Physical Activity and Body Composition Changes during the First Two Years of College

by

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Abstract

Objective: The effects of vigorous and moderate aerobic and resistance physical activity on changes in body weight, body mass index, body fat %, fat mass, and fat-free mass were examined in two cohorts of males and females during the freshman and sophomore years of college. In addition, the percentages of students meeting physical activity recommendations by the American College of Sports Medicine were evaluated. Methods: Participants were recruited at the beginning of their college freshman year. Participants were assessed 2 to 3 times during the freshman and sophomore years. Assessments included height, weight, body composition (using bioelectrical impedance), and physical activity (using a self-reported questionnaire). Results: Cohort 1 included 240 students (35 % males, 65 % females) and cohort 2 included 295 students (36 % males, 64 % females). Cohort 1 females participated in significantly less moderate physical activity during sophomore year (195 ± 151 mins/week) than during the freshman year (257 ± 172 mins/week), while cohort 2 females significantly increased moderate physical activity from 165 ± 112 mins/week during the freshman year to 208 ± 169 mins/week during the sophomore year. For each cohort, during the freshman and sophomore years, males reported significantly more resistance physical activity than females, and during the sophomore year, cohort 1 males participated in significantly more vigorous and moderate physical activity than cohort 1 females. Males (both cohorts) were more likely than females to meet vigorous physical activity and resistance training recommendations during the freshman and sophomore years. Significant decreases between the freshman and sophomore years were seen in vigorous physical activity for cohort 2 females, in moderate physical activity for cohort 1 males and females, and in resistance training for cohort 1 males. Those meeting resistance physical activity recommendations ranged from 47 to 50 % in the freshman year to 40 to 45 % in the sophomore year. Students meeting vigorous activity recommendations ranged from 67 to 69 % in the freshman year and 57 to 67 % in the sophomore year. Those meeting moderate activity recommendations ranged from 52 to 79 % in the freshman year and 58 to 62 % in the sophomore year. During freshman year, cohort 2 females participating in low levels of vigorous physical activity gained significantly more body fat % (1.2 ± 2.3 %) than those with high levels of participation (0.3 ± 2.1 %). During the sophomore year, cohort 2 males with higher vigorous levels gained significantly more weight and fat mass (2.5 ± 3.6 lbs and 3.3 ± 3.4 lbs, respectively) than those with lower vigorous physical activity levels (-0.5 ± 4.8 lbs and 0.3 ± 4.7 lbs, respectively). Cohort 2 females with higher levels of vigorous activity gained significantly less body fat % (0.1 ± 2.2 %) than those with lower vigorous activity levels (1.1 ± 2.2 %). Also, cohort 2 females who reported higher levels of resistance physical activity gained less body fat % (0.2 ± 2.1 %) and fat mass (0.4 ± 4.1lbs) than those with lower resistance physical activity levels (body fat % 1.3 ± 1.4 %, and fat mass 2.1 ± 2.7 lbs). Conclusions: Many students are not meeting minimum recommendations for physical activity. Further, many students' participation in physical activity appears to diminish between the freshman and sophomore year of college. High levels of vigorous and resistance physical activity tended to benefit some college females in terms of preventing unhealthy changes in body fat %, fat mass, and fat-free mass.

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Chapter 1

Introduction

Throughout the United States, the prevalence of overweight and obese has continued to rise. Obesity has almost doubled from 15.9 to 27.6 % in the past 15 years, and the percentage of individuals that are classified as normal weight or below has declined from 50 % to 35 % (CDC 2010a). Obesity increases the risk of mortality and morbidity in problems such as cardiovascular disease, stroke, type 2 diabetes, arthritis, and several forms of cancer (CDC 2010b). Physical activity generally reduces body fat and weight gain and encourages healthy weight maintenance while lessening the risk of chronic disease (Brooks and others 2004, DHHS 2008, Haskell and others 2007, U.S. Surgeon General 2010). However, technology, television use, and sedentary work-based lifestyles typically discourage otherwise higher levels of activity during daily living (Bowman 2006, Haskell and others 2007). These trends are reflective in the 51 % of Americans that did not meet the American College of Sports Medicine's minimum recommendations for healthful aerobic physical activity levels in 2010 (CDC 2010a).

Obesity is widespread in Alabama where 33 % of residents are classified as obese and the state is ranked second highest in national standings for obesity (CDC 2010a). Along with these obesity statistics is a high percentage of Alabamians that are not physically active. The percentage of Alabama residents not meeting physical activity recommendations is 59 % (CDC 2010a). Younger adults, aged 18-24 years, living in Alabama are not excluded from these trends where 48.2 % are classified as overweight or obese (CDC 2010a), and only half (50 %) of young adult Alabamians are meeting the minimum aerobic physically activity recommendations (CDC 2010a).

Young adults, especially those entering college are at risk for obesity. While few gain the notorious " Freshman 15", a freshman weight gain of 4 to 5 lbs is fairly common (Edmonds and others 2008; Gropper and others 2009, 2011; Hajhosseini and others 2004; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009). Moreover, weight gain appears to continue throughout college (Gropper and others 2011; Racette and others 2005, 2008); albeit, most young adults exhibit unhealthy gains in body weight, BMI, fat mass, and waist circumference during the freshman year (Butler and others 2004; Gropper and others 2009, 2011; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009; Racette and others 2005, 2008). Coupled with weight gain is a change in physical activity, which begins to decline especially during the transition period from high school to college (Bray and Born 2004, Buckworth and Nigg 2004, Edmonds and others 2008, Mestek and others 2008, Pullman and others 2009). Increases in weight and/or body mass index coupled with a reduction in physical activity are well documented during the freshman year of college (Butler and others 2004, Huang and others 2003, Kasparek and others 2008, Pullman and others 2009, Wengreen and others 2009). But, few studies have examined physical activity and weight change beyond the freshman year (Racette and others 2005, 2008). These freshman year studies indicate that the majority of students are not meeting physical activity recommendations while weight gain continues. Yet, missing from the literature is an examination of the changes in body weight and composition for both males and females as it relates to physical activity type during and after the freshman year. The purposes of this study were to examine associations between changes in weight and body composition and participation in physical activity (moderate, vigorous and resistance training) in males and females during the first two years of college. Additionally, the percentages of males and females meeting physical activity recommendations during the freshman and sophomore years were determined.

Chapter 2

Review of Literature

This review of the literature is divided into six main sections, including definitions of physical activity and exercise, the benefits of physical activity, recommendations for participation in physical activity, compliance with physical activity recommendations, the effects of physical activity on body composition, and finally, observations in physical activity and body composition among college students. Subsections under the effects of physical activity on body composition provide information on inactivity as well as how the frequency, duration, intensity and type of physical activities influence body composition. The last section on observations in physical activity and body composition among college students is further subdivided into studies focusing on the freshman year of college and then studies beyond the freshman year.

Definitions: Physical Activity and Exercise

Physical activity is any energy expenditure produced by the skeletal muscles which results in force generation. Exercise is a form of physical activity that is planned, structured, repetitive, and preformed with a goal to improve fitness (Caspersen and others 1985). There are two main modes of exercise training: aerobic and muscle strengthening.

Aerobic exercise or endurance activity is characterized by a state of movement where the body's large muscles move in a rhythmic manner for a sustained period of time and the heart rate is elevated. Examples are: brisk walking, running, and bicycling. Intensity, frequency, and duration vary for aerobic exercise sessions. Muscle strengthening, also known as resistance training, is characterized by large muscle group movements against an applied force; forces usually involve heavy objects, resistance bands, and/or body weight. Similar to aerobic activity, muscle-strengthening consists of three components: the amount being lifted relative to a maximum weight a person is able to lift, how often, and number of repetitions performed during a session (DHHS 2008, Katzmarzyk and others 2006).

The Benefits of Physical Activity

Decreased physical activity is a strong independent predictor of mortality among men (Paffenbarger and others 1993) and women (Hu and others 2004, Stevens and others 2002). Physical activity lowers the risks of premature death, coronary heart disease, stroke, breast and colon cancers, type 2 diabetes, metabolic syndrome, high blood pressure, and hypercholesterolemia (DHHS 2008, Katzmarzyk and others 2006). Improvements in physical fitness, symptoms of depression, cognitive function in the elderly, and a diminished likelihood of heart attacks have been documented in those who engage in regular physical activity. Additionally, physical activity lowers the risk for osteoporosis, increases functional capacity for daily activities, and reduces abdominal fat mass (DHHS 2008). Physical activity clearly promotes health; however, 65% of adult Americans do not engage in adequate leisure-time physical activity (DHHS 2009).

Physical Activity Recommendations

Physical activity recommendations vary among organizations. However, all organizations agree that a minimum level of exercise is needed to achieve health benefits. This section provides information on physical activity recommendations from the: 2005 Dietary Recommendations for Americans, World Health Organization, American College of Sports

Medicine and American Heart Association, U.S. Department of Health and Human Services' 2008 Physical Activity Guidelines for Americans, and Institute of Medicine.

In 1995, the Center for Disease Control and Prevention and the American College of Sports Medicine published the recommendations that “every U.S. adult should accumulate 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week” (Pate and others 1995). This recommendation has been endorsed in both the U.S. Public Health Service's Surgeon General's Report on Physical Activity and Health and the 2005 Dietary Recommendations for Americans (Bennett and others 2009). The recommendation also served as a basis for similar recommendations issued by the World Health Organization (WHO 2004).

The Institute of Medicine has published recommendations addressing both dietary intake and physical activity to maintain healthy weight and avoid undesirable fat accretion. The Institute of Medicine suggests that adults obtain at least 60 minutes of accumulated moderately-intense physical activity (i.e., brisk-walking at 2-4 km/hr) per day while also balancing intakes of dietary macronutrients (carbohydrate providing 45-65% of energy, fat providing 20-35%, and protein providing 10-35% of energy) (Brooks and others 2004).

The American College of Sports Medicine and American Heart Association have more recently jointly published guidelines to clarify types and amounts of physical activity for the promotion and maintenance of health (Haskell and others 2007). These updated guidelines have been used in the foundation for the U.S. Department of Health and Human Services' 2008 Physical Activity Guidelines for Americans (DHHS 2008). Specifically, the American College of Sports Medicine and the American Heart Association recommend a combination of both aerobic and muscle strengthening activities. At least 30 structured minutes of aerobic moderate-intensity exercise five days a week or 20 minutes of aerobic vigorous-intensity exercise three days a week are suggested in addition to daily routine and light-intensity activity accumulated at work and/or at home (Haskell and others 2007). Alternatives to meet the aerobic recommendations are provided and include combinations of moderate and vigorous-intensity aerobic exercise sessions. For example, two 30 minute bouts of moderate-intensity exercise (e.g., brisk walking) in combination with two 20 minute bouts of vigorous-intensity exercise (e.g., jogging) equate to the recommended aerobic exercise for the week. Further, while daily aerobic exercise sessions must be at least 10 minutes in duration, one 30 minute aerobic moderate-intensity session can be composed, for example, of three different 10 minute bouts of moderate-intensity exercise. In addition to aerobic activity recommendations, muscle strengthening exercises are suggested on two nonconsecutive days each week to promote physical independence and good health. Muscle strengthening exercises include progressive weight-training programs, weight-bearing exercises, calisthenics, stair climbing, and similar load-bearing/ resistance exercises that use the major muscle groups. It is further suggested, to maximize the load-bearing session, that a minimum of 8-10 major muscle group exercises with at least one set of 8-12 repetitions per exercise be performed (Haskell and others 2007). However, exceeding these minimal recommendations may further improve a person's fitness level and musculoskeletal health, while also reducing both premature chronic health conditions and unhealthy weight gain (Haskell and others 2007, Pate and others 1995).

In addition to the more specific health organizations recommendation, accumulating 10,000 steps per day is commonly promoted and often associated with healthful levels of physical activity. Besides an individual's routinely taken steps, researchers and clinicians have recommended 10,000 steps per day to encourage the accumulation of an additional 3,000 to 4,000 active steps. Actively walking at a minimum rate of 100 steps per minute for 30 minutes has been reported equivalent to 30 minutes of moderate-intensity (Tudor-Locke et al 2008).

Compliance (non-compliance) with Physical Activity Recommendations by Young Adults

Despite the existence of physical activity guidelines, most young Americans do not meet the minimum physical activity recommendations to achieve health benefits. According to the Centers for Disease Control and Prevention's National Center for Health Statistics, 33.7% of all U.S. adults aged 18-24 years are not engaged in physical activity during their leisure-time (Schoenborn 2010); in contrast, 37.5% report being regularly active, meeting minimum physical activity guidelines based on duration, intensity, and frequency set forth by the American College of Sports Medicine and American Heart Association (Haskell and others 2007, Pate and others 1995). Of those young adults who are engaged in physical activity, 15.9% achieved the minimum recommendations for moderate-intensity aerobic activity, and 16.7% and 15.5% completed at least 20 minutes of vigorous-intensity exercise on 3-4 occasions per week and 5 or more occasions per week, respectively (Schoenborn 2010).

Smaller studies also have examined physical activity participation among college students. Driskell and associates (2005) found that less than 50% of college students met the American College of Sports Medicine and American Heart Association physical activity recommendations. Specifically, 42% of juniors and seniors that were studied (n=147) and 47.8% of freshmen and sophomores that were studied (n=114) reported aerobic activity participation at least three times weekly. Approximately 30% of students reported doing resistance training for more than 31 minutes daily. About 50% reported walking or doing other aerobic activities and resistance training at least once weekly (Driskell and others 2005).

A study by Buckworth and Nigg (2004) found that college students (n=493) typically spent 30 hours a week engaged in sedentary behaviors. Only 30.6% of students engaged in moderate-intensity activity on ≥ 5 of the previous 7 days and 53.2% of students engaged in vigorous-intensity activity on ≥ 3 of the previous 7 days. Males, in contrast with females, participated significantly more often in strength training (3.28 vs. 2.45 days/week) and vigorous-intensity activity (2.69 vs. 1.80 days/week). Males also were reported participating in physical activity more frequently (3.84 vs. 3.1 days/week) and for longer duration (61.89 vs. 37.21 minutes) than females. Females tended to participate in more moderate-intensity exercise and stretching than males (Buckworth and Nigg 2004).

Huang and company (2003) found that over a 7-day period students' (n=738; 382 males, 354 females) average participation in aerobic physical activity was 2.8 ± 2.1 days per week and 2.2 ± 2.1 days per week for strength training. Males were significantly more likely to report participation in aerobic physical activity than females (3.1 ± 2.0 days/week for males and 2.5 ± 2.1 days/week for females). Students, 20 years or older, were significantly more likely to not engage in aerobic (+8.2%) and strength training (+9.8%) activities than younger students (Huang and others 2003).

Mestek and others (2008) reported men (aged 22 years, n=44) were more likely to meet the 10,000 steps per day recommendation than women (aged 21 years, n=44); men took significantly more steps (10,027 ± 3,535 steps/day) than women (8,610 ± 2,252 steps/day). Men also reported engaging in vigorous physical activity significantly more than women (6.0 ± 5.4 hours/week for men versus 2.6 ± 2.1 hours/week for women). No significant differences were found between men and women's participation in moderate-intensity activity, walking, and hours spent sitting.

Two studies investigating the effects on physical activity levels and the transition from high school to college have yielded varying results. Edmond and colleagues (2008) reported that aerobic vigorous-intensity activity participation significantly increased from 2.3 ± 0.14 times per week to 3.1 ± 0.18 times per week among 116 females; strength training and moderate-intensity activity participation, however, did not change in this group. In contrast, Bray and Born (2004) found that vigorous-intensity physical activity participation among undergraduates (39 males and 106 females) significantly declined from 3.32 ± 2.12 times per week to 2.68 ± 2.24 times per week.

In summary, young adults typically do not meet physical activity recommendations. The likelihood of meeting recommendations appears to decline with aging, and overall females appear less likely to meet recommendations than males.

Effects of Physical Activity on Body Composition

The type of exercise and the frequency, duration, and intensity of exercise influence body composition especially fat-free mass (which represents body mass devoid of fat including organs, connective tissue, skeletal muscle, bone, and extracellular fluid), lean body mass (which includes fat-free mass as well as essential body fat – that is fat in the bone marrow and body organs and for females fat associated with reproductive system), skeletal muscle, and fat mass. This section will discuss how body composition is affected by inactivity as well as the frequency, duration, intensity and type of physical activity.

Effects of Inactivity

To examine the effects of inactivity on body composition, several bed-rest studies have been reported. In an investigation of eight healthy men (age 28.0 ± 0.8 years), body weight significantly decreased (74.8 ± 3.0 kg to 72.0 ± 3.2 kg) after 42 days of -6° head-down bed-rest. Throughout the experiment, lean body mass also significantly decreased from 61.2 ± 1.8 kg to 58.5 ± 1.6 kg. Fat mass did not significantly change (Blanc and others 1998).

Biolo and colleagues (2008) reported that body weight significantly decreased from 76.5 ± 2.9 to 75.4 ± 2.8 kg (n=10) and from 76.3 ± 3.7 to 73.9 ± 3.5 kg (n=9) on two separate occasions of 5-weeks of bed rest in a group of males (age 24 ± 1 years). Additionally, fat mass significantly increased from 10.2 ± 1.6 kg to 11.9 ± 1.6 kg and 13.6 ± 2.1 kg to 14.4 ± 2.3 kg while fat-free mass significantly decreased from 66.3 ± 2.1 kg to 63.4 ± 1.9 kg and from 62.7 ± 2.2 to 59.4 ± 1.9 kg. In a similarly executed trial, Mazzucco and colleagues (2010) examined 24 healthy males (age 23.2 ± 0.4 years) and reported a significant 4.0 % decrease in fat-free mass from 61.9 ± 1.2 kg to 59.4 ± 1.1 kg. Fat mass remained unchanged.

After 60-days of bed-rest, 16 women (aged 29-38 years) experienced a significant decrease of 3.3 ± 0.3 kg body weight with most of the significant loss as fat-free mass (-2.9 ± 0.1 kg). When the bed-rest was combined with in-bed exercise, the decrease in body weight was accompanied by a significant fat mass loss (-1.9 ± 0.3 kg). These data suggested that exercise helped to attenuate muscle atrophy (Bergouignan and others 2010). Supporting this conclusion, Alkner and others (2004) reported healthy males (n=17; age 26-41 years) confined to bed-rest without exercise (n=9) experienced a significant 10% decrease in quadriceps muscle volume; whereas, the bed-rest with exercise group (n=8) did not experience significant changes.

Although restricted physical activity in these studies is not typical, the findings suggest that fat and lean body mass are redistributed during periods of inactivity. Consequently, lean body mass is lost to inactivity and fat mass is either added or maintained.

Effects of Physical Activity

In contrast to inactivity, physical activity typically has more desirable effects on body composition. Five studies are examined that present the effects of exercise, in the absence or presence of dietary restrictions, on body composition.

In a study of U.S. Marine Corps female recruits exposed to the rigors of intense physical and psychological demands, 51 volunteers (19.7 ± 2.1 years) completed a 13-week recruit training study. By the end of the study, statistically significant decreases were observed in body fat (6.5 %), body weight (2.3 ± 0.4 kg), and fat mass (4.7 ± 0.4 kg) along with significant gains in muscle mass (2.5 ± 0.2 kg) (Lieberman and others 2008).

In an intervention involving 33 overweight, postmenopausal women with type 2 diabetes, a 14-week exercise program (used exclusively as the means for caloric deficit) resulted in a significant 1.7 kg reduction in body weight and no change in fat-free mass (Giannapoulou and others 2005).

Changes in fat mass, fat-free mass, lean body mass, skeletal muscle mass, and fat % were studied in 1003 men (age 18-28 years) during Finnish military service (6-12 months, depending on type of service). Findings from normal weight servicemen (n=655) revealed significant increases in fat mass, fat-free mass, lean body mass, skeletal muscle mass, and fat % (0.3 ± 2.9 kg, 0.9 ± 2.4 kg, 0.8 ± 2.3 kg, 0.7 ± 1.5 kg, 0.3 ± 3.8 %, respectively). Likewise, fat mass, fat-free mass, lean body mass, skeletal muscle mass, and fat % significantly increased for 37 underweight men (1.9 ± 1.8 kg, 1.9 ± 2.0 kg, 1.7 ± 1.9 kg, 1.2 ± 1.2 kg, 2.7 ± 2.8 %, respectively), but fat % was the only parameter that was significantly different compared to the normal weight servicemen. Overweight participants (n=235) experienced significant decreases in fat mass and fat % (4.0 ± 4.6 kg and 3.9 ± 4.4 %) and increases in fat-free mass and skeletal muscle mass (0.3 ± 2.3 kg and 0.2 ± 1.4 kg). No significant change was seen in lean body mass (0.3 ± 2.2 kg); however, the normal weight men entering service differed significantly in terms of fat mass, fat % and skeletal muscle mass. Similarly, the obese group (n=76) experienced the greatest significant decrease in fat mass (8.9 ± 6.1 kg) and fat % (6.4 ± 4.1 %) which was significantly different from normal weight servicemen, and a significant increase in fat-free mass, lean body mass, and skeletal muscle mass was reported, that is, within the obese servicemen group (0.8 ± 2.9 kg, 0.7 ± 2.7 kg, and 0.5 ± 1.7 kg, respectively). Thus, in absolute terms, only overweight and obese participants lost fat mass and fat % with service while normal weight and underweight participants gained fat mass and fat %; all participants gained fat-free mass, lean body mass, and skeletal muscle mass (Mikkola and others 2009).

Similar effects are seen when caloric restriction and exercise are combined. For example, obese, sedentary men (n=52) randomly assigned to a diet-induced weight loss (n=14), exercise-induced weight loss (n=16), exercise without weight loss (n=14), or control group (n=8) were examined by Ross and co-workers (2000). Both weight loss groups lost ~7.5 kg of body weight. Body weight did not change in the exercise without weight loss group (that performed the same level of exercise, but compensated by increasing energy intake to maintain body weight) and the control. Both the diet-induced and exercise-induced weight loss groups significantly decreased fat mass (4.8 kg and 6.1 kg, respectively), but the exercise-induced weight loss group lost significantly more (1.3 kg) than the dieting group. Compared to the control, both exercise groups retained skeletal muscle mass, while the diet-induced weight loss group significantly lost 1.7 kg skeletal muscle mass (Ross and others 2000).

Over six months, Redman and co-workers (2007) examined body composition in 16 males and 19 females assigned to a dieting group (n=12), a dieting and exercise (n=12) group, or a weight maintenance control group (n=11). Both deficit groups experienced significant weight loss (8.3 ± 0.8 kg with dieting; 8.1 ± 0.8 kg with exercise and dieting). Fat mass decreased by ~5.9 kg for subjects dieting and ~6.4 kg for dieting and exercising. Both dieting females and dieting and exercising females experienced a significant decrease in fat-free mass (~3.3 kg) by the end of the study. Similarly, dieting males and dieting and exercising males significantly lost ~2.9 kg fat-free mass by the end of the study (Redman and others 2007).

Despite the presence of dietary restriction, fat mass and lean body mass are positively affected by exercise. The literature suggests fat mass tends to decrease while lean body mass or fat-free mass is more likely to be preserved in the presence of increased physical activity as exercise.

Aerobic Intensity

Aerobic exercise increases energy expenditure and influences body composition; however, intensity combined with increased duration and frequency may generate more beneficial effects on body composition. Several studies have examined the effects of exercise intensity on body composition and will be reviewed further.

Jakicic and others (2003) examined 196 sedentary, overweight/obese women (age 21-45 years) for a 3-month randomized trial. Participants were assigned to a vigorous intensity/ high duration, a vigorous intensity/ moderate duration, a moderate intensity/ high duration, or moderate intensity/ moderate duration exercise group. Body weight and BMI for all exercise groups significantly decreased (vigorous intensity/ high duration 8.9 ± 7.3 kg, 3.4 kg/m^2; vigorous intensity/ moderate duration 7.0 ± 6.4 kg, 2.5 kg/m^2; moderate intensity/ high duration 8.2 ± 7.6 kg, 3.1 kg/m^2; and moderate intensity/ moderate duration 6.3 ± 5.6 kg, 2.4 kg/m^2, respectfully). A post hoc analysis was also done based on self-administered 7-day physical activity recalls completed at 6 and 12-months; participants were grouped based on exercise duration in minutes per week. Groups consisted of individuals reporting 200 or more minutes, an inconsistent average of minutes, 150 or more minutes, or less than 150 minutes of exercise per week. Weight loss at 12-months was significantly greater (7.8 kg) with 200 minutes per week or more of exercise compared with the groups obtaining less than 150 minutes per week or some average combination. Weight loss was not significantly different when 150 minutes were obtained or exceeded (Jakicic and others 2003).

In an 8-month exercise intervention, 120 overweight/ obese men and women age 40-65 years were randomly assigned to one of three exercise groups or to a sedentary control. Men and women were not analyzed separately. The exercise groups were defined by amount and intensity level of physical activity as follows: low amount/ moderate-intensity (12 miles/week at 40-55% peak oxygen consumption; n=28), low amount/ vigorous-intensity (12 miles/week at 65-80 % of peak oxygen consumption; n=28), and high amount/ vigorous-intensity (20 miles/week at 65-80% peak oxygen uptake; n=27). The low amount/ moderate-intensity and high amount/ vigorous-intensity groups significantly lost weight (1.3 ± 2.2 kg and 2.9 ± 2.8 kg, respectively). Body weight decreased 1.1 ± 2.1 kg in the low amount/ vigorous-intensity group, but did not reach statistical significance. Fat mass significantly decreased in all exercise groups (high amount/ vigorous-intensity 4.9 ± 3.0 kg; low amount/ vigorous-intensity 2.6 ± 3.4 kg; and low amount/ moderate-intensity 2.0 ± 2.7 kg, respectively). Both low amount groups were significantly different when compared to the high amount/ vigorous-intensity group. No significant differences in gender or dietary intakes were found (Slentz and others 2004). In a follow-up study, Slentz and colleagues (2005) reported that body weight decreased ~0.60 kg for a low amount/ moderate-intensity and low amount/ high-intensity groups, and 2.31 kg in a high-amount/ high-intensity group.

Others examining the effects of moderate-intensity physical activity have reported similar findings as those by Slentz and others (2004, 2005). Over 16-months, Donnelly and co-workers (2003) reported overweight men who exercised (n=16) decreased body weight (5.2 ± 4.7 kg), BMI (1.6 ± 1.4 kg/m^2), and fat mass (4.9 ± 4.4 kg). Exercising overweight women (n=25) maintained baseline, body weight, BMI, and fat mass. Participants were 17-35 years of age. In contrast, 10 exercising normal weight females (age 18-24 years), who participated in 60 minutes of moderate-intensity aerobic cycling 3 times weekly for two months, had significant decreases in body weight by 1.8 kg, BMI by 1.48 kg/m^2, and body fat % by 1.88 % (Stasiulis and others 2010).

When duration and frequency are eliminated as variables and intensity is exclusively examined, similar changes in body composition have been reported; however, the absolute difference in change may be negligible. In a study balancing weekly energy expenditure and varying the intensity of physical activity, Irving and others (2008) studied obese sedentary, middle aged women (n=27) who participated in a 16-week intervention. Each participant was randomly assigned to one of three groups: a non-exercising control; a 5 day a week light-intensity exercise intervention group; and a 3 day a week high-intensity intervention group. The high-intensity intervention group significantly reduced weight (3.5 kg), BMI (1.3 kg/m^2), and fat mass (2.8 kg) from baseline. The low intensity intervention group tended to decrease weight (2.1 kg), BMI (0.8 kg/m^2), and fat mass (1.3 kg). Most notable, body fat % decreased for both light and high intensity intervention groups and was not significant between groups. The control experienced no change in weight, BMI, or fat mass. Fat-free mass remained unchanged for all three groups.

Data are limited and varied for fat-free mass maintenance related to intensity level and aerobic activity. Donnelly and co-workers (2003) reported no change in fat-free mass with moderate-intensity exercise in males and females. On the other hand, Slentz and others (2004) reported significant increases in lean body mass % with high amount/ vigorous-intensity (4.7 ± 3.3%), low amount/ vigorous-intensity (2.7 ± 3.5 %), and low amount/ moderate-intensity (1.9 ± 2.7 %).

Clearly, intensity of aerobic physical activity affects fat loss and may attenuate fat-free mass loss; however, the overall energy expenditure created by the combination of intensity, duration, and frequency may impose a greater effect than intensity level alone. These studies support a dose response relationship that Slentz and colleagues (2004 and 2005) have suggested.

Resistance/ Strength Training

Like aerobic physical activity, resistance training increases energy expenditure and can influence body composition, especially attenuating fat-free mass loss. Some of the findings of studies examining the effects of resistance training on body composition are provided hereafter.

A 16-week diet and resistance training program study resulted in significantly decreased fat mass (8.6 ± 2.4 kg) with no change in skeletal muscle mass in a group of 14 postmenopausal obese women (Janssen and others 2002). Hunter and co-workers (2008) reported that resistance training maintained fat-free mass following a diet and exercise induced weight loss. Fat-free mass significantly increased from 46.9 ± 5.2 to 47.2 ± 5.0 kg for 37 overweight women that had previously lost ~12 kg (Hunter et al. 2008). Additionally, 20 moderately obese male and female subjects lost an average 9.0 kg after participating in an 8 week resistance exercise and diet protocol. Significantly less fat-free mass was lost in the resistance exercise and diet group (1.1 kg) compared to the diet and aerobic exercise group (2.3 kg) and the diet only group (2.7 kg) (Geliebter and others 1997).

When weight loss is not an outcome measure, resistance physical activity stimulates fat-free mass accretion and may decrease fat mass. For example, in a study examining the effects of aerobic activity (n=14), resistance training (n=13), and the combination of the two (n=15) on the body composition of men (40 to 65 years of age), body fat % significantly decreased from baseline measurements in all training groups (aerobic activity 2.1 kg; resistance activity 1.9 kg; resistance and aerobic activity 1.7 kg). Lean body mass increased and was similar for the resistance (1.8 %) and the resistance and aerobic activity groups (1.6 %), but the change was only significant for the resistance and aerobic activity group (Sillanpää and others 2007). Further, Kemmler and co-workers (2010) reported that lean body mass significantly increased 0.51 kg and fat mass decreased 0.69 kg in 123 postmenopausal women (65 to 80 years) after an 18-month resistance protocol. Additionally, 24 collegiate swimmers who trained 3 days a week with resistance activity and 6 days a week with endurance swimming training maintained body weight with significantly decreased fat mass (1.3 kg) and body fat percentage (1.7 %), and significantly increased lean body mass (0.5 kg) (Petersen and others 2006).

Others have published similar lean body mass increases, but have varying evidence of resistance training's effect on fat mass loss. Poehlman and co-workers (2002) reported that 16 young women (17 to 35 years) who participated in a resistance training program (but for which energy intake was not monitored or controlled) significantly increased fat-free mass by 1.3 kg and maintained fat mass. In a study examining 50 healthy inactive elderly (aged 65 years or older) adults, Hanson and colleagues (2009) reported that men (n=20) significantly increased fat-free mass 1.1 kg and women (n=26) non-significantly increased fat-free mass 0.4 kg. Fat mass did not change in either group. To further support this association in a younger population, 12 obese children (6 males and 6 females) who participated in a resistance training program twice weekly for 16 weeks experienced a significant increase in lean body mass (2.1 ± 0.5 kg), but no significant change in fat mass (Van Der Heijden and others 2010).

The overall effect of resistance training appears to reduce fat mass for all age groups; however, resistance training plays a key role in lean body mass maintenance and accretion. The American College of Sports Medicine and the American Heart Association's recommendations include both aerobic and resistance training activities to promote health (Haskell and others 2007). This combination of activity type may be more beneficial in terms of body composition than either activity used alone (Sillanpää and others (2007).

Long-term Effects of Physical Activity

While studies examining the effects of prolonged participation in physical activity on body composition are limited, positive effects on BMI and weight have been documented. In a

30-year longitudinal study involving 214,449 males and 206,136 females (age 20 to 70 years) grouped according to their reported combined work and leisure-time physical activity, BMI increased the most among males who exercised the least, such that BMI increase in sedentary men was 0.060 ± 0.004 kg/m^2, in men with intermediate activity 0.047 ± 0.004 kg/m^2, in men with high physical activity 0.036 ± 0.004 kg/m^2. Based on last 15 years of study data, BMI significantly increased in females in the sedentary (0.137 ± 0.012 kg/m^2) and in the intermediate groups (0.080 ± 0.003 kg/m^2), but not in the high (-0.001 ± 0.039 kg/m^2) physical activity group. Overall, annual BMI increase reported for sedentary individuals was larger when compared with the more active groups for both genders (Anderssen and others 2006).

Waller and colleagues (2008) reported that from 1975 to 2005, active twins (mean age 29 years in 1975) from 89 twin pairs gained significantly less weight than their inactive co-twin (8.4 ± 7.1 vs. 11.2 ± 9.0 kg, respectively). The trend for weight gain was similar in male and females. Further, among the 42 consistently discordant twin pairs (i.e. one twin was consistently active and the other inactive), body weight was significantly greater for the inactive co-twin (78.9 ± 15.4 kg) compared to the active twin (72.0 ± 11.8 kg) in 2005.

These longer term studies of physical activity provide evidence that maintaining an active lifestyle tends to be associated with diminished weight and BMI gains. Yet, most adults generally do not engage in physical activity and these habits may have their origins in college.

Observations in Physical Activity and Body Composition among College Students

The Freshman Year

Common to most college freshmen is the buzzword, “freshman 15.” This notorious 15 lbs (6.8 kg) weight gain maybe more accurately a 3 to 5 lbs (1.36 to 2.27 kg) increase for most first year college students and about 6 lbs (2.27 kg) for those who gain weight (Gropper and others 2009). Moreover, much of the gained weight is associated with increased body fat (Gropper and others 2009). Multiple factors are thought to contribute to the weight gain as well as body composition changes, including diminished participation in physical activity in college. For example, Butler and coworkers (2004) suggested that a reduction in all forms of physical activity, including leisure, sport, and occupational, were associated with a 2.89 lbs (1.31 kg) fat mass increase and a 1.39 lbs (0.61 kg) fat-free mass decrease during the first 5-months of college in 54 female college freshmen. Five studies are presented that have examined aerobic and resistance physical activity and BMI and weight changes in college students.

Kasparek and others (2008) investigated weight change as well as physical activity in 193 freshmen (169 females; 14 males) during a 6-month study during fall and spring semesters. Students completed self-reported surveys regarding weight, height, age, sex, race, and campus residency. Students were categorized into normal weight, overweight, or obese groups based on calculated BMI. Subjects also answered questions regarding the number of times that they participated in activity for 20 minutes or longer and maintained a sweat, the number of times that they participated in activity for 30 minutes or more without breaking a sweat, and the number of times per week that they strength-trained. Overall, a significant 2.5 kg (5.5 lbs) weight gain was reported for males and females over the study period. At the beginning of the fall, 18.1% of the respondents engaged in 0-1 activity sessions per week (low), 56.0% in 2-3 sessions per week (moderate), and 24.9 % in 4 or greater (high frequency). As compared to the fall, aerobic physical activity did not change. Participation dropped from 62.5 % in the fall to 45.9 % in the spring in males who were engaged in strength-training at a moderate to high frequency per week;

whereas, participation by women increased from 37.8 % to 42.1 %. Although no significant association between weight gain and physical activity participation was reported, students reporting the lowest number of activity sessions were twice as likely to have a BMI of 30 kg/m^2 or greater, and, for those who participated in physical activity more frequently, BMI scores were significantly lower at the end of the freshman year (Kasparek and others 2008).

Pullman and company (2009) assessed changes in anthropometric measures, waist circumference, dietary intake, and physical activity in 108 male (mean age 18.5 years) freshmen. Data were collected at the beginning and the end of fall and the end of the spring semesters. Physical activity participation was assessed using a self-assessment questionnaire requiring participants to categorize their intensity and duration of exercise into fast or slow aerobic activity, strength training, and flexibility training. Fast aerobic activity was defined as activity lasting ≥ 20 minutes that caused sweating and accelerated breathing; whereas, slow was ≥ 30 minutes and did not cause altered signs of sweating and breathing. Significant increases in body weight were observed whereby beginning of fall body weight averaged 74.7 ± 1.0 kg, end of fall body weight averaged 76.1 ± 1.0 kg, and end of spring body weight averaged 77.7 ± 1.1 kg (for a total gain of about 3 kg / 6.6 lbs). BMI and waist circumference also significantly increased after both semesters, height marginally (0.4 cm) and body fat (0.82 kg / 1.8 lbs) significantly increased over the study period. Participation in fast aerobic activity significantly decreased approximately 40 %; however, slow aerobic activity, strength training, and flexibility training did not significantly change. Additionally, sedentary activities, including computer use and TV watching significantly increased and nightly sleep significantly decreased. With energy intakes remaining unchanged throughout the study, the authors concluded that the decreased physical activity and increased sedentary behaviors were plausible reasoning for the observed weight gain (Pullman and others 2009).

Mifsud and colleagues (2009) evaluated body weight and composition, peak oxygen uptake, energy intake, and physical activity on three occasions, early September, close to Christmas break, and the end of the spring semester, in 29 college freshmen (16 females; 13 males). Over the first semester, significant increases in body weight (1.4 kg / 3.08 lbs), waist circumference (2.9 cm), % body fat (1.9 %), and fat mass (1.8 kg / 3.96 lbs) were reported in males, but not females. Additionally, males at the end of the academic year significantly increased body weight (1.9 kg / 4.18 lbs), BMI (0.6 km/m^2), waist circumference (2.7 cm), % body fat (3.1 %), and fat mass (2.6 kg / 5.72 lbs). Over the freshmen year, significant associations were found between changes in body weight and baseline % body fat and changes in % body fat and baseline % body fat (r=-0.53; r=-0.41, respectively). In other words, with lower initial % body fat, larger changes in body weight and % body fat were reported. Also, significant associations between changes body weight and % body fat and baseline peak oxygen uptake (r=0.51; r=0.48, respectively) were reported; as a result, higher initial peak oxygen uptakes were associated with larger increases in body weight and % body fat. Consequently, the authors suggested that male students entering college with a lower level of adiposity and a higher maximum oxygen uptake, indications of greater physical fitness, gain more fat mass than students who are less physically fit due to increased sedentary behavior conducive to the transition into college life.

The results of these freshman year studies investigating physical activity and weight and body composition changes suggest that college students, especially males, typically gain weight and fat mass during the first year of college and that reductions in physical activity, increases in sedentary activities, and perhaps pre-college body fat and fitness levels may be associated with these gains.

Beyond the Freshman Year

The declines in physical activity participation and increases in body weight appear to continue in college students beyond the freshman year; however, only two studies have studied these trends. Racette and coworkers (2005) examined the changes in body weight, BMI, exercise, and dietary habits in males and females aged 18 to 20 years during both the freshman and sophomore years of college. A stage-of-change questionnaire was used to collect self-reported participation in aerobics, strength, and flexibility training. The three categories were defined as: (1) regular aerobic activity- planned and performed to increase physical fitness, 3 to 5 times a week for 20 to 60 minutes that increases heart rate and perspiration, (2) regular strength training- planned physical activity to increase strength on 2 to 3 days weekly with one set of 8 to 10 repetitions for the largest muscle groups, (3) regular stretching- any planned physical activity to improve flexibility, 2 to 3 times weekly with the goal to increase or to maintain full range of motion. Initially, the amount of aerobic, stretching and inactivity by males and females did not significantly differ, but males reported participating in significantly more strength training activity than females (35 % for females and 55 % for males). Of the 764 initial freshman participants, 290 student participants returned for the follow-up assessment at the end of the sophomore year. By the end of the sophomore year, weight (1.8 ± 5.2 kg / 3.96 ± 11.44 lbs) and BMI (0.6 ± 1.8 kg/m^2) significantly increased for students; height remained largely the same. Weight decreased 26 % and did not change for 3 % of the students; however, 70 % increased weight by 4.1 ± 3.6 kg (9.02 ± 7.92 lbs). At the end of sophomore semester, aerobic exercise participation significantly declined from 62 to 55 %; low-intensity stretching participation significantly increased from 30 to 38 %; strength training participation tended to increase from 41 to 45 %; and inactive participation tended to decrease from 30 to 29 % (Racette and others 2005).

Racette and co-workers (2008) also published results for weight and BMI change from the beginning of the freshman year to the end of the senior year. There were 204 (66 males and 138 females) students that completed the assessment at both time points and were included in the analysis. Weight change over the four year time period ranged from -13.2 kg to +20.9 kg (-29.04 to +45.98 lbs) with significant average increases in body weight for both males (4.2 ± 6.4 kg / 9.24 ± 14.08 lbs) and females (1.7 ± 4.5 kg / 3.74 ± 9.9 lbs). Height and BMI also significantly increased for both males (0.9 ± 1.2 cm and 1.1 ± 2.0 kg/m^2, respectively) and females (0.6 ± 0.9 cm and 0.5 ± 1.6 kg/m^2, respectively). As freshmen, 29% did not exercise regularly while 59% of the students regularly participated in aerobic activity, and 45% in strength training. By senior year, there was no significant change in strength training, aerobic physical activity, or inactivity (Racette and others 2008). Body composition was not measured in these studies.

In summary, college freshmen typically gain body weight especially during their first semester of college. There are evident signs that physical activity is being replaced by sedentary behaviors which could be associated with weight gain, and especially, weight gain in the form of body fat. Should college students be maintaining participation in physical activity, it is possible that some of the observed weight gain may be associated with increases in fat-free / lean body mass.

Justification

Participating in physical activity has been clearly shown to have numerous health benefits. Physical activity lowers the risks of premature death, heart attack, coronary heart disease, stroke, breast and colon cancers, type 2 diabetes, metabolic syndrome, high blood pressure, high blood cholesterol concentrations, symptoms of depression, and osteoporosis as well as improves cognitive function and functional capacity for daily activities in older Americans (DHHS 2008, Katzmarzyk and others 2006). Physical activity may result in beneficial effects on body composition, including reductions in fat mass and gains in lean body mass depending on the type of physical activity and the intensity, duration, and frequency of the activity. Long-term physical activity also appears to be associated with decreased weight gain over time. Despite these benefits, young adults, including those attending college, do not typically meet minimum physical activity recommendations (Bray and Born 2004, Buckworth and Nigg 2004, Driskell and others 2005, Huang and others 2003). Moreover, during college, especially the freshman year, most young adults exhibit unhealthy gains in body weight, BMI, fat mass, and waist circumference (Butler and others 2004; Gropper and others 2009, 2011; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009; Racette and others 2005, 2008). While several studies in college freshmen have suggested a relationship between changes in weight and/or BMI and physical activity participation, few of the studies have investigated changes in body composition (Butler and others 2004, Kasparek and others 2008, Mifsud and others 2009, Pullman and others 2009). Moreover, only two studies have examined weight, BMI, and physical activity participation change beyond the freshman year (Racette and others 2005, 2008). The purposes of this study were to examine associations between changes in weight and body composition and participation in physical activity (moderate, vigorous and resistance training) in males and females during the first two years as college students.

Research Questions

1. Is there a difference in body weight, body fat, or fat-free mass among males participating in high levels of moderate physical activity than those participating in low levels?
2. Is there a difference in body weight, body fat, or fat-free mass among females participating in high levels of moderate physical activity than those participating in low levels?
3. Is there a difference in body weight, body fat, or fat-free mass among males participating in high levels of vigorous physical activity than those participating in low levels?
4. Is there a difference in body weight, body fat, or fat-free mass among females participating in high levels of vigorous physical activity than those participating in low levels?
5. Is there a difference in body weight, body fat, or fat-free mass among males participating in high levels of resistance physical activity than those participating in low levels?
6. Is there a difference in body weight, body fat, or fat-free mass among females participating in high levels of resistance physical activity than those participating in low levels?

For each of these questions, differences will be examined in both males and females for the freshman year and sophomore year. Additionally, the percentages of males and females meeting physical activity recommendations during the freshman and sophomore years were determined.

Chapter 3

Physical Activity and Body Composition Changes during the First Two Years of College

Abstract

Objective: The effects of vigorous and moderate aerobic and resistance physical activity on changes in body weight, body mass index, body fat %, fat mass, and fat-free mass were examined in two cohorts of males and females during the freshman and sophomore years of college. In addition, the percentages of students meeting physical activity recommendations by the American College of Sports Medicine were evaluated. Methods: Participants were recruited at the beginning of their college freshman year. Participants were assessed 2 to 3 times during the freshman and sophomore years. Assessments included height, weight, body composition (using bioelectrical impedance), and physical activity (using a self-reported questionnaire). Results: Cohort 1 included 240 students (35 % males, 65 % females) and cohort 2 included 295 students (36 % males, 64 % females). Cohort 1 females participated in significantly less moderate physical activity during sophomore year (195 ± 151 mins/week) than during the freshman year (257 ± 172 mins/week) while cohort 2 females significantly increased moderate physical activity from 165 ± 112 mins/week during the freshman year to 208 ± 169 mins/week during the sophomore year. For both cohorts, during the freshman and sophomore years, males reported significantly more resistance physical activity than females, and during the sophomore year, cohort 1 males participated in significantly more vigorous and moderate physical activity than cohort 1 females. Males (both cohorts) were more likely than females to meet vigorous physical activity and resistance training recommendations during the freshman and sophomore years. Significant decreases between the freshman and sophomore years were seen in vigorous physical activity for cohort 2 females, in moderate physical activity for cohort 1 males and females, and in resistance training for cohort 1 males. Those meeting resistance physical activity recommendations ranged from 47 to 50 % in the freshman year to 40 to 45 % in the sophomore year. Students meeting vigorous activity recommendations ranged from 67 to 69 % in the freshman year and 57 to 67 % in the sophomore year. Those meeting moderate activity recommendations ranged from 52 to 79 % in the freshman year and 58 to 62 % in the sophomore year. During freshman year, cohort 2 females participating in low levels of vigorous physical activity gained significantly more body fat % (1.2 ± 2.3 %) than those with high levels of participation (0.3 ± 2.1 %). During the sophomore year, cohort 2 males with higher vigorous levels gained significantly more weight and fat mass (2.5 ± 3.6 lbs and 3.3 ± 3.4 lbs, respectively) than those with lower vigorous physical activity levels (-0.5 ± 4.8 lbs and 0.3 ± 4.7 lbs, respectively). Cohort 2 females with higher levels of vigorous activity gained significantly less body fat % (0.1 ± 2.2 %) than those with lower vigorous activity levels (1.1 ± 2.2 %). Also, cohort 2 females who reported higher levels of resistance physical activity gained less body fat % (0.2 ± 2.1 %) and fat mass (0.4 ± 4.1lbs) than those with lower resistance physical activity levels (body fat % 1.3 ± 1.4 %, and fat mass 2.1 ± 2.7 lbs). Conclusions: Many students are not meeting minimum recommendations for physical activity. Further, many students' participation in physical activity appears to diminish between the freshman and sophomore year of college. High levels of vigorous and resistance physical activity tended to benefit some college females in terms of preventing unhealthy changes in body fat %, fat mass, and fat-free mass.

Introduction

Throughout the United States, the prevalence of overweight and obese has continued to rise. Obesity has almost doubled from 15.9 to 27.6 % in the past 15 years, and the percentage of individuals that are classified as normal weight or below has declined from 50 % to 35 % (CDC 2010a). Obesity increases the risk of mortality and morbidity in problems such as cardiovascular disease, stroke, type 2 diabetes, arthritis, and several forms of cancer (CDC 2010b). Physical activity generally reduces body fat and weight gain and encourages healthy weight maintenance while lessening the risk of chronic disease (Brooks and others 2004, DHHS 2008, Haskell and others 2007, U.S. Surgeon General 2010). However, technology, television use, and sedentary work-based lifestyles typically discourage otherwise higher levels of activity during daily living (Bowman 2006, Haskell and others 2007). These trends are reflective in the 51 % of Americans that did not meet the American College of Sports Medicine's minimum recommendations for healthful aerobic physical activity levels in 2010 (CDC 2010a).

Obesity is widespread in Alabama where 33 % of residents are classified as obese and the state is ranked second highest in national standings for obesity (CDC 2010a). Along with these obesity statistics is a high percentage of Alabamians that are not physically active. The percentage of Alabama residents not meeting physical activity recommendations is 59 % (CDC 2010a). Younger adults, aged 18-24 years, living in Alabama are not excluded from these trends where 48.2 % are classified as overweight or obese (CDC 2010a), and only half (50 %) of young adult Alabamians are meeting the minimum aerobic physical activity recommendations (CDC 2010a).

Young adults, especially those entering college are at risk for obesity. While few gain the notorious “ Freshman 15”, a freshman weight gain of 4 to 5 lbs is fairly common (Edmonds and others 2008; Gropper and others 2009, 2011; Hajhosseini and others 2004; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009). Moreover, weight gain appears to continue throughout the college years (Gropper and others 2011; Racette and others 2005, 2008); albeit, most young adults exhibit unhealthy gains in body weight, BMI, fat mass, and waist circumference during the freshman year (Butler and others 2004; Gropper and others 2009, 2011; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009; Racette and others 2005, 2008). Coupled with weight gain is a change in physical activity, which begins to decline especially during the transition period from high school to college (Bray and Born 2004, Buckworth and Nigg 2004, Edmonds and others 2008, Mestek and others 2008, Pullman and others 2009). Increases in weight and/or body mass index coupled with a reduction in physical activity are well documented during the freshman year of college (Butler and others 2004, Huang and others 2003, Kasparek and others 2008, Pullman and others 2009, Wengreen and others 2009). But, few studies have examined physical activity and weight change beyond the freshman year (Racette and others 2005, 2008). These freshman year studies indicate that the majority of students are not meeting physical activity recommendations while weight gain continues. Yet, missing from the literature is an examination of the changes in body weight and composition for both males and females as it relates to physical activity type during and after the freshman year. The purposes of this study were to examine associations between changes in weight and body composition and participation in physical activity (moderate, vigorous and resistance training) in males and females during the first two years of college. Additionally, the percentages of males and females meeting physical activity recommendations during the freshman and sophomore years were determined.

Methods

Participants

Freshmen were recruited from Auburn University's incoming freshman class via e-mail, posted fliers, and announcements in introductory level classes at the beginning of the fall semester of 2007 (cohort 1) and 2008 (cohort 2). Freshmen volunteers were excluded from participation if they were under 17 and older than 19 years of age, pregnant, married, had children, or reported a diagnosed eating disorder. Also, participants that were enrolled at the university for the summer semester of 2007 and 2008 were excluded for not being "true" first-semester freshmen.

Study Design

Cohorts 1 and 2 were assessed at 3 points during the freshman year; at the beginning of the fall semester (2007 and 2008, respectively), at the end of the fall semester (2007 and 2008, respectively), and at the end of the spring semester (2008 and 2009, respectively). During the sophomore year, cohort 1 was again assessed at 3 time points; at the beginning of the fall semester (2008), the end of fall semester (2008), and at the end of spring semester (2009); whereas, cohort 2 was assessed only at the beginning of the fall semester (2009) and at the end of spring semester (2010).

Assessments included anthropometric measurements (height, weight, body composition and size/shape) and the completion of a questionnaire providing self-reported demographic information, dietary, physical activity and sleep habits as well as psychological behaviors. Only the demographic information and selected anthropometric measures and physical activity habits were used for this research; this study was part of a larger longitudinal study examining factors associated with changes in body weight and composition during college. Study participants received monetary incentive after completion of each assessment. Informed consent and assent for subjects younger than 19 years or informed consent for those who were 19 years were obtained prior to participation in the study. This study was approved by the Institutional Review Board for the Use of Human Subjects in Research at Auburn University (appendix B).

Anthropometric Assessment

Height was measured at the beginning and end of freshman and sophomore years. Weight and body composition were measured at all assessments. Throughout all assessments, the same scales, height rods, and bioelectrical impedance equipment were used to measure height, weight, and body composition. Weight and height were assessed using a digital scale with an attached height rod (Healthometer, model 500KL; Pelstar, Bridgeview, IL). Each subject's height was measured to the nearest quarter-inch. Weight was measured to the nearest 0.2 lbs. The accuracy of the scales was verified with external weights. Subjects were asked to wear similar clothing for each assessment and to remove shoes, belts, outerwear jackets or sweaters, and items such as wallets and cell phones from their pockets.

Body composition was measured using bioelectrical impedance analysis (Bodystat; BioVant Systems, Detroit, MI). Measurements varied by less than 0.5% with repeated measurements of the same subject. Prior to conducting measurements, subjects were asked to lie down on their back for at least five-minutes to help normalize body water distribution. Subjects' arms and legs were separated laterally from the medial axis before the attachment of electrodes to the right hand and foot. Since hydration status affects accuracy, subjects were also instructed not to eat for 2-4 hours prior to assessment, not to drink caffeine or alcohol, and not to engage in strenuous exercise for 12 hours prior to assessment (NIH 1996). To help subjects satisfy these criteria, data were collected between 8 A.M. and 11 A.M. Only the assessment information from the beginning and end of freshman and sophomore years was used for the calculations of body composition change indices.

Questions regarding physical activity habits included a subsample of questions from the National College Health Risk Behavior Survey (CDC 1995). Physical activity questions included: (1) How many days per week do you participate in vigorous physical activity? (Vigorous activities are those that cause you to sweat and breathe hard.); (2) How many days per week do you participate in moderate physical activity? (Moderate activities include walking or bicycling. Be sure to include walking or biking to class, if applicable.); (3) How many days per week do you participate in strengthening exercises? (Strengthening exercises include activities such as push-ups, sit-ups, or weight lifting.). Immediately following each question regarding vigorous, moderate, and strengthening exercises, participants were asked to specify the number of minutes per day spent in in each activity.

Statistical Analyses

Statistical analyses were performed using Instat 3.0 (Graphpad Software, San Diego, CA) and JMP Version 8.0.2 (SAS Institute, Inc., Cary, NC). Outliers were excluded based on their relative position to two standard deviations from the freshman and sophomore weight, fat mass, fat-free mass, vigorous, moderate, and resistance means. However, partial inclusion of data was used. For example, valid freshman data was not excluded if sophomore data were beyond two standard deviations.

Gender and ethnicity between cohorts and the Auburn University freshman population comparisons were evaluated using Pearson Chi-squared Test. Auburn University enrollment data were obtained from the Auburn University Office of Institutional Research and Assessment (Auburn University OIRA). One-way analysis of variance (ANOVA) was used to compare baseline weight, BMI, and vigorous, moderate, and resistance activity of those who returned for all assessments throughout (end of freshman, beginning of sophomore, and end of sophomore year) and non-returners (i.e., those who did not return for any assessment after the initial measurement). A two-way ANOVA was used to evaluate differences in baseline outcome measures between cohorts and gender. For each outcome measure (weight, body mass index, body fat %, fat mass, and fat-free mass), main effects for year (freshman and sophomore) and gender (female and male) and related interactions were examined in a two-way ANOVA. Follow-up Tukey HSD Multiple Comparison Test or one-way ANOVA was used to examine statistically significant findings. A two-way ANOVA was used to examine the effects of gender and year for weekly aerobic and resistance physical activity, chi-square analyses were used to evaluate the number of students meeting physical activity recommendations, and a Bowker's Test was used to test for continuous variable differences. Additionally, to evaluate the effects of physical activity, males and females were separated into physical activity tertiles for each activity type (vigorous, moderate, and resistance). Freshman and sophomore weight, body fat %, fat mass, and fat-free mass outcomes were tested in a one-way ANOVA that examined the effects of level of physical activity. A two-way ANOVA was used to examine effects between freshman and sophomore year and male and females for vigorous, moderate, and resistance activity. Statistical significance was set as $p < 0.05$. Degrees of freedom varied because of missing data.

Data are represented as mean (SD) unless noted otherwise.

Results

Participants from 2007's cohort 1 consisted of 240 freshmen (35% males and 65% females) who were mostly Caucasian (81.7 %), followed by African American (12.1 %), Hispanic (2.9 %), Asian (1.7 %), and Native American (1.7 %). Cohort 2 included 295 freshmen (36 % males and 64 % female) entering in 2008 who were 88.8 % Caucasian, 3.7 % African American, 3.7 % Hispanic, 3.4 % Asian, and < 1 % Native American. Thus, a total of 535 students participated in two convenience samples. Baseline demographic and anthropometric data are presented in Table 3.1. As noted from table 3.1, the percentage of female and male participants did not vary between cohorts (females cohort 1: 65 %, cohort 2: 64%; males cohort 1: 35 % and cohort 2: 36%). Age and height did not significantly differ. Largely, participants were Caucasian, lived in on-campus housing, and reported permanent residence within the state of Alabama. Furthermore, both cohorts did not significantly differ from the Auburn University freshman classes of 2007 and 2008.

At the end of the freshman and sophomore years, 205 and 164, respectively, of the 240 initial participants in cohort 1, and 236 and 178, respectively, of the 295 initial participants in cohort 2 returned. The exclusion of outliers resulted in a total of 221 participants (146 females and 75 males) from cohort 1 and 266 participants (176 females and 90 males) for cohort 2. Of those that began the study, 136 participants and 137 participants returned (returners) for all assessment periods for cohort 1 and cohort 2, respectively. Baseline weight, BMI, aerobic (vigorous or moderate) and resistance physical activity participation for returners did not significantly differ from non-returners (data not shown). While subjects in cohort 1 and 2 did not significantly differ in baseline body weight, BMI, and fat-free mass, significant differences in body fat % and fat mass, as well as changes in body composition, were present between the two cohorts. Consequently, each cohort was evaluated separately.

Changes in body weight, BMI, body fat %, fat mass, and fat-free mass during the freshman (beginning of freshman fall semester to the end of spring term) and sophomore (beginning of sophomore fall semester to the end of spring term) years for cohorts 1 and 2 are presented in Table 3.2. These findings, although not directly related to the purposes of the study, provide a perspective on the observed changes associated with variations in physical activity presented later in tables 3.5 and 3.6. Females for both cohorts and males of cohort 2 gained significantly more weight their freshman year than the sophomore year. With respect to gender differences, cohort 1 males gained significantly more weight than cohort 1 females in the sophomore year. Significant BMI changes were found between females in both cohorts and cohort 2 males whereby BMI change significantly decreased freshman year versus sophomore year. Gender differences were observed with cohort 1 males gaining significantly more BMI than cohort 1 females during the sophomore year. Changes in body fat % were only significant in cohort 1 with both males and females exhibiting lower changes the sophomore versus freshman year. Similarly, fat mass change during the sophomore year was significantly lower than the freshman year for males and females of cohort 1. Cohort 1 males gained significantly more fat-free mass during the sophomore year than the freshman. Cohort 2 males and females gained significantly more fat-free mass during the freshman year than during the sophomore year. With respect to gender differences, cohort 1 females gained significantly less fat-free mass than cohort 1 males during the sophomore year.

Weekly aerobic (vigorous and moderate) and resistance physical activity participation are reported in Table 3.3. Between the freshman and sophomore years, cohort 1 females' participation in moderate physical activity significantly decreased, while cohort 2 females significantly increased their moderate physical activity. No significant difference was found between year and the amount of resistance training reported by both cohorts; however, during both the freshman and sophomore years, males reported significantly more resistance training days than females (both cohorts). Further, during the sophomore year, cohort 1 males reported significantly more vigorous and moderate physical activity than cohort 1 females.

Table 3.4 presents the percentage of cohort participants meeting recommendations for vigorous and moderate weekly minutes and number of weekly resistance days during the freshman and sophomore year. Males (both cohorts) were significantly more likely than females to meet the vigorous and resistance training physical activity requirements during freshman and sophomore years. Vigorous participation significantly decreased for cohort 2 females (60 % to 43 %), moderate physical activity participation significantly decreased in cohort 1 males (80 % to 61 %) and females (77 % to 58 %), and resistance training participation significantly decreased in cohort 1 males (69 % to 66 %) between the freshman and sophomore years.

Table 3.5 presents the freshman year weight, body fat %, fat mass, and fat-free mass changes in those with high (top tertile) and low (bottom tertile) physical activity level. Cohort 2 females (n=93) participating in higher levels of vigorous physical activity gained significant less body fat % (0.3 ± 2.1 %) and tended ($p=0.0680$) to gain less fat mass (1.0 ± 3.5 lbs) than females with low participation levels (1.2 ± 2.3 %; 2.4 ± 3.3 lbs, respectively). Cohort 1 females (n=79) tended ($p=0.0949$) to maintain fat-free mass with higher versus lower levels of moderate physical activity while cohort 2 females tended (p=0.0740) to gain more fat-free mass with higher levels of moderate physical activity compared to lower levels. Similar data for the sophomore year are presented in table 3.6. Cohort 2 males (n=32) with high vigorous activity experienced significantly greater weight gains(2.5 ± 3.6 lbs) and fat mass gains (3.3 ± 3.4 lbs) than those with low vigorous physical activity (weight -0.5 ± 4.8 lbs; fat mass 0.3 ± 4.7 lbs). Also, gains in body fat % tended (p=0.0779) to be higher in those cohort 2 males with higher levels of vigorous physical activity. Females of cohort 2 (n=65) with low vigorous activity gained significantly more body fat % than those with higher levels of vigorous physical activity (1.1 ± 2.2 % and 0.1 ± 2.2 %, respectively), and tended (p=0.0797) to gain more fat mass. In terms of resistance physical activity, low activity level cohort 2 females exhibited significantly greater gains in body fat % (1.3 ± 1.4 % and 0.2 ± 2.1 %, respectively) and fat mass (2.1 ± 2.7 lbs and 0.4 ± 4.1 lbs, respectively) than those with higher activity. Cohort 2 females also reporting higher levels of resistance physical activity tended (p=0.0616) to maintain fat-free mass better than those with lower levels.

A few gender effects were observed (appendix A). Cohort 2 high level vigorous activity males gained significantly more fat-free mass than females (3.5 ± 4.7 lbs vs. 1.4 ± 3.2 lbs, respectively) during the freshman year. Cohort 1 males (3.9 ± 3.8 lbs) gain significant more fat mass than females of cohort 1 (1.8 ± 3.3 lbs) for those reporting higher levels of moderate physical activity. Males of cohort 2 reporting lower levels of moderate physical activity experienced a significantly greater increase in fat-free mass than females with low moderate physical activity (3.3 ± 2.8 lbs vs. 0.9 ± 2.9 lbs, respectively). For the sophomore year, cohort 2 males (1.7 ± 1.8 % and 3.3 ± 3.4 lbs) participating in higher levels of vigorous physical activity gained significantly more body fat % and fat mass than females participating in high vigorous physical activity (0.1 ± 2.2 % and -0.1 ± 4.0 lbs). Cohort 1 males participating in high levels of vigorous activity significantly gained 2.4 ± 3.6 lbs of fat-free mass compared to females in cohort 1 (0.3 ± 2.8 lbs). Cohort 1 males with the highest participation levels of resistance activity gained significantly more weight than females (3.7 ± 3.5 lbs vs. -1.5 ± 4.2 lbs). Also, cohort 1 males participating in high levels of resistance activity gained significantly more fat-free mass (3.4 ± 4.3 lbs) than females participating in high levels of resistance activity (-0.2 ± 3.0 lbs).

Discussion

This study examined the effects of physical activity on weight gain and body composition changes in males and females during the freshman and sophomore years of college. To date, this study is the first to examine such changes beyond the freshman year for both males and females. Because excessive gains in weight and body fat and inadequate physical activity are associated with an increased risk of chronic disease, the identification of such changes are critical to enable both health promotion and intervention strategies for at risk college students.

This study's findings support the widely published reports of freshman year weight and BMI gains among college students; although, like other studies, weight gain averaged less than 5 lbs and gains in BMI averaged less than 0.6 kg/m^2 (Butler and others 2004; Gropper and others 2009; Hull and others 2007; Kasparek and others 2008; Mifsud and others 2009; Pullman and others 2009; Racette and others 2005, 2008). Despite the tendency for modest gains to continue during the sophomore year, weight and BMI gains generally plateau as shown by Hull and others (2007) and Hovell and others (1985), especially in females. Studies reporting weight and BMI responses are limited during the sophomore year, Racette and others (2005) reported gains of 4.0 lbs body weight and 0.6 kg/m^2 BMI during the first two years of college for a group of males and females (n=290). Gains in the present study were slightly higher, with average weight gains ranging from 1.9 to 4.3 lbs, and BMI gains ranging from 0.3 to 0.9 kg/m^2 during the freshman and sophomore academic years.

Changes in body fat %, fat mass, and fat-free mass were inconsistent between cohorts. Absolute body fat % and fat mass gains were observed both years with a general tendency for males and females to gain body fat % and fat mass during both freshman and sophomore years; the exception was cohort 1 females during the sophomore year whereby slight absolute decreases in both body fat % and fat mass were found. In terms of changes in fat-free mass, both gains and losses were observed with no consistency between genders and/or cohorts. Only one other study to date has examined body composition changes beyond the freshman year; this study supported similar stagnations or declines in body fat % and fat mass, but increased or maintenance of fat-free mass as found in cohort 1 females (Hull and others 2007). Reasons for the observed differences in changes in body composition between the two cohorts are thought to reflect differences in dietary habits. One major known dietary difference between the cohorts is the meal plan requirements. In contrast to cohort 1, all incoming freshmen (both on and off campus) in cohort 2 were required to purchase a meal plan that promoted access to a myriad of on-campus fast food dining areas. Such a plan may have contributed to greater energy intakes and perhaps thus differences in body composition changes by cohort 2 versus cohort 1. While the trends observed in physical activity habits (discussed later in this section) are not consistent with the observed differences in changes in body composition, interindividual variations in body composition response, more specifically fat mass accretion and utilization, to the duration and intensity of physical activity, as well as gender, are commonly found in the literature (Barwell and others 2009, Venables and others 2005) and may be responsible.

Participation in physical activity also was examined in the present study. Nationally, approximately 30 % of college aged young adults (18-24 years) are not meeting the minimum recommendation for aerobic and resistance physical activity (Schoenborn and others 2010); the present study's findings are fairly consistent with these national data for aerobic physical activity and slightly higher for resistance physical activity. Overall, students meeting vigorous activity recommendations, in the present study, ranged from 67 to 69 % the freshman year and 57 to 67 % the sophomore year. In comparison, Racette and others (2005) reported slightly lower percentages with 62 % of freshman and 55 % of sophomores meeting vigorous minimum recommendations. Reported participation, in the present study, in moderate physical activity ranged from 52 to 79 % during the freshman year and 58 to 62 % during the sophomore year. These findings tend to be higher than those of Buckworth and Nigg (2004) who reported that only 30.6% of college students engaged in moderate intensity activity. Additionally, in this study, 47 to 50 % of freshmen and 40 to 45 % of sophomores met the resistance physical activity recommendations. These findings are similar to those by Racette and others (2005) who reported 45 % participation during both years and higher than 35 % nationally (Schoenborn and others 2010).

The present study's finding that males typically met the minimum recommendations for vigorous and resistance physical activity more so than females has been noted in a few studies (Buckworth and Nigg 2004, Huang and others 2003, Mestek and others 2008). Because a lower percentage of females met these minimum recommendations than males, females may be at greater risk of gaining weight and developing associated health-related ailments than males. The significant decreases observed between the freshman and sophomore years in vigorous physical activity for cohort 2 females, in moderate physical activity for cohort 1 males and females, and in resistance training for cohort 1 males are an added reason for concern. While reasons for the observed reductions are not clear, it is well established that an exercise routine throughout life is important to health.

The level of participation in physical activity impacted body composition to a limited extent in the present study, although there were a number of trends suggesting beneficial effects of increased participation. Similar to the findings in the literature, the effects were mostly observed with vigorous and resistance training activity. Females of cohort 2 who participated in greater levels of vigorous activity significantly or tended to gain less body fat % and fat mass during the freshman and sophomore years and those who participated in moderate physical activity maintained or gained more fat-free mass during the freshman year as compared to the low level group. Regardless of gender, other studies have shown that high levels of vigorous activity result in decreases in body fat % and fat mass (Jackicic and others 2003; Slentz and others 2004, 2005). Against expectation, males of cohort 2 participating in high vigorous activity gained significantly more fat mass and weight during sophomore year versus those in the lower vigorous activity group. However, other studies have shown that males with high physical fitness levels may gain greater amounts of fat mass than there lesser physically fit counterparts; such findings could explain some of the observed cohort differences in males (Mifsud and others 2008). In addition, a greater energy intake by cohort 2 males may have contributed to the greater weight and fat mass gains.

Resistance physical activity has been shown to reduce body fat % and fat mass and positively impact fat-free mass (Janssen and others 2002, Kemmler and others 2010, Sillanpää and others 2008, Van Der Heijden and others 2010). In the current study, females of cohort 2 with high levels of resistance physical activity had significantly less gains in body fat % and fat mass while tending to maintain fat-free mass during the sophomore year. Reasons why such changes were not observed in cohort 1 females are not clear, but may relate to differences in dietary habits. It appears high levels of vigorous and resistance physical activity may benefit some college females in terms of preventing unhealthy changes in body fat %, fat mass, and fat-free mass.

Limitations

The results of this study must be interpreted with caution since this study has several limitations. First, because this study was conducted at a public university, the results presented may not be appropriate for individuals who attend private universities or who do not attend a university given the study did not have a comparison, a control group of young adults not seeking higher education. Self-selection bias is another limitation whereby those individuals not returning after the initial visit may have done so because they were not comfortable or secure enough to be reassessed. Further, while the questions used to assess physical activity were those used in the National College Health Risk Behavior Survey (CDC 1995), which has been extensively tested for validity and reliability, physical activity diaries or logs kept over the study's period are superior to recall (Ainslie and others 2003, Conway and others 2002). However, these methods, like questionnaires, are subject to the same under and/or overreporting.

The study's findings relied on the subject's honesty to accurately self-report their usual physical activity habits. The use of accelerometers or pedometers would have enabled a more accurate assessment of physical activity throughout the study; however, such study requirements were thought to diminish study participation and were too costly to employ due study's fairly large sample size. Additionally, due to notable cohort effects, separation of the cohorts limited the power of analyses.

Conclusions

The freshman year is characterized by largely greater weight gains than the sophomore year; although, unhealthy body composition changes were observed during both the freshman and sophomore years in many participants. Many (at least one third) of the freshmen and sophomores, especially females, did not meet the minimum recommendations for vigorous and moderate aerobic and resistance physical activity. Moreover, significant decreases in the various types of physical activity were documented between the freshman and sophomore years. While consistent changes in body weight and composition were not found between cohorts in response to level of participation in vigorous and moderate physical activity and resistance training, high levels of vigorous and resistance physical activity tended to benefit some college females in terms of preventing unhealthy changes in body fat %, fat mass, and fat-free mass.

Implications

Modest gains in weight especially if coupled with reductions in physical activity participation during the college years may be contributing to the increasing prevalence of obesity as well as the potential for health problems in young adults; therefore, this is an at risk population. Further studies are required to identify body composition changes and lifestyle habits in males and females during the junior and senior years of college to unmask unhealthy changes as well as any factors contributing to unhealthy gains in body weight and fat mass. Because regular participation in physical activity, especially vigorous and resistance physical activity may help prevent excessive gains in weight and body fat and is associated with decreased risk of premature death, coronary heart disease, stroke, breast and colon cancers, type 2 diabetes, metabolic syndrome, high blood pressure, and hypercholesterolemia, among other health problems (DHHS 2008, Katzmarzyk and others 2006), studies are needed to examine the likelihood of participation, especially by females, in different combinations and/or types of activities that may be enjoyed not only throughout college, but also beyond the college years. Such studies also need to investigate whether such activities generate positive changes in body weight and composition to promote health among college students.

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Table 3.1: Selected demographics and anthropometric characteristics of the baseline measurements of two separate student cohorts attending a public university in the southern U.S.

	Cohort 1 (n = 240)[1]	Cohort 2 (n = 295)[2]
Gender[a]		
Female	155 (65%)	190 (64%)
Male	85 (35%)	105 (36%)
Age (years)	18.12 (0.40)	18.10 (0.38)
Height (inches)	66.64 (3.49)	66.25 (3.60)
Weight (lbs)		
Female	133.5 (28.9)	129.5 (18.5)
Male	163.5 (28.4)	160.3 (22.4)
Body Mass Index (kg/m^2)		
Female	22.4 (4.4)	22.1 (2.7)
Male	23.5 (3.92)	23.1 (2.7)
Fat Mass (lbs)		
Female	31.6 (18.2)	31.7 (9.8)
Male	18.6 (15.4)	19.5 (9.6)
Fat-Free Mass (lbs)		
Female	101.8 (13.3)	97.9 (11.3)
Male	143.0 (18.4)	140.8 (16.6)
Race[a]		
Caucasian	196 (81.7%)	262 (88.8%)
African American	29 (12.1%)	11 (3.7%)
Hispanic	7 (2.9 %)	11 (3.7%)
Asian	4 (1.7%)	10 (3.4%)
Other	4 (1.7%)	1 (<1%)
Permanent Residence[a]		
Alabama	149 (62.1%)	180 (61.0%)
Georgia	37 (15.4%)	38 (12.8%)
Tennessee	11 (4.6%)	17 (5.7%)

Texas	9 (3.8%)		7 (2.4%)
North Carolina	7 (2.9%)		3 (1.0%)
Florida	4 (1.7%)		12 (4.1%)
Louisiana	2 (0.4%)		4 (1.4%)
Maryland	2 (0.4%)		5 (1.7%)
Illinois	2 (0.4%)		3 (1.0%)
Mississippi	2 (0.4%)		2 (<1.0%)
Ohio	2 (0.4%)		2 (<1.0%)
Virginia	2 (0.4%)		2 (<1.0%)
Arizona	2 (0.4%)	Kentucky	3 (1.0%)
Other (1 each) 22 different states	9 (3.8%)	Other (1 each) different states	6 (2.0%)
School Residence[a]			
Campus dorm	147 (61.3%)		168 (56.0%)
Apartment, house, duplex, or trailer	90 (37.5%)		124 (42.0%)
With parents	2 (1.2%)		3 (1.0%)

[a] Data are presented as n (percent) except for age, height, body mass index, fat mass, and fat-free mass which are expressed as mean (SD).
[1] Baseline assessment beginning Fall 2007.
[2] Baseline assessment beginning Fall 2008.

Table 3.2: Body weight, body mass index (BMI), and body composition changes during the first two years of college.

	Year	
	Freshman[a]	Sophomore[b]
Weight Change (lbs)		
Cohort 1[1]	2.3 (5.1)	0.7 (4.6)
Males	3.0 (4.8)	2.5 (4.2)†
Females	1.9 (5.2)*	0.0 (4.6)†*
Cohort 2[2]	3.5 (4.8)	0.7 (4.7)
Males	3.7 (5.5)*	0.8 (4.5)*
Females	3.4 (4.5)*	0.6 (4.9)*
BMI Change (kg/m^2)		
Cohort 1[1]	0.3 (0.8)	0.1 (0.8)
Males	0.4 (0.7)	0.4 (0.6)†
Females	0.3 (0.9)*	0.0 (0.8)†*
Cohort 2[2]	0.6 (0.8)	0.2 (0.8)
Males	0.5 (0.8)*	0.2 (0.6)*
Females	0.6 (0.8)*	0.1 (0.8)*
Body Fat Change (%)		
Cohort 1[3]	1.4 (2.0)	-0.2 (2.1)
Males	1.6 (1.8)*	0.1 (1.7)*
Females	1.2 (2.0)*	-0.3 (2.2)*
Cohort 2[4]	0.6 (2.0)	0.9 (1.7)
Males	0.3 (1.9)	1.2 (1.8)
Females	0.7 (2.0)	0.8 (1.7)
Fat Mass Change (lbs)		
Cohort 1[3]	2.4 (3.5)	0.0 (3.5)
Males	3.0 (3.3)*	0.6 (3.1)*
Females	2.1 (3.6)*	-0.3 (3.6)*
Cohort 2[4]	1.5 (3.4)	1.5 (3.3)
Males	0.9 (3.6)	2.2 (3.3)

Females	1.8 (3.1)	1.2 (3.3)
Fat-Free Mass Change (lbs)		
Cohort 1[3]	-0.1 (3.3)	0.7 (3.5)
Males	0.0 (3.6)*	1.9 (3.9)†*
Females	-0.1 (3.6)	0.3 (3.2)†
Cohort 2[4]	2.0 (3.6)	-0.9 (3.2)
Males	2.9 (4.2)*	-1.3 (4.2)*
Females	1.6 (3.3)*	-0.6 (2.6)*

* Values in rows are statistically significantly different $p < 0.05$.
† Values within cohorts and in columns are statistically significantly different $p < 0.05$.
[a,,1] Males, n = 63 and females, n = 122. [b,1] Males, n = 38 and females, n = 97.
[a,2] Males, n = 68 and females, n = 140. [b,2] Males, n = 48 and females, n = 90.
[a,3] Males, n = 60 and females, n = 122. [b,3] Males, n = 38 and females, n = 97.
[a,4] Males, n = 67 and females, n = 140. [b,4] Males, n = 48 and females, n = 90.

Tables 3.3: Mean (SD) weekly vigorous and moderate aerobic and resistance physical activity during the freshman and sophomore years.

	Vigorous (min) means (SD)	Moderate (min) means (SD)	Resistance Training (days) means (SD)
Freshman Year			
Cohort 1[a]	146 (131)	257 (163)	1.9 (1.7)
Males	210 (149)	257 (144)	2.7 (1.8)*
Females	112 (107)	257 (172)[A]	1.5 (1.5)*
Cohort 2[b]	142 (111)	182 (142)	1.9 (1.6)
Males	211 (120)	218 (185)	2.6 (1.5)*
Females	108 (90)	165 (112)[B]	1.6 (1.5)*
Sophomore Year			
Cohort 1[c]	128 (105)	222 (178)	1.7 (1.5)
Males	164 (98)*	290 (221)*	2.3 (1.4)*
Females	114 (104)*	195 (151)[A,*]	1.5 (1.5)*
Cohort 2[d]	140 (137)	218 (173)	1.6 (1.6)
Males	229 (167)	247 (179)	2.3 (1.7)*
Females	92 (86)	208 (169)[B]	1.2 (1.4)*

* Values within column and between gender are statistically significantly different, $p < 0.05$.
[A &B] Values in columns are significantly different for cohort and year, $p < 0.05$.
[a] n = 186; males, n = 64; females, n = 122.
[b] n = 208; males, n = 68; females, n = 140.
[c] n = 133; males, n = 38; females, n = 95.
[d] n = 138; males, n = 48; females, n = 90.

Table 3.4: Percentage of vigorous and moderate aerobic and resistance physical activity participation for cohorts 1 and 2 meeting the American College of Sports Medicine's minimum recommendations for physical activity.

	Vigorous (%)	Moderate (%)	Resistance (%)
Freshman Year			
Cohort 1[a]	67	79	47
Males	81*	80[B]	69[D,*]
Females	59*	77[C]	35*
Cohort 2[b]	69	52	50
Males	88*	62	70*
Females	60[A,*]	48	41*
Sophomore Year			
Cohort 1[c]	67	58	45
Males	84*	61[B]	66[D,*]
Females	60*	58[C]	37*
Cohort 2[d]	57	62	40
Males	81*	65	63*
Females	43[A,*]	61	28*

* Values within cohort and in columns are statistically significantly different, $p < 0.05$.
[A,B,C,&D] Values statistically significantly different freshman versus sophomore year.
[a] n = 186; males, n = 64; females, n = 122.
[b] n = 208; males, n = 68; females, n = 140.
[c] n = 133; males, n = 38; females, n = 95.
[d] n = 138; males, n = 48; females, n = 90.

Table 3.5: Cohort 1 and 2 vigorous and moderate aerobic physical activity and resistance training effects on weight, body fat %, fat mass, and fat-free mass for the freshman year.

	Freshman Year					
	Vigorous		Moderate		Resistance Training	
	High	Low	High	Low	High	Low
Weight Change (lbs)	(150-780 min)	(0-70 min)	(295-1375 min)	(0-170 min)	(2.5-6 days)	(0-0.5 day)
Cohort 1[a]	2.7 (5.2)	2.6 (5.2)	2.9 (5.1)	1.9 (5.7)	2.7 (5.0)	2.4 (5.0)
Males	3.2 (4.9)	3.3 (4.8)	4.5 (6.0)	2.1 (4.4)	3.2 (5.3)	2.8 (4.3)
Females	2.3 (5.4)	2.3 (5.4)	2.1 (4.4)	1.8 (6.3)	2.5 (4.8)	2.3 (4.5)
	(173-570 min)	(0-75 min)	(195-930 min)	(0-105 min)	(2.5-6.5 days)	(0-1 days)
Cohort 2[b]	3.1 (5.0)	3.9 (4.8)	3.5 (4.8)	3.6 (4.4)	3.0 (5.5)	3.6 (4.2)
Males	4.4 (5.5)	4.4 (5.9)	3.8 (6.1)	4.8 (4.0)	3.1 (6.0)	4.5 (4.9)
Females	2.5 (4.6)	3.7 (4.3)	3.4 (4.1)	3.1 (4.5)	2.9 (5.4)	3.2 (3.8)
Body Fat Change (%)						
Cohort 1[a]	1.2 (2.1)	1.5 (1.9)	1.4 (2.0)	1.6 (2.0)	1.6 (2.0)	1.5 (1.9)
Males	1.4 (1.9)	1.8 (1.9)	2.1 (2.0)	1.6 (2.0)	1.8 (1.8)	1.7(1.8)
Females	1.2 (2.2)	1.4 (1.9)	1.0 (1.9)	1.6 (2.0)	1.5 (2.1)	1.4 (1.9)
Cohort 2[b]	0.3 (2.1)	1.0 (2.2)	0.4 (2.3)	0.8 (1.8)	0.3 (2.1)	0.8 (1.8)
Males	0.4 (2.4)	0.6 (1.9)	0.1 (1.9)	0.5 (1.9)	0.2 (2.1)	0.7 (1.7)
Females	0.3 (2.1)*	1.2 (2.3)*	0.5 (2.4)	1.0 (1.7)	0.4 (2.2)	0.8 (1.8)

Fat Mass Change (lbs)						
Cohort 1[a]	2.2 (3.6)	2.6 (3.3)	2.5 (3.6)	2.8 (3.6)	2.8 (3.5)	2.6 (3.2)
Males	2.6 (3.4)	3.0 (4.2)	3.9 (3.8)	2.9 (3.3)	3.2 (3.6)	3.0 (2.9)
Females	2.0 (3.8)	2.4 (3.4)	1.8 (3.3)	2.7 (3.8)	2.6 (3.4)	2.4 (3.4)
Cohort 2[b]	1.0 (3.7)	2.1 (3.5)	1.1 (3.4)	2.0 (3.4)	1.1 (3.8)	1.8 (3.2)
Males	1.0 (4.2)	1.6 (4.0)	0.7 (0.8)	1.4 (0.8)	0.7 (3.8)	1.7 (3.7)
Females	1.0 (3.5)[1]	2.4 (3.3)[1]	1.3 (3.3)	2.2 (3.1)	1.3 (3.9)	1.8 (2.9)
Fat-Free Mass Change (lbs)						
Cohort 1[a]	0.4 (3.1)	0.0 (3.3)	0.4 (3.0)	-0.8 (3.6)	-0.2 (3.1)	-0.1 (3.5)
Males	0.8 (3.6)	0.2 (2.8)	0.6 (3.9)	-0.8 (3.8)	-0.4 (3.4)	0.0 (3.3)
Females	0.3 (2.8)	-0.1 (3.6)	0.3 (2.6)[2]	-0.9 (3.6)[2]	-0.1 (3.0)	-0.2 (3.6)
Cohort 2[b]	2.1 (3.9)	1.7 (3.6)	2.5 (4.1)	1.7 (3.1)	1.9 (3.9)	1.8 (3.0)
Males	3.5 (4.7)	2.9 (3.9)	3.2 (5.0)	3.3 (2.8)	2.4 (4.9)	2.8 (3.1)
Females	1.4 (3.2)	1.3 (3.4)	2.1 (3.7)[3]	0.9 (2.9)[3]	1.7 (3.4)	1.3 (2.9)

* Values in rows are statistically significantly different, $p < 0.05$.
[1] Values in rows tend to differ, $p < 0.0680$.
[2] Values in rows tend to differ, $p < 0.0949$.
[3] Values in rows tend to differ, $p < 0.0740$.
[a] Cohort 1: n = 125; males, n = 43; females, n = 79.
[b] Cohort 2: n = 140, males, n = 44; females, n = 93.

Table 3.6: Cohort 1 and 2 vigorous and moderate aerobic physical activity and resistance training effects on weight, body fat %, fat mass, and fat-free mass for the sophomore year.

	Sophomore Year					
	Vigorous		Moderate		Resistance Training	
	High	Low	High	Low	High	Low
Weight Change (lbs)	(150-450 min)	(0-65 min)	(225-900 min)	(0-115 min)	(2.5-7 days)	(0-0.5 day)
Cohort 1[a]	0.3 (4.2)	0.4 (4.2)	0.7 (4.6)	0.6 (4.8)	0.1 (4.6)	0.7 (4.5)
Males	0.3 (4.8)	0.8 (4.7)	2.5 (4.4)	1.8 (5.4)	3.7 (3.5)	2.6 (5.0)
Females	0.2 (4.1)	-0.4 (3.9)	-0.2 (4.5)	0.1 (4.6)	-1.5 (4.2)	0.0 (4.1)
	(160-600 min)	(0-60 min)	(240-1140 min)	(0-120 min)	(2-6 days)	(0-0.5 days)
Cohort 2[b]	0.4 (4.9)	0.7 (4.8)	0.7 (4.6)	0.5 (5.3)	1.5 (4.8)	1.0 (4.7)
Males	2.5 (3.6)*	-0.5 (4.8)*	1.7 (4.1)	-0.8 (5.3)	0.7 (5.3)	2.9 (2.9)
Females	-0.7 (5.2)	1.2 (4.7)	0.1 (4.8)	1.1 (5.3)	0.7 (5.4)	1.2 (4.5)
Body Fat Change (%)						
Cohort 1[a]	-0.5 (2.0)	0.1 (1.8)	-0.1 (2.9)	-0.1 (2.1)	-0.6 (2.2)	-0.2 (1.5)
Males	0.0 (2.3)	0.2 (2.2)	0.7 (3.6)	0.2 (2.3)	-0.2 (1.7)	0.6 (1.0)
Females	0.1 (1.7)	-0.5 (2.2)	-0.5 (2.4)	-0.2 (2.0)	-0.8 (2.4)	-0.5 (1.6)
Cohort 2[b]	0.6 (2.2)	0.8 (1.9)	0.7 (2.0)	0.9 (2.1)	0.6 (2.2)	1.3 (1.7)
Males	1.7 (1.8)[1]	0.2 (2.7)[1]	0.7 (2.3)	0.6 (2.5)	1.4 (2.2)	1.1 (2.1)
Females	0.1 (2.2)*	1.1 (2.2)*	0.6 (1.9)	1.1 (1.9)	0.2 (2.1)*	1.3 (1.4)*

Fat Mass Change (lbs)						
Cohort 1[a]	-0.6 (3.4)	0.3 (3.3)	0.2 (5.1)	0.0 (3.6)	-0.8 (3.7)	-0.1 (2.7)
Males	-0.4 (3.2)	0.5 (4.2)	1.6 (6.9)	0.6 (4.4)	0.3 (3.0)	1.3 (2.1)
Females	-0.7 (3.5)	0.2 (3.0)	-0.5 (4.0)	-0.2 (3.3)	-1.3 (3.9)	-0.6 (2.8)
Cohort 2[b]	1.0 (4.1)	1.3 (3.6)	1.1 (3.6)	1.5 (4.0)	1.3 (4.2)	2.1 (3.0)
Males	3.3 (3.4)*	0.3 (4.7)*	1.7 (4.0)	0.8 (4.4)	3.0 (4.1)	1.9 (3.6)
Females	-0.1 (4.0)[2]	1.8 (2.7)[2]	0.8 (3.4)	1.9 (3.8)	0.4 (4.1)*	2.1 (2.7)*
Fat-Free Mass Change (lbs)						
Cohort 1[a]	0.9 (3.2)	0.1 (2.6)	0.5 (4.1)	0.6 (3.4)	0.9 (3.8)	0.8 (3.1)
Males	2.4 (3.6)	0.2 (3.0)	0.9 (6.2)	1.2 (3.7)	3.4 (4.3)	1.3 (3.6)
Females	0.3 (2.8)	0.1 (2.5)	0.3 (2.7)	0.4 (3.3)	-0.2 (3.0)	0.6 (2.8)
Cohort 2[b]	-0.6 (3.1)	-0.6 (4.2)	-0.4 (3.1)	-1.0 (4.4)	0.2 (3.0)	-1.0 (3.4)
Males	-0.8 (3.5)	-0.8 (6.3)	0.1 (4.2)	-1.5 (6.5)	0.0 (3.5)	-1.2 (4.7)
Females	-0.6 (2.9)	-0.6 (2.7)	-0.7 (2.4)	-0.8 (2.9)	0.2 (2.7)[3]	-0.9 (2.5)[3]

* Values within rows are statistically significantly different, $p < 0.05$.
[1] Values within rows tend to differ, $p < 0.0779$.
[2] Values within rows tend to differ, $p < 0.0797$.
[3] Values within rows tend to differ, $p < 0.0616$.
[a] Cohort 1: n = 90; males, n = 26; females, n = 62.
[b] Cohort 2: n = 99, males, n = 32; females, n = 65.

Chapter 4

Summary of Findings

Because consistent changes in body weight and composition were not found between cohorts in response to level of participation in vigorous and moderate physical activity and resistance training, none of the research questions are completely supported by the study's findings. Some changes in body composition were exhibited in response to the level of physical activity participation by one cohort, but not the other, and/or in one gender, but not the other. Such findings are listed below.

Moderate Physical Activity

Questions addressing moderate physical activity included: Is there a difference in body weight, % body fat, or fat-free mass among males (or females) participating in higher levels of moderate physical activity versus those who do not? There were no significant differences in body weight, body fat %, and fat-free mass for males or females participating in high levels of moderate physical activity versus those who did lower levels during the freshman and sophomore year.

Vigorous Physical Activity

The research questions addressing vigorous physical activity asked: Is there a difference in body weight, body fat %, or fat-free mass among males (or females) participating in higher levels of vigorous physical activity versus those who do not? During the freshman year, cohort 2 females who had high levels of vigorous physical activity gained significantly less body fat % than females with low levels of vigorous physical activity. During the sophomore year, cohort 2 males with high vigorous physical activity gained significantly more body weight and fat mass than those with low vigorous physical activity.

Resistance Physical Activity

The final research questions asked: Is there a difference in body weight, body fat %, or fat-free mass among males (or females) participating in higher levels of strength training physical activity versus those who do not? No significant differences were observed in body weight, body fat %, and fat mass changes during either the freshman or sophomore year for males reporting high levels of resistance training versus those reporting low levels. During the sophomore year, cohort 2 females involved with high levels of resistance training gained significantly less body fat % and fat mass than those involved in the low levels.

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Appendix A

Summary of activity level and gender differences for body weight, body fat %, fat mass, and fat-free mass change for the freshman year.

	Freshman Year					
	Vigorous		Moderate		Resistance Training	
	High	Low	High	Low	High	Low
Weight Change (lbs)	(150-780 min)	(0-70 min)	(295-1375 min)	(0-170 min)	(2.5-6 days)	(0-0.5 day)
Cohort 1[a]	2.7 (5.2)	2.6 (5.2)	2.9 (5.1)	1.9 (5.7)	2.7 (5.0)	2.4 (5.0)
Males	3.4 (4.9)	3.3 (4.8)	4.5 (6.0)	2.1 (4.4)	3.2 (5.3)	2.8 (4.3)
Females	2.3 (5.4)	2.3 (5.4)	2.1 (4.4)	1.8 (6.3)	2.5 (4.8)	2.3 (4.5)
	(173-570 min)	(0-75 min)	(195-930 min)	(0-105 min)	(2.5-6.5 days)	(0-1 days)
Cohort 2[b]	3.1 (5.0)	3.9 (4.8)	3.5 (4.8)	3.6 (4.4)	3.0 (5.5)	3.6 (4.2)
Males	4.4 (5.5)	4.4 (5.9)	3.8 (6.1)	4.8 (4.0)	3.1 (6.0)	4.5 (4.9)
Females	2.5 (4.6)	3.7 (4.3)	3.4 (4.1)	3.1 (4.5)	2.9 (5.4)	3.2 (3.8)
Body Fat Change (%)						
Cohort 1[a]	1.2 (2.1)	1.5 (1.9)	1.4 (2.0)	1.6 (2.0)	1.6 (2.0)	1.5 (1.9)
Males	1.4 (1.9)	1.8 (1.9)	2.1 (2.0)	1.6 (2.0)	1.8 (1.8)	1.7 (1.8)
Females	1.2 (2.2)	1.4 (1.9)	1.0 (1.9)	1.6 (2.0)	1.5 (2.1)	1.4 (1.9)

Cohort 2[b]	0.3 (2.1)	1.0 (2.2)	0.4 (2.3)	0.8 (1.8)	0.3 (2.1)	0.8 (1.8)
Males	0.4 (2.4)	0.6 (1.9)	0.1 (1.9)	0.5 (1.9)	0.2 (2.1)	0.7 (1.7)
Females	0.3 (2.1)	1.2 (2.3)	0.5 (2.4)	1.0 (1.7)	0.4 (2.2)	0.8 (1.8)
Fat Mass Change (lbs)						
Cohort 1[a]	2.2 (3.6)	2.6 (3.3)	2.5 (3.6)	2.8 (3.6)	2.8 (3.5)	2.6 (3.2)
Males	2.6 (3.4)	3.0 (4.2)	3.9 (3.3)†	2.9 (3.3)	3.2 (3.6)	3.0 (2.9)
Females	2.0 (3.8)	2.4 (3.4)	1.8 (3.8)†	2.7 (3.8)	2.6 (3.4)	2.4 (3.4)
Cohort 2[b]	1.0 (3.7)	2.1 (3.5)	1.1 (3.4)	2.0 (3.4)	1.1 (3.8)	1.8 (3.2)
Males	1.0 (4.2)	1.6 (4.0)	0.7 (0.8)	1.4 (0.8)	0.7 (3.8)	1.7 (3.7)
Females	1.0 (3.5)	2.4 (3.3)	1.3 (3.3)	2.2 (3.1)	1.3 (3.9)	1.8 (2.9)
Fat-Free Mass Change (lbs)						
Cohort 1[a]	0.4 (3.1)	0.0 (3.3)	0.4 (3.0)	-0.8 (3.6)	-0.2 (3.1)	-0.1 (3.5)
Males	0.8 (3.6)	0.2 (2.8)	0.6 (3.9)	-0.8 (3.8)	-0.4 (3.4)	0.0 (3.3)
Females	0.3 (2.8)	-0.1 (3.6)	0.3 (2.6)	-0.9 (3.6)	-0.1 (3.0)	-0.2 (3.6)
Cohort 2[b]	2.1 (3.9)	1.7 (3.6)	2.5 (4.1)	1.7 (3.1)	1.9 (3.9)	1.8 (3.0)
Males	3.5 (4.7)†	2.9 (3.9)	3.2 (5.0)	3.3 (2.8)†	2.4 (4.9)	2.8 (3.1)
Females	1.4 (3.2)†	1.3 (3.4)	2.1 (3.7)	0.9 (2.9)†	1.7 (3.4)	1.3 (2.9)

† Values in columns are statistically significantly different, $p < 0.05$.
[a] Cohort 1: n = 125; males, n = 43; females, n = 79.
[b] Cohort 2: n = 140, males, n = 44; females, n = 93.

Summary of activity level and gender differences for body weight, body fat %, fat mass, and fat-free mass change for the sophomore year.

	Sophomore Year					
	Vigorous		Moderate		Resistance Training	
	High	Low	High	Low	High	Low
Weight Change (lbs)	(150-450 min)	(0-65 min)	(225-900 min)	(0-115 min)	(2.5-7 days)	(0-0.5 day)
Cohort 1[a]	0.3 (4.2)	0.4 (4.2)	0.7 (4.6)	0.6 (4.8)	0.1 (4.6)	0.7 (4.5)
Males	0.3 (4.8)	0.8 (4.7)	2.5 (4.4)	1.8 (5.4)	3.7 (3.5)†	2.6 (5.0)
Females	0.2 (4.1)	-0.4 (3.9)	-0.2 (4.5)	0.1 (4.6)	-1.5 (4.2)†	0.0 (4.1)
	(160-600 min)	(0-60 min)	(240-1140 min)	(0-120 min)	(2-6 days)	(0-0.5 days)
Cohort 2[b]	0.4 (4.9)	0.7 (4.8)	0.7 (4.6)	0.5 (5.3)	1.5 (4.8)	1.0 (4.7)
Males	2.5 (3.6)	-0.5 (4.8)	1.7 (4.1)	-0.8 (5.3)	0.7 (5.3)	2.9 (2.9)
Females	-0.7 (5.2)	1.2 (4.7)	0.1 (4.8)	1.1 (5.3)	0.7 (5.4)	1.2 (4.5)
Body Fat Change (%)						
Cohort 1[a]	-0.5 (2.0)	0.1 (1.8)	-0.1 (2.9)	-0.1 (2.1)	-0.6 (2.2)	-0.2 (1.5)
Males	0.0 (2.3)	0.2 (2.2)	0.7 (3.6)	0.2 (2.3)	-0.2 (1.7)	0.6 (1.0)
Females	0.1 (1.7)	-0.5 (2.2)	-0.5 (2.4)	-0.2 (2.0)	-0.8 (2.4)	-0.5 (1.6)
Cohort 2[b]	0.6 (2.2)	0.8 (1.9)	0.7 (2.0)	0.9 (2.1)	0.6 (2.2)	1.3 (1.7)
Males	1.7 (1.8)†	0.2 (2.7)	0.7 (2.3)	0.6 (2.5)	1.4 (2.2)	1.1 (2.1)

Females	0.1 (2.2)†	1.1 (2.2)	0.6 (1.9)	1.1 (1.9)	0.2 (2.1)	1.3 (1.4)
Fat Mass Change (lbs)						
Cohort 1[a]	-0.6 (3.4)	0.3 (3.3)	0.2 (5.1)	0.0 (3.6)	-0.8 (3.7)	-0.1 (2.7)
Males	-0.4 (3.2)	0.5 (4.2)	1.6 (6.9)	0.6 (4.4)	0.3 (3.0)	1.3 (2.1)†
Females	-0.7 (3.5)	0.2 (3.0)	-0.5 (4.0)	-0.2 (3.3)	-1.3 (3.9)	-0.6 (2.8)†
Cohort 2[b]	1.0 (4.1)	1.3 (3.6)	1.1 (3.6)	1.5 (4.0)	1.3 (4.2)	2.1 (3.0)
Males	3.3 (3.4)†	0.3 (4.7)	1.7 (4.0)	0.8 (4.4)	3.0 (4.1)	1.9 (3.6)
Females	-0.1 (4.0)†	1.8 (2.7)	0.8 (3.4)	1.9 (3.8)	0.4 (4.1)	2.1 (2.7)
Fat-Free Mass Change (lbs)						
Cohort 1[a]	0.9 (3.2)	0.1 (2.6)	0.5 (4.1)	0.6 (3.4)	0.9 (3.8)	0.8 (3.1)
Males	2.4 (3.6)†	0.2 (3.0)	0.9 (6.2)	1.2 (3.7)	3.4 (4.3)†	1.3 (3.6)
Females	0.3 (2.8)†	0.1 (2.5)	0.3 (2.7)	0.4 (3.3)	-0.2 (3.0)†	0.6 (2.8)
Cohort 2[b]	-0.6 (3.1)	-0.6 (4.2)	-0.4 (3.1)	-1.0 (4.4)	0.2 (3.0)	-1.0 (3.4)
Males	-0.8 (3.5)	-0.8 (6.3)	0.1 (4.2)	-1.5 (6.5)	0.0 (3.5)	-1.2 (4.7)
Females	-0.6 (2.9)	-0.6 (2.7)	-0.7 (2.4)	-0.8 (2.9)	0.2 (2.7)	-0.9 (2.5)

† Values within cohorts and in columns are statistically significantly different, $p < 0.05$.
[a] Cohort 1: n = 90; males, n = 26; females, n = 62.
[b] Cohort 2: n = 99, males, n = 32; females, n = 65.

Appendix B

AUBURN

UNIVERSITY

Office of Human Subjects Research
307 Samford Hall
Auburn University, AL 36849

Telephone: 334-844-5966
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July 10, 2009

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

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

IRB AUTHORIZATION NO.: 07-153 EP 0707

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

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

> "Collection of data from voice, video, digital, or image recordings made for research purposes.
>
> Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies."

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

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

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

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

Sincerely,

Kathy Jo Ellison

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

cc: Dr. Doug White