_2	1573 ± 30
BIA	1450 ± 22
$Kg^{0.75}$	1598 ± 23
Harris-Benedict	1594 ± 23
Mifflin / St Jeor	1506 ± 22

Table 3 Correlation Coefficients Between Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict (HB-BEE), and Mifflin / St. Jeor (MSJ) Equations

	Correlation Coefficient (r)	P
O_2 vs $Kg^{0.75}$	0.853	0.001
O_2 vs HB-BEE	0.782	0.001
O_2 vs MSJ	0.777	0.001
O_2 vs BIA	0.681	0.001
$Kg^{0.75}$ vs MSJ	0.932	0.001
$Kg^{0.75}$ vs HB	0.911	0.001
$Kg^{0.75}$ vs BIA	0.713	0.001
HB vs MSJ (female)	0.995	0.001
HB vs MSJ (male)	0.981	0.001
BIA vs MSJ	0.841	0.001
BIA vs HB-BEE	0.697	0.001

LEGEND FOR FIGURE 1

Figure 1. Correlations Between Ventilated Oxygen Consumption (O_2), Bioelectrical Impedance (BIA), Metabolic Body Size ($Kg^{0.75}$), Harris-Benedict (HB-BEE), and Mifflin / St. Jeor (MSJ) Equations RMR

BIA_RMR = bioelectric impedance apparatus RMR

bodygem RMR = O_2 consumption RMR

MBSRMR = metabolic body size RMR

HBRMR = Harris-Benedict RMR

a

b

c

d

e

f

Journal Article 2

CHANGES IN BODY WEIGHT, BODY COMPOSITION, RESTING METABOLIC
RATE AND PHYSICAL ACTIVITY IN COLLEGE FRESHMEN

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ABSTRACT

Overweight and obesity has increased dramatically in the United States in the last 30 years. The first year of college has been shown to be a time in one's life when a substantial amount of weight is gained at an accelerated rate. The purpose of the present study is to investigate changes that occurred in body weight, body composition, and RMR, how diet and physical activity practices affected these changes in newly enrolled college freshmen, and whether or not this weight gain is long-lasting or transient. A convenience sample of 63 male and female freshmen students attending San Jose State University were recruited for the present study. The study was designed as a longitudinal study, which was completed over the course of one semester (16 weeks). Subjects' heights, weights, resting metabolic rate, body composition, dietary habits, and exercise practices were assessed throughout the semester. A subset of 29 male and female freshmen students returned for a follow-up visit to assess changes in weight at the end of one year. The results showed that both males and females in the study gained an average of 2.5 pounds during the first semester. Forty-four (70%) of the participants gained weight, with 24 (38%) of the individuals gaining 5 or more lbs during the study period. Sixteen (25%) of the participants lost weight and in 3 individuals' weights did not change. There were significant changes in body composition in females ($p = 0.002$), but not in males, with females increasing fat mass from 29.4 ± 1.1 % at baseline to 31.5 ± 1.0 % by the end of the study. There were no significant changes in RMR, total energy, or macronutrient intake for males or females during the study. Males and females reported similar activity levels. Seven (37%) males and 8 (47%) females met or exceeded the

ACSM minimum exercise guidelines for healthy adults over the entire semester.

Individuals who met the American College of Sports Medicine (ACSM) minimum guidelines for exercise gained a mean of 0.8 ± 1.1 lbs, whereas individuals who did not meet ACSM exercise guidelines gained an average of 3.1 ± 0.9 lbs. Finally, body weights in a representative sample of 29 of the 63 individuals studied (46%) returned toward initial baseline body weights and no significant differences were noted in mean body weight at 1 year. The present study demonstrates that a significant amount of weight is gained upon entering the first year of college and this weight gain is variable; however, this weight gain appears to be transient in nature. The data in this study demonstrates that weight gain in some individuals can be substantial and females seem to gain their weight in fat mass. The findings in this study also suggest that a small amount of exercise may be protective against initial weight gain in this population.

KEY WORDS: Freshman weight gain, resting metabolic rate, body composition, physical activity and weight maintenance

INTRODUCTION

An estimated 64.5% of adults are overweight ($\text{BMI} \geq 25.0 \leq 29.9 \text{ kg/m}^2$) and 30.5% of adults are clinically defined as obese ($\text{BMI} \geq 30 \text{ kg/m}^2$) in the United States (1). This represents an 8% increase in less than a decade (1). Although success at maintaining weight loss is possible, increasing trends of overweight and obesity suggest that long-term weight loss may be unsuccessful (2). It has been estimated that 90 to 95% of persons who lose weight regain their weight (3). Because current weight loss programs have little long-term success and weight gain is rarely reversed, prevention of weight gain is critical in weight control. Targeting important times when weight is gained throughout the lifespan and identifying who is at the greatest risk for gaining weight are important factors in slowing the rate of obesity in the United States.

The first year of college represents an important life-style change that is often accompanied by weight gain (4,5,6). There is a well-established belief that freshmen gain approximately 15 pounds during their first year of college. This notion is commonly referred to as “The Freshman 15.” Although research indicates that weight is gained during the first year of college, the amount of weight that is gained varies. Lifestyle practices that may “protect” or lead to weight gain in this population and how weight is gained are incomplete. For example, it is not clear from existing research whether changes in body composition and resting metabolic rate (RMR) take place as a result of changes in body weight. In addition, previous studies on freshmen weight gain have not investigated specific changes in diet or physical activity and how these may affect changes in body weight. These may be important factors in both assessing risk and

developing successful prevention strategies. Therefore, the purpose of the present study was to determine changes that occurred in body weight, body composition and RMR, and how diet and physical activity practices affected these changes in newly enrolled college freshmen.

METHODS AND PROCEDURES

Subject Population

A convenience sample of 63 male and female freshmen students attending San Jose State University were recruited for the present study. A subset of 29 male and female freshmen students was followed for their entire first year of college. Changes in diet, physical activity habits, and body composition of freshmen students were emphasized as the purpose of the study in order to avoid a focus on changes in body weight. Preliminary demographic characteristics were documented for each subject and coded by the last 4 digits of their student ID numbers. All additional data collected was coded in the same manner in order to make comparisons throughout the semester while still maintaining individual confidentiality.

Experimental Design

The study was designed as a longitudinal study, which was completed over the course of one semester (16 weeks). An additional subset of 29 of the original participants returned at 1 year for follow-up. Approval for the study was obtained from the Human Subjects Committee at SJSU. An orientation held in the Department of Nutrition and Food Science was offered to prospective volunteers during the first 3 weeks of the fall semester. During this meeting, the study was described to participants and general

questions concerning the protocol were answered. In addition, short presentations, which offered the same information as the orientation meetings, were performed in classes containing predominantly freshmen. Individuals who volunteered to take part in the study signed an informed consent approved by the Human Subjects Committee at San Jose State University. After obtaining informed consent, investigators demonstrated the proper procedure for completing the 3-day diet record and food frequency questionnaire, and participants were then scheduled for an initial visit (clinic visit 1).

Subjects' baseline height, weight, resting metabolic rate, body composition, 3-day diet records, and food frequency questionnaires were assessed in the initial study visit. One of the study investigators queried participants about their responses to their 3-day dietary record and food frequency questionnaire to clarify responses and eliminate potential ambiguity. All study investigators received the same training and followed the identical protocol for each participant. A subset of 36 of the participants was also asked to fill out a detailed survey concerning their present and past physical activity. Upon completing the exercise survey, subjects were scheduled for two additional clinic visits, one between weeks 7 and 8 (clinic visit 2) and again between weeks 14 and 16 (clinic visit 3). Body weight, body composition and 3-day diet record were repeated at clinic visit 2 and 3. Resting metabolic rate, food frequency questionnaire and the exercise survey were repeated only during clinic visit 3. Finally, a subset of 29 participants was weighed at the beginning of their sophomore year (1-year follow-up).

Participants were asked to abstain from consuming any food or drink other than water or engaging in any exercise for a minimum of 2 hours prior to their scheduled

appointment time. Subjects who exercise or ate within 2 hours of their appointment were rescheduled. The importance of proper hydration for accurate measurements of body composition was explained to all subjects. Hydration was measured during body composition analysis at each visit and subjects were rescheduled if not properly hydrated (between 50%-70%). All subjects were appropriately hydrated, and the mean hydration percentages during the three measurement periods were 54%, 54% and 53%, respectively.

Determination of Body Composition / BMI / Resting Metabolic Rate (RMR)

Body composition was estimated by whole body bioelectrical impedance (BIA; Physiological Event Analyzer (PEA), RJL Systems). Body Mass Index (BMI) was calculated by dividing subject's weight in kg by their height in meters squared (kg/m^2). RMR was calculated by measurements of ventilated oxygen consumption while seated and at rest (Body Gem, Health Tech Inc.) (7). The device was fitted with a SCUBA type mouthpiece, which is placed in the individual's mouth. The individual breathed through the device continuously until steady state oxygen consumption was reached. Sensors in the device measure oxygen consumption and ventilation. Oxygen consumption at rest is used as a basis to calculate RMR. Each individual used a new mask for each measurement taken.

Variability of BIA and RMR Measurements

BIA measurements were repeated ten times, one minute apart in nine individuals to determine an intra-assay coefficient of variation (repeated measurement within an individual) for body composition. This same method was repeated one week later in the

same nine individuals to assess inter-assay coefficient of variation for body composition (repeated measurements between different days). Inter-assay variation for BIA was $1.1 \pm 0.9\%$, while inter-assay variation was $0.3 \pm 0.2\%$.

Measurements of RMR were performed three times during the same visit in 13 individuals to determine an intra-assay coefficient of variation in RMR. Intra-assay coefficient of variability in RMR was $4.6 \pm 2.5\%$. Fasting RMR was repeated in 8 individuals on a stable diet at three intervals over a period of two weeks, on day 1, 5 and 14 for the determination of inter-assay variability (repeated measurements on different days). The inter-assay coefficient of variability was $2.3 \pm 0.7\%$.

3-Day Dietary Records

Three-day diet records were collected at each of the three clinic visits. The dietary records were recorded over three days including two weekdays and one weekend day, excluding Friday. Specifically, records were kept Wednesday, Thursday and Saturday, or Sunday, Monday and Tuesday. Participants were asked to record estimated portions of all food and to include brand names of items when possible, to indicate which foods were consumed in restaurants and which were prepared at home, and were queried about the relative amounts of ingredients in all combinations foods (burritos, pizza, casseroles, etc). All dietary records were checked by the investigators during each visit for completeness, clarity, and accuracy. Recorded intakes of food were analyzed, using both USDA food guide pyramid and by computer-based analysis using the Food Processor Nutrition and Fitness software (version 8.0, 2002, ESHA Research, Salem, OR).

Exercise Survey

Exercise was assessed with a close-ended survey. Participants were queried about the following: Number of days per week they exercise (1-7), level of intensity (1-10 from exercise intensity scale), duration (>20 minutes or <20 minutes) type of exercise (aerobic, anaerobic, both or other), how long they have been doing this exercise (1-4, 5-8, or 9-12 weeks), whether or not they played a sport in high school, whether or not they took physical education in high school, and if they presently participated in an organized sport. Individuals were assessed by whether or not they met or exceeded the American College of Sports Medicine (ACSM) aerobic fitness recommendations (8). ACSM recommends that healthy adults should perform a minimum of 20 minutes of moderate to vigorous aerobic exercise on 3 or more days a week (8).

Statistical Analysis

Descriptive statistics, which included t tests for paired comparisons and general linear model (GLM) and Pearson's Bivariate Regression Analysis, were performed using SPSS software version 10.0 for Macintosh. All data are shown as mean $\pm$ standard deviation (SD) and statistical significance was set at $p < 0.05$. Males and females were analyzed separately due to gender differences reflected in data collection and the known differences in body composition.

RESULTS

The clinical characteristics of study participants are presented in Table 1. There were approximately twice as many females ($n = 40$) than males ($n = 23$). The mean age was 18 ± 0.1 years. The mean body weight was 165.9 ± 34.3 in males and 129.2 ± 19.5

in females. The mean BMI was 24.6 ± 4.3 in males and 22.5 ± 2.8 in females. The clinical characteristics of the 29 individuals who completed the 1-year follow-up evaluation (Table 1) were not significantly different from the initial study population; however, males and females were more equally representative in this sampling. Fourteen of the 63 (22.5%) students could be clinically defined as overweight (13%; BMI $\geq 25.0 \leq 29.9$ kg/m²) or obese (9.5%; BMI > 30.0 kg/m²), while only one individual (1.5%) was underweight (BMI < 18.5 kg/m²). The majority of students (48 out of 63; 76%) were normal body weight (BMI $\geq 18.5 \leq 24.9$ kg/m²). The study population was ethnically diverse, with 31 of the 63 participants (49.2%) Asian and Pacific Islander, 17 (27%) Caucasian, 11 (18%) Hispanic and 4 (6%) African American. The ethnic distribution within the study population represents the ethnic distribution within the student population at San Jose State University.

The results of changes in body weight, body composition, RMR, total energy intake, and macronutrient composition in the diet are shown in Table 2. Both males and females in the study showed a statistically significant weight gain by the end of the study period (2.8 lbs; $p = 0.002$ and 2.4 lbs; $p = 0.001$, respectively). Baseline mean body weight in males increased from 165.9 ± 7.2 lbs to 168.7 ± 7.3 by week 16, while mean body weight for females increased from 129.2 ± 3.1 lbs to 131.6 ± 3.2 lbs by week 16. Individual changes in body weight over the 16 weeks are shown in Figure 1. The reference lines on the figure represent the weight maintenance, and it is clear that the reference line is shifted far to the left indicating that the vast majority of students gained weight over the 16 weeks. More specifically, 44 (70%) of the participants gained weight

with 24 (38%) of the individuals gaining 5 or more lbs during the 16-week study period, while 16 (25%) of the participants lost weight and weights remained unchanged in only 3 individuals.

Five of the 63 individuals changed weight categories during the 16-week study; one decreased weight and moved from normal weight to underweight, while four normal weight individual moved into the overweight category and one of the obese students lost weight and moved to the overweight category. There was no significant relationship between changes in body weight and individual's initial weights ($r = 0.15$; $p = 0.25$).

There were significant changes in body composition in females, but not in males. Percent fat mass in females increased from $29.4 \pm 1.1\%$ at baseline to $31.5 \pm 1.0\%$ ($p = 0.002$) by the end of the study, while percent lean body mass decreased proportionately from $70.8 \pm 1.1\%$ to $68.6 \pm 1.0\%$ ($p = 0.001$). There were no significant changes in RMR for males (1780 ± 83.5 kcal vs. 1801 ± 89.8 ; $p=0.627$) or females (1450 ± 31.9 kcal vs. 1463 ± 36.9 kcal; $p = 0.569$). No significant changes in total energy intake were reported by either males or females in the study ($+61$ kcal; $p = 0.680$ and -40 kcal; $p = 0.866$, respectively). Males reported an increase in their mean total energy intake from 2100 ± 114 kcal at baseline to 2161 ± 220 kcal by the end of the study, while females slightly decreased their mean total energy intake from 1840 ± 98 kcal at baseline to 1800 ± 75 kcal by the end of the study. There were no significant differences in intakes of fat, protein, or carbohydrate between baseline and the end of the study in either males or females.

Table 3 presents the correlation coefficients between changes in body weight, body composition, RMR and total energy intake of college freshmen participants during the 16-week study period. There was a significant association between changes in body weight and change in RMR ($r = 0.472$; $p = 0.001$) and, change in percent fat mass ($r = 0.297$; $p = 0.019$). Exercise practices among the 36 participants who completed exercise surveys are presented in Table 4. Males and females in this study population were very similar in their physical activity levels. Seven (37%) males and 8 (47%) females met or exceeded the American College of Sports Medicine (ACSM) minimum exercise guidelines for healthy adults over the entire semester. Five (26%) males and 10 (59%) females played a sport in high school. Twelve (63%) males and 12 (71%) females performed a minimum of 1 day of exercise throughout the entire semester. Of the individuals who exercised, 1 (8%) male and 0 females performed resistance training only, 4 (33%) males and 4 (33%) females performed aerobic exercise only, and 7 (58%) males and 8 (67%) females performed both resistance and aerobic exercise. Ten (83%) males and 11 (92%) females exercised at an intensity of “5” or greater.

Table 5 presents changes in body weight, percent fat mass, and RMR between those that followed the minimum ACSM exercise guidelines vs. those who did not. There were marginally significant differences in changes in body weight ($p = 0.09$); however, no significant differences between RMR ($p = 0.40$) or percent fat mass ($p = 0.34$) were observed. Individuals who did not meet the ACSM minimum guidelines for exercise gained an average of 3.1 ± 0.9 lbs, whereas individuals who met ACSM exercise

guidelines only gained a mean of 0.8 ± 1.1 lbs. There was a strong negative association between exercise intensity and changes in body weight ($r = -0.851$; $p = 0.001$).

Table 6 presents data on changes in body weight of the 29 individuals in whom data was obtained at 1-year follow-up. Although statistically significant changes in body weight and BMI were observed in these individuals at the end of the 16-week study ($+2.0 \pm 4.2$ lbs; $p = 0.014$), there were no significant differences at the end of 1 year ($+0.8 \pm 4.2$ lbs; $p = 0.269$). Figure 2 illustrates the individual differences in body weight of the 29 individuals that completed the 1-year follow-up, at the end of 16 weeks (a), between the end of 16-weeks and 1 year (b), and at the end of 1 year (c). The data are stratified in ascending order as a function of weight gain. Again, the reference lines indicate weight maintenance. It is clear from this illustration that the vast majority of individuals gained weight during the first 16 weeks of the study. This is consistent with the data of the larger group presented in Figure 1. However, the tendency toward positive weight gain was reversed between 16 weeks and 1 year (panel b), and the weight maintenance reference line has shifted far to the right, and is now located between 76th and 79th percentile. As a result, by the end of 1 year (panel c), the reference line falls between the 48th and 52nd percentile, indicating the number of individuals who gained weight was essentially similar to the number of individuals who lost weight.

DISCUSSION

The results from the present study clearly support the established belief that individuals gain a significant amount of weight during their first semester of college. However, this weight gain appears to be transient in nature, and by the end of 1 year no

significant differences in weight remained. Furthermore, it is clear from the Figure 1 that weight gain is extremely variable and that some students gain a substantial amount of weight during the first semester in college. Seventy percent of the participants in the present study gained weight and the average weight gain among males and females was 2.5 ± 0.5 lbs, with 38% of the individuals gaining 5 or more lbs over the 16-week study period. The weight gain observed in the present study is similar to previous studies, which reported a range in freshman weight gain of between 3-7 lbs (4,5,6).

The present study also indicated that changes in body composition accompanied the weight gain in females, but not in males. Females showed increases in % body fat of 2.1% over the 16-week study period, which suggests that weight gained in females was predominantly in fat mass. There is currently little data on the nature of how weight is gained in freshmen students. The only study that previously reported changes in body composition used skin-fold calipers; however, the sites measured and methods used were not specified (4). Because the methods used in this study were incomplete, the data is difficult to interpret. Thus, the present study provides important new information on the nature of weight gain in these individuals during the initial 16 weeks of college life.

There were no significant changes in mean RMR for either males or females, although RMR was moderately associated with changes in weight ($r = 0.47$; $p = 0.001$). The insignificant changes in RMR may have been due to the small changes observed in lean body mass, which is the best predictor for RMR (9,10,11).

The present study investigated how diet and exercise practices affected body weight in freshmen students. Although no significant differences in energy intake were

observed, males reported a slight mean increase in kcal (+61.2 kcal) and females moderately decreased mean kcal (−40.4 kcal). Macronutrient distribution was not significantly different throughout the study. Neither energy intake or macronutrient distribution was associated with changes in body weight. Although this data is important, it is critical to remember that dietary intakes were self-reported and therefore are only semi-quantitative in nature. In addition, diet analysis of specific foods may vary in nutrient and energy content between brands. However, if we ignore these potential inaccuracies, the small daily increase in energy reported by men only accounts for approximately 2 pounds of the 2.9 pounds gained. The difference between energy intake and energy output is responsible for changes in body weight; therefore, a decrease in energy output may partially explain the changes in body weight in this population.

Meeting or exceeding the minimum ACSM exercise recommendation for healthy adults was used as a tool to categorize (individuals who met or exceeded ACSM recommendations vs. individuals who did not) activity levels of these freshmen. Males and females practiced similar exercise patterns. Actual weight change was poorly associated with exercise practices. Although the differences were only marginally significant ($p = 0.09$) using a two-tailed test, the recommendation of ACSM for exercise in regard to body weight is directed toward the prevention of weight gain and general fitness. Thus, a more appropriate test of the recommendation would be one-tailed in nature. In this regard, the present study provides evidence which suggests that individuals who followed the ACSM recommendations of a minimum of 20 minutes of moderate to vigorous exercise at least 3 days per week were protected from weight gain

relative to those individuals who did not meet ACSM guidelines. Individuals who met or exceeded ACSM minimum guidelines gained less weight than those who did not (0.8 ± 1.1 lbs vs. 3.1 ± 0.9 lbs, respectively). Although the differences were only marginally significant ($p = 0.09$) on a two-tail test, they indicate that meeting or exceeding the ACSM recommendations were protective against weight gain ($p = 0.045$). This is supported by the evidence presented in the present study, which indicates a strong negative association ($r = -0.851$; $p = 0.03$) between exercise intensity and changes in body weight. Thus individuals who train at harder intensities may gain less weight during their first semester at college.

Twenty-nine of the 63 individuals were followed for an entire academic year (34 weeks or 9 months total) to investigate whether or not weight gain continued throughout the remainder of the first year of college, was maintained or reverted back to baseline. An unexpected outcome of the present study was the observation that the weight gain observed during the first semester was transient in nature, and by the end of one year no significant differences in weight remained. One of the limitations of the literature on freshmen weight gain is that the studies have been conducted over relatively short periods of time (generally one semester). Thus, the information provided by the present study suggesting that weight gain in freshmen may be transient in nature, represents new and important information. A previous study on the notion of “holiday weight gain,” (17) demonstrated very similar findings. The mean weight gain reported in that study was between 0.4 to 0.6 kg (0.88 to 1.3 lbs) over a one-year period.

CONCLUSIONS

The present study demonstrates that a clinically significant amount of weight is gained in the first semester of college and that this weight gain is variable. The data in this study also demonstrates that weight gain in some individuals can be substantial. In addition, the findings in this study suggest that a small amount of exercise may be protective against weight gain in this population. More research using a larger sample size is needed for a better understanding of long-term weight gain in this population. Instilling good nutrition and fitness habits at a time when lifelong habits are being formed could prove to be a powerful method of improving the health of college populations and discouraging this initial college weight gain. Further research should include pilot studies on developing a college level course, which teaches basic nutrition, metabolism, and exercise programming.

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Table 1: Clinical Characteristics of the 63 Study Subjects Studied for 16 Weeks and the Sub-Group of 29 Followed for 1 Year

	N = 63	N = 29
Age (years)	18 ± 0.1	18 ± 0.1
Gender (M/F)	Male 23 / Female 40	Male 13 / Female 16
Weight (lbs.)	Male 165.9 ± 34.3 Female 129.2 ± 19.5	Male 157.8 ± 24.1 Female 130.2 ± 20.9
Body Mass Index (BMI) (kg/m ²)	Male 24.6 ± 4.3 Female 22.5 ± 2.8	Male 23.3 ± 2.5 Female 22.6 ± 2.7
Underweight (BMI < 18.5 kg/m ²)	0M / 1F	0M / 0F
Normal Weight (BMI 18.5– 24.9 kg/m ²)	16M / 32F	11M / 15F
Overweight (BMI 25.0 – 29.9 kg/m ²)	3M / 5F	2M / 0F
Obese (BMI > 30.0 kg/m ²)	4M / 2F	0M / 1F

Table 2: Changes in Body Weight, Body Composition, RMR, Total Energy Intake, and Macronutrient Composition in Diet in 63* College Freshmen**

	Gender	Week 1	Weeks 7-8	Weeks 15-16	P value
Weight (lb)	M	165.9 ± 7.15	170.2 ± 0.51	168.7 ± 7.34	0.002
	F	129.2 ± 3.08	129.4 ± 3.24	131.6 ± 3.21	0.001
Fat Mass (%)	M	20.8 ± 1.27	20.8 ± 1.17	20.5 ± 1.42	0.825
	F	29.4 ± 1.12	29.7 ± 0.98	31.5 ± 1.02	0.002
Lean Mass (%)	M	79.2 ± 1.27	79.1 ± 1.17	79.5 ± 1.42	0.825
	F	70.83 ± 1.12	70.3 ± 0.98	68.6 ± 1.02	0.001
RMR (kcal)	M	1780.0 ± 83.46	_____	1800.5 ± 89.76	0.627
	F	1449.9 ± 31.87		1462.8 ± 36.93	0.580
Total Energy Intake (kcal)	M	2100.4 ± 114.37	_____	2161.6 ± 220.38	0.680
	F	1840.7 ± 98.16		1800.3 ± 74.80	0.763
Fat (g)	M	338.1 ± 70.60	_____	187.0 ± 48.55	0.179
	F	195.9 ± 44.43		135.5 ± 31.25	0.444
Protein (g)	M	84.7 ± 5.02	_____	93.9 ± 10.35	0.474
	F	76.1 ± 6.02		70.1 ± 3.49	0.512
Carbohydrate (g)	M	256.1 ± 18.54	_____	273.3 ± 26.82	0.356
	F	219.8 ± 13.26		241.4 ± 12.39	0.162

- Male = 23; female = 40
- ** Mean ± SD

Table 3: Correlation Coefficients between Changes in Body Weight, Body Composition, RMR and Total Energy Intake of College Freshmen Participants During the 16-Week Study Period

	Correlation Coefficient (r)	P-value
Body Weight vs. RMR	0.472	0.001
Body Weight vs. Fat Mass	0.297	0.019
RMR vs. Fat Mass	0.119	0.355
LM vs. RMR	0.104	0.422
Total Energy Intake vs. Body Weight	0.203	0.126
Total Energy Intake vs. RMR	0.094	0.481
Total Energy Intake vs. Fat Mass	0.108	0.423

Table 4: Exercise Patterns Among 36 First Semester Freshmen Students

	Frequency	Percent (%)
Met or exceeded ACSM minimum guidelines entire semester †	Males 7 Females 8	Males 36.8 Females 47.1
Played a sport in high school	Males 5 Females 10	Males 26.3 Females 58.8
Performed at least 1 day of exercise	Males 12 Females 12	Males 63.2 Females 70.6
Performed resistance training only	Males 1 Females 0	Males 8.3 Females 0
Performed aerobic exercise only	Males 4 Females 4	Males 33.3 Females 33.3
Performed resistance and aerobic exercise	Males 7 Females 8	Males 58.3 Females 66.7
Exercise intensity 5 or greater‡	Males 10 Females 11	Males 83.3 Females 91.7

† ACSM recommends that healthy adults should perform aerobic exercise 3 to 5 days a week at 40% or 50% to 85% of their maximum oxygen uptake reserve (moderate to vigorous physical activity, respectively) for 20 to 60 minutes (ACSM, 2004).

‡ Descriptions of intensities are as follows: 5= I'm slightly uncomfortable, but can still talk easily; 6 = I can still talk, but am slightly breathless; 7 = Talking is difficult, I can't finish a sentence without taking a breath; 8 = I can utter a response to your question, and I can only keep this pace for a short time period; 9 = I feel nauseous and I can hardly breath; 10 = If I keep this pace one more second I will black out.

Table 5: Changes in Weight, Fat Mass, Lean Mass, and RMR in College Freshmen Who Followed the American College of Sports Medicine (ACSM) Recommendations for Exercise and Those Who Did Not

	Exercised <3 Days/Wk for 20+ Minutes/Workout	Exercised ≥ 3 Days/Wk for 20+ Minutes/Workout	P-value
Change in Weight (lbs)	3.1 ± 0.855	0.79 ± 1.05	0.094
Change in Fat Mass (%)	0.47 ± 0.82	1.06 ± 1.17	0.341
Change in RMR (kcal)	13.8 ± 220.7	-1.6 ± 136.5	0.399

Table 6: Changes in Body Weight in 29 Freshmen Students a 16 Weeks, and at 1 Year Follow-up

	Baseline	16 weeks	P value*	1 year	P value**
Weight (lbs)	142.6 $\pm$ 26.0	144.6 $\pm$ 27.3	0.014	143.4 $\pm$ 27.6	0.269
BMI (kg/m ²)	22.5 $\pm$ 2.7	22.9 $\pm$ 2.9	0.017	22.7 $\pm$ 3.0	0.307

* = comparison between baseline and 16-weeks

** = comparison between baseline and 1 year

Figure 1. Individual Changes in Body Weight in 63 First Semester Freshmen

Figure 2. Changes in Body Weight in 29 Freshmen Students at 16 Weeks (a), between 16 Weeks and 1 Year (b), and at the End of 1 Year (c)

a.

b.

Figure 2. Changes in Body Weight in 29 Freshmen Students at 16 Weeks (a), between 16 Weeks and 1 Year (b), and at the End of 1 Year (c)

c.

CHAPTER 3
SUMMARY AND RECOMMENDATIONS
REFERENCES

Summary and Recommendations

National data on weight gain in the United States indicate that weight loss programs are ineffective; therefore, targeting when weight is gained is imperative to maintaining a healthy weight. Previous studies have demonstrated an average weight gain of 3-7 lbs. during the first year of college. Data from this study support the established belief that individuals gain a clinically significant amount of weight during their first semester of college. The average weight gain in the present study was 2.5 ± 0.5 lbs. Weight gain was highly variable between individuals and was substantial in some participants. Seventy-five percent of the individuals gained weight and 38% of the participants gained 5 or more lbs. Baseline weights did not appear to have any impact on the amount of weight that was gained. Although the participants in this study gained a clinically significant amount of weight during their first semester, as a group, this weight gain appeared to be transient in nature, and was no longer significant after one year. Of importance, approximately half of the participants maintained their weight gain after one year, supporting the belief that freshmen students are at risk for weight gain.

The nature of how weight is gained was also studied in this population. The data showed that females gained their weight in predominantly fat mass while males gained equally in fat and lean tissue. This new information suggests that females may be at a greater risk for weight related diseases than men in this population.

The present study observed how energy balance affected weight gain. There were no significant differences in energy or macronutrient intake among this study population. There were, however, differences in exercise habits between individuals. Evidence from

this study suggests that a small amount of exercise may be protective against weight gain that commonly occurs during the first semester of college. Data from this study also suggests that the more intense the exercise, the more protective.

In order to lose or maintain weight, it is important to know daily caloric needs. The present study compared five methods of estimating TEE. Although the present study does not allow these methods to be compared with “true” RMR, the results indicate that all five methods provide reasonably similar estimates, with strong significant correlations among the techniques. Moreover, they suggest that $Kg^{0.75}$, Harris-Benedict, and Mifflin / St. Jeor, which do not require expensive equipment, closely predict RMR estimated by either O_2 or BIA. Therefore, $Kg^{0.75}$, Harris-Benedict and Mifflin / St. Jeor can be more affordable, useful tools for providing caloric recommendations to healthy, young adults. These estimates can then be used to prescribe appropriate caloric recommendations for young healthy persons seeking weight loss or maintenance.

More research using a larger sample size is needed for a better understanding of long-term weight gain in this population. Instilling good nutrition and fitness habits at a time when lifelong habits are being formed could prove to be a powerful method of improving the health of college populations and discouraging this initial college weight gain. Further research should include pilot studies on developing a college level course, which teaches basic nutrition, metabolism, and exercise programming. Metabolic body size, Harris-Benedict and Mifflin/St. Jeor equations, can be utilized in these courses to estimate caloric needs of freshmen students and provide important awareness of energy balance and weight maintenance.

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APPENDIXES

APPENDIX A

IRB Approval

San José State
UNIVERSITY

**Office of the Academic
Vice President
Academic Vice President
Graduate Studies and Research**

Office of the Academic Vice President
San José State University
One Washington Square
San José, CA 95192-0120
Phone: (408) 939-1200
Email: academic@sjstate.edu

To: Dr. Tawni Holmes
College of Applied Sciences and Arts
Nutrition and Food Science
San José State University
One Washington Square
San José, CA 95192 - 0120

From: Nabil Ibrahim,
AVP, Graduate Studies & Research

Date: June 3, 2003

This letter acknowledges that the Human Subjects-Institutional Review Board has received the request for extension of the following study:

“Nutritional Changes of Incoming Freshman College Students.”

Since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one-year extension effective from the date of this letter. Data collection beyond June 3, 2004 requires an extension request.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.

The California State University:

San José State University
One Washington Square
San José, CA 95192-0120
Phone: (408) 939-1200
Email: academic@sjstate.edu

APPENDIX B

Consent Form

San José State
UNIVERSITY

College of Applied
Sciences and Arts
Nutrition and Food Science
Central Classroom Bldg. 200

Dr. Clarie Hollenbeck
Dr. Tawni Holmes
San José, CA 95128
Phone: (408) 281-1111

Agreement to Participate in Research

Responsible Investigators: Clarie Hollenbeck, and Tawni Holmes

Title of Protocol: Nutritional Changes of Incoming College Freshman Students

I have been asked to participate in a research study investigating dietary and nutritional changes that occur in incoming college freshman students.

I will be asked to keep 3-day dietary records on three separate days during the Fall semester occasions (beginning, middle and end). In addition, I will be asked to fill out a shortened version of a food frequency questionnaire at the beginning and end of the study period. I will also have nutritional measurements made of my resting energy expenditure, body weight and body composition at three times during the semester, corresponding to the three-day dietary records. Resting energy expenditure is a measurement of my energy requirement during rest and is made by measuring the amount of oxygen I used over the course of a few minutes. The measurement is made by having me breath into a mouthpiece attached to a device that measures oxygen. Body composition will be measured by a standard bioelectrical impedance apparatus. This is a computer device that estimates percent body fat and lean body mass (non-fat components of my body). Two electrode patches similar to electro-cardiographic patches will be placed on one of my hands and one of my feet, and the resistance to the flow of a small electrical current (from the computer) between the two patches will provide an estimate of my body composition. Both of these two measurements require only a few minutes of my time (less than 15 minutes).

I understand that the risk involved in participating in this study is very low and would not be greater than the risk encountered in everyday life.

I understand that I will receive no direct benefit from the study. However, my participation will help advance our understanding of dietary changes faced every year by freshman starting college.

I also understand that my personal information obtained from my participation in this study, will be shared with me, but will not be disclosed to any other sources in a manner that would identify me in any manner without my explicit written permission. I also understand that the results of this study may be published but no information will be released in a manner that could identify me or any of the subjects participating in this study.

I understand that I will receive no compensation for participating in this study.

_____
(subject's initials)

San José State University
1000 S. San Carlos Ave.
San José, CA 95128
Phone: (408) 281-1111
Fax: (408) 281-1111
Web: www.sjsu.edu

I understand that if I have any questions about this research that I am expected to ask them of the principle investigators Drs. Hollenbeck, Holmes and Sucher at (408) 924-3100. Complaints about the research may be presented to Dr McProud (Chair, Department of Nutrition and Food Science (408) 924-3100). Questions about research, subjects' rights, or research-related injury may be presented to (Nabil Ibrahim, PH.D.) Associate Vice President for Graduate Studies and Research, at (408) 924-2480.

I understand that my participation in this study is strictly voluntary and that I may refuse to participate in any part of the study or to withdraw from the study at any time without prejudice to myself or my relationship to San Jose State University or any other participating institution; and, that my decision to not participate or to withdraw from the study will not cause me to lose any services to which I would otherwise be entitled.

I understand that the information gathered from this research study will only be valid if I complete the entire program, including all the metabolic measurements made and record by dietary food intake accurately and completely on the three occasions.

I acknowledge that I have received a signed and dated copy of this consent form.

- My signature on this document indicates my agreement to participate in the study.
- The signature of one of the investigators on this document indicates agreement to include the named subject in the research and attestation that the subject has been fully informed of his or her rights

---

Signature (Participant)

Date

Signature (Investigator)

Date

APPENDIX C

Exercise Surveys

Exercise Questions for Frosh Study, Semester 1, #1

1. Did you play sports in high school? If yes, what sport, and did you play your senior year?

0 Yes
1 No

2. Did you take a PE class during your last semester (in high school)?

0 Yes
1 No

3. Do you work? 0 = yes; 1 = no

Is your job:

- 0 Sedentary (seated most of the day)
1 Moderately active (stand most of the day, e.g.: grocery checker)
2 Active (walking, lifting, squatting throughout the entire day, e.g.: waitress)
3 Very active (Lifting heavy objects all day, e.g.: lumber jack)

4. If you work, how many hours a week do you work?

0 0
2 1 – 15
3 16 – 30
4 31 +

5. Did you do any type of exercise over the summer? 0 = yes; 1 = no

If yes, what type?

a. Cardiovascular:

Type of exercise:

Duration:

0 <20 minutes

1 >20 minutes

ii. Number of days per weeks:

0

1

2

3

4

5

6

7

iii. Number of weeks exercise was consistently performed:

0 1-4

1 5-8

2 9-12

iv. Intensity Level: 1-10__ (From exercise intensity scale on last page)

b. Resistance Training:

i. Number of days/week:

0

1

2

3

4

5

7

ii. Number of weeks exercise was consistently performed:

0

1 1-4

2 5-8

3 9-12

iii. Number of sets (total/workout):

- 0 <8
- 1 8-10
- 2 11+

iv. Number of reps:

- 0 <8
- 1 8-12
- 2 13+

c. Other (such as an organized sport or yoga): type of exercise:

i. Duration:

- 0 <20 minutes
- 1 >20 minutes

ii. Number of days/week:

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

6. Do you exercise now?

0 = yes; 1 = no

If it is different than the summer or your senior year of high school, in what way(s) is it different?

- 1 Decrease
- 2 Same
- 3 Increase

7. What do you do for exercise right now?

a. Cardiovascular:

Type of exercise:

Duration:

0 <20 minutes

1 >20 minutes

ii. Number of days per weeks:

0

1

2

3

4

5

6

7

iii. Number of weeks exercise was consistently performed:

0 1-4

1 5-8

2 9-12

iv. Intensity Level: 1-10_____ (From exercise intensity scale)

b. Resistance Training:

i. Number of days/week:

0

1

2

3

4

5

6

7

ii. Number of weeks exercise was consistently performed:

0

1 1-4

2 5-8

3 9-12

iii. Number of sets (total/workout):

- 0 <8
- 1 8-10
- 2 11+

iv. Number of reps:

- 0 <8
- 1 8-12
- 2 13+

c. Other (such as an organized sport or yoga): type of exercise:

i. Duration:

- 0 <20 minutes
- 1 >20 minutes

ii. Number of days/week:

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

8. (If you currently exercise) Why do you exercise? (if more than one reason, rank them in order of preference with 1 being your 1st reason and so on.

- 0 Weight control: yes/no **rank** _____
- 1 Stress management: yes/no **rank** _____
- 2 You enjoy it: yes/no **rank** _____
- 3 You want to build muscle: yes/no **rank** _____
- 4 Other: _____

Exercise Intensity Scale

- Level 1: I'm watching TV
- Level 2: I'm comfortable and could maintain this pace all day long
- Level 3: I'm still comfortable, but am breathing a bit harder
- Level 4: I feel good and can carry on a conversation effortlessly
- Level 5: I'm slightly uncomfortable, but can still talk easily
- Level 6: I can still talk, but am slightly breathless
- Level 7: Talking is difficult, I can't finish a sentence without taking a breath
- Level 8: I can utter a response to your questions and I can only keep this pace for a short time period.
- Level 9: I feel nauseous and I can hardly breathe.
- Level 10: If I keep this pace one more second I will black out

Exercise Questions for Frosh Study, Semester 1 & 2, #2

1. Did you exercise throughout the entire semester? If yes, was it different than the beginning of the year? Did your exercise:

- 1 Decrease
- 2 Same
- 3 Increase

2. Average number of days per week exercised:_____

3. Average number of minutes exercise:_____

4. Average intensity exercised: (1-10) _____ (from intensity scale on last page)

5. Do you work? 0 = yes; 1= no   **Is your job:**

- 0 Sedentary (seated most of the day)
- 1 Moderately active (stand most of the day, e.g.: grocery checker)
- 2 Active (walking, lifting, squatting throughout the entire day, e.g.: waitress)
- 3 Very active (Lifting heavy objects all day, e.g.: lumber jack)

6. If you work, how many hours a week do you work?

- 0 0
- 1 1 – 15
- 2 16 – 30
- 3 30 +

7. Do you currently exercise? 0 = yes; 1= no

If yes, what type?

a. Cardiovascular:

Type of exercise:

i. Duration:

0 <20 minutes

1 >20 minutes

ii. Number of days per weeks:

0

1

2

3

4

5

6

7

iii. Number of weeks exercise was consistently performed:

0 1-4

1 5-8

2 9-12

iv. Intensity Level: 1-10_____ (From exercise intensity scale)

b. Resistance Training:

i. Number of days/week:

0 1

1 2

2 3

3 4

4 5

5 6

6 7

ii. Number of weeks exercise was consistently performed:

0

1 1-4

2 5-8

3 9-12

iii. Number of sets (total/workout):

- 0 <8
- 1 8-10
- 2 11+

iv. Number of reps:

- 0 <8
- 1 8-12
- 2 13+

b. Other (such as an organized sport or yoga): type of exercise:

i. Duration:

- 0 <20 minutes
- 1 >20 minutes

ii. Number of days/week:

- 0
- 1
- 2
- 3
- 4
- 5
- 6

10 (If you currently exercise) Why do you exercise? (if more than one reason, rank them in order of preference with 1 being your 1st reason and so on.

- 0 Weight control: yes/no rank _____
- 1 Stress management: yes/no rank _____
- 2 You enjoy it: yes/no rank _____
- 3 You want to build muscle: yes/no rank _____
- 4 Other: _____

Exercise Intensity Scale

- Level 1: I'm watching TV
- Level 2: I'm comfortable and could maintain this pace all day long
- Level 3: I'm still comfortable, but am breathing a bit harder
- Level 4: I feel good and can carry on a conversation effortlessly
- Level 5: I'm slightly uncomfortable, but can still talk easily
- Level 6: I can still talk, but am slightly breathless
- Level 7: Talking is difficult, I can't finish a sentence without taking a breath
- Level 8: I can utter a response to your questions and I can only keep this pace for a short time period.
- Level 9: I feel nauseous and I can hardly breathe.
- Level 10: If I keep this pace one more second I will black out

Exercise Questions for Frosh Study, Semester 2, #1

1. Do you work? 0= yes; 1= no   Is your job:

- 0 Sedentary (seated most of the day)
- 1 Moderately active (stand most of the day, e.g.: grocery checker)
- 2 Active (walking, lifting, squatting throughout the entire day, e.g.: waitress)
- 3 Very active (Lifting heavy objects all day, e.g.: lumber jack)

2. If you work, how many hours a week do you work?

- 0 0
- 1 1 - 15
- 2 16 – 30
- 3 30 +

3. Do you currently exercise? 0 = yes; 1= no
If yes, what type?

- c. Cardiovascular:
Type of exercise:
  - i. Duration
    - 1 = <20 minutes
    - 2 = >20 minutes

ii. Number of days per weeks:

0
1
2
3
4
5
6
7

ii. Number of weeks exercise was consistently performed:

0
1-4
5-8
9-12

iii. Intensity Level: 1-10_____ (From exercise intensity scale)

d. Resistance Training:

i. Number of days/week:

0
1
2
3
4
5
6
7

ii. Number of weeks exercise was consistently performed:

0
1-4
5-8
9-12

iii. Number of sets (total/workout):

<8
8-10
11+

iv. Number of reps:

<8
8-12
13+

e. Other (such as an organized sport or yoga): type of exercise:

i. Duration:

0 <20 minutes
1 >20 minutes

ii. Number of days/week:

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

4. (If you currently exercise) Why do you exercise? (if more than one reason, rank them in order of preference with 1 being your 1st reason and so on.

- 0 Weight control: yes/no rank _____
- 1 Stress management: yes/no rank _____
- 2 You enjoy it: yes/no rank _____
- 3 You want to build muscle: yes/no rank _____
- 4 Other: _____

Exercise Intensity Scale

- Level 1: I'm watching TV
- Level 2: I'm comfortable and could maintain this pace all day long
- Level 3: I'm still comfortable, but am breathing a bit harder
- Level 4: I feel good and can carry on a conversation effortlessly
- Level 5: I'm slightly uncomfortable, but can still talk easily
- Level 6: I can still talk, but am slightly breathless
- Level 7: Talking is difficult, I can't finish a sentence without taking a breath
- Level 8: I can utter a response to your questions and I can only keep this pace for a short time period.
- Level 9: I feel nauseous and I can hardly breathe.
- Level 10: If I keep this pace one more second I will black out