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RELATIONSHIP BETWEEN DIETARY INTAKE, FITNESS LEVEL, AND BODY COMPOSITION IN COLLEGE-AGED STUDENTS

by

Garrett J. Serd

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Nutrition and Health Sciences

Under the Supervision of Professor Wanda Koszewski

Lincoln, NE

June, 2012

RELATIONSHIP BETWEEN DIETARY INTAKE, FITNESS LEVEL, AND BODY COMPOSITION IN COLLEGE-AGED STUDENTS

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University of Nebraska, 2012

Advisor: Wanda Koszewski

BACKGROUND The overweight and obesity rates have risen to epidemic proportions in all age groups in the United States, especially in those approaching the college years of life. Differences in macronutrient composition of the diet may have an influencing effect on the epidemic of obesity; however, further research is needed.

OBJECTIVES To determine the strength of correlation between eating patterns differing in carbohydrate (CHO) content and body fatness among college-aged students.

SETTING Participants completed several nutrition consultation forms, underwent a body composition analysis and performed four fitness tests at a university located in the Midwestern United States.

PARTICIPANTS 162 college-aged students enrolled in Nutrition 100 courses during the spring and fall 2011 semesters at a Midwestern university.

METHODS An automated self-administered 24-hour recall system was used to obtain caloric and macronutrient data from participants. The three-site skin fold method procedure was used to collect data on body composition and protocols for fitness tests followed the standards published in the YMCA Fitness Testing and Assessment Manual, 4th Ed.

RESULTS No significant association was found between a high carbohydrate eating pattern and any measure of adiposity. Carbohydrate intake, expressed as a percentage of total calories, was inversely related to both BMI (p = .009) and LBM (p = .023), while protein intake was positively associated with LBM (p = .032). None of the independent fitness tests were significantly associated with any of the classifications of carbohydrate intake; however, when fitness data was analyzed into a composite score, there was a significant, inverse correlation found between carbohydrate intake and 1.5-mile run time.

CONCLUSIONS AND IMPLICATIONS College-aged students consuming diets that are high in carbohydrate do not have more fat mass compared to students consuming diets that are low or moderate in carbohydrate. Based on these results, registered dietitians or other health professionals should use caution when advocating a low carbohydrate eating pattern as the primary treatment of prevention of excess adiposity in college-aged students.

ACKNOWLEDGEMENTS

I would like to, first and foremost, thank my Almighty God for giving me the opportunity to attend graduate school at the University of Nebraska-Lincoln, and for all His gifts, talents, and acts of discipline He has bestowed upon me that has allowed me to persist diligently throughout this journey one step at a time. Without Him, none of this would have been possible. In that regard, I would also like to send gratitude my loving parents – Tim and Betsy Serd – for allowing me to chase after my dreams by giving me their incessant love and support.

To my friend, adviser, mentor and colleague – Dr. Koszewski – who supported me immeasurably throughout this experience and who provided me with the confidence, knowledge, and tools that I needed to effectively and successfully carry out this task to the best of my ability, thank you very, very much. Also, a special thank you to Dr. Shinya Takahashi and Dr. Jeffrey Rudy for also taking the time and effort to serve on my thesis committee. I truly appreciate all the guidance and support given to me by each of my committee members.

And lastly, I would also like to thank Dustin Nitz, Chelsea Munoz, Katie Willet, Korey Van Wyk, the 2011-2012 UNL dietetic interns and any one else who took part in the data collection process. This paper would not have been possible without your selflessness, generosity and hard work.

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CHAPTER I

INTRODUCTION

America and the Obesegenic Environment

Over the past several decades, the overweight and obesity rates have risen to epidemic proportions in all age groups in the United States. Between 1980 and 2008, the prevalence of obesity among children aged 6 to 11 years nearly tripled from 7% to 20% (1) and the prevalence of overweight and obesity among the American adult population aged 20 to 74 increased from 47% to 68% (2). However, the largest increase in obesity during this time period, with rates more than tripling from 5.0% to 18.1%, was observed in the adolescent population approaching the college years of life (1).

Being overweight or obese during childhood directly increases the risk of developing high cholesterol, high blood pressure, type 2 diabetes, respiratory ailments, musculoskeletal discomfort, fatty liver disease, and psychosocial problems as a youth (3-7). Adolescents who are obese are not only at a higher risk for developing these conditions at a young age, but they are also seventy-percent more likely to become obese as an adult compared to their normal weight counterparts, which further increases their chances of carrying these debilitating conditions into their adult years (8). Furthermore, significant economic costs are also coupled with this life-threatening condition. In 2008 alone, the direct medical costs for obesity were estimated at a staggering $147 billion, with 16% of the total expenses directed solely towards hospital costs incurred from childhood obesity (9). If the incidence of obesity continues to increase at this rate, the projected health-care costs would double every decade to 861-959 billion dollars by the year 2030, which would account for 16% to 18% of all medical expenses (10). The

development of dietary- and physical activity-based interventions aimed specifically at young adults who are progressing through their college years of life may help reduce the transition and continuation of excess adiposity from adolescence into adulthood and thereby lessen the future economic burden this condition has on future generations.

The accumulation of excess adipose tissue is simply the result of an energy imbalance – a chronic state of energy intake exceeding energy expenditure – primarily due to unhealthy eating patterns, a lack of physical activity, or a combination of the two. One specific dietary component that has recently emerged as a primary causative agent for this nationwide trend in obesity is the consumption of a high-fat, Western-style diet (11). Consuming diets that are high in fat have been cautioned against due to their adverse effects on body weight maintenance and cardiovascular functioning. However, national trends in dietary intake reveal that since the 1970's – the approximate time period in which the American public was advised to consume a low-fat diet for the prevention of heart disease – the percentage of energy consumed from fat drastically decreased (12) while concomitant and significant increases were observed in the rates of obesity and deaths related to heart disease (13), which highlights the notion that differences in the macronutrient composition of the diet may have an influencing effect on the development of obesity.

Furthermore, physical activity, which is another major component in this metabolic equation, is a key prevention factor for not only the prevention of cardiovascular disease (CVD) but also for overweight and obesity. Participation in daily physical activities is correlated with higher aerobic fitness levels (14) and lower levels of body fat (15). Despite the recent rise in obesity, physical activity patterns among

adolescents have remained relatively stable throughout the past decade (16), which further questions the role different dietary factors have in the progression of obesity and clearly signifies the need for further investigation.

Purpose:

The purpose of this study is to examine data collected on dietary intake, fitness parameters, and body composition from college-aged students attending a University located in the Midwestern region of the United States to determine if there are any implications between eating patterns differing in carbohydrate content (high [> 55% of total calories]; moderate [45-55% of total calories]; or low [< 45% of total calories]) and body fatness - dependent on fitness level. Results from this study will help reveal the need for the development and implementation of nutritional interventions in this specific area.

Hypothesis:

Among the sample of college-aged students selected from the University of Nebraska-Lincoln's Nutrition 100 courses during the spring and fall 2011 semesters, those consuming a diet with a carbohydrate intake that comprises more than 55% of his or her total caloric value will have significantly (p <.05) more fat mass compared to students with carbohydrate intakes that do not exceed the 55% margin.

Objectives:

1. To determine the correlation between eating patterns differing in carbohydrate content and body fatness among college-aged students.
2. To determine if college students consuming a low carbohydrate diet have more lean body mass and less body fat compared to students consuming a high carbohydrate diet.
3. To determine if college students consuming a diet consisting of a carbohydrate-to-protein ratio (CHO/PRO) of less than or equal to 2.0 have more lean body mass and less body fat compared to students consuming a diet consisting of a CHO/PRO greater than to 2.0.

CHAPTER II

LITERATURE REVIEW

Dietary and Physical Activity-Based Recommendations for College-Aged Students

Healthy eating and physical activity patterns are important components in the lives of students and have shown to be positively correlated with academic success (17, 18). For example, students engaged in healthful eating practices are less likely to be absent from school and more likely to score higher on cognitive functioning tests (19). Research also suggests that students who are physically active have higher brain function, higher levels of attentiveness and self-esteem, and behave more appropriately in a classroom setting (20,21). It is a priority that students of all ages adhere to their age appropriate nutrition and physical activity-based recommendations to enhance their learning potential and overall health. However, it is particularly important for college-aged students to develop and sustain sound eating and exercise habits early in their college careers as lifestyle habits established during this time period are likely to carry forward into the adult years and have a critical impact on future outcomes of health and disease susceptibility (22).

Dietary and physical activity-based recommendations for the college-aged population are based on the specifications set forth by the Dietary Guidelines for Americans. Specific recommendations for energy and macronutrient (carbohydrate, fat, and protein) content of the diet should closely reflect the recommendations from the Dietary Guidelines, but should also be based on the Dietary Reference Intakes (DRI) and the Recommended Dietary Allowance (RDA), according to the appropriate age, gender and life-stage group. Knowing, understanding, and applying these health-based

guidelines on a daily basis is vital for achieving success in body weight regulation and disease prevention throughout the lifecycle.

According to the DRI reports, physically active males and females over the age of 18 years should consume approximately 3,000 and 2,400 kilocalories each day depending on their level of physical activity (23). Maintaining an adequate intake of energy is imperative to sustain the normal physiological functions of the body such as respiration, circulation, and physical work. However, the concept of energy balance is a commonly misunderstood and overlooked term in regards to body weight maintenance among the young-adult population and may be a potential limiting factor in the achievement of desirable body weight goals (24).

Carbohydrates serve as an important energy source for the body especially during periods of intense, anaerobic activity. Carbohydrate consumption enhances cognitive processes such as memory and attention (25), which may be beneficial for students striving for academic success. The RDA for dietary carbohydrates, which is based on its role as the brain's primary source of energy, is 130 grams per day for males and females (23). However, for maintenance of body weight, it is recommended that total carbohydrate intake each day comprise approximately 45%-65% of an individual's total caloric intake (23).

Dietary fat is macronutrient that is also a vital energy source for the human body, but is found to be largely over consumed among college-aged students (26,27). During periods of caloric restriction, dietary fat is often the first macronutrient to be limited due to its high caloric density. However, dietary fats are also sources of essential fatty acids that must be obtained through the diet in adequate amounts to prevent nutritional

deficiencies and to maintain a variety of the body's biological processes. Approximately 20%-35% of the total daily calories consumed by male and female college students should be from dietary fat (23).

Lastly, it is recommended that college-aged individuals consume 10%-35% of their total energy intake from dietary protein (23). To achieve nitrogen balance, the RDA for protein has been set at 0.8 g/kg of body weight for both men and women. However, recent evidence suggests that dietary protein intakes above the RDA are beneficial for maintaining muscle function and mobility (28) and in the treatment of health-related conditions such as obesity and type 2-diabetes (29,30). Furthermore, it has been established that individuals participating in strength and endurance events have slightly higher protein requirements (1.2-1.7g/kg body weight) due to increased protein losses that occur during training and competition (31).

In conjunction with a balanced and varied diet that coincides with the above-mentioned recommendations, college-aged students need to balance the other side of the energy balance equation with physical activity. For persons 18 to 64 years of age who are seeking substantial health benefits, it is recommended to engage in at least 150 minutes of moderately intense activity per week or 75 minutes of vigorous aerobic activity per week (32). For those requiring more extensive health benefits, physical activity should be increased to 300 minutes per week (32). Furthermore, muscle-strengthening activities that involve all of the body's major muscle groups, such as a total body resistance-training program, are recommended on two or more days of the week.

However, in regards to the nutrition and physical-activity-based recommendations previously listed, it is important to acknowledge and take into consideration that

individual metabolic responses to different macronutrient compositions may vary as well as the effects they may elicit on an individual's health status and body composition. For example, the degree to which an individual is sensitive to the effects of insulin ultimately determines the deposition rate and storage location of ingested nutrients. Decreased glucose disposal rates are independent risk factors for obesity and cardiovascular disease (33) and are known to vary according to an individual's gender (34), ethnic background (35), and distribution of adipose tissue, especially in the abdominal region (34). Furthermore, the involvement in certain behavior practices such as endurance training may increase one's sensitivity to insulin (36) and allow the body to become more efficient at utilizing stored lipids as energy during higher aerobic thresholds (37). Thus, diet, physical activity, and genetic influences have independent roles in the way in which the body processes and utilizes nutrients for energy and must be accounted for before prescribing individual recommendations.

Dietary Patterns Among College-Aged Students

The unique social and physical environment that comprises college-life exerts a powerful and potentially life-long influence on the eating behaviors of young adults. It has been well established that the majority of students attending college are not adhering to the nutrient guidelines advocated by the Dietary Guidelines for Americans (27,38). The typical diet of college students consists of foods that are high in fat (26,27) and sodium and low in fruits, vegetables, and dairy products (39). Additionally, findings propose that the diets of college students are also lacking in fiber (38), which, along with the other unfavorable eating habits mentioned may compromise the future health status of

individuals if carried into the adult years. Though, differences in nutritional intake of students have been observed according to their place of residency. For example, research suggests that college students living off campus have significantly higher overall intakes of energy and protein compared to students living on campus (40), which may be due in part to the idea that students living off campus are more apt to purchase food items from fast food restaurants to meet their dietary needs. Furthermore, one benefit to living on-campus is the opportunity to participate in a prepaid meal plan offered by the institution's cafeteria and food courts. Research investigating the relationship between diet quality and involvement in a prepaid meal plan revealed that students not participating in a meal plan had lower intakes of vegetables, fruit, milk, and meat compared to those with a prepaid meal plan (41), which further supports the concept that students living off campus may be more likely to replace foods from these essential food groups with nutritionally inferior items offered by fast food restaurants or other easily accessible convenience type-stores.

The eating patterns of college students are often disrupted by their irregular class schedules, part-time jobs, variable homework loads and erratic sleeping patterns. As a result of their inconsistent eating patterns, many college students develop the habit of snacking mindlessly throughout the day to temporarily curb their appetite. Students purchasing snack items on college campuses are usually limited to those that are available in vending machines or from on-campus convenience stores. These overpriced food items are usually high in energy and low in nutritional value, which may be a contributing factor to the unhealthy diets commonly seen among college students.

Weight change, either through natural or purposeful means, is frequently observed in students throughout the college years. A common nutritional behavior employed by many students to control or reduce their weight has consisted of restricting calories, mainly in the form of skipping meals, particularly breakfast. However, research shows that individuals who skip breakfast are more likely to have a higher body mass index (BMI) compared to those who eat breakfast (42). Furthermore, other studies exploring the relationship between BMI and meal pattern behaviors reveal that students with higher BMI's eat less vegetables – especially green leafy vegetables – and dairy products and more meat products on a daily basis compared to those with a lower BMI (43).

These unhealthy eating patterns commonly seen among college students regardless of BMI should not be ignored because research has shown that the dietary habits adopted throughout the college years are likely to be internalized and potentially develop into lifelong behavioral practices, which, if continued, may exert a strong influence on the future health and well-being of individuals (44). Therefore, education that encompasses personalized strategies to adopt healthy eating behaviors should be the forefront of intervention in order to obtain long-term success in weight management and disease prevention.

Physical Activity Benefits and Behaviors Among College-Aged Students

One of the physical activity objectives stated in Healthy People 2020 is to increase the proportion of adolescents who meet current Federal physical activity guidelines for aerobic and muscle-strengthening activities from 18.4% to 20.2% (45). There are important reasons for this. Both physical activity and physical fitness are strong determinants in health outcomes. For instance, exercise training is associated with

a beneficial change in both fat mass and lean body mass (LBM), (46) an increase in insulin sensitivity (36) and a reduction in the presence of circulating inflammatory markers (47). Collectively, these effects from exercise can decrease an individual's risk for developing diseases – especially those associated with the cardiovascular system – if the exercise routine is maintained within one's daily lifestyle while jointly following a healthy, well-balanced nutrient plan. Furthermore, from a student's perspective, regular involvement in physical activity can help manage stress levels, improve mood, reduce depression and anxiety, and enhance both academic behavior and potential.

Given these known benefits, one would expect that students as well as individuals in the general population would over indulge in various types of activities that promote physical fitness. However, recent data suggests that only about half of all college students are physically active (48). Furthermore, evidence from epidemiological research reveals that the level of physical activity among students declines substantially from high school to college (49). More specifically, research that has examined this phenomenon found that 77.67% to 81.3% of college students reported engaging in adequate amounts of vigorous physical activity (VPA) during their high school years; while, only 64.8% to 67.2% of those students reported maintaining a similar level of VPA throughout their college career (50). This downward trend in VPA may be due in part to the higher level of sports participation that is encouraged throughout high school; however, it still well recognized that the cognitive demands and social pressures placed upon students throughout college can negatively affect their ability to maintain a consistent exercise schedule.

Factors that can discourage an active lifestyle in a college environment include hectic class and work schedules, lack of discretionary time, social pressures from friends or family, crowded college gyms, and an over reliance on buses or other easily accessible motored vehicles for transportation. Various cognitive determinants such as self-efficacy, perceived enjoyment of physical activity and self-motivation are also known to influence an individual's internal desire to maintain a consistent exercise regime (48). Of the previous variables listed, special attention has been given to self-efficacy, as it has known to be highly correlated with participation in physical activity (51). Students who are unconfident or unsure of their ability to correctly perform or complete an exercise are less likely to take part in such activities, which highlights the importance of having support from peers or other social networks to encourage physical activity regardless of experience. Moreover, higher educational settings should continue to develop health promotion strategies and interventions to encourage students of all fitness and experience levels to embark on and maintain a healthy level of physical activity despite the known barriers that are present in a college environment.

Macronutrient Composition of the Diet and Body Composition

An imbalance in energy, regardless of macronutrient composition, will result in a net gain or loss in body mass. This simple energy equation is the cornerstone that drives the regulation of weight in all living species. In this context, the typical dietary intervention that is commonly implemented for weight reduction in an obese population is a low-fat, high-carbohydrate (45%-60% of total calories) diet that is energy restricted. However, the escalating rates of obesity since the 1970's, which has been primarily

attributed to the significant increase in the intake of dietary carbohydrates (52), have fueled a resurgence in the public's interest for modifying the macronutrient composition of the diet to ward off obesity and augment body composition. However, an ideal ratio of dietary carbohydrate, protein, and fat for weight maintenance and disease prevention purposes has yet to be established, but is still under intense investigation. Though, the few experimental studies that do provide evidence in this area suggests that the proportion of carbohydrate in the diet in relation to the other macronutrients, specifically protein, may have an important influence on an individual's BMI and body fat percentage (53-55). To be more specific research proposes that dietary patterns with low ratios of carbohydrate-to-protein (CHO/PRO) elicit more favorable effects on body composition compared with diets composed of higher ratios of CHO/PRO (53-55).

For example, Layman et al. (53) found support for this proposition by examining the efficacy of weight loss between two separate isoenergetic diets differing only in the ratio of carbohydrate-to-protein (CHO/PRO) in which obese adult were randomly assigned to either a CHO Group (CHO/PRO – 3.5:1; 56% CHO, 16% PRO, 28% Fat) or a Protein Group (CHO/PRO – 1.4:1; 41% CHO, 33% PRO, 26% Fat) for ten weeks. The researchers found that weight loss after a ten week period did not differ significantly between groups (CHO Group -6.96 kg vs. Protein Group -7.53 kg); however, the authors found that weight loss in the Protein Group was partitioned to a significantly higher loss of fat/lean tissue compared to the CHO Group, indicating that an increased proportion of PRO/CHO in the diet has positive effects on body composition by its ability to improve the utilization of body fat for oxidation while retaining lean body mass during times of caloric restriction.

Skov et al. (54) found similar results by randomly assigning 65 healthy, overweight and obese adults to either a high carbohydrate (HC) diet (CHO/PRO – 4.8:1; 58% CHO, 12% protein, 30% fat) or a high protein (HP) diet (CHO/PRO – 1.8:1; 45% CHO, 25% protein, 30% Fat) for a total of six months. The subjects were allowed to consume the food – which was provided for them by the researchers – under *ad libitum* conditions. After the six month intervention, results revealed that participants receiving the high protein diet consumed 17% less energy per day, lost more body weight (HC -5.1 kg vs HP -8.9kg) and more body fat (HC -4.3 kg vs HP -7.6 kg) compared to the high carbohydrate group. It was also found that intra-abdominal adipose tissue decreased two-fold in the HP compared to the HC group. Similarly to Layman et al.'s (53) study, researchers in this study found that diets with CHO/PRO ratios of <2.0 partitioned weight loss more towards body fat, highlighting one of the aesthetic benefits of consuming a higher protein diet.

Furthermore, the quantity of fat in the diet has been suspected of being the main causative factor in the progression of obesity due to its qualities of being both highly palatable and calorically dense. Thus, recommendations have been established to limit (<30% of total energy) the intake of this macronutrient for both health and weight maintenance purposes. However, emerging research suggests that fat may not be the dietary culprit for disease or corpulency as once believed (56). For instance, investigators examining the effects of an *ad libitum*, very-low carbohydrate, high fat (VLCHF) diet (<20g CHO/day) and a calorie restricted, low-fat, high-carbohydrate (LFHC) diet (55% CHO; 30% Fat; 15% PRO) on body composition found that the VLCHF diet, despite its *ad libitum* standards, resulted in greater losses in body weight

and fat mass compared to the LFHC group after a period of six months (57). Likewise, normal weight participants consuming a high fat, ketogenic diet (8% CHO, 30% PRO, 61% Fat) administered ad libitum for six weeks, lost significantly more weight compared to subjects consuming a habitual diet (47% CHO, 17% PRO, 32% Fat), and did not acquire any deleterious effects on their CVD risk profile (58).

However, questions still remain on whether or not weight loss in overweight or obese subjects is maintained after adhering to different diets that emphasize specific macronutrient compositions for longer periods of time. Therefore, to fill this gap in literature, Sacks et al. (59) conducted a two-year study to examine the long-term effects of such eating patterns on body weight regulation. Researchers randomly assigned 811 overweight adults to one of the four following four hypoenergetic (-750 kcals below maintenance level) diets: low fat, average protein (65% CHO, 15% protein, 20% fat; CHO/PRO ratio – 4.3:1); low-fat, high protein (55% CHO, 25% protein, 20% fat; CHO/PRO ratio – 2.2:1); high-fat, average protein (45% CHO, 15% protein, 40% fat; CHO/PRO ratio – 3:1); or high-fat, high protein (35% CHO, 25% protein, 40% fat; CHO/PRO ratio 1.4:1). The primary outcome of this study was the change in body weight over the two-year period by comparing low fat versus high fat and average protein versus high protein and the highest and lowest carbohydrate content. The results showed that even though weight loss was slightly higher in participants following the higher protein diets, the average amount of weight lost between all groups after the two-year period was not significantly different. From these findings the authors proposed that long-term consumption of reduced-calorie diets, regardless of which macronutrients they emphasize, results in a loss of weight that is similar and clinically meaningful. It is also

important to note that the authors in this study did not assess the participants' body composition before and after the dietary intervention. Therefore, despite the equal variances in weight loss among groups, the long-term effects that these diets have on an individual's specific fat and lean tissue compartments, as it relates body composition, remains unknown and requires further investigation.

Carbohydrate Quality and Body Composition

In addition to the quantity of carbohydrates in the diet and its potential influence on an individual's weight status and body composition, another facet of carbohydrate intake that has received considerable attention in regards to the recent increase in the number of overweight and obese individuals is the *quality* of carbohydrate that comprises an individual's diet. Nutritional researchers have employed two commonly used tools – the glycemic index and the glycemic load – to assess the quality of carbohydrate in the diet. The glycemic index (GI) is a measure of the glucose response to the ingestion of a fixed amount of available carbohydrates, whereas the glycemic load is a measure of not only the qualitative component of the carbohydrate containing item (i.e., GI), but also the quantitative portion (i.e. the amount of carbohydrates ingested), which more accurately predicts the impact of a carbohydrate-containing food on post-prandial insulin secretion (60). For health and weight maintenance purposes, nutrition and other healthcare professionals have advised the general public to increase their consumption of complex, fiber-rich carbohydrates that are low-glycemic in nature and decrease their consumption of high-glycemic, refined carbohydrates (61-64).

It has been noted that the primary types of carbohydrate that comprises the average American diet are those that are derived from nutritionally inadequate sources

such as sugar and starches and grains that have been refined. The quality of carbohydrate in the diet is of importance in the context of body weight regulation due to the fact that high-glycemic carbohydrates, as those previously mentioned, have been shown to increase insulin levels, which can promote hunger, and, over the long-term, may increase the rates of obesity and other chronic diseases associated with aging (65,66). However, the hypothesized link between carbohydrate quality and obesity remains controversial (67).

For example, Spieth et al. (68) conducted a 12-month, non-randomized trial to compare the effects of a low-GI diet (n = 64) to a conventional, reduced-fat diet (n = 43) in the management of pediatric obesity and found that patients following the low-GI diet lost significantly more body weight and had a lower body mass index (BMI) compared to patients consuming the conventional, reduced-fat diet. These results were consistent even after the adjusting for age, sex, ethnicity, baseline BMI, and baseline weight, which allowed the authors to conclude that a diet comprised of low-GI carbohydrates may be a more effective alternative to standard dietary treatment for obese children.

Similarly, in terms of weight change regarding diets comprised of different glycemic values, Clapp (69) randomly assigned 12 healthy pregnant women into two groups that were instructed to consume high carbohydrate diets that were either high- or low-glycemic in nature. Participants began consuming their specified diet at 8 weeks gestation and their weight status was monitored carefully throughout their pregnancy. The investigators found that the subjects consuming the diet comprised of high-GI carbohydrate sources gained significantly more weight by full-term compared to subjects following the low-GI diet (19.7 kg compared with 11.8 kg, $p < 0.05$).

However, in contrast to the results stated above by Spieth et al. (68), findings from the work of Wolever et al. (70) showed that weight loss did not differ between two groups of obese, type 2 diabetic subjects who were randomly assigned to consume either a high- or low-GI hypoenergetic diet for a total of 6 weeks (2.5 kg compared with 1.8 kg). To add to these results, Rossi et al. (71) investigated the relationship between glycemic index (GI) and glycemic load (GI) with body mass index (BMI) and waist-to-hip ratio (WHR) in 7,724 patients (3,482 men, 4,242 women; age ranged between 18 and 82 years) who were admitted to a network of hospitals in six different Italian settings. Trained interviewers interviewed each patient during their hospital stay using a validated 78-item food-frequency questionnaire and also assessed their waist and hip circumferences. The findings from this study revealed that GI and GL were inversely related to BMI. The authors found that the average BMI decreased from the lowest to the highest tertile of GI from 26.59 to 26.18 kg/m^2 in men and from 25.81 to 25.09 kg/m^2 in women. Furthermore, the authors did not find any consistent associations between GI and GL with the participants' WHR.

Therefore, due to the conflicting data presented on the topic regarding carbohydrate quality and its potential effect on an individual's body composition, further research is needed to investigate this phenomenon more closely before establishing definite recommendations in an effort to improve the health and well-being of the current population.

Fitness Level and Body Composition

Physical fitness can be defined as a measure of how well an individual can perform a particular type of physical activity. It consists of various components such as endurance, strength, flexibility, coordination and balance (72). A variety of exercise tests are available and have been used in research to determine the fitness level of different populations. For example, the bench press exercise and the 1.5-mile endurance run are both field tests that are commonly implemented in a various settings to assess an individual's neuromuscular and aerobic fitness levels.

Obtaining a high level of fitness can be achieved by participating in regular bouts of physical activity. As previously mentioned in this review, increases in physical activity are associated with beneficial changes in body mass, including a decrease in central adiposity, a decrease in waist circumference, and an increase in fat free mass (36,46,47). Therefore, it can be stated that an individual's body composition may be a strong predictor of his or her level of physical fitness.

Fogelholm et al. (73) studied the association between BMI and fitness level in adolescents and found that being overweight was negatively correlated with both aerobic and muscular endurance as well as explosive power. However, no association was observed between weight status and scores on the flexibility (sit-and-reach) or motor skills (back-and-forth jumping) portions of the tests, indicating that these types of tests are less affected by excess weight and thus may be more appealing exercise options for overweight adolescents wanting to improve their fitness level.

Similarly, McGavock et al. (74) conducted a two-year longitudinal study to determine the association between cardiovascular fitness and the risk of overweight status

in youth participants (n = 222; age: 6-15 years). Researchers found that low levels of cardiorespiratory fitness, which was measured by performance on the Leger 20 meter shuttle run, was strongly associated with the risk of becoming or remaining overweight during childhood. Findings from this study also showed that a reduction in cardiorespiratory fitness over time was significantly correlated with weight gain over a two-year period. Likewise, the authors found that high levels of cardiorespiratory fitness were associated with a reduction in visceral body fat and a reduction in the age-related change in waist circumference during preadolescence.

However, literature that investigates this phenomenon in a college-aged population is rather limited at this time, though, the research (75) that is available suggests, like others (73,74), that a negative association exists between BMI and the majority of fitness assessment parameters. To be more precise, research reveals that an inverse relationship exists between BMI and fitness scores in the cardiovascular and flexibility categories, meaning that as BMI increases, performance on cardiorespiratory and flexibility tests decreases. Unlike previous research; however, the author from this study did not observe a signification correlation between BMI and muscular fitness, indicating that excess weight may not have a negative impact on young adults performing activities that involve the contraction of muscles to generate power and force.

Nonetheless, additional research is clearly needed to explore further into this specific subject area among college-aged students. Doing so will not only help fill gaps in existing literature, but it will also support the limited amount of data that is currently available, which, in the long run, may ultimately help in the development of more effective nutrition and physical activity interventions to promote physical fitness among

college-aged individuals and to reduce the escalating rate of obesity that is incessantly increasing throughout our nation's youth.

CHAPTER III

METHODOLOGY

The purpose of this study was to identify the relationships between carbohydrate intake and fitness level with body composition among college students. The data for this project was collected through the use of two-day dietary recalls, a number of different fitness tests, and standard skinfold caliper procedures to estimate body fat percentage. The study was designed to produce results that may identify an optimal ratio of dietary macronutrients to aid in achieving desired body weight and body composition goals. Prior to the implementation of the protocol for this study, the researcher gained approval from the University of Nebraska-Lincoln's (UNL's) Institutional Review Board (IRB). (Appendix A)

Subjects

All University of Nebraska-Lincoln college students enrolled in Nutrition (NUTR) 100 during the spring and fall 2011 semesters were eligible to participate in this study. No exclusion based on gender, age, or ethnicity was present for this study. Participants of various age groups at the college level were asked to take part in this study. Participation in this research study was voluntary and those who volunteered received 20 extra credit points toward their final grade.

Data Collection Tools

Upon enrolling in the University of Nebraska-Lincoln's NUTR 100 classes during the spring and fall 2011 semesters, students received a syllabus and a packet of information before beginning any of the course assignments that were required for class

or available for extra credit. The information in the packet that pertained to the required course assignments included a fitness assessment form and several nutrition consultation forms. The nutrition consultation forms included a weight history form, a dietary recall assignment, and blank 2-day diet analysis form. (Appendix B) The students were also given an opportunity to earn extra credit by participating in a research project. Information in the packet that pertained to the research component included an informed consent form in which the students were required to sign and date before engaging in any of the activities included in the research project. The additional two components to the standard class assignment for NUTR 100 included an analyses of each students' body composition to assess percent body fat and lean body mass and the participation in a 1.5 mile run to assess the students' VO_2 max. A personal profile was established for each subject. The profile included an assessment on the subjects' cardiovascular, flexibility, and strength fitness levels as well as data pertaining to each of the subject's body composition (height, weight, waist circumference, and body fat percentage estimated by the three site skin fold procedure using Lange skin calipers).

Data Collection Procedure

Data that was used in the analysis of this study was collected during the fall and spring 2011 semesters. The aggregated data has been stored in a database on a locked computer as well as in a secure file cabinet located on East Campus in Room 14 of the Home Economics building.

All fitness assessments were conducted and led by Dustin Nitz, the Strength and Conditioning Graduate Assistant, and his staff at the City Campus Recreation Center.

Each participant's fitness level was assessed on the following three fitness components: muscular strength/endurance, flexibility and cardiorespiratory endurance. Data on the participants' muscular strength/endurance was collected by having each participant perform a standard, max push-up test and a timed, 1-minute half sit-up test. The sit-and-reach test was implemented to measure flexibility and the 1.5-mile run was conducted to assess the participants' level of cardiorespiratory endurance. The results of these four tests were entered into and analyzed by online fitness testing calculators that contained formulas derived from the standards set by the YMCA protocol. Prior to the start of the fitness tests, researchers collected measurements on the participants' waist circumference through the use of a flexible measuring tape. Protocols for each of the above mentioned tests can be found in Appendix C.

Data pertaining to body composition – fat mass, fat-free mass, and percent body fat – were collected by Dustin Nitz as well as the primary investigator. Researchers used the Lange skinfold calipers following the three-site skinfold procedure for both males and females. Each of the sites (males – chest, abdomen, and thigh; females – triceps, suprailium, and thigh) were measured twice and averaged to achieve the most accurate assessment of the participants' percentage of body fat (%BF). Height and weight were collected from each subject at the beginning of each assessment and was used to calculate BMI. The following formula (all units were based on the English numerical system) was used for BMI calculation: BMI = [weight in pounds/(height in inches)^2]x703.5.

The Automated Self-Administered 24-hour (ASA24) Recall software program, which was developed by the National Cancer Institute, was used to collect and analyze the participants' dietary data. This particular type of food assessment database is based

on the United States Department of Agriculture (USDA) Automated Multiple-Pass Method (AMPM), which has been validated and shown to accurately estimate mean total energy and protein intakes compared to recovery biomarkers (77, 78). Students in this study were assigned a random numerical code to access this program and input their dietary information from their two-day food records into the ASA24 program. Information pertaining to each of the macronutrients as well as calories were coded and analyzed for correlations with fitness and body composition data.

To maintain confidentiality, researchers did not record any individual names throughout the data collection process. Participants missing one or more variables in the final data set were discarded and not subjected to analysis.

Data Analysis

Multiple tests were conducted in order to obtain a comprehensive view of the participants' level of fitness. Individuals were scored based on their performances and these scores were used in determining the fitness rankings. The subjects' scores were entered into online fitness testing calculators that utilized the formulas derived from the Fourth Edition of the YMCA Fitness Testing and Assessment Manual (76). However, to maintain a level of consistency, the researcher used the ranking system (Excellent, Good, Average, Fair, or Poor) computed from the online fitness testing calculators rather than the ranking system (Superior, Excellent, Good, Fair, Poor, or Very Poor) used in the manual previously describe. A description of the online fitness testing calculators for each fitness variable as well a link to each of the respected websites can be found in Appendix D.

To obtain the most accurate insight on the participants' dietary intake, the researcher added each of the measured independent variables (carbohydrates, fat, protein, and total calories) from the food records, which were analyzed by the ASA24 software, and divided by the number of days in which dietary intake was recorded to achieve an overall average of each participant's dietary intake. The average of each macronutrient as well as total calories consumed was subjected to final analysis in the dataset.

Statistical Analysis

The final dataset which included the results from the fitness assessments, anthropometric measurements, body composition tests and two-day food records were coded and entered into an excel spreadsheet. The combined data was then transferred to Statistical Analysis Software (SAS) and analyzed by a trained statistician at the Nebraska Evaluation and Research (NEAR) Center. Each of the body composition (BMI, %BF, LBM, and fat mass [FM]) and fitness measures (VO_2 max, 1.5 run score and rating, as well as ratings for the sit-and-reach, sit-ups, push-ups) were independently analyzed with the three classifications of dietary carbohydrate (high [> 55% of total calories]; moderate [45-55% of total calories]; or low [< 45% of total calories]) by using the one-way analysis of variance (ANOVA) statistical procedure to determine correlations between the carbohydrate content of the diet (high, moderate, or low) with body fatness and fitness level. To determine if the consumption of a low-carbohydrate diet elicits more favorable effects on body composition (i.e. more lean body mass and less body fat) compared to a high-carbohydrate diet, BMI, %BF, and LBM were once again independently analyzed using an ANOVA with regard to the total consumption (% of

total calories) of carbohydrate in the diet. A multivariate regression analysis was performed to compare the intake of dietary carbohydrate and protein to the participants' total fitness score, which was derived from all five dependent variables (VO_2 max, 1.5 mile run score, sit-and-reach, sit-ups, and push-ups). Lastly, independent samples *t*-tests were used to determine if the consumption of a diet with a CHO/PRO of less than or equal to 2.0 results in more lean body mass and less body fat compared to diets with a CHO/PRO ratio greater than 2.0. The level of significance was set at an alpha level of less than .05 ($p < .05$).

CHAPTER IV

RESULTS

Description of Participants

A total of 162 college-aged students completed all necessary requirements to take part in the current study. As shown in Table 1, of the 162 students who agreed to participate, approximately 59% (n=95) were female and 41% (n=67) were male. The mean age for the participants was 19.22 ± 1.75 years. As also shown in Table 1, an average weight and height of 153.2 pounds and 57.27 inches, respectively, gave rise to a mean BMI of 23.72 ± 3.64 kg/m^2. According to the standard BMI classifications depicted in Table 2, the majority, about 66%, of the students were classified as having a BMI within the normal range, while 31% of the participants had a BMI above the normal range and only 3% of the population had a BMI below the normal range. An average waist circumference of 31.17 ± 3.73 inches was also observed in this population.

Table 1. Mean ± SD of Participant Demographics According to Gender. (n = 162)

	Total n = 162	Male n = 67	Female n = 95	p - value
Age (years)	19.22 ± 1.75	19.37 ± 1.70	19.12 ± 1.80	.359
Height (in)	67.27 ± 3.65	70.30 ± 2.44^a	65.14 ± 2.75^b	<.001*
Weight (lbs)	153.2 ± 29.45	176.51 ± 23.26^a	136.83 ± 21.16^b	<.001*
BMI (kg/m^2)	23.72 ± 3.64	25.11 ± 3.03^a	22.75 ± 3.72^b	<.001*
WC (in)	31.17 ± 3.73	33.26 ± .403^a	29.70 ± .339^b	<.001*

BMI = Body Mass Index; WC = Waist Circumference
*Means with different subscripts are significantly different based on ANOVA and LSD at p < .05

Table 2. Standard BMI Classifications
(n = 162)

BMI (kg/m^2)		Number of Participants per Classification
<18.5	Underweight	5
18.5 – 24.9	Normal	106
25 – 29.9	Overweight	44
30+	Obese	7

BMI = Body Mass Index

Furthermore, as illustrated again in Table 1, there were significant differences observed among the biometric variables – height, weight, BMI, and WC – between genders in this population. The males in this studied population had a significantly taller stature (70.30 ± 2.44 vs. 65.14 ± 2.75) (p <.001) and heavier bodyweight (176.51 ± 23.26 vs. 136.83 ± 21.16) (p <.001) compared to females, which lead to a significant gender difference in BMI (25.11 ± 3.03 vs. 22.75 ± 3.72) (p<.001). Waist circumference was also significantly higher in males (33.26 ± .403) compared to females (29.70 ± .339) (p <.0001). No significant differences were observed between gender in regards to age (p = .359).

Carbohydrate Intake and Body Composition

The average intake of carbohydrate from each participant's 2-day food record was coded and analyzed for correlations with each measure of body composition. As depicted in Table 3, approximately 44.5% (n=72) of the participants had a mean carbohydrate intake within the range classified as 'moderate' (45%-55% of total kcals), while 32% (n=52) and 23.5% (n=38) of the participants had a mean carbohydrate intake classified as 'low' (<45% of total kcals) and 'high' (>55% of total kcals), respectively. No measure of

body composition was significantly affected across any of the ranges of carbohydrate content in the diet except for lean body mass. Participants consuming a low intake of carbohydrates had significantly more lean body mass (130.51 ± 37.55 vs. 112.26 ± 24.92) compared to participants with a high intake of carbohydrates (p = .0342). However, no significant differences in lean body mass were observed between a low and moderate or moderate and high intake of carbohydrates. Even though it was not significant, a low intake of carbohydrate was associated with a larger waist circumference (p = .0614) and a higher body mass index (p = .0917) compared to a high intake of carbohydrate. No significant correlations were observed between %BF or FM with carbohydrate consumption in the current study. Furthermore, as expected, but not shown, there were significant differences between males and females in regards to the carbohydrate classifications and body composition data.

Table 3. Mean ± SD of Body Composition Data According to Classification of CHO Intake. (n=162)

	Low CHO Intake (<45% of Total Kcals)	Moderate CHO Intake (45%-55% of Total Kcals)	High CHO Intake (>55% of Total Kcals)	
	n = 52	n = 72	n = 38	*p*-value
BMI	24.63 ± 3.61	23.34 ± 3.61	23.21 ± 3.57	.0917
%BF	19.40 ± 9.94	19.36 ± 8.55	22.77 ± 9.52	.1442
LBM*	130.51^{a} ± 37.55	$122.72^{a,b}$ ± 32.22	112.26^{b} ± 24.92	.0342
FM	29.87 ± 15.00	28.06 ± 11.54	33.07 ± 17.12	.2131
WC	32.17 ± 3.99	30.74 ± 3.59	30.60 ± 3.44	.0614

CHO = Carbohydrate; BMI = Body Mass Index; %BF = Percent Body Fat
LBM = Lean Body Mass; FM = Fat Mass; WC = Waist Circumference
*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05.

When looking at body composition data according to mean female and male carbohydrate intake based on the classifications (Tables 3a and 3b), the researcher did not find any significant differences between any of the measures of adiposity or LBM in regards to any of the ranges of carbohydrate content in either the males or females in this study. However, it is interesting to note that only 9 male participants (13%) were classified as having a diet that consisted of a carbohydrate intake within the high range, while 28 (42%) of the subjects had a carbohydrate intake in the low range, and 30 (45%) had a carbohydrate intake in the moderate range.

Table 3a. Mean ± SD of Body Composition Data According to Mean Female CHO Intake Based on the Classifications. (n=95)

	Low CHO Intake (<45% of Total Kcals)	Moderate CHO Intake (45%-55% of Total Kcals)	High CHO Intake (>55% of Total Kcals)	
	n = 24	n = 42	n = 29	*p*-value
BMI	23.51 ± 4.28	22.15 ± 3.35	22.97 ± 3.73	.3367
%BF	28.22 ± 5.66	25.16 ± 5.03	26.61 ± 7.16	.1302
LBM	96.16 ± 21.72	99.89 ± 12.15	100.84 ± 13.98	.5210
FM	39.31 ± 2.50	33.91 ± 8.57	37.80 ± 16.49	.2103
WC	30.44 ± 4.66	29.08 ± 2.98	29.56 ± 3.45	.3092

CHO = Carbohydrate; BMI = Body Mass Index; %BF = Percent Body Fat
LBM = Lean Body Mass; FM = Fat Mass; WC = Waist Circumference
*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05.

Table 3b. Mean ± SD of Body Composition Data According to Mean Male CHO Intake Based on the Classifications. (n=67)

	Low CHO Intake (<45% of Total Kcals)	Moderate CHO Intake (45%-55% of Total Kcals)	High CHO Intake (>55% of Total Kcals)	
	n = 28	n = 30	n = 9	*p*-value
BMI	25.58 ± 2.64	25.00 ± 3.35	23.99 ± 3.09	.3858
%BF	11.84 ± 5.57	11.24 ± 5.15	10.39 ± 3.68	.7509
LBM	159.95 ± 17.71	154.67 ± 22.85	149.04 ± 13.88	.3151
FM	21.77 ± 2.31	19.88 ± 10.18	17.82 ± 7.80	.5561
WC	33.65 ± 2.56	33.07 ± 3.08	32.67 ± 2.59	.5839

CHO = Carbohydrate; BMI = Body Mass Index; %BF = Percent Body Fat
LBM = Lean Body Mass; FM = Fat Mass; WC = Waist Circumference
*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05.

Carbohydrate-to-Protein Ratio and Body Composition

The researcher calculated a ratio of carbohydrate-to-protein by dividing the total amount of dietary carbohydrate (in grams) by the total amount of protein (in grams) from each participant's 2-day food record, which was averaged. Each ratio was then classified as being less than or equal to 2.0 (≤ 2.0) or greater than 2.0 (>2.0) and analyzed for correlations with BMI, LBM, and %BF. The researcher chose to classify each ratio in such a manner because past literature has shown that individuals following a diet with a CHO/PRO ratio of ≤ 2.0 have more lean body mass and less body fat compared to individuals adhering to a diet consisting of a CHO/PRO ratio of >2.0 (53,54).

As shown in Table 4, approximately 19% (n=31) of the participants had a CHO/PRO ratio of ≤ 2.0, while the remaining 81% (n=131) of the participants had a CHO/PRO ratio >2.0. Students with a CHO/PRO ratio of ≤ 2.0 had a significantly higher BMI (25.03 kg/m^2 vs 23.34 kg/m^2) (p = 0.023) and significantly more lean body mass (136.10 lbs vs. 119.61 lbs) (p = 0.012) compared to students consuming a diet that

consisted of a CHO/PRO ratio of >2.0. No significant correlations were found between the ratio of CHO/PRO and %BF ($p = 0.206$).

Furthermore, as expected, there were significant differences found between males and females in regards to the CHO/PRO ratio and body composition ($p < 0.0001$); however this data is not shown. However, when looking at the relationship between the CHO/PRO ratio within each gender (Table 4a.) – males and females – there were no significant differences observed. For each body composition variable, females and males, which were analyzed as separate entities, had similar physical and biometric characteristics in regards to the ratio of carbohydrate-to-protein.

Table 4. Mean ± SD of Body Composition Data in Relation to CHO/PRO. (n=162)

	CHO/PRO ≤ 2.0 n = 31	CHO/PRO >2.0 n = 131	*p* -value
BMI (kg/m^2)*	25.03 ± 4.12^a	23.34 ± 3.44^b	.023
LBM (lbs)*	136.10 ± 41.42^a	119.61 ± 30.09^b	.012
BF (%)	18.27 ± 9.42	20.63 ± 9.27	.206

CHO/PRO = Carbohydrate-to-Protein Ratio; BMI = Body Mass Index; LBM = Lean Body Mass; %BF = Percent Body Fat *Means with different superscripts are significantly different based on Independent Samples t-tests & LSD.

Table 4a. Mean ± SD of Body Composition Data in Relation to CHO/PRO by Gender. (n=162)

	Females			Males		
	CHO/PRO ≤ 2.0 n = 12	CHO/PRO >2.0 n = 83	*p-value*	CHO/PRO ≤ 2.0 n = 19	CHO/PRO >2.0 n = 48	*p-value*
BMI	23.48 ± 5.15	22.64 ± 3.49	.3389	26.09 ± 3.02	24.72 ± 2.98	.0976
LBM	95.28 ± 29.82	99.81 ± 12.45	.3472	161.85 ± 22.47	153.85 ± 18.51	.1387
%BF	28.27 ± 6.10	26.10 ± 5.94	.2423	11.93 ± 4.04	11.15 ± 5.51	.5784

CHO/PRO = Carbohydrate-to-Protein Ratio; BMI = Body Mass Index; LBM = Lean Body Mass; %BF = Percent Body Fat; *Means with different superscripts are significantly different based on Independent Samples t-tests & LSD.

Carbohydrate and Protein Intake and Body Composition

To investigate further into the potential effect carbohydrate and protein intake may have on body composition, the researcher analyzed the percentage of total calories derived from both of these macronutrients with the dependent variables representing each measure of body composition. As displayed in Table 5, there were significant relationships found between the percentage of total calories derived from carbohydrates with both BMI ($p = 0.009$; $R^2 = 0.72$) and LBM ($p = 0.023$). For example, according to the results, for every 1% increase in the intake of dietary carbohydrate, BMI was predicted to decrease by .08 kg/m^2 while LBM was predicted to decrease by 0.67 pounds. However, there was no significant relationships observed between carbohydrates, as expressed as a percentage of total calories, and percent body fat to further support this correlation.

In regards to the percentage of total calories derived from protein, a significant association was observed between protein intake and LBM ($p = 0.032$). More specifically, the results revealed that for every 1% increase in protein, LBM was predicted to increase by approximately 1.19 pounds. Values for both BMI and %BF were not significantly correlated with the percentage of total calories derived from protein. However, despite its non-significance ($p = .390$), there was a negative trend observed in regards to protein intake and %BF, with a higher percentage of calories ingested from protein being related to a lower percent body fat.

Furthermore, to investigate any potential differences within each gender, the researcher also analyzed the intake of carbohydrate and protein, based on a percentage of total calories, in relation to the body composition data with both males and females in this

population (Tables 5a. and 5b.). However, after interpretation of the results, the only significant (p =.027) difference that was observed among these criteria was in reference to the LBM with the intake of protein for males. The higher the intake of protein in the diet for a male, based on a percentage of total calories, the more LBM would be expected to have. For example, for every 1% increase in protein intake, males were predicted to have an increase of about 1.078 pounds of LBM. No other significant associations were observed between any of the measures of body composition with protein or carbohydrate intake in either the males or females.

Table 5. Unstandardized Coefficients and Standard Errors of CHO & PRO Intake based on Percentage of Total Kcals in Relation to Body Composition Data. (n = 162)

	% Total Kcals CHO			% Total Kcals PRO		
	Coefficient	*SE*	*p* - value	Coefficient	*SE*	*p* - value
BMI (kg/m^2)	-8.00	3.016	.009***	5.25	5.66	.355
LBM (lbs)	-0.67	.293	.023***	1.19	.550	.032***
BF (%)	0.06	0.085	.455	-0.139	0.162	.390

BMI = Body Mass Index; LBM = Lean Body Mass, %BF = Percent Body Fat
*** $p < .05$

Table 5a. Unstandardized Coefficients and Standard Errors of CHO Intake by Gender based on Percentage of Total Kcals in Relation to Body Composition Data. (n = 162)

	% Total Kcals CHO					
	Males n = 67			Females n = 95		
	Coefficient	*SE*	*p* - value	Coefficient	*SE*	*p* - value
BMI (kg/m^2)	-.0250	.0490	.612	-.0625	.0413	.133
LBM (lbs)	-.0556	.319	.862	.0341	.1772	.848
BF (%)	-.1389	.0843	.105	-.0827	.0670	.220

BMI = Body Mass Index; LBM = Lean Body Mass, %BF = Percent Body Fat
*** $p < .05$

Table 5b. Unstandardized Coefficients and Standard Errors of PRO Intake by Gender based on Percentage of Total Kcals in Relation to Body Composition Data. (n = 162)

	% Total Kcals PRO					
	Males n = 67			Females n = 95		
	Coefficient	*SE*	*p* - value	Coefficient	*SE*	*p* - value
BMI (kg/m^2)	.1364	.0733	.067	.0915	.0908	.316
LBM (lbs)	1.078	.4763	.027***	.1366	.3895	.727
BF (%)	-.1710	.1259	.179	.1088	.1473	.462

BMI = Body Mass Index; LBM = Lean Body Mass, %BF = Percent Body Fat
*** $p < .05$

Fitness Level and Carbohydrate Intake According to Classification

To further explore the implications between eating patterns differing in carbohydrate content and body fatness while taking into account the participants' fitness level, the researcher analyzed each eating pattern differing in carbohydrate content (low, moderate, and high) with each one of the fitness variables assessed in the study. Results from the previously mentioned data are detailed below in Table 6. There were no significant correlations found between any of the measured fitness variables and carbohydrate intake. Participants consuming a moderate intake of carbohydrate (45%-55% of total calories) did perform better during the 1.5 mile run and sit-and-reach tests than the other participants consuming a low (<45% of total calories) or high (>55% of total calories) intake of carbohydrate; however, these correlations did not reveal to be significant ($p = .1346$).

Furthermore, to explore the potential differences within each gender, the researcher also analyzed the female and males fitness level scores, which were calculated

by using the YMCA fitness testing equations, with each fitness measure based on each range (low, moderate, and high) of carbohydrate intake (Tables 6a. and 6b.). Even though the researcher observed that the males having a moderate intake of carbohydrate had a higher sit-and-reach score compared to the males consuming a low or high intake of carbohydrate, this relationship or any other relationship investigating this criterion regardless of gender, was not statistically significant.

Table 6. Mean ± SD of Fitness Level Data According to Classification of CHO Intake. (n = 162)

	Low CHO Intake (<45% of Total Kcals) n = 52	Moderate CHO Intake (45%-55% of Total Kcals) n = 72	High CHO Intake (>55% of Total Kcals) n = 38	*p*-value
VO_2 Max (mg/kg/min)	41.56 ± 6.97	41.99 ± 7.16	39.75 ± 5.67	.2488
1.5-Mile Run	47.42 ± 26.60	57.89 ± 28.81	53.00 ± 30.66	.1346
S/R	62.10 ± 22.40	67.36 ± 21.33	61.92 ± 21.50	.3061
SUs	56.93 ± 20.86	54.88 ± 20.49	56.23 ± 23.2	.8609
PUs	46.42 ± 22.20	50.36 ± 21.83	51.76 ± 16.31	.4276

VO_2 Max = Maximal Oxygen Uptake; CHO = Carbohydrate; S/R = Sit-and-Reach Test; SUs = Sit-ups; PUs = Push-ups; *Means with different superscripts are significantly different based on Independent Samples t-tests & LSD.

Table 6a. Mean ± SD of Female Fitness Level Scores as Calculated by the YMCA Fitness Testing Equations According to CHO Classifications.
(n = 95)

	Low CHO Intake (<45% of Total Kcals) n = 24	Moderate CHO Intake (45%-55% of Total Kcals) n = 42	High CHO Intake (>55% of Total Kcals) n = 29	*p*-value
VO_2 Max (mg/kg/min)	37.10 ± 3.78	38.92 ± 6.23	38.78 ± 5.55	.3997
1.5-Mile Run	49.96 ± 23.21	63.00 ± 27.18	59.76 ± 29.17	.1667
S/R	63.50 ± 20.43	62.76 ± 23.86	60.10 ± 20.61	.8309
SUs	50.13 ± 19.52	51.48 ± 22.46	54.10 ± 24.78	.8023
PUs	51.79 ± 21.39	54.52 ± 18.81	54.34 ± 16.16	.8346

VO_2 Max = Maximal Oxygen Uptake; CHO = Carbohydrate; S/R = Sit-and-Reach Test; SUs = Sit-ups; PUs = Push-ups; *Means with different superscripts are significantly different based on Independent Samples t-tests & LSD.

Table 6b. Mean ± SD of Male Fitness Level Scores as Calculated by the YMCA Fitness Testing Equations According to CHO Classifications.
(n = 67)

	Low CHO Intake (<45% of Total Kcals) n = 28	Moderate CHO Intake (45%-55% of Total Kcals) n = 30	High CHO Intake (>55% of Total Kcals) n = 9	*p*-value
VO_2 Max (mg/kg/min)	45.38 ± 6.85	46.29 ± 6.15	42.88 ± 5.13	.3734
1.5-Mile Run	45.24 ± 29.44	50.73 ± 29.95	31.22 ± 25.86	.2203
S/R	60.89 ± 24.26	73.80 ± 15.35	67.78 ± 24.50	.0679
SUs	62.75 ± 20.52	59.63 ± 16.55	63.33 ± 16.44	.7676
PUs	41.82 ± 22.21	44.53 ± 24.63	43.44 ± 14.67	.9007

VO_2 Max = Maximal Oxygen Uptake; CHO = Carbohydrate; S/R = Sit-and-Reach Test; SUs = Sit-ups; PUs = Push-ups; *Means with different superscripts are significantly different based on Independent Samples t-tests & LSD.

Fitness Level and Percentage of Energy from Total Carbohydrate and Protein

To further examine the relationship between eating patterns differing in carbohydrate content and body composition while accounting for fitness level, the researcher used Chi Square and multiple regression analyses to compute and analyze a composite fitness score for each participant and relate that back to each participant's intake of carbohydrate and protein. According to the results derived from each of the previously mentioned analyses, the only significant association observed was between carbohydrate intake and 1.5-mile run time (p = .003). Carbohydrate intake was positively correlated to 1.5-mile run time, meaning that higher intakes of carbohydrates were associated with faster 1.5-mile run times. No other significant differences were seen among any of the dependent variables and carbohydrate or protein intake.

Differences in Nutrient Intake According to Gender

Given these results, it is also important to take into consideration the differences within each gender that were found among this studied population in regards to the intake of calories and macronutrients according to each range (low, moderate, and high) of carbohydrate content. As shown in Table 7, no significant difference was found in regards to the intake of calories across any of the ranges of carbohydrate intake in females; however, significant differences were found in regards to the percentage of total calories derived from carbohydrates (p = <.0001), protein (p = .0183), and fat (p = 0003) as well as the ratio of carbohydrate-to-protein (p = <.0001). Female participants consuming a low carbohydrate diet had a lower consumption of carbohydrate compared to those with a moderate or high intake of carbohydrate as well as a higher consumption

of both protein and fat compared to either of the two other ranges of carbohydrate ranges, which is supported by the significantly lower (<.0001) CHO/PRO ratio that was found with this range of carbohydrate intake compared to the others – moderate or high.

Table 7a. displays this data – the intake of calories and macronutrients according to each range (low, moderate, and high) of carbohydrate intake – but in regards to the males in this studied population. Males having a low intake of carbohydrate had a significantly higher intake of calories (.0299), protein (.0002), and fat (<.0001) compared to males having a moderate or high intake of carbohydrate. As expected, the males with a low intake of carbohydrate had a significantly lower intake of carbohydrate (<.0001) than those with a moderate or high intake of carbohydrate, which is further supported by the significantly lower (<.0001) ratio of carbohydrate-to-protein that was observed with this range of carbohydrate intake compared to the others – moderate or high.

The findings previously mentioned are further supported in Table 7b, which details the nutrient intake data in relation to the CHO/PRO ratio (≤ 2.0 and >2.0) with each gender. Females and males consuming a diet that consists of a low ratio (≤ 2.0) of CHO/PRO had a significantly lower intake of carbohydrate (<.0001), but a significantly higher intake of protein (<.0001) compared to females and males with a high (>2.0) ratio of CHO/PRO). Furthermore, as expected and again not shown, there were significant differences that were found between males and females in this population in regards to intake of each of the energy yielding macronutrients as well as total calories and the ratio of carbohydrate-to-protein.

Table 7. Mean ± SD of Percent of Energy and Nutrient and Caloric Intake of Female Participants According to CHO Classification

	Females n = 95			
	Low CHO Intake (<45% of Total Kcals) n = 24	Moderate CHO Intake (45%-55% of Total Kcals) n = 42	High CHO Intake (>55% of Total Kcals) n = 29	*p*-value
Total Kcals	1772.08 ± 569.96	1614.43 ± 496.16	1544.24 ± 553.32	.2929
CHO (%)*	$.391^{a}$ ± .058	$.497^{b}$ ± .029	$.619^{c}$ ± .061	<.0001
PRO (%)*	$.193^{a}$ ± .049	$.173^{b}$ ± .041	$.158^{c}$ ± .041	.0183
FAT (%)*	$.389^{a}$ ± .066	$.345^{b}$ ± .043	$.269^{c}$ ± .177	.0003
CHO/PRO*	2.19^{a} ± .750	3.03^{b} ± .792	4.16^{c} ± 1.165	<.0001

CHO = Carbohydrate; PRO = Protein; CHO/PRO = Carbohydrate-to-Protein Ratio; FAT = Fat

*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05

Table 7a. Mean ± SD of Percent of Energy and Nutrient and Caloric Intake of Males Participants According to CHO Classification

	Males n = 67			
	Low CHO Intake (<45% of Total Kcals) n = 28	Moderate CHO Intake (45%-55% of Total Kcals) n = 30	High CHO Intake (>55% of Total Kcals) n = 9	*p*-value
Total Kcals*	2878.04^{a} ± 1094.05	2199.07^{b} ± 788.78	2664.89^{c} ± 1031.28	.0299
CHO (%)*	$.381^{a}$ ± .047	$.502^{b}$ ± .032	$.582^{c}$ ± .021	<.0001
PRO (%)	$.212^{a}$ ± .055	$.187^{b}$ ± .048	$.129^{c}$ ± .028	.0002
FAT (%)	$.398^{a}$ ± .073	$.318^{b}$ ± .057	$.301^{c}$ ± .025	<.0001
CHO/PRO*	1.90^{a} ± .503	2.87^{b} ± .792	4.73^{c} ± 1.19	<.0001

CHO = Carbohydrate; PRO = Protein; CHO/PRO = Carbohydrate-to-Protein Ratio; FAT = Fat

*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05

Table 7b. Mean ± SD of Nutrient Intake Data in Relation to CHO/PRO by Gender. (n=162)

	Females			Males		
	CHO/PRO ≤ 2.0 n = 12	CHO/PRO >2.0 n = 83	*p-value*	CHO/PRO ≤ 2.0 n = 19	CHO/PRO >2.0 n = 48	*p-value*
Total Kcals	1492 ± 446.78	1653.06 ± 545.27	.3346	2430.00 ± 676.65	2591.06 ± 1102.22	.5555
CHO (%)	.382 ± .077[a]	.526[b] ± .087	<.0001	.381[a] ± .062	.494[b] ± .067	<.0001
PRO (%)	.251 ± .038[a]	.163[b] ± .033	<.0001	.249[a] ± .052	.166[b] ± .037	<.0001
FAT (%)	.373 ± .087	.327 ± .119	.1968	.372 ± .095	.340 ± .063	.1103

CHO/PRO = Carbohydrate-to-Protein Ratio; BMI = Body Mass Index; LBM = Lean Body Mass; %BF = Percent Body Fat;
*Means with different superscripts are significantly different based on ANOVA and LSD at p <.05

CHAPTER V

DISUCSSION, CONCLUSION, AND LIMITATIONS

Macronutrient composition of the Diet and Body Composition

This study's primary aim was to evaluate the relationship between eating patterns differing in carbohydrate content (low, moderate, and high) with body composition among college-aged students. More specifically, the investigator sought to examine whether adhering to a low carbohydrate diet will correlate with an individual having more lean body mass and less body fat compared to an individual following a high carbohydrate meal plan. The data found in this study provides evidence in support of the link that shows that eating patterns emphasizing a low intake of carbohydrate are associated with a higher degree of lean body mass compared to eating patterns emphasizing a high intake of carbohydrate, which has been presented in previous research (53,54,55). However, the results from this study are not completely consistent with previous literature (53,54,55) in that diets that are low or restricted in carbohydrate do not result in greater decrements in body fat, which is expected when there is a higher intake of protein or an increase in the intake of protein and a subsequent maintenance or accrual of lean tissue.

For example, Skov and colleagues (54) assigned overweight and obese adults to either a high carbohydrate (HC) diet (CHO/PRO – 4.8:1) or a high protein (HP) diet (CHO/PRO – 1.8:1) for six months and found that subjects consuming the HP (lower carbohydrate) diet lost more body fat and retained more lean body mass compared to subjects adhering to the HC diet. Though, an interesting finding in this study (54) was

that the individuals consuming the HP diet lost twice the amount of intra-abdominal adipose tissue compared to the subjects in the HC group, which is not paralleled with the results shown in this particular study. Despite the fact that the participants in the current study were consuming their food intake under *ad libitum* conditions, as were the subjects in the HP group conducted by Skove et al. (54), no marked decrease or difference was observed in waist circumference among the individuals following an eating pattern that consisted of a low intake of carbohydrate compared to those adhering to a high carbohydrate eating pattern. In fact, participants in this study with a carbohydrate intake in the 'high' category had a smaller waist circumference, and presumably less central adiposity, than those with a carbohydrate intake in the 'low' category; however, this difference was not statistically significant. It is important to note; however, that the researcher in this current study assessed the participant's body composition by using the three-site skinfold procedure, while work from Skov et al. (54) and those previously mentioned (53,55) assessed percent body fat by using a dual-energy X-ray absorptiometry (DXA) scanner, which may have led to a discrepancy in the results simply due to the fact that DXA has been accepted as a criterion method of assessing body composition because of its accuracy, its reliability, and the timely manner in which assessments can be made (79,80,81).

Findings from this current study that further support the notion that a lower carbohydrate eating pattern may elicit more favorable changes in body composition (i.e. more lean body mass) than a higher carbohydrate eating pattern are shown through the results obtained by the CHO/PRO ratio. The purpose of calculating and analyzing a CHO/PRO ratio for each participant was to determine whether college students

consuming a diet consisting of a carbohydrate-to-protein ratio (CHO/PRO) of less than or equal to 2.0 (≤2.0) would have more lean body mass and less body fat compared to students consuming a diet consisting of a CHO/PRO ratio greater than 2.0 (>2.0). The findings from this study, like others (53,54,55), reinforce that claim that individuals consuming an eating pattern that emphasizes a CHO/PRO ratio of less than or equal to 2.0 have and retain more lean body mass compared to individuals following an eating pattern that has a CHO/PRO ratio greater than 2.0. However, an interesting and quite unexpected finding from this study was that a CHO/PRO ratio of less than or equal to 2.0 was also highly correlated with significantly higher BMIs. Body mass index is a measure that should solely be used to identify body fatness in individuals among a population, not to estimate one's content of body fat. However, the results received from assessing body fatness by using body mass index should be interpreted with caution (82) due to the fact that individuals with a high proportion of bone structure and/or muscle mass will likely result in having a higher BMI, which may allow them to be misinterpreted as being overfat, despite being relatively lean. Therefore, it may be assumed from this finding that a significantly higher amount of lean body mass can positively influence BMI, especially since the targeted population is approaching the age in which the body responds more acutely and quickly to external stimuli; therefore, making it more likely for individuals, especially those who are active, to gain and maintain lean body mass.

Based on these findings, it is important for registered dietitians and other health professionals who are involved with structuring meal plans to help their clientele meet their body weight and body compositions goals to realize that the simple manipulation of macronutrients can elicit changes in body composition. For example, from the results

found in this study, recommending an increase in the intake of total calories from protein while deemphasizing the carbohydrate content of the diet, favoring a CHO/PRO ratio of ≤2.0, may be an attractive macronutrient distribution for individuals wanting to add lean body mass. However, it is important for a dietitian to express the proper way to achieve optimal health by consuming a healthy, well-balanced diet, rather than emphasizing an increased or decreased need for individual macronutrients to attain specific health or body composition goals. Showing support for this previous statement are results from the work of Sacks and colleagues (59), in which they found that weight loss; and therefore an improvement in overall health, can occur with any reduced-calorie diet regardless of which specific macronutrients they emphasize. The researchers found that a low fat, average protein; a low-fat, high protein; a high-fat, average protein; and a high-fat, high protein diet all resulted in similar and clinically meaningful decreases in body weight after a two-year period suggesting that the adherence to a nutrition plan is the most powerful factor influencing whether or not an individual achieves his or her body weight or body composition goals, not just merely the distribution of macronutrients in the diet.

Dietary Intake of College-Aged Students

In 2011, the United States Department of Agriculture (USDA) introduced MyPlate as a visual tool to reinforce the dietary guidelines in a simple and precise manner to all Americans aged 2 years and older. If college-aged students closely follow these recommendations, which are based on an individual's age, gender, height, weight, and activity level, then they should be consuming an adequate amount of foods and nutrients to support a healthy lifestyle. However, past research suggests that the majority

of today's college students are not adhering to these nutrient guidelines (27,38). In fact, the typical diet of college-aged students has been shown to consist of foods that are high in fat (26,27) and sodium and low in fruits, vegetables and dairy products (39). Furthermore, research has shown that students who reside in off campus housing have significantly higher overall intakes of energy and protein (40). Even though this study did not aim to directly assess the living situation of its participants, it did; however, collect important data regarding the participant's overall energy and macronutrient intake.

For example, when comparing the participant's average intake of total calories over a two-day period to the recommendations set forth by the Dietary Guidelines for Americans for a physically active male and female population of the appropriate age, it was observed that neither the male or female participants met these suggested standards. However, it would be inaccurate to assume that all the individuals in the studied population exercise frequently enough to be considered 'active'; therefore, the caloric requirements for males and females would not be set to such a high standard. Nonetheless, even at the lowest possible activity level (i.e. sedentary), the average intake of calories consumed by the females would still be below the recommendations and the average intake of calories consumed by males would be slightly over the recommendations, which rather conflicts with that fact that over one-third of the participants in the study is classified as overweight or obese according to the BMI standards – highlighting the notion that an average caloric intake taken from a two-day food record may not be the true representation of the participant's usual eating habits.

Furthermore, in regards to the individual macronutrients consumed, the ingestion of dietary fat, which has previously been shown to be largely over consumed among college-aged students (26,27), was at the high-end – 35% and 33% – of the acceptable macronutrient distribution range (AMDR) for both males and females, respectively. The current study was not designed to identify the specific food sources consumed that helped contribute to this rather high intake of fat; however, it can be assumed that the food items chosen are most likely from fast food restaurants or convenience type stores since previous research has suggested that the average college student's diet is nutrient poor, and lipid rich (26,27,39) and the fact that research has shown that adolescents, on average, frequent fast food outlets at least twice per week (83). Furthermore, the percentage of energy consumed from carbohydrate and protein, based on total calories, were within the normal ranges for both male and female participants in this population.

Fitness Level and Carbohydrate Intake

Research has shown that one of the added benefits of participating in regular, frequent bouts of physical activity, besides an improvement in fitness level (84), is the beneficial changes that occur to one's body mass, which may include a decrease in central adiposity, a decrease in waist circumference, and an increase in fat free mass (36,46,47). Therefore, it can be extrapolated that an individual's body composition, which can be further affected by his or her dietary intake, may be a strong predictor of his or her level of fitness.

Diets that are moderate-to-high in carbohydrate are critical for optimal exercise performance because of the role glucose has in the maintenance of muscle and liver

glycogen stores (85). Previous literature has shown that diets that are moderate-to-high in carbohydrate (50%-70% of total calories) may enhance endurance performance and improve exercise capacity in activities that involve the musculoskeletal system (85). However, the results in the current study did not reveal any strong correlations between any of the classifications of carbohydrate and exercise performance. Higher performance scores were observed in the 1.5-mile run and sit-and-reach tests in participants consuming a moderate intake of carbohydrate compared to those consuming a low or high intake of carbohydrate; however, the difference was not significant. However, when carbohydrate intake was analyzed based on a percentage of total calories, the researcher found that higher intakes of carbohydrates were associated with faster 1.5-mile run times, which is in line with previous research (85).

Even though there was a strong correlation observed between a high carbohydrate intake and cardiorespiratory endurance performance, one cannot assume that a high carbohydrate diet was the primary factor that attributed to an increase in performance. It may very well be likely that individuals who maintain a carbohydrate rich diet have higher fitness levels because they participate in a more frequent exercise routine and; therefore, understand the importance of consuming an adequate amount of carbohydrates to allow for optimal performance compared to individuals who do not exercise as regularly and do not monitor their intake of any specific macronutrient.

Differences in Nutrient Intake According to Gender

Other important aspects of this study's findings that are worth mentioning are the differences in nutrient intake that were observed between genders in this population (not

shown). Past literature suggests that men consume more calories on a daily basis compared to women (86). Findings from this study support previous literature (86) by revealing that the average calorie intake in males was significantly higher than in females. This may be due to the fact that men have different hormonal and metabolic influences that elicit a higher need for energy to meet the body's physiological demand to support normal functions of daily living. Furthermore, as expected with a higher overall caloric intake, there were also significant differences found among the intake of macronutrients between genders, with males consuming significantly more grams of carbohydrate, protein, and fat compared to females.

In regards to the findings that pertain to the nutrition intake data in relation to the CHO/PRO ration within each gender, a simple explanation can be provided to justify the differences in macronutrient intake, based on a percentage of total calories, with low and high ratios of carbohydrate intake. Individuals consuming a low ratio of carbohydrate-to-protein are classified as such due to their low intake of carbohydrate and high intake of protein, which is paralleled with the findings in this study. Fat intake was also found to be inversely related to the ratio of CHO/PRO, with higher intakes of fat being associated with lower ratios of CHO/PRO and lower intakes of fat being related to higher ratios of CHO/PRO.

CONCLUSIONS

Based on the data collected in this study, a few key findings emerged in regards to the macronutrient composition of the diet which may be helpful for registered dietitians or other health professionals who are responsible for tailoring individualized nutrition

plans for college-aged students. First of all, from these results, diets high (>55% of total calories) in carbohydrate do not appear to be related to any of the measures of adiposity – BMI, %BF, FM, WC - assessed in this study. Therefore, recommending a diet that is low or moderate in carbohydrate for the prevention of treatment of excess weight does not seem plausible at this time. However, it does seem accurate, based on the results in the present study, to suggest a diet that is low in carbohydrate and moderate in protein to individuals seeking to gain or retain lean body mass. Though for individuals looking solely to gain lean body mass, basic knowledge of nutrition and exercise dictates that the overall caloric content of the diet must also be taken into consideration as well as participation in a well-designed resistance training program; however, information regarding the latter two statements is beyond the scope of this paper.

Furthermore, for dietitians involved in designing meal plans for an athletic population, data from this study suggests that the carbohydrate content of the diet (high, medium or low) was not positively related to performance with any of the fitness variables assessed in this study, which questions the role a carbohydrate rich diet has in the improvement of exercise performance during activities that involve the cardiovascular and muscular systems. However, when looking at the macronutrient content of the diet in a different context (i.e. based on a percentage of total calories) this study does provide hopeful evidence in regards to athletic performance. The author found that diets high in carbohydrate are associated with faster times in the 1.5-mile run compared to diets that are low in carbohydrate, which highlights the need for ingestion of proper fuel substrates to support this type activity. However, a complete assessment of the individual's fitness level should be conducted prior to making any of the above the recommendations.

Lastly, a final key finding from this study that is important to consider when outlining a nutrition plan for college-aged students are the differences in the intake of nutrients that were observed between male and female participants. The male participants in this study, as expected, consumed significantly more calories and more calories from each of the macronutrients than the female population. Therefore, advising college-aged males on the importance of including nutrient and energy dense foods in the diet to allow for a sufficient calorie intake is critical for optimal growth and development. Furthermore, in regard to females, dietitians should be aware of the different hormonal or lifestyle factors that can influence the intake of carbohydrates within this specific population and should intervene with proper education and intervention when and if necessary.

Furthermore, efforts should be made to educate college students on the nutrition recommendations advocated by the Dietary Guidelines for Americans. Even though the average intake of each macronutrient consumed by both genders were within the acceptable macronutrient distribution ranges, interventions should be established to help reduce the intake of fat among college-aged students by educating the importance of consuming healthy, nutrient dense foods on a daily basis for the achievement of not only a healthy body weight but also for optimal health and wellbeing.

LIMITATIONS

This study, like others, was not of perfect design; therefore, several important limitations must be considered. First of all, the sample size selected for this study was relatively small. Recruiting a larger sample size from the population may have possibly

revealed more significant differences among the variables that were assessed in this study. Furthermore, the small sample size selected for this study may not be a true representation of the population studied; therefore, these results should not be generalized to all college-aged individuals.

It is also important to note that the class chosen for this study was open for all students at the selected university; however, it is a prerequisite for students in the nutrition and/or exercise science departments. Therefore, the students recruited for this study may have been more conscious about their eating and exercise habits compared to other students in different departments, which may have potentially skewed the data.

Secondly, even though the type of food recall system – Automated Self-Administered 24-hour Recall – employed in this study has been validated and shown to be able to accurately estimate mean total energy and protein intakes compared to recovery biomarkers (77,78), the limitations of this or any food recall system for that matter should not be ignored. Assessing an individual's dietary intake through the use of a 24-hour recall does not always provide an accurate picture of an individual's usual dietary pattern. Even though the directions were specifically stated, individuals may have altered their usual dietary intake by knowing that they would have to record each food consumed. Also, a lack of understanding of proper servings sizes may have led to inaccurate documentations of the foods recorded.

There were also a few limitations associated with the collection of the fitness data during the fitness assessments. The push-up and sit-up tests required each student to find and work with a partner so that each repetition performed could be counted. There is a possibility that the student responsible for counting the number of repetitions performed

may have lost count or simply forgot the total number of repetitions completed, which could detract from the true results of the fitness data. Lastly, the females were given the option to perform the push-up test in the standard or modified position. This may be a potential limitation due to the fact that performing the push-ups in the modified position (i.e. knees on the ground) could potentially result in the females performing more push-ups than if they were in the standard position, and also because not all females chose to complete the push-up test in such manner.

IMPLICATIONS FOR FUTURE RESEARCH

In light of the findings in this current study, an avenue that may be of value to explore in regards to future research is the potential differences present among eating patterns differing in carbohydrate content of the diet and body fatness in respect to the type or quality of carbohydrate consumed. While this study collected valuable data concerning the nutrient intake of college-aged students, a more in-depth investigation of the specific types of foods consumed may be advantageous to the implementation and delivery of future intervention programs.

It also may be beneficial to implement a study similar to this one in a population that is of older age. It is well documented that weight gain and an increase in adiposity commonly occurs as individuals age; therefore, studying a population that a higher proportion of the participants are in the overweight and obese BMI category may reveal interesting results . Furthermore, examining the participants' current body weight goals (lose, maintain, or gain weight) in order to determine if specific eating patterns differing

in carbohydrate content are emphasized more than others when attempting to attain a certain body weight goal may be valuable as well.

The original purpose of the data collected in this study was to identify an optimal ratio of dietary macronutrients that could help individuals meet their body weight and body composition goals. Therefore, the last avenue that future research should consider investigating is an optimal ratio of macronutrients for individuals based on their unique physical, genetic and metabolic characteristics. Establishing nutrient profiles tailored specifically to individuals may hasten the achievement of body weight and body composition goals while improving overall health and wellbeing.

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APPENDIX A

Institutional Review Board Letter of Approval

January 24, 2011

Garrett Serd
Department of Nutrition and Health Sciences
3227 Q Street Lincoln, NE 68503

Wanda Koszewski
Department of Nutrition and Health Sciences
120C LEV, UNL, 68583-0806

IRB Number: 20110111482EP
Project ID: 11482
Project Title: Assessing Dietary Intake, Body Composition, and Physical Activity Patterns in College Students

Dear Garrett:

This letter is to officially notify you of the approval of your project by the Institutional Review Board (IRB) for the Protection of Human Subjects. It is the Board's opinion that you have provided adequate safeguards for the rights and welfare of the participants in this study based on the information provided. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46). Your project was approved as an Expedited protocol, category 4.

You are authorized to implement this study as of the Date of Final Approval: 01/24/2011. This approval is Valid Until: 01/23/2012.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or

* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

For projects which continue beyond one year from the starting date, the IRB will request continuing review and update of the research project. Your study will be due for continuing review as indicated above. The investigator must also advise the Board when this study is finished or discontinued by completing the enclosed Protocol Final Report form and returning it to the Institutional Review Board.

If you have any questions, please contact the IRB office at 472-6965.

Sincerely,

William Thomas, Ph.D.
Chair for the IRB

APPENDIX B-1

Weight History Form

University of Nebraska, Lincoln
Campus Recreation
Fitness & Wellness Services
Weight History

Name: _____ UNL ID #: _____

Daytime Phone: _____ Home Phone: _____

Gender: M F Age: _____ Height: _____

Weight History:
Current Weight: _____ Goal Weight: _____

Highest weight as an adult and at what age? (18 years or older) _____
_____

Lowest weight as an adult and at what age? (18 years or older) _____
_____

Have you ever been at your goal weight? _____If yes, when and for how long? _____

Please list any pertinent family or personal weight management history or issues. _____
_____
_____

Medication/Supplement: _____

Identify one question you would like answered or one subject you would like to discuss in your nutrition consultation. _____
_____

Do you have any nutrition related goals? Explain_____
_____

Women Only: Do you menstruate monthly? Yes No

APPENDIX B-2

Dietary Recall Assignment

Dietary Recall Assignment

- Please keep track of everything you eat and drink for two days. Be sure to include meals, snacks and beverages.
- Please record how the items are prepared—i.e. baked, fried, broiled, etc.
- Please record the approximate serving size—i.e. ½ cup, 1 cup, 3 ounces, etc. (Use the Helpful Hints chart below).
- If you know brand names, please include that information.
- The most accurate way to keep food journals is to record it as soon after eating as possible.

Helpful and Fun Hints for Estimating Serving Sizes

Use the following estimates to equate serving sizes with everyday items:

3 ounces meat, poultry, pork or fish	= palm of your hand = deck of cards = cassette tape
½ cup of cooked rice, potatoes, pasta or vegetables.	= tight fist of hand = tennis ball =billiard ball
1 medium fruit	=tight fist of hand
1 ounce of cheese	= your thumb = four dice = ping pong ball
1 medium potato	= computer mouse

APPENDIX B-3

2-Day Diet Analysis Form

Diet Analysis Form Day 1

Food No.	Breakfast:	Brand Name (If Known)	Method of Preparation	Weight or Measurement: Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice
	toast										
	juice										
	milk										
	egg										

	Morning Snack:	Brand Name (If Known)	Method of Preparation	Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice
	soda										

	Lunch:	Brand Name (If Known)	Method of Preparation	Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice
	sandwich										
	soda										
	chips										

	Afternoon Snack:	Brand Name (If Known)	Method of Preparation	Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice

	Dinner:	Brand Name (If Known)	Method of Preparation	Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice
	meat										
	potatoes										
	vegetable										

	Evening Snack:	Brand Name (If Known)	Method of Preparation	Item	Serving	OZ.	FL. OZ.	Cup	Tbsp	Tsp	Slice
	ice cream										

APPENDIX C-1

Push-up Test Protocol

Standard and Modified Push-Up*

Alert! If you have shoulder, elbow, or wrist pain, doing this test may aggravate your condition.

The muscles of the upper body and shoulders are another frequently measured muscle group. Several tests (for example, pull-up and push-up) are used to measure the strength and endurance of these muscle groups. Less muscular strength and endurance of the upper body and shoulder group may increase the chances that a person may have shoulder pain in middle or older adulthood.

In the standard push-up test, you push your body up and down using muscles in your arms, shoulders and chest, while keeping your body straight with your feet serving as the pivot point. Your body weight is your workload. Females can reduce the load by having their knees touching the floor and acting as the pivot point. In this test, only the upper body is the load. We are going to use standard push-ups and modified push-ups as our tests for upper body and shoulder muscular strength and endurance.

Directions:

Up position for standard and modified push-up.

Down position for standard and modified push-up. Note the 2 inch space between the chest and floor.

1. Males start in the standard push-up position (elevated). Hands should be shoulder width apart, arms extended straight out under the shoulders, back and legs in a straight line, and toes curled under. Females do a modified push-up with knees bent and touching the floor. Starting in the up position, hands should be slightly ahead of the shoulders so hands are in the proper position for the downward motion.
2. Lower until the chest is about 2 inches from the floor and rise up again.
3. Perform the test until you cannot complete any more push-ups while keeping your back straight and, if you are a male, keeping the legs straight as well. The key to completing the test properly is to maintain a rigid position and keep the back flat. If necessary, you can take a brief rest in the up position (not lying on the floor).
4. Record your results.

* Normative data for the push-up and modified push-up are based on a population that is 20 years of age and older. These data and the test protocol are used with permission of The Cooper Institute, 12330 Preston Road, Dallas, TX 75230.

APPENDIX C-2

Half Sit-up Test Protocol

The Half Sit-Up Test*

One of the most frequently measured muscle groups is the abdominal (stomach) muscles. Several tests (for example, sit-up and curl-up tests) have been developed to measure mainly abdominal muscular strength and endurance. We are going to use an abdominal muscular strength and endurance test called the "YMCA Half Sit-Up" test, which is a curl-up test since you lift your trunk only partially off the floor.

Equipment/Test Setting:

- Mat or rug,
- Stopwatch or watch with a second hand,
- Four strips of tape to place 3.5 inches apart on mat or rug to provide start and end position for the curl-up.

Prepare the mat or rug with the tape strips as shown in the picture. You need to be able to feel the tape as your fingers move across the mat or rug from the starting and ending positions. We recommend that you do the test with a partner.

Directions:

Starting position for half sit-up.

Up position for half sit-up. Note the forward movement of the fingers relative to the tape.

1. Lie face-up on mat or rug with knees at a right angle (that is, 90º) and feet flat on the ground. The feet are not held down.
2. Place hands palms facing down on the mat or rug with the fingers touching the first piece of tape.
3. Flatten your lower back to the mat or rug, and half sit-up so that your fingers move from the first piece of tape to the second. Then return your shoulders to the mat or rug and repeat the movement as described. Your head does not have to touch the surface. Keep your lower back flat on the mat or rug during the movements – if you arch your back, it can cause injury.
4. Your partner will count the number of half sit-ups performed in one minute. Pace yourself so you can do half sit-ups for one minute.
5. Record your results.

* The half sit-up test is re-printed from the *YMCA Fitness Testing and Assessment Manual, 4th edition*, 2000, with permission of YMCA of the USA, 101 N. Wacker Drive, Chicago, IL 60606.

APPENDIX C-3

Sit-and-Reach Test Protocol

The Sit-and-Reach Test *

Alert! If you have low-back pain, doing this test may aggravate your condition.

Equipment/Test Setting

Tape measure or yardstick and tape and a partner to help record your score.

Directions:

Starting position for sit and reach. Note placement of feet about 12 inches apart and heels at the 14 inch mark.

Sit and reach stretch.

1. Perform a series of static stretches. These stretches should focus on stretching the trunk and legs. Following the stretches, you may also want to do some brisk walking.
2. Place a yardstick on the floor and put a long piece of masking tape over the 15 inch mark at a right angle to the yardstick.
3. Remove your shoes and sit on the floor with the yardstick between the legs (0 mark close to your crotch), with your feet about 12 inches apart. Heels should be at the 14 inch mark at the start of the stretch to account for the fact that the legs tend to move forward when performing the stretch.
4. With the fingertips in contact with the yardstick, slowly stretch forward with both hands as far as possible noting where the fingertips are to the closest inch. Exhaling when you stretch forward and dropping the head may allow you to stretch a bit further. Do not use fast and sudden motions, which can injure your hamstring muscles.
5. Perform the stretch three times with a few seconds of rest between stretches.
6. Record the best measurement.

* The sit and reach test is re-printed from the *YMCA Fitness Testing and Assessment Manual, 4th edition, 2000, 60606.*

APPENDIX C-4

1.5-Mile Run Test Protocol

1.5-Mile Run

Alert! Do not try to take this test unless you run at least 20 minutes continuously three or more times a week. If you do not do any type of physical activity (walking, swimming, bicycling) DO NOT try to take this test.

Equipment/Test Setting

For this test you must run all out for 1.5 miles (6 times around a standard quarter-mile track, located at many schools and some parks) and record your time. Keep in mind that you need to pace yourself for the full 1.5 miles. We recommend that you take this test with a partner who can record your time and count laps. You may also want to keep track of your time using your own watch as a back-up.

Treadmill Directions

This test can be performed on a treadmill. When running on the treadmill, be sure to let your arms swing freely at your sides (do not hold on to the handrails). Keep the incline of the treadmill level (at zero). You or your partner need to record the time on the treadmill when you complete 1.5 miles at your testing speed (keep in mind it takes a few seconds to increase the speed of the treadmill).

Directions

1. Runner completes a warm-up of slow jogging.
2. The runner starts on the partner's command--when the partner starts the watch. Runner runs as quickly as possible for 1.5 miles.
3. The partner counts the number of laps and lets the runner know how many laps are left.
4. The partner stops the watch when the runner crosses the start/finish line and records the time.
5. The runner cools down by jogging slowly until walking for at least one lap.

APPENDIX D-1

Push-up Online Fitness Testing Calculator

Push Up Test

ExRx.net > Fitness Testing > Calculator

TRANSLATE

Male Sex	Population Average
Age	Score
Repetitions	Rating

Calculate Reset

Instructions

Select sex and enter information in left column. Click "Calculate". Evaluates upper body muscular endurance for ages 15 through 69 years of age.

Subject performs as many repetitions as possible without pausing. Subject should be encouraged to perform one or two trial repetitions before test.

AdChoices

Become a Personal Trainer
Get ISSA Certified At Your

The push-up fitness testing calculator can be found at the following URL address:

http://www.exrx.net/Calculators/PushUps.html

APPENDIX D-2

Half Sit-up Online Fitness Testing Calculator

ExRx.net: Curl-up / Half Sit-up Test

ExRx.net > Fitness Testing > Calculator TRANSLATE

Male Sex	Population Average
Age	Score
ACSM Protocol	Rating
Repetitions	

Calculate Reset

Instructions

Enter information in left column; select appropriate menus. Click "Calculate". See ACSM Curl-up or YMCA Half Sit-up for protocol instructions. Evaluates abdominal muscular endurance for ages 20-69 years (ACSM) and 18-70 years (YMCA).

The half sit-up fitness testing calculator can be found at the following URL address:

http://www.exrx.net/Calculators/CurlUp.html

APPENDIX D-3

Sit-and-Reach Online Fitness Testing Calculator

Sit and Reach Flexibility Test

ExRx.net > Fitness Testing > Calculator

TRANSLATE

Male Sex	Population Average
Age	Score
Inches Distance	Rating

Calculate Reset

Instructions

Enter information in left column; select appropriate menus. Click "Calculate". Evaluate hamstrings and lower back flexibility for adults.

After a brief warmup the subject sits on floor with shoes off. Subject places bottom of feet (10 to 12 inches apart) against side of box (approximately 12" or 30 cm high) with knees straight. Tester places measuring stick on box parallel to subjects legs; 15" or 38 cm at edge of box closest to subject and end of measuring stick ("0") toward subject. Subject places hand over hand and reaches as far as possible over measuring stick without bending knees. Best of three tries is recorded.

The quality of the stretch should also be examined for smoothness of spinal curve and the angle of hip (near 90° or more). See Sit and Reach Spinal Flexion Assessment.

Golding LA, Myers CR, Sinning WE (eds): The Y's Way to Physical Fitness. Rosemont, IL: YMCA of the USA, 1982.

The sit-and-reach fitness testing calculator can be found at the following URL address:

http://www.exrx.net/Calculators/SitReach.html

APPENDIX D-4

1.5-Mile Run Online Fitness Testing Calculator

ExRx.net: Distance Run

ExRx.net > Fitness Testing > Calculator

TRANSLATE

Male Sex	METs
Age	VO2 Max
1.5 mile (2414 m) Distance	Population Average
Minutes	Score
Seconds	Rating
Calculate Reset	

Instructions

Enter information in left column; select appropriate menus. Click "Calculate".

After a warm up, the subject runs as fast a possible for 1.5 miles (2413.5 meters) or 2 miles (3218 meters). Tester records time to completion. Evaluates cardiovascular fitness for adults using the 1.5 mile run or the 2 mile run.

SEE ± 5.0 ml/kg/min

The 1.5-Mile Run fitness testing calculator can be found at the following URL address:

http://www.exrx.net/Calculators/OneAndHalf.html