# “The Freshman Fifteen” and Beyond: A Meta-Analysis

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## Abstract

The rising rates of overweight and obesity have led to concerns about the increased risk for developing several negative health consequences. Poor eating habits and lack of sufficient levels of physical activity contribute to an increase in adiposity and body weight. Not surprisingly, the transition to college is associated with a variety of lifestyle changes that may contribute to additional weight gain, such as poor sleep, alcohol consumption, poor nutrition, and increased sedentary behavior. Many individual studies have commented on and attempted to examine the phenomenon known as the "Freshman 15". The present meta-analysis intends to discern the patterns related to body weight and adiposity changes over the first year of college. In addition, this study examines these changes from the beginning of freshman year to the end of senior year of college, as well as potential moderators of weight gain and body composition changes. We conducted a search on seven electronic databases, resulting in 55 studies for inclusion in the meta-analysis. An overall mean weight gain of 0.74 kg (1.63 lbs) was found for freshman year and 0.90 kg (1.98 lbs) for the end of senior year. Increases in BMI, percent body fat, absolute fat mass, and waist circumference, and a decrease in fat-free mass were observed for both freshman year and senior year of college. Significant differences between males and females were found in weight and BMI change. Body composition changes in college are concerning because of the potential negative health behaviors and patterns that are carried into adulthood. Focus should be paid not only to the freshman year of college but also throughout students' experiences with college.

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## Introduction

The obesity epidemic has increased over the past several decades at an alarming rate (Palisch, Greenwald, Arabas, Jorn, & Mayhew, 2010). If the recent trends of overweight and obesity continue at their current rates, an estimated 60% of the adult population will be affected by 2030 (Kelly, Yang, Chen, Reynolds, & He, 2008). With the increased rates of obesity, we are likely to see higher rates of negative health consequences and associated healthcare costs. Being overweight or obese is a risk factor for a variety of health complications, such as hypertension, heart disease, stroke, diabetes mellitus, and some forms of cancer (Gropper, Simmons, Connell, & Ulrich, 2012).

Not surprisingly, attending college is associated with many lifestyle changes for young adults. Pinto, Cherico, Szymanski, and Marcus (1998) found that in college freshmen significant decreases in total physical activity occur with as many as 42% of individuals not meeting the recommended levels of weekly activity. A recent study (Brock, Carr, & Todd, 2015) examined the relationship between campus recreation usage and BMI in college freshmen, and found that one day per week change in campus recreation usage did not significantly impact BMI. Additional analyses for two days per week decrease in campus recreation usage indicated an upward trend in BMI, though there were no significant differences between the groups. Therefore, college freshmen may be at risk for a higher BMI regardless of physical activity occurring at campus recreation centers, which was thought to be a tool to prevent weight increase.

Notably, researchers have also reported that students appear to be eating high-fat fried or fast foods three or more days per week and consuming inadequate levels of fruits and vegetables, with only 1.3% of the college freshmen meeting recommended vegetable servings and 31% meeting recommended fruit servings (Racette, Deusinger, Strube, Highstein, & Deusinger, 2005). Consequently, increases in sedentary behavior and decreases in healthy food consumption and physical activity pose a significant risk to students for weight gain beginning the freshman year of college (Adams & Rini, 2007; Cluskey & Grobe, 2009; Deforche, Van Dyck, Deliens, & De Bourdeaudhuij, 2015). During the transition from adolescence to independence, young adults are faced with developing habits and making choices that may set the stage for patterns to take root and be present throughout adulthood.

## The "Freshman 15"

The weight gain phenomenon often seen during the transition to college has become a topic of considerable attention and frequently identified as the "Freshman 15" - the stereotyped gain of 15 lbs (6.8 kg) during one's first year of college. The phenomenon of weight gain during this period of college was first introduced in 1985 in a peer-reviewed article (Hovell, Mewborn, Randle, & Fowler-Johnson, 1985). Four years later, a popular magazine, *Seventeen* coined the term 'Freshman 15' (Watkins, 1989). However, the 'Freshman 15' was not widely referred to until the late 1990s, when notable increases of articles were published in university newspapers and peer-reviewed journals (Brown, 2008). A key word search of 'Freshman 15' and other related terms in PsycINFO, as recently as April 2016, yielded 4,312 total hits, suggesting that the notion of considerable weight gain during college is a robust and salient issue.

## Weight Gain Factors for College Students

College students appear to be at an increased risk of making poorer health-related decisions than young adults of the same age who are not attending college, due to the access to campus dining halls, as well as the potential stresses associated with pursuing higher education (Deforche et al., 2015; Hovell et al., 1985; Kapinos & Yakusheva, 2011; Kapinos, Yakusheva, & Eisenberg, 2014; Levitsky, Halbmaier, & Mrdjenovic, 2004; Provencher et al., 2009). Pliner and Saunders (2008) found that students who lived on campus often gained more weight than students still living at home. The results of this study indicate that the relocation associated with attending college and living on campus may make some young adults more vulnerable to weight gain. Mifsud, Duval, and Doucet (2009) evaluated whether pre-university adiposity and physical fitness protects against body weight and adiposity during the freshman year of college. They found that for males, significant increases in weight (1.9 kg), BMI ($0.6\ kg{\cdot}m^2$), body fat (3.1%), and waist circumference (2.7 inches) occurred in the first year. For the females in their sample, no significant changes were observed. Further analyses indicated that lower pre-university adiposity was actually associated with greater increases in weight and adiposity during the first year of college.

In addition, access to dining facilities in residence halls on campus has been shown to be positively associated with more weight gain among students (Kapinos & Yakusheva, 2011). In particular, males appear to eat more meals and snacks per day while living near a dining hall, whereas females living in dormitories with a dining hall reported exercising less often. The higher rate of weight gain in college students is concerning for future implications regarding overweight and obesity rates in adulthood. In the Coronary Artery Risk Development in Young Adults study, adults aged 18-30 were found to gain about 1.87 lbs (0.85 kg) per year (Racette, Deusinger, Strube, Highstein, & Deusinger, 2008). However, the rate at which young adults gained weight while attending college was higher. Recently, Bodenlos, Gengarelly, and Smith (2015) estimated an average weight gain of 4.89 lbs (2.22 kg) in college freshmen.

**Weight Changes Over Four Years**

A study by Girz and colleagues (2013) examined changes in weight for college students across all four years of college (*n* = 478). They found that weight increased between the first and the fourth years of college and that the majority of students (63.9%) gained weight. In those who gained weight, rates were much higher than the average weight gain, such that men gained an average of 9 lbs (4.08 kg) and women gained an average of 7.8 lbs (3.54 kg) over the course of four years. Moreover, the researchers found that the mean increases in weight showed a linear relationship over the course of four years. Thus, weight gain is not simply occurring during the first year and remaining stable; weight gain appears to be incrementally increasing each year of college.

A study by Gropper and colleagues (2012) found significant gains in weight, BMI, body fat, and absolute fat mass over the course of four years in college (*n* = 131). A large range of weight change was found in this study, ranging from -19.2 lbs to +37 lbs (-8.71 kg to +16.78 kg) across four years. Gains in BMI (1.0 $kg{\cdot}m^2$), body fat (3.6%) and absolute fat mass (3.2 kg) were also observed. While some may have lost weight, the majority (70%) of students gained weight over four years, averaging 11.7 lbs (5.31 kg). Importantly, overweight/obesity rates increased from 18% to 31%. If, over four years, rates of overweight and obesity increase to about one-third of young adults in college, there is reason for concern that this trend may be a harbinger of elevated rates of overweight/obesity later in adulthood. This significant increase supports the necessity of attention paid to college students’ health.

In a longitudinal study over all four years of college, Racette and colleagues (2008) examined weight changes, exercise, and dietary behaviors in 204 college students. They found a highly variable range of weight change of -29.10 lbs (-13.2 kg) to +46.08 lbs (+20.9 kg), with females gaining an average of 3.75 lbs (1.70 kg) and males gaining an average of 9.26 lbs (4.20 kg). The prevalence rates of overweight/obesity also increased, from 15% to 23%, over the four years. The investigators found that their participants tended to gain the most weight during freshman year, at a rate that did not incrementally continue each year. However, the weight gain consequences during college for future rates of overweight/obesity is still concerning. Potential health behaviors may explain the observed increase in weight and overweight/obesity. Consuming less healthy foods and more high caloric foods may have contributed to weight gain in this sample, with less than 1/3 of the students meeting the recommended servings of fruits and vegetables. Coupled with a decrease in physical activity, it is no surprise that weight gain occurs.

**Gender as a Moderator of Weight and Body Composition Changes**

Given some of the previously reviewed findings on changes in weight and body composition, there may be a need to differentially target and focus attention on males and females. Bodenlos and colleagues (2015) examined predictors of weight gain separately by gender through the first year of college. Participants ($n$ = 304) were recruited at the beginning of the academic year and data collection was acquired at three time points, using objective measurement. The researchers found that the average weight gain over freshman year was 6.38 lbs (2.89 kg) for males and 4.38 lbs (1.99 kg) for females. The study by Gropper and colleagues (2012) found significant gains in weight, BMI, body fat, and absolute fat mass over four years in college and found that males tended to gain greater amounts in all these areas over females. Males increased weight by 5.9 kg, BMI by 1.8 kg·$m^2$, 5.2% in body fat, 4.9 kg of fat mass, and gained 1.3 kg of fat-free mass. Females had an observed weight change of 1.7 kg, BMI change of 0.6 kg·$m^2$, 2.9% in body fat, 2.3 kg of fat mass, and lost -0.7 kg of fat-free mass. In a separate study, Cluskey and Grobe (2009) found that females were more likely than males to maintain or lose weight while males gained more weight than females. Conducting a meta-analysis will help to discern patterns from individual studies with varied or mixed findings, allowing for a pooled and more comprehensive look at the differences between genders.

**Previous Meta-Analyses**

Vella-Zarb and Elgar (2009) published the first meta-analysis on the average amount of weight gain in college freshmen. Using articles dated 1985 to 2008 retrieved from three databases, 24 studies met inclusion criteria ($n$ = 3,401). Studies were excluded if they extended beyond the freshmen year or if they did not examine weight change. There was no exclusion criteria based on the minimum baseline onset of data collection or follow-up observation. The researchers found an average weight gain of 3.86 lbs (1.75 kg) and that weight gain ranged from 1.6 – 8.8 lbs (0.73 kg – 3.99 kg), a range somewhat lower than subsequent studies (Girz et al., 2013; Gropper et al., 2012; Racette et al., 2008). It was also found that only 2 of the 24 studies reported no significant weight gain. Additional analyses included investigating the effect of reporting method on weight gain, and found a small yet statistically significant difference among studies that used self-report ($M$ = 3.88, $SD$ = 0.83) versus objective measurements ($M$ = 3.83, $SD$ = 2.41).

Since the Vella-Zarb and Elgar (2009) meta-analysis, a number of research studies have been published which provide a more recent and comprehensive look at the body composition changes in college students. Vadeboncoeur, Townsend, and Foster (2015) attempted to update the previous meta-analysis, using studies from 1980 to 2014. From this expanded range, 32 studies met inclusion criteria ($n$ = 5,549). Studies were excluded if the sample was not a representation of a typical first year student population, if the follow-up data collection was shorter than 4 weeks or longer than 8 months, if initial data collection did not begin at the start of the academic year, different data collection procedures were used at time points, or if weight change was not examined. Only 22 of the 32 studies were included in the main analysis due to 10 studies missing reported standard error data. Vadeboncoeur and colleagues (2015) found an overall pooled mean weight gain of 3 lbs (1.36 kg) and that 60.9% of the participants showed weight gain with a pooled mean weight gain of 7.45 lbs (3.38 kg).

Additional analyses included location, measurement method, gender, and study quality (Vadeboncoeur et al., 2015). The results indicated that due to the small sample of studies, an inference regarding differences in weight gain according to study location could not be made. Subgroup analysis by measurement method did not find a significant difference of weight change between studies using self-report and those using objective measurement. Using 14 studies, due to a lack of reporting standard deviations, analysis of gender showed that females and males did not differ in the amount of weight gain, with females gaining on average 1.34 kg (CI: 1.02-1.65) and males gaining 1.43 kg (CI: 1.02-1.65). Finally, analyses by study quality indicated that studies with low or medium quality ratings did not have significantly different weight change compared to studies with high quality ratings (Vadeboncoeur et al., 2015).

While this study included more studies than Vella-Zarb and Elgar's (2009) meta-analysis, there are some limitations with this more recent review as well. Both Vella-Zarb and Elgar (2009) and Vadeboncoeur and colleagues (2015) used only weight change to describe body composition changes, and excluded other measures, including BMI, percent/absolute fat mass, fat-free mass, and waist circumference. BMI was introduced based on an observation that body weight should be proportional to one's height and has since been widely used to guide recommendations for weight loss (Romero-Corral et al., 2008). Using BMI, as compared to weight change, is useful because in females, height typically ceases at a median age of 17.3 years, whereas men typically stop gaining in height at a median age of 21.2 years, though these height changes can vary greatly (Spear, 2002).

Both weight and BMI, however, have significant limitations due to their lack of distinction between fat and muscle tissue (Goacher, Lambert, & Moffatt, 2012). Absolute body fat relates to the total weight of fat and can be measured by multiple methods, including dual energy X-ray absorptiometry and skinfold thickness measurements (Deurenberg, Yap, & van Staveren, 1998). Fat-free mass describes the total weight of muscle mass, whereas body fat percent is the total percentage of fat in the body. Waist circumference includes the measurement of the waist, which can increase related to weight and percent body fat changes. Including additional body composition measures of percent/absolute fat mass, fat-free mass, and waist circumference may provide better insight into the actual body changes that occur, such as healthy gain, or muscle (fat-free) gain, or unhealthy gain, such as fat gain.

Although more recently published, the meta-analysis by Vadeboncoeur and colleagues (2015) used fewer and different databases, as well as differing criteria for the inclusion of studies. Therefore, their study appears to have omitted many relevant studies on body changes in college students (i.e., Allard et al., 2013; Boyce & Kuijer, 2014; Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010; Economos, Hildebrandt, & Hyatt, 2008; Girz et al., 2013; Gropper et al., 2012; Hovell et al., 1985; Jung, Bray, & Ginis, 2008; LeCheminant, Smith, Covington, Hardin-Renschen, & Heden, 2011; Lloyd-Richardson, Lucero, DiBello, Jacobson, & Wing, 2008; Mailey et al., 2012; Meckel, Galily, Nemet, & Eliakim, 2011; Middleton & Perri, 2014; Morgan et al., 2012; Poddar et al., 2009; Racette et al., 2005; Racette et al., 2008; Strimas & Dionne, 2010; Timko, Mooney, & Juarascio, 2010; Uchiyama, Shimizu, Nakagawa, & Tanaka, 2008; Yakusheva, Kapinos, & Weiss, 2011; Yakusheva, Kapinos, & Eisenberg, 2014; Yamane et al., 2014). In addition, since their study, more research studies have been published (i.e., Bodenlos, Gengarelly, & Smith, 2015; Boyce & Kuijer, 2015; Brock, Carr, & Todd, 2015; Deforche et al., 2015; Ekuni et al., 2014; Epton et al., 2014; Kawada, Nakanishi, Ohama, Nishida, Yamauchi-Takihara, & Moriyama, 2015; Meisel, Beeken, van Jaarsveld, & Wardle, 2015; Yamane et al., 2014). Thus, this meta-analytic review builds upon the two previous meta-analyses, the first of which was composed of studies from 1985 to 2008, to examine more contemporary research and additional metrics of weight gain.

Although the mean weight gain amongst college freshman in their first year may appear closer to 4 than 15 lbs, the range of weight change in those who gain appears quite variable (Vella-Zarb & Elgar, 2009). Examining the amount of weight change observed in this group, through a meta-analysis, will help in determining the actual magnitude of weight change that occurs among young adults during this time of transition. Distinguishing among college students who lose/maintain their weight is important because the majority of college students have been found to gain weight and therefore, this group warrants closer examination (Anderson, Shapiro, & Lundgren, 2003; Cluskey & Grobe, 2009; Deforche et al., 2015).

**Goals for the Present Study**

Due to the attrition rates of individual studies, sample sizes can be somewhat limiting. In particular, studies examining weight change across all four years of college are at particular risk for attrition and small sample sizes. Because of these small sample sizes, body composition changes may not be strong enough to be reliably detected. An increase in sample size by pooling the datasets via meta-analysis methodology may provide a more accurate description of the body composition changes that occur in college students.

The present meta-analysis also includes the additional measures of body composition changes, including percent body fat, fat-free mass, absolute fat mass, and waist circumference to provide a greater overall picture of the changes that occur in college students. When considering just those individuals who gain weight, the typical weight gain has been reported to be considerably higher. For instance, Gropper and colleagues (2012) found that across the four years of college, in those who gained weight, the average was 11.7 lbs (5.3 kg). Other studies have found even more dramatic weight gain across four years in college in those who gain weight (+46.08 lbs; +20.9 kg; Racette et al., 2008). The present meta-analysis examines weight change as an average across all college students, as well as amongst those who are in the weight gain category.

Vadeboncoeur and colleagues (2015) included studies that examined weight change over 6 weeks to 8 months at the end of the first year. Studies examining body composition changes in college students have ranged from six weeks (Gow, Trace, & Mazzeo, 2010) to the end of senior year (Girz et al., 2013; Gropper et al., 2012; Racette et al., 2008; Uchiyama, Shimizu, Nakagawa, & Tanaka, 2008). Vella-Zarb and Elgar's (2009) meta-analysis found that studies over longer durations had an increase in weight gain over the course of the year, which resulted in greater weight gain overall. In addition, Vadeboncoeur and colleagues (2015) found that the length of follow-up was significant in predicting higher weight change. Therefore, it is important to examine weight change over longer periods of time rather than 6 to 12 weeks, especially over the course of attending college.

Although the 'Freshman 15' may highlight weight gain amongst first year students, less attention has been paid to weight gain throughout all four years of college. Consequently, it is necessary to examine whether the previously reported pattern of an average gain of 3.86 lbs (1.75 kg; Vella-Zarb & Elgar, 2009) or 3 lbs (1.36 kg; Vadeboncoeur et al., 2015) continues each year following the first year or if this rate plateaus across time. There have been independent studies examining weight change over four years that may provide better insight into trends of weight gain (Girz et al., 2013; Gropper et al., 2012; Racette et al., 2008; Uchiyama et al., 2008). Thus, the present meta-analysis also examined studies that tracked weight change over the course of four years. If weight gain is found to significantly increase each year following high school, then college students may be at an even higher risk for overweight and obesity than previously thought.

Other aspects of the studies to be examined will include the reporting method of data collection. Some studies use self-report to gather data regarding weight and BMI, but this may have implications for the validity of data reported. Vella-Zarb and Elgar (2009) found a significant difference amongst those who self-reported weight loss and those who had weight measured more objectively. McCabe, McFarlane, Polivy, and Olmsted (2001) examined accuracy of self-reported weight and found that in college students, there was a significant difference for dieters (-3.54 kg) and non-dieters (-1.06 kg) between self-reported weight and actual weight with a tendency to underreport weight. Future examination of this may provide important information regarding the validity of reporting methods. The present meta-analysis includes many studies that use objectively measured data rather than self-report, but some studies were conducted using only self-report methodology. Due to the potential discrepancies in accuracy, the present study evaluates whether there are differences between the reporting methods of data collection.

Examining the course of weight gain and other body composition changes over four years (as well as potential moderators) via meta-analytic techniques can help to more systematically quantify the patterns and magnitude of changes in a way that is quite difficult to do with reliance on narrative reviews and summaries. Thus, based on the current literature, an updated and expanded meta-analysis is warranted.

## Hypotheses and Predicted Outcomes

**Primary Hypotheses**

Hypothesis 1: There will be an increase in weight, BMI, percent/absolute fat mass, and waist circumference in the first year of college. However, the rate of weight gain will be less than the popular "Freshman 15" concept suggests. The study also predicts that fat-free mass will decrease in the first year of college.

Hypothesis 2: Over the four years of college, an increase of weight, BMI, percent/absolute fat mass, and waist circumference will be observed. Fat-free mass will decrease from the beginning to the end of college.

Hypothesis 3: Gender will be a moderator for weight and body composition changes. Men will show an increase in weight, BMI, fat-free mass, and a decrease in percent/absolute fat mass and waist circumference. Females will show lower increases than males in changes of weight, BMI, percent/absolute fat mass, and waist circumference, but still show significant change. In addition, females will show a decrease in fat-free mass change.

**Secondary and Exploratory Hypotheses**

Hypothesis 4: In college students who gain weight, the rates will be greater than the overall mean weight gain.

Hypothesis 5: Self-report measurement of weight and BMI will yield lower rates of change than those observed via objectively measured protocols.

Hypothesis 6: Weight and body composition changes will be different according to the location of the study conducted with studies from the United States and Canada showing higher rates of weight gain than studies conducted in other countries.

# Method

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher, Liberati, Tetzlaff, & Altman, 2009) guidelines for conducting and reporting a meta-analysis. The completed PRISMA Checklist can be found in Appendix A.

## Search Strategy and Study Selection

A comprehensive literature search was conducted with seven databases to gather the relevant literature. Consultation with a reference librarian resulted in recommendations to direct the search using the databases of PsycINFO, PubMed, Web of Science, SPORTDiscus, Health Source, Scopus, and Cochrane Reviews. The search terms included a combination of three different headings: (1) Student (or freshman or freshmen), (2) Universities (or college or higher education), and (3) weight (or weight gain or weight change or weight increase or BMI or body mass index or adiposity). The search of the databases was conducted in October of 2015. An example of the search syntax that was used can be found in Appendix B. A total of 18,912 studies were extracted from the database search with their abstracts and titles exported to RefWorks. The reference lists on included studies were manually searched for potential additional studies to be included in the review. After removing duplicates, 14,268 studies were included in the title and abstract review.

## Data Extraction

A data extraction coding, including the article's title, authors, year, journal, and abstract, was developed and pilot-tested between three researchers. One review author extracted the data from included studies and the second and third authors checked the extracted information. Disagreements were resolved by discussing between two review authors, and a third author.

**Eligibility Criteria**

Only articles published in scientific, peer-reviewed journals were included. Unpublished theses or dissertations were not included in the study because the present meta-analysis focused upon studies of likely higher quality resulting from the peer-review evaluation occurring during publication. To be included in review of the full article, studies had to collect body composition change at baseline and follow-up, be published in English language, and be an empirical quantitative study, including prospective, observational, longitudinal, and/or no-treatment control group of randomized trial interventions. Studies gathering data from freshman year and studies gathering data beyond freshman year were included in the analysis (Table 1).

We excluded articles if the sample was not from a four-year college, such as a two-year community college or military university, or if the sample was exclusively focused on college varsity athletes. In addition, the baseline data collection had to occur at most four weeks prior to the start of the academic year or at most four weeks after the onset of the academic year. If follow-up were less than ten weeks after baseline, the article was excluded for further review. Lastly, the article could not use different data collection methods at baseline and follow-up, such as using objective measures at baseline and self-report at follow-up, due to the potential discrepancy in the validity of body measures between self-report and objective measurement.

Using these criteria, 14,065 articles were excluded from further review. The remaining 203 articles were reviewed fully by the main author to determine inclusion in the analysis. Using the inclusion and exclusion criteria, 148 articles were excluded after full review. Of the initial articles extracted, a total of 55 articles were included for analyses. Refer to Figure 1 for the flowchart detailing the study selection during the phases of the systematic review.

**Coding Procedures**

Articles were coded in a systematic manner. The study's publication year, title, authors, and journal were recorded. Other study characteristics collected from the articles included sample size, attrition rates, study location, duration of the study, design of the study, demographic characteristics of participants (age, race, gender composition), and type of measure (i.e., self-report or objective measure). Measures of body composition change, including weight, BMI, percent/absolute fat mass, fat-free mass, and waist circumference were coded, including the mean change, the standard error, standard deviation, and significance of change. Weight that was reported in pounds was transformed into kilograms and study duration was transformed into weeks. If the article described the study length in terms of semester or academic year, the data was transformed into 14 weeks for a semester and 28 weeks for an academic year. In addition, the percentage of students who gained weight, and the weight gain of those who gained, including the mean weight gain, SE, SD, and significance values, was coded. If reported, the percentage of students gaining 15 lbs (6.8 kg) was also coded. The main author coded these study characteristics twice in order to ensure accuracy. To check for accurate study inclusion and exclusion for further review, a second author reviewed a random selection of 10% of the article titles and abstracts. The comparison between the first and second author ratings revealed good interrater reliability (Cohen's $k = 0.71$).

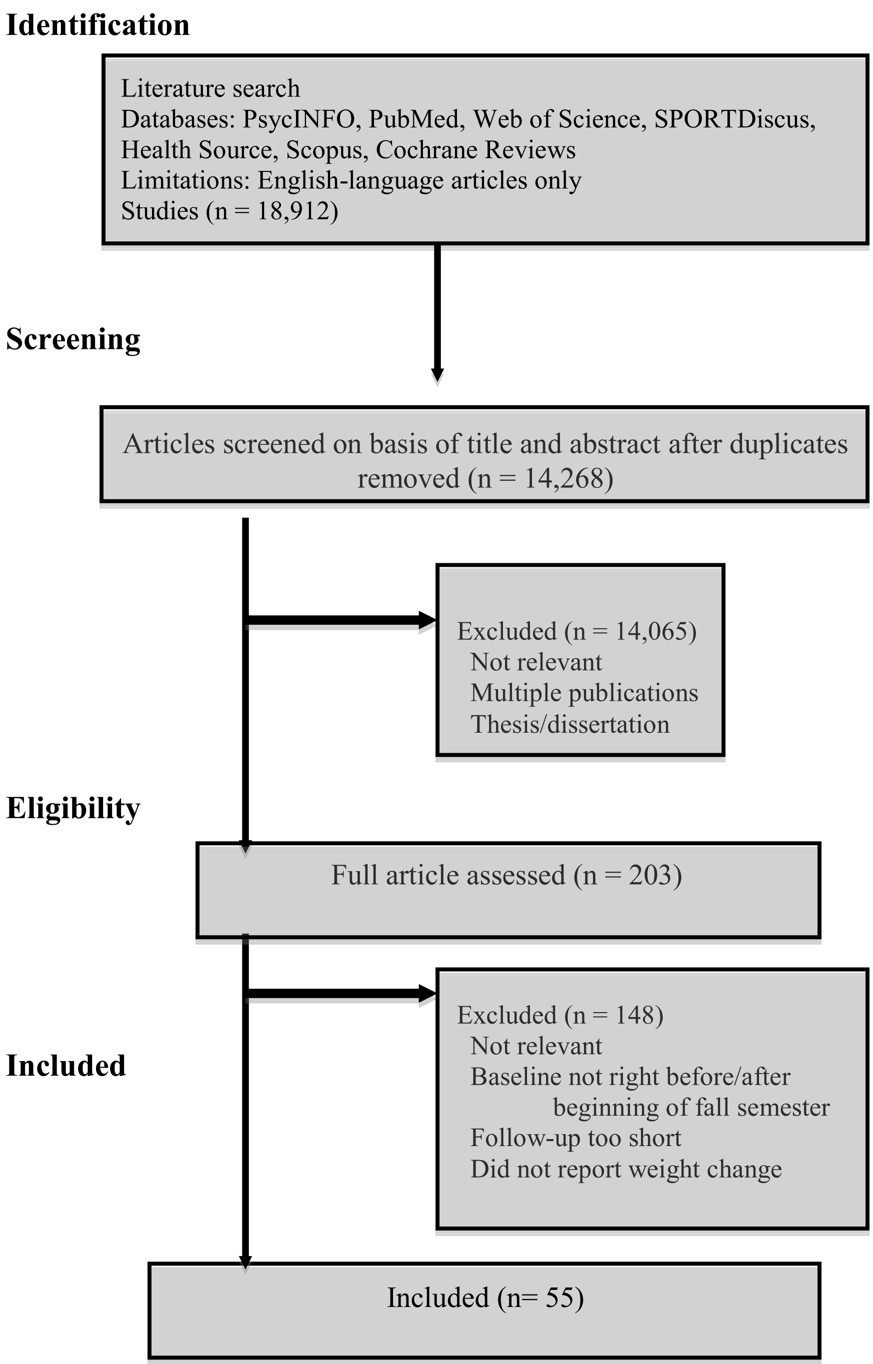


*Figure 1*. Flow chart of selected studies on body composition changes

Studies were evaluated using an adaptation of the Newcastle-Ottawa Quality Assessment Scale (NOS; Wells, Shea, O'Connell, Peterson, Welch, Losos, & Tugwell, 2000). The NOS was developed to assess the quality of nonrandomized studies in the interpretation of meta-analysis results. The NOS was adapted to fit the necessary information in this meta-analysis. A study could receive a maximum of one star for each item within the Selection, Outcome, and Bias Assessment categories. Studies were assessed on a total score of seven stars. Scores of six and above are considered high quality, four and five average quality, and three or lower are considered low quality. Agreement between two coders for study quality ratings was assessed and a Cohen's kappa value of 0.85 was determined, indicating a high level of agreement. Refer to Appendix C for the NOS criteria.

**Statistical Analyses**

The meta-analysis was conducted using Comprehensive Meta-Analysis (CMA) software. Study characteristics were coded and then statistical analysis, using CMA, was conducted. The pooled mean differences for weight and body composition changes were calculated using the mean difference, sample size, and *p*-value for each study. Authors were contacted to collect missing information that was not reported in the published article. The related *z*-value used to evaluate statistical significance was calculated by taking the estimated difference divided by standard error.

To assess homogeneity and heterogeneity, the *Q* statistic and $I^2$ value were computed. The *Q* statistic tests for homogeneity in whether the effect sizes from all studies are equal or if the amount of variation in effect sizes are related to expected sampling variability (Valentine, Pigott, & Rothstein, 2010). The $I^2$ value is helpful in describing the amount of heterogeneity in the outcomes of studies and represents the proportion of total variation in effect sizes based by between-study variance. $I^2$ values of 25% or less represent a small amount of heterogeneity, 50% represents a moderate amount, and 75% represents a large amount of heterogeneity (Valentine, Pigott, & Rothstein, 2010). Due to the high heterogeneity of the studies, with most of the $I^2$ values > 80%, related to the differences in sample size, study length, gender composition, and country of study conducted, a random effects analysis was used. A random effect model assumes that the mean effect size in the population has variance between studies, or heterogeneity, and is most appropriate for use in studies with high heterogeneity (Fields & Gillett, 2010).

Bias analysis of the studies was assessed using a funnel plot and fail-safe N for all body composition and adiposity changes in freshman year and in four-year studies. The fail-safe N was calculated to evaluate whether the results are due to sampling, or the number of unpublished studies reporting null results required to reduce the effect to non-significance. Although this technique does not address the magnitude of the potential sampling bias, it is a useful technique for assessing the issue of whether the resulting mean effects are null in the total population of studies, despite the positive results in the meta-analyses (Field & Gillett, 2010).

The CMA software uses the meta-analytic Hedges and Olkin technique to establish one measure of effect size. This technique converts study outcomes into standard deviation units, which are then corrected for bias (Johnson, Mullen, & Salas, 1995). This bias may occur in overestimate of population effect size, a concern that may occur in small samples. The transformed values are combined and their homogeneity is examined. Using continuous or categorical moderators, the variability of the values can thus be explained.

Study characteristics were weighted by the sample size. Body composition changes were reported by overall difference in means, due to the reported information being on the same scale. Mean weight gain was calculated using weighted data by sample size, reported mean weight change, and the *p*-value of this difference. Mean weight gain was calculated on overall average weight change in studies examining freshman year changes and overall college change. In addition, mean weight change was calculated amongst those in the "gain only" group for studies over freshman year providing this information. Mean weight gain was calculated by weighting the mean weight gain in each study with the number of participants in each study. BMI was calculated in a similar method, to see whether a significant change occurs, which would be helpful for overweight and obesity rates. Other body composition changes, including percent and absolute fat mass, fat-free mass, and waist circumference were also examined, by weighting sample size, to provide additional analyses into the specific bodily changes in college students. All of the body composition and adiposity changes were evaluated separately for effect size as well as were separated in studies occurring over only freshman year and those over all four years. For studies over four years, analyses were conducted with and without the study by Kawada et al. (2015) because of the large sample size ($n = 6{,}838$). Unless noted, subgroup analyses were evaluated separately for studies over freshman year and four years.

Additional subgroup analyses were used to examine effect of study location effect on the reported body composition changes. When possible, comparisons were made between studies from the United States and Canada, and studies from North America to other continents. This subgroup analysis was conducted for both study lengths. In addition, in only studies of freshman year, a subgroup analysis was conducted to determine whether studies of shorter duration ($\leq$ 4 months) differed in reported body composition changes to studies of longer duration (> 4 months).

To test the association between study duration and body composition changes, a meta-regression was conducted. This gives insight into whether a longer study has a significantly different amount of body composition change from shorter studies. In addition, a meta-regression was conducted to determine whether there are any differences found in body composition changes in the quality of the study. Due to some potential limitations related to a lower quality study, it is important to examine whether there are differences between high- and low-rated quality studies.

Gender association was conducted using subgroup analysis in the CMA software of gender composition of the study and body composition changes, using the weighted data. Potential differences may be found amongst males and females, so examining each independently gives insight into these differences.

In order to analyze the potential effects for the type of measurement in each study on body composition changes, a subgroup analysis on weighted data of studies using self-report and those that use objectively measured weight was conducted on studies examining kg and BMI change.

Table 1
*Summary of Included Articles*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Allard, 2013, Canada | 150 | Mean age:<br>Male: 20<br>Female: 19<br>Gender: 76%<br>Ethnicity: 1 | 104 | 1 | 3 | yes | no | yes | no | no | no |
| Anderson, 2003, US | 135 | Mean age: 17.9<br>Gender: 57%<br>Ethnicity: 1 | 28 | 1 | 3 | yes | yes | no | no | no | no |
| Bodenlos, 2015, US | 304 | Mean age: 18.08<br>Gender: 70%<br>Ethnicity: 1 | 28 | 1 | 4 | yes | no | no | no | no | no |
| Boyce, 2014, New Zealand | 65 | Mean age: 18.2<br>Gender: 69%<br>Ethnicity: 1 | 34 | 1 | 3 | yes | yes | no | no | no | no |
| Brock, 2015, US | 179 | Mean age: NR<br>Gender: 73%<br>Ethnicity: 1 | 30 | 1 | 3 | no | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Butler, 2004, US | 54 | Mean age: 17.79<br>Female: 17.79<br>Gender: 100%<br>Ethnicity: 1 | 20 | 1 | 4 | yes | yes | yes | yes | yes | no |
| Calitri, 2010, UK | 102 | Mean age: 19<br>Gender: 57%<br>Ethnicity: NR | 48 | 1 | 3 | no | yes | no | no | no | no |
| Deliens, 2013, Belgium | 101 | Mean age: 18<br>Gender: 57%<br>Ethnicity: 1 | 20 | 1 | 4 | yes | yes | no | yes | yes | yes |
| Delinsky, 2008, US | 149 | Mean age: 17.92<br>Female: 17.92<br>Gender: 100%<br>Ethnicity: 1 | 32 | 1 | 2 | yes | yes | no | no | no | no |
| Economos, 2008, US | 396 | Mean age: 17.82<br>Gender: 65%<br>Ethnicity: 1 | 32 | 1 | 3 | yes | no | no | no | no | no |
| Edmonds, 2008, Canada | 116 | Mean age: 18.5<br>Female: 18.5<br>Gender: 100%<br>Ethnicity: 1 | 28 | 1 | 6 | yes | yes | yes | no | no | yes |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | Body change BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ekuni, 2014, Japan | 224 | Mean age: 18.2<br>Gender: 54%<br>Ethnicity: 3 | 156 | 1 | 5 | no | yes | no | no | no | no |
| Epton, 2014, UK | 709 | Mean age: 19.04<br>Gender: 55%<br>Ethnicity: 1 | 24 | 1 | 3 | no | yes | no | no | no | no |
| Finlayson, 2012, UK | 247 | Mean age: 19.2<br>Gender: 78%<br>Ethnicity: 1 | 52 | 1 | 4 | yes | yes | no | yes | yes | yes |
| Gillen, 2011, US | 390 | Mean age: 19.5<br>Gender: 54%<br>Ethnicity: 4 | 45 | 1 | 5 | yes | yes | no | no | no | no |
| Girz, 2013, Canada | 478 | Mean age: 17.9<br>Gender: 64%<br>Ethnicity: 1 | 180 | 1 | 3 | yes | yes | no | no | no | no |
| Gow, 2010, US | 32 | Mean age: 18.1<br>Gender: 74%<br>Ethnicity: 1 | 10 | 2 | 4 | yes | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Graham, 2002, US | 49 | Mean age: 18.5<br>Gender: 80%<br>Ethnicity: NR | 28 | 1 | 6 | yes | no | yes | no | no | no |
| Gropper, 2012, US | 131 | Mean age:<br>Male: 18.2<br>Female: 18.1<br>Gender: 68%<br>Ethnicity: 1 | 208 | 1 | 5 | yes | yes | yes | yes | yes | no |
| Hajhosseini, 2006, US | 27 | Mean age: 18.3<br>Gender: 81%<br>Ethnicity: 4 | 16 | 1 | 4 | yes | yes | yes | no | no | no |
| Hodge, 1993, US | 61 | Mean age: 17.93<br>Female: 17.93<br>Gender: 100%<br>Ethnicity: 1 | 24 | 1 | 2 | yes | no | no | no | no | no |
| Hoffman, 2006, US | 67 | Mean age: NR<br>Gender: 52%<br>Ethnicity: 1 | 28 | 1 | 3 | yes | yes | yes | yes | yes | no |

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[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hovell, 1985, (a) US | 43 | Mean age: 18<br>Female: 18<br>Gender: 100%<br>Ethnicity: 1 | 30 | 2 | 3 | yes | no | no | no | yes | no |
| Hovell, 1985, (b) US | 43 | Mean age: 18<br>Female: 18<br>Gender: 100%<br>Ethnicity: 1 | 21 | 1 | 4 | yes | no | no | no | yes | no |
| Jung, 2008, Canada | 101 | Mean age: 18.5<br>Female: 18.5<br>Gender: 100%<br>Ethnicity: 1 | 52 | 1 | 5 | yes | yes | no | no | yes | no |
| Kapinos, 2011, US | 388 | Mean age:<br>Male: 18.1<br>Female: 18.2<br>Gender: 63%<br>Ethnicity: 1 | 52 | 1 | 4 | yes | no | no | no | yes | no |
| Kapinos, 2014, US | 1935 | Mean age: NR<br>Gender: 55%<br>Ethnicity: 1 | 36 | 1 | 3 | yes | yes | no | no | yes | no |
| Kasperek, 2008, US | 193 | Mean age: NR<br>Gender: 88%<br>Ethnicity: 1 | 24 | 1 | 3 | yes | yes | no | no | yes | no |

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[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kawada, 2015, Japan | 6838 | Mean age: 18<br>Gender: NR<br>Ethnicity: 3 | 156 | 1 | 5 | yes | yes | no | no | no | no |
| LeCheminant, 2011, US | 18 | Mean age: 18.5<br>Gender: 61%<br>Ethnicity: 1 | 28 | 2 | 4 | yes | no | yes | no | no | yes |
| Levitsky, 2004, US | 60 | Mean age: 18.2<br>Gender: 85%<br>Ethnicity: 1 | 12 | 1 | 3 | yes | yes | no | no | no | no |
| Levitsky, 2006, (a) US | 15 | Mean age: NR<br>Gender: 100%<br>Ethnicity: NR | 14 | 2 | 4 | yes | no | no | no | no | no |
| Levitsky, 2006, (b) US | 16 | Mean age: NR<br>Gender: 100%<br>Ethnicity: NR | 10 | 2 | 4 | yes | no | no | no | no | no |
| Lloyd-Richardson, 2008, US | 282 | Mean age: 18.6<br>Gender: 61%<br>Ethnicity: 1 | 28 | 1 | 4 | no | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | Body change BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lloyd-Richardson, 2009, (study 1) US | 904 | Mean age: 18.66<br>Gender: 45%<br>Ethnicity: 1 | 89 | 1 | 3 | yes | no | no | no | no | no |
| Lloyd-Richardson, 2009, (study 2) US | 326 | Mean age: 18.5<br>Gender: 61%<br>Ethnicity: 1 | 28 | 1 | 6 | yes | yes | no | no | no | no |
| Lowe, 2006, US | 69 | Mean age: 18.06<br>Female: 18.06<br>Gender: 100%<br>Ethnicity: 1 | 40 | 1 | 6 | yes | no | no | no | no | no |
| Mailey, 2012, US | 123 | Mean age: 17.8<br>Female: 17.8<br>Gender: 100%<br>Ethnicity: 1 | 28 | 2 | 5 | yes | no | no | no | no | no |
| Meckel, 2011, Israel | 174 | Mean age: NR<br>Gender: 51%<br>Ethnicity: NR | 156 | 1 | 5 | yes | no | yes | yes | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Megel, 1994, US | 57 | Mean age: 18.5<br>Female: 18.5<br>Gender: 100%<br>Ethnicity: NR | 28 | 1 | 5 | yes | no | no | no | no | no |
| Meisel, 2015, UK | 310 | Mean age: 22.4<br>Gender: 51%<br>Ethnicity: NR | 32 | 1 | 5 | yes | yes | no | no | no | no |
| Middleton, 2014, US | 48 | Mean age: 18.53<br>Female: 18.53<br>Gender: 100%<br>Ethnicity: 4 | 15 | 2 | 5 | yes | yes | no | no | no | no |
| Mifsud, 2009, Canada | 29 | Mean age:<br>Male: 18.2<br>Female: 18.4<br>Gender: 55%<br>Ethnicity: 1 | 26 | 1 | 4 | yes | yes | yes | yes | yes | yes |
| Morgan, 2012, US | 542 | Mean age: 18<br>Gender: 65%<br>Ethnicity: 1 | 125.2 | 1 | 6 | no | no | yes | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pliner, 2008, Canada | 72 | Mean age:<br>Male: 18.6<br>Female: 18.1<br>Gender: NR<br>Ethnicity: NR | 22 | 1 | 5 | yes | no | no | no | no | no |
| Poddar, 2009, US | 76 | Mean age: 19.2<br>Gender: 86%<br>Ethnicity: NR | 28 | 1 | 4 | yes | no | yes | no | no | yes |
| Provencher, 2009, Canada | 1323 | Mean age:<br>Male: 18.8<br>Female: 17.9<br>Gender: 54%<br>Ethnicity: 1 | 28 | 1 | 3 | yes | yes | no | no | no | no |
| Racette, 2008, US | 204 | Mean age: 18<br>Gender: 68%<br>Ethnicity: 1 | 184 | 1 | 5 | yes | yes | no | no | no | no |
| Racette, 2010, US | 290 | Mean age: 18.1<br>Gender: 53%<br>Ethnicity: 1 | 80 | 1 | 5 | yes | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Strimas, 2010, Canada | 33 | Mean age: 18.11<br>Gender: NR<br>Ethnicity: 4 | 12 | 2 | 3 | yes | yes | no | no | no | no |
| Timko, 2010, US | 18 | Mean age: NR<br>Gender: 61%<br>Ethnicity: NR | 28 | 1 | 4 | yes | yes | no | no | no | no |
| Uchiyama, 2008, Japan | 6178 | Mean age: NR<br>Gender: 32%<br>Ethnicity: NR | 184 | 1 | 5 | no | yes | no | no | no | no |
| Vella-Zarb, 2010, Canada | 84 | Mean age: 18.32<br>Gender: 77%<br>Ethnicity: 4 | 11 | 1 | 6 | yes | no | no | no | no | no |
| Webb, 2012, US | 83 | Mean age: 18.1<br>Female: 18.1<br>Gender: 100%<br>Ethnicity: 1 | 18 | 1 | 3 | yes | yes | no | no | no | no |
| Wengreen, 2009, US | 159 | Mean age: NR<br>Gender: 64%<br>Ethnicity: 1 | 15 | 1 | 5 | yes | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

Table 1 *Summary of Included Articles (continued)*

| First author, year, country, citation | N | Characteristics[a] | Length (in weeks) | Type[b] | Quality (of 7) | Body change kg | BMI | %body fat | Fat-free mass | Absolute fat mass | Waist circumference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yakusheva, 2011, US | 633 | Mean age: 18.1<br>Female: 18.1<br>Gender: 100%<br>Ethnicity: 1 | 28 | 1 | 3 | yes | no | no | no | no | no |
| Yakusheva, 2014, US | 1596 | Mean age:<br>Male: 18.5<br>Female: 18.3<br>Gender: 53%<br>Ethnicity: 1 | 36 | 1 | 6 | yes | no | no | no | no | no |
| Yamane, 2014, Japan | 1314 | Mean age: 18.4<br>Male: 18.5<br>Female: 18.4<br>Gender: 49%<br>Ethnicity: 3 | 156 | 1 | 5 | yes | yes | no | no | no | no |

[a]Ethnicity: 1 = >60% white; 2 = >60% black; 3 = >60% other minority; 4 = mixed, none more than 60%; 5 = mixed, cannot estimate
[a]Gender: Percentage of females
[a]NR = Not reported
[b]Type of Design: 1 = Observational/cohort/prospective; 2 = Randomized trial no treatment control group

# Results

## Studies Included

From the search performed, 18,912 articles were obtained. After removing duplicates and screening the articles further, 55 articles met the inclusion criteria (Fig. 1). The number of studies included in the main analyses varied due to some missing standard deviation. Studies were published from 1985 to 2015 and represented seven locations, including the United States, Canada, United Kingdom, New Zealand, Belgium, Japan, and Israel. Studies varied in sample size, ranging from 13 to 6,838. Study follow-up ranged from 10 weeks following the beginning of the freshman academic year to the end of senior year of college. A summary of included studies can be found in Table 1.

## Heterogeneity and Bias Analyses

The main meta-analyses for kg, BMI, percent body fat, fat-free mass, and fat mass change in freshman year had high rates of heterogeneity ($I^2$ above 80%). Waist circumference heterogeneity was medium to high ($I^2 = 67.9\%$). In four-year studies, high heterogeneity was also observed ($I^2 > 75\%$), suggesting that the differences in effect sizes were due to between-study variance.

Publication bias was assessed through a funnel plot for all body composition changes occurring in studies of one year and four years (Figures 2-7). Funnel plots are a scatter plot of the effect estimates of individual studies against the measure of the study's standard error, and can help in assessing publication bias (Higgins & Green, 2011). Funnel plots can show publication bias in studies with or without intervention effects. In this meta-analysis examining studies without intervention effects, selective publication bias can be based on the significance value of the results. Individual studies are represented by open circles, which are plotted on the graph. Studies plotted on the funnel plot to the extreme left or right, with fewer studies in the middle, suggests possible bias because those to the extreme left or right are more likely to be published. In addition, it may contribute to biasing the estimated between-study heterogeneity variance. Considering the high rates of heterogeneity ($I^2 > 80\%$) in the present study, publication bias may explain the reasoning behind it. For all body composition changes in one-year studies, the funnel plots indicated potential publication bias or systematic heterogeneity. We observed symmetric funnel plots for the four-year studies on kg and BMI change, which indicate likely low publication bias.

An additional measure of publication bias is the fail-safe N. The fail-safe N calculates the number of additional 'negative' studies, or studies that had an effect of zero, to bring the effect size significance value above 0.05 (Higgins & Green, 2011). The fail-safe N was calculated for all body composition changes in freshman year and over college. For weight change occurring freshman year, $z = 13.20$ ($p < 0.001$), 1,243 studies would be needed to bring the results to non-significance. Over four year studies, $z = 7.08$ ($p < 0.001$), 229 studies would be needed. In BMI change over freshman year, 838 studies are needed ($z = 11.74$, $p < 0.001$), whereas four-year studies would need an additional 44 ($z = 3.71$, $p < 0.001$). An additional 49 studies are needed for percent body fat change in one-year studies ($z = 4.74$, $p < 0.001$) and 21 studies are needed in studies of four years ($z = 5.48$, $p < 0.001$). In studies collecting data on only freshman year, absolute fat mass change would need 13 studies to show non-significance ($z = 4.01$, $p < 0.001$), whereas waist circumference would require 24 studies ($z = 4.11$, $p < 0.001$). The fail-safe N shows that in body composition changes, such as weight, BMI, and percent body fat, publication bias may not be as great of a concern due to the number of non-significant studies required to affect the effect size findings of the study. Thus, the various publication bias metrics taken together suggest the heterogeneity among the studies, rather than systematic publication bias per se, is more paramount. This pattern of findings may also suggest the influence of moderators on the data.

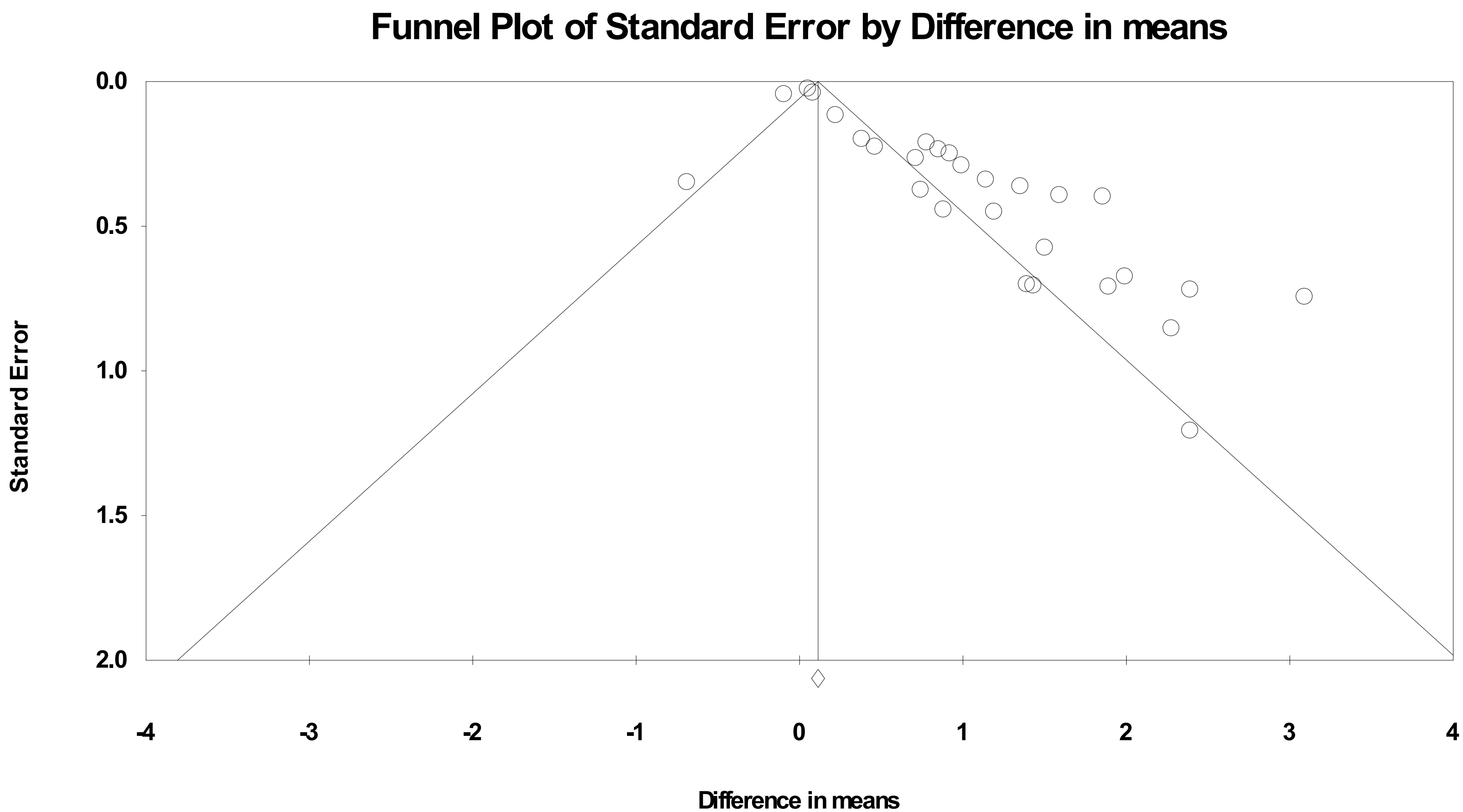



*Figure 2*. Funnel plot for kg change freshman year

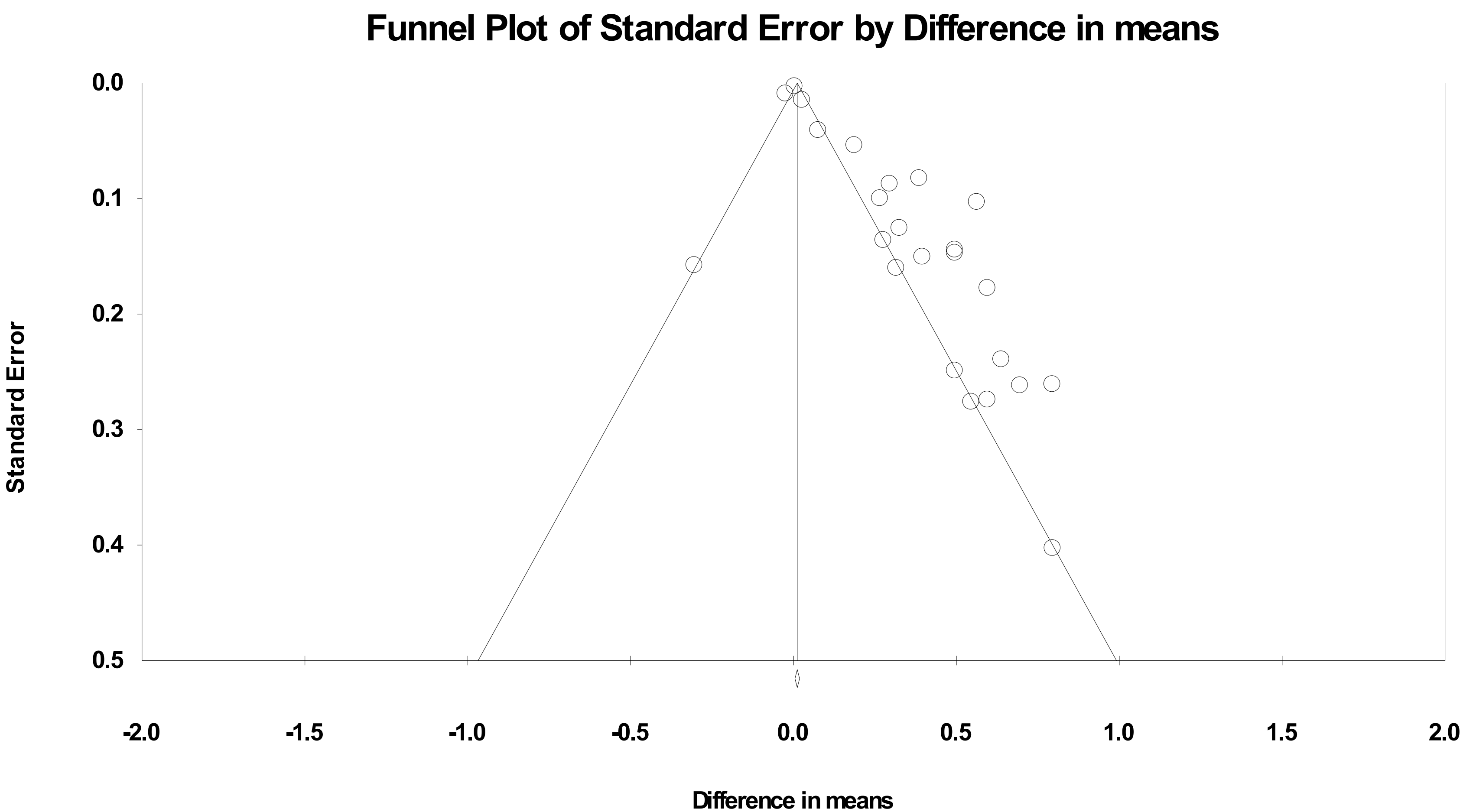



*Figure 3*. Funnel plot for BMI change freshman year

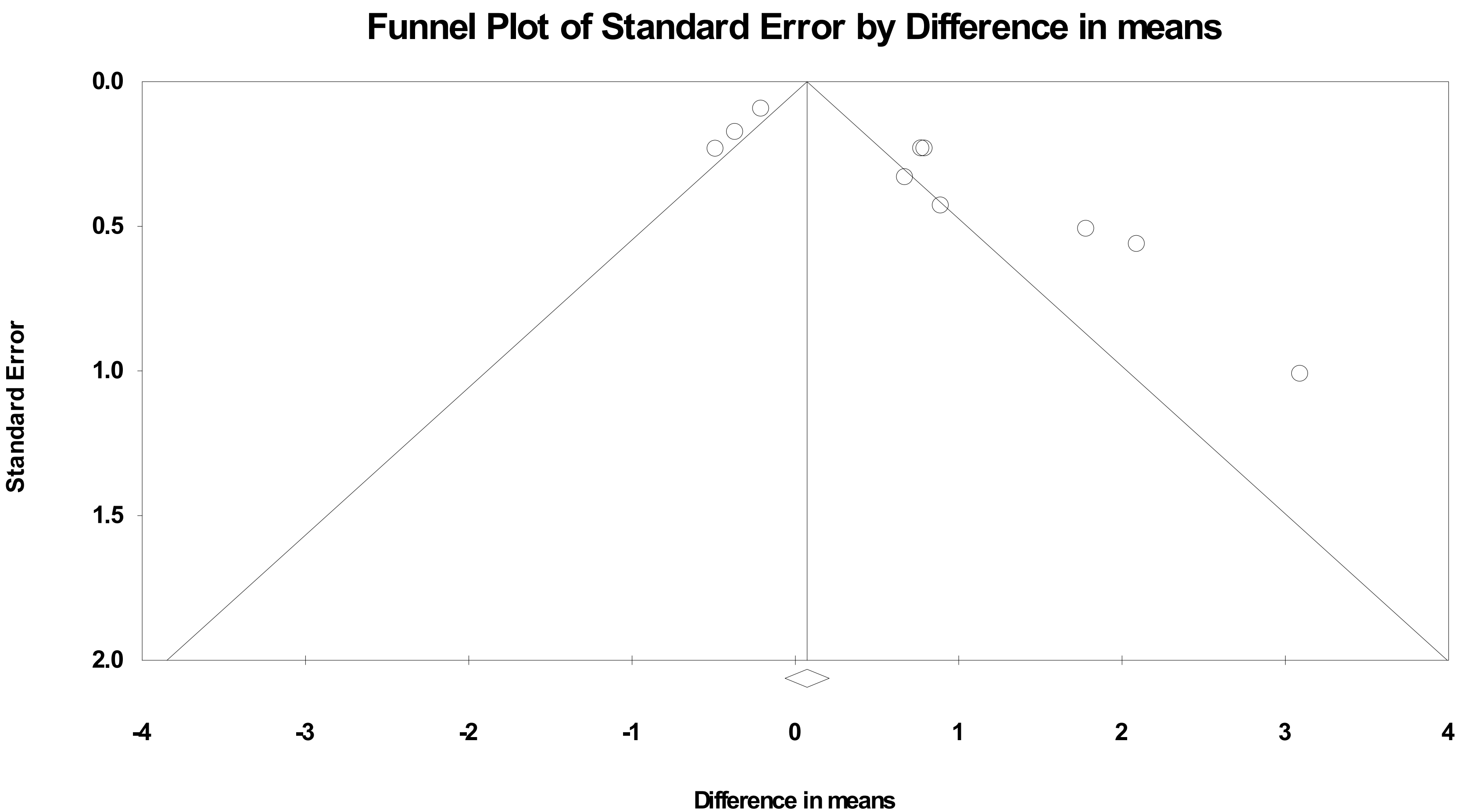



*Figure 4*. Funnel plot for body fat change freshman year

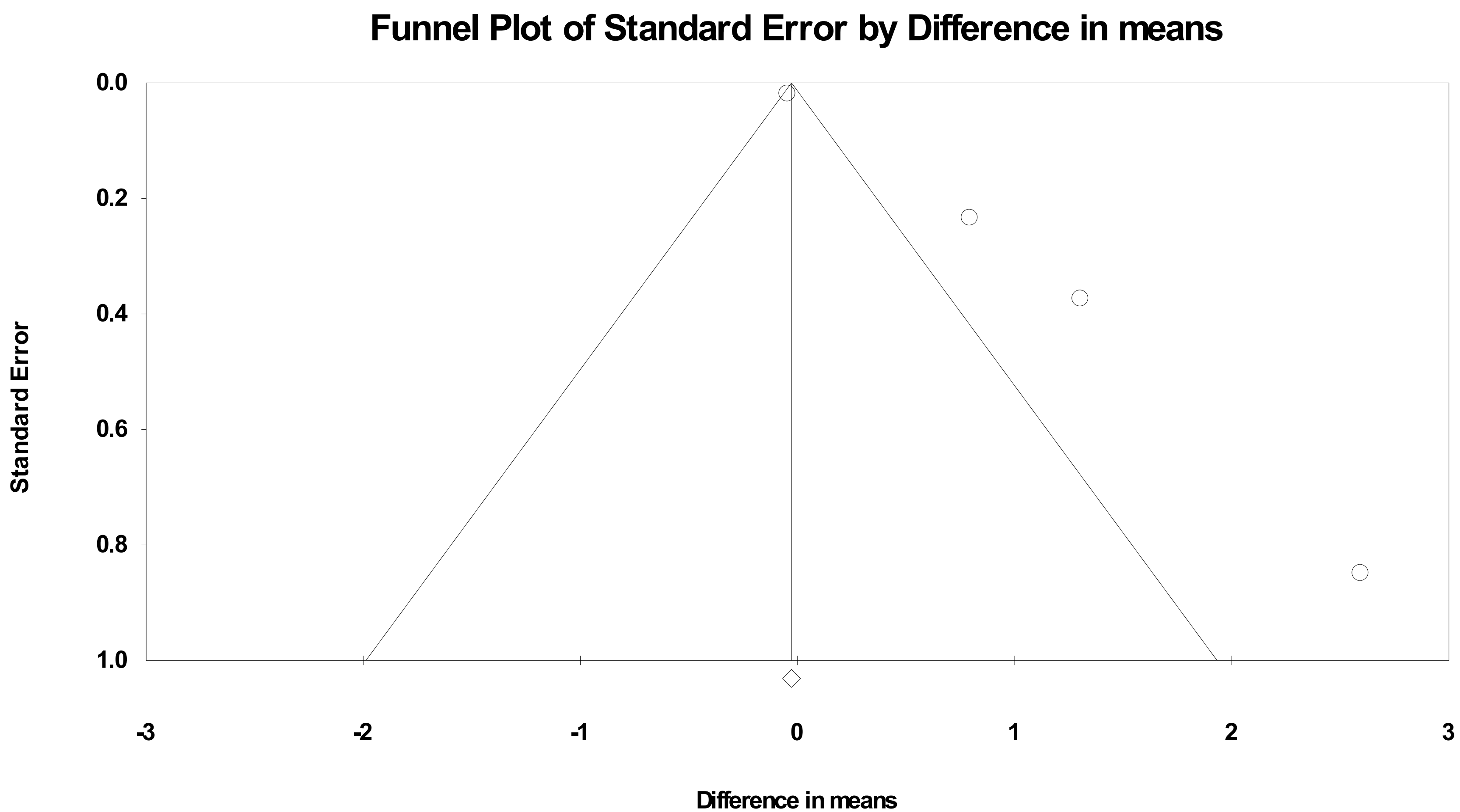


*Figure 5*. Funnel plot for fat mass change freshman year

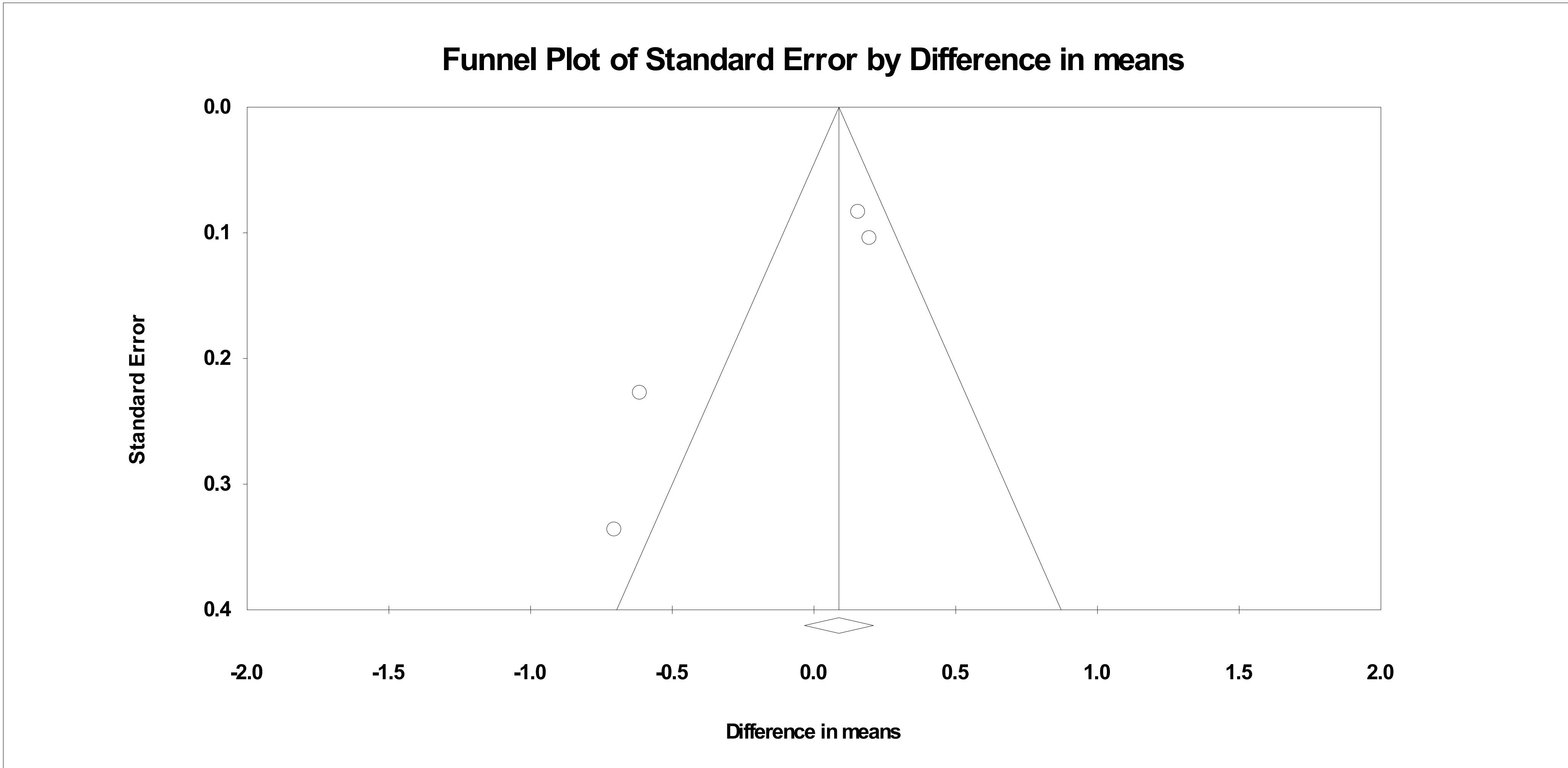



*Figure 6.* Funnel plot for fat-free mass change freshman year

v

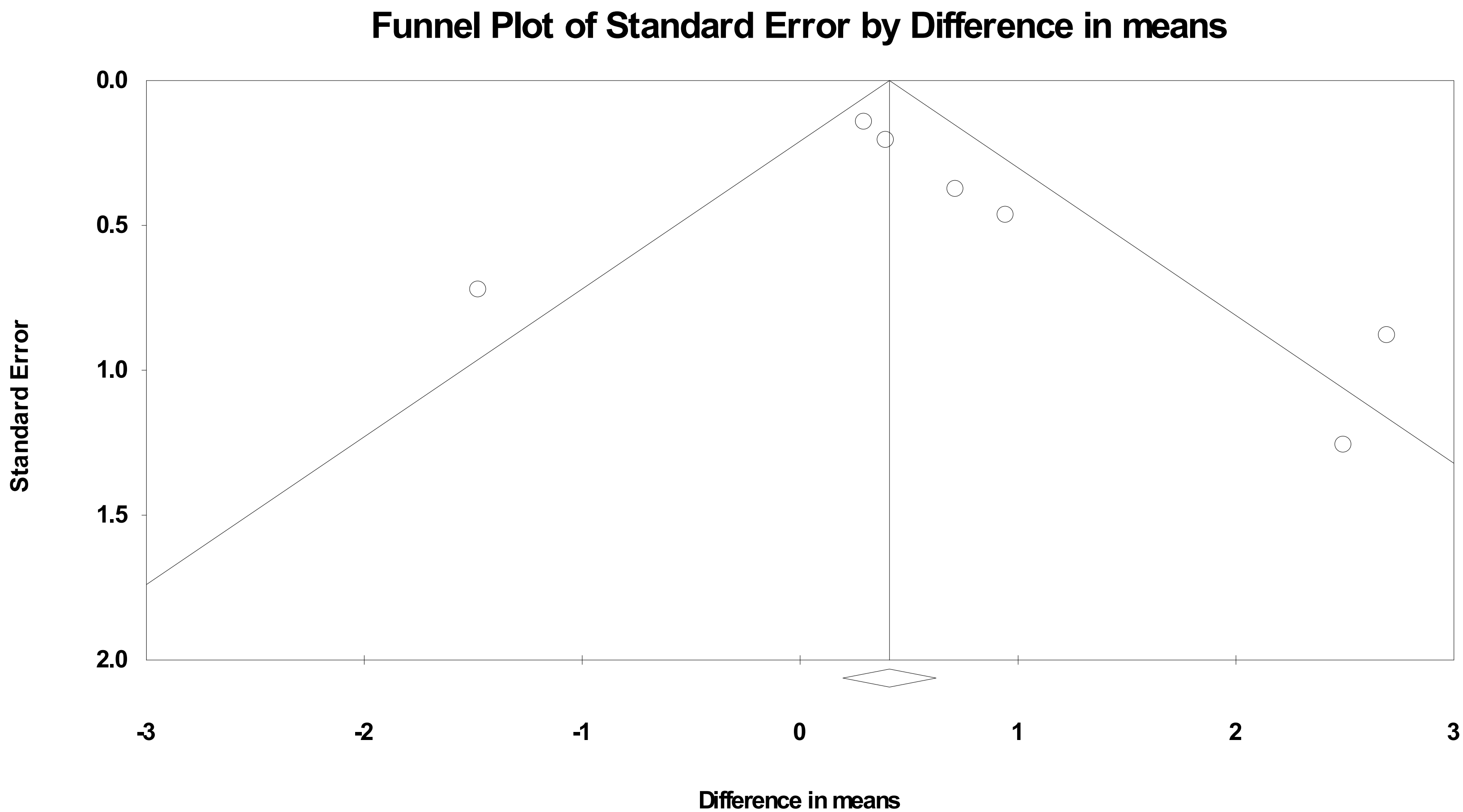


*Figure 7*. Funnel plot for waist circumference change freshman year

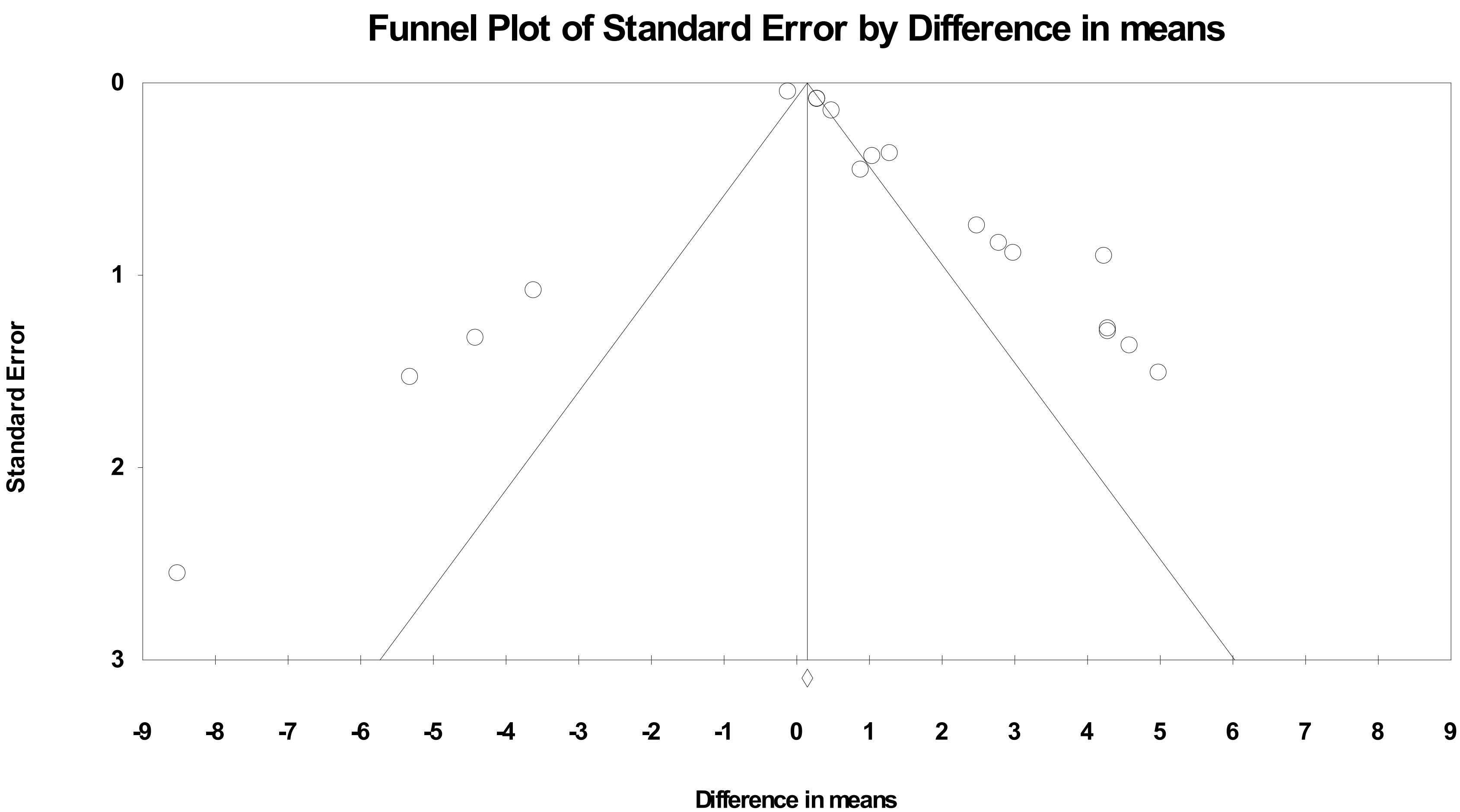


*Figure 8.* Funnel plot for kg change over four years

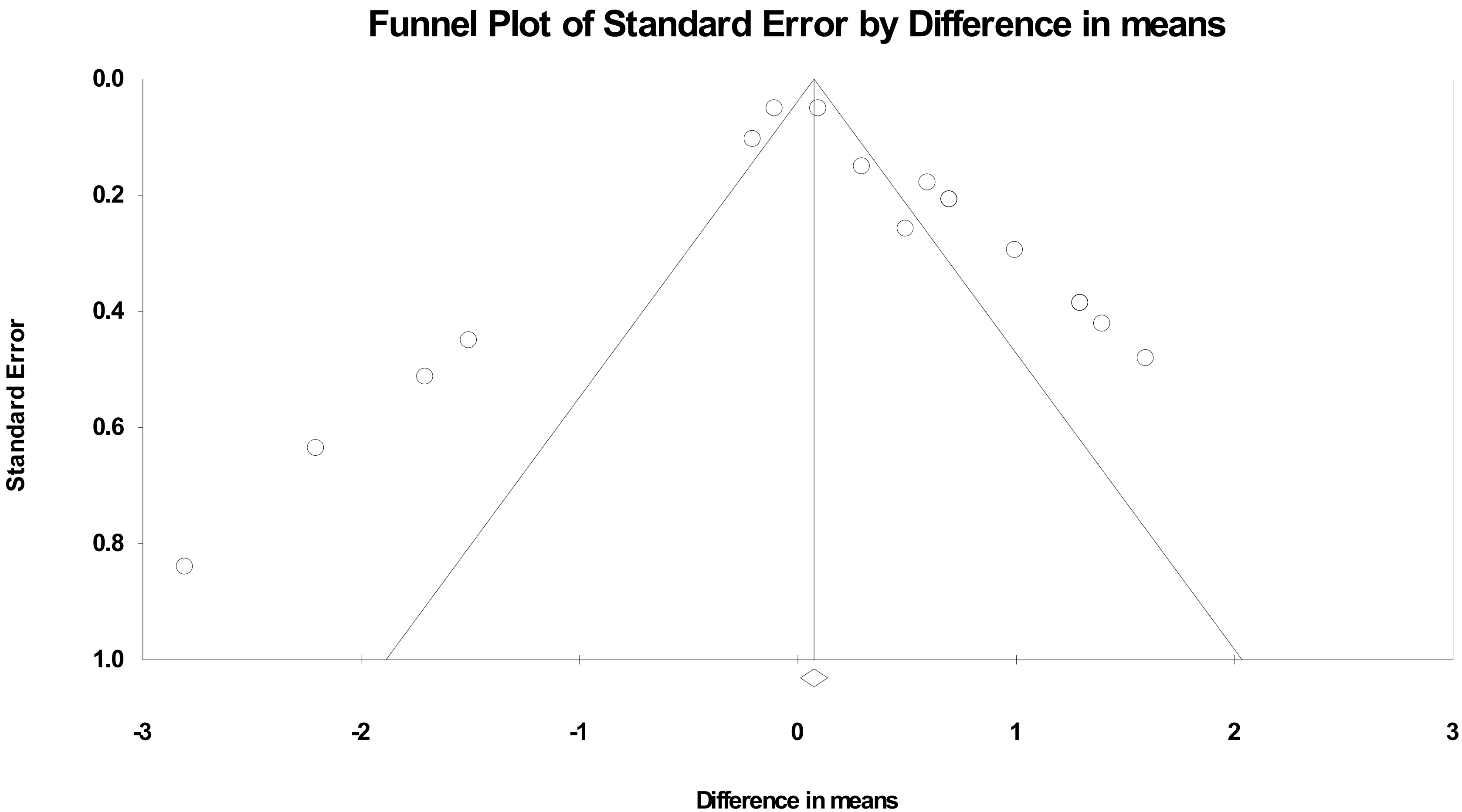



*Figure 9.* Funnel plot for BMI change over four years

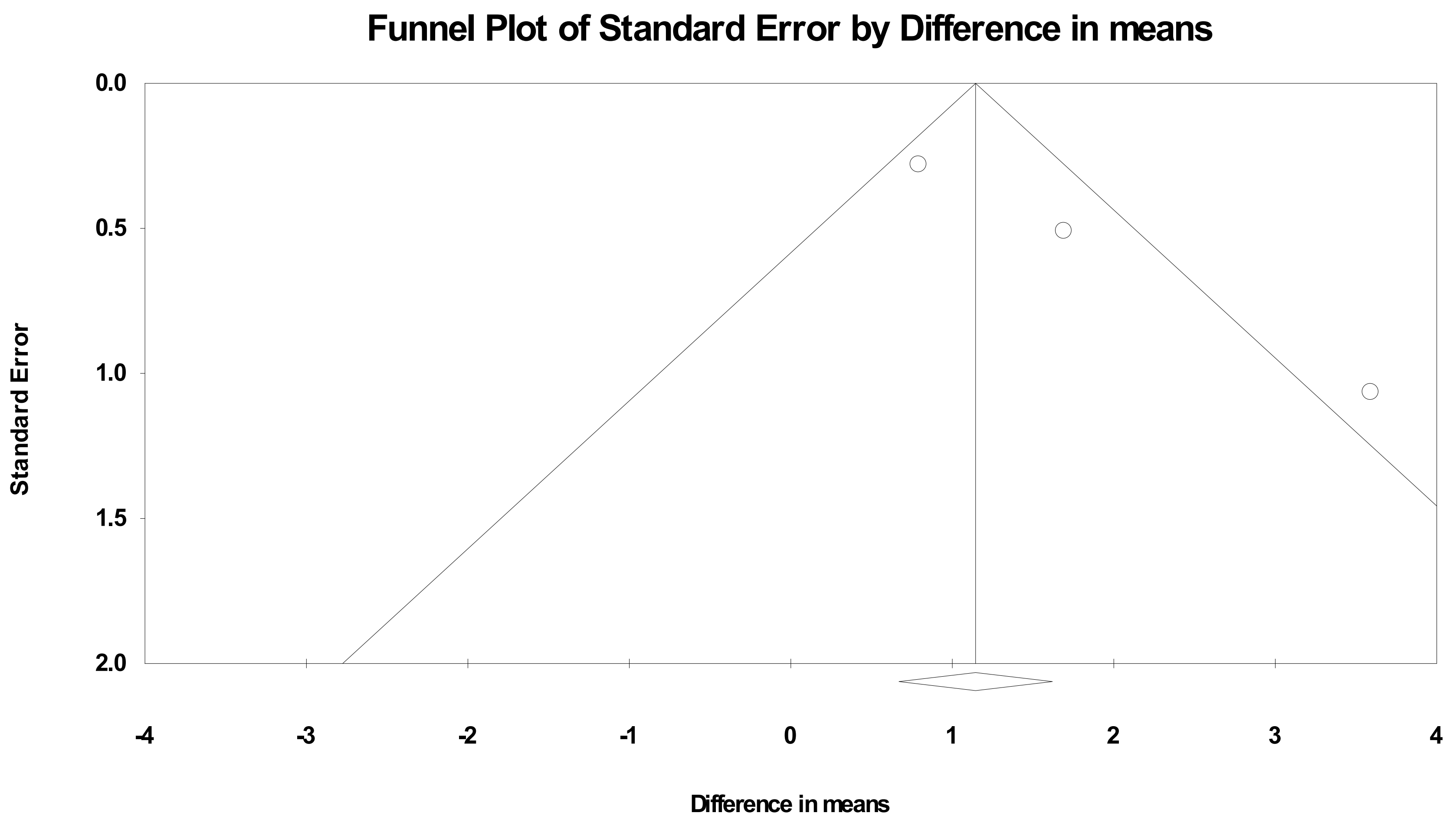



*Figure 10.* Funnel plot for percent body fat change over four years

**Mean Weight Change Freshman Year**

To be included in the main meta-analysis, studies needed to report the mean weight change from the beginning to end of freshman year of college, sample size, and the *p*-value of the weight change. From this information, the CMA software is able to calculate the effect size. Of the 44 studies examining body composition changes freshman year, only 27 studies reported the necessary data to be included in the weight change analysis. Due to the high heterogeneity observed in this sample, a random effects model was used (Q statistic = 201.89, $I^2 = 86.6\%$). A final sample of 6,389 students comprised this analysis, with a statistically significant weight gain of 0.74 kg (CI: 0.56-0.92) ($z = 8.19$, $p < 0.001$). The results indicate a small effect size (Hedge's $g = 0.22$). A summary of all results can be found in Table 2 and 3.

**Mean BMI Change Freshman Year**

A total of 45 studies were available to be included in the analysis of BMI change over freshman year. Of these, 23 studies reported the necessary data, accounting for a sample of 7,033 students. A statistically significant BMI change of 0.21 $kg \cdot m^{-2}$ (CI: 0.16-0.27, $I^2 = 87.7\%$, $z = 7.69$, $p < 0.001$) was observed, which suggests a small effect size (Hedge's $g = 0.20$).

**Mean Percent Body Fat Change Freshman Year**

Eight studies, composed of 891 students, were used in the analysis of percent body fat change over freshman year. A significant mean percent body fat increase of 0.65% (CI: 0.17-1.13, $I^2 = 88.4\%$, $z = 2.66$, $p < 0.05$) was found. From this analysis, a small effect size was observed (Hedge's $g = 0.19$).

**Mean Fat-Free Mass Change Freshman Year**

Only four studies (n = 288) reported the necessary data to examine fat-free mass change freshman year of college. A non-statistically significant change of -0.13 kg (CI: -0.48-0.22, $I^2 = 82.0\%$, $z = -0.73$, $p > 0.47$) was observed with a Hedge's $g$ of 0.02.

**Mean Absolute Fat Mass Change Freshman Year**

Four studies, accounting for a sample of 288, reported data for absolute fat mass change. We observed a statistically significant change of 0.92 kg (CI: 0.07-1.78, $I^2 = 91.4\%$, $z = 2.12$, $p < 0.05$), with a Hedge's $g$ of 0.31.

**Mean Waist Circumference Change Freshman Year**

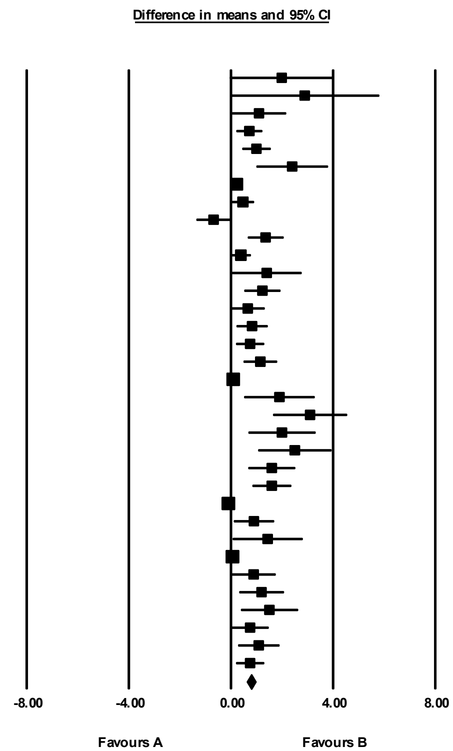
Over the course of freshman year, five studies evaluated waist circumference change. A total of 442 students resulted in a statistically significant mean change of 0.58 inches (CI: 0.05-1.09, $I^2 = 67.9\%$, $z = 2.21$, $p < 0.05$). A small effect size was observed (Hedge's $g = 0.19$).

**Weight Gain in Gainers**

An analysis was conducted for studies that provided separate data on the mean weight change in those who gained. Eighteen studies reported the percentage of students who gained weight, for an average of 60.9% of students gaining weight. Only four studies provided separate data on the mean weight gain of gainers, for a sample size of 618 students. A mean weight difference in gainers was found to be 3.43 kg (CI: 2.32-4.53, $I^2 = 42.9$), with an observed small-to-medium effect size (Hedge's $g = 0.27$).

## Weight change freshman year

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Bodenlos et al., 2015 (Female) | Female | 1.990 | 1.047 | -0.062 | 4.042 |
| Bodenlos et al., 2015 (Male) | Male | 2.890 | 1.498 | -0.046 | 5.826 |
| Boyce & Kuijer, 2014 | Both | 1.100 | 0.551 | 0.021 | 2.179 |
| Butler et al., 2004 | Female | 0.720 | 0.269 | 0.192 | 1.248 |
| Deliens et al., 2013 | Both | 1.000 | 0.295 | 0.422 | 1.578 |
| Economos et al., 2008 | Both | 2.400 | 0.724 | 0.981 | 3.819 |
| Finlayson et al., 2012 | Both | 0.230 | 0.121 | -0.007 | 0.467 |
| Gow et al., 2010 | Both | 0.470 | 0.230 | 0.018 | 0.922 |
| Graham & Jones, 2002 | Both | -0.680 | 0.353 | -1.372 | 0.012 |
| Hajhosseini et al., 2006 | Both | 1.360 | 0.367 | 0.641 | 2.079 |
| Hodge et al., 1993 | Female | 0.390 | 0.203 | -0.009 | 0.789 |
| Jung et al., 2008 | Female | 1.400 | 0.706 | 0.017 | 2.783 |
| Kapinos & Yakusheva, 2011 (Female) | Female | 1.230 | 0.369 | 0.506 | 1.954 |
| Kapinos & Yakusheva, 2011 (Male) | Male | 0.660 | 0.348 | -0.022 | 1.342 |
| Kapinos & Yakusheva, 2014 (Female) | Female | 0.830 | 0.322 | 0.200 | 1.460 |
| Kapinos & Yakusheva, 2014 (Male) | Male | 0.750 | 0.291 | 0.181 | 1.319 |
| Kasperek et al., 2008 | Both | 1.150 | 0.344 | 0.476 | 1.824 |
| LeCheminant et al., 2011 | Both | 0.090 | 0.043 | 0.005 | 0.175 |
| Levitsky et al., 2004 | Both | 1.900 | 0.714 | 0.501 | 3.299 |
| Levitsky et al., 2006 (Group 1) | Female | 3.100 | 0.749 | 1.633 | 4.567 |
| Levitsky et al., 2006 (Group 2) | Female | 2.000 | 0.679 | 0.670 | 3.330 |
| Lloyd-Richardson et al., 2009 Study 2 (Female) | Female | 2.500 | 0.742 | 1.045 | 3.955 |
| Lloyd-Richardson et al., 2009 Study 2 (Male) | Male | 1.600 | 0.479 | 0.661 | 2.539 |
| Mailey et al., 2012 | Female | 1.600 | 0.398 | 0.821 | 2.379 |
| Mifsud et al., 2009 (Female) | Female | -0.100 | 0.049 | -0.196 | -0.004 |
| Mifsud et al., 2009 (Male) | Male | 0.900 | 0.413 | 0.090 | 1.710 |
| Poddar et al., 2009 (Group 1) | Both | 1.440 | 0.710 | 0.048 | 2.832 |
| Poddar et al., 2009 (Group 2) | Both | 0.060 | 0.030 | 0.002 | 0.118 |
| Vella-Zarb & Elgar, 2010 | Both | 0.890 | 0.447 | 0.013 | 1.767 |
| Webb, 2012 | Female | 1.200 | 0.455 | 0.308 | 2.092 |
| Wengreen & Monocur, 2009 | Both | 1.510 | 0.579 | 0.375 | 2.645 |
| Yakusheva et al., 2011 | Female | 0.750 | 0.379 | 0.006 | 1.494 |
| Yakusheva et al., 2014 (Female) | Female | 1.090 | 0.422 | 0.262 | 1.918 |
| Yakusheva et al., 2014 (Male) | Male | 0.750 | 0.290 | 0.181 | 1.319 |
| | | 0.765 | 0.086 | 0.596 | 0.934 |

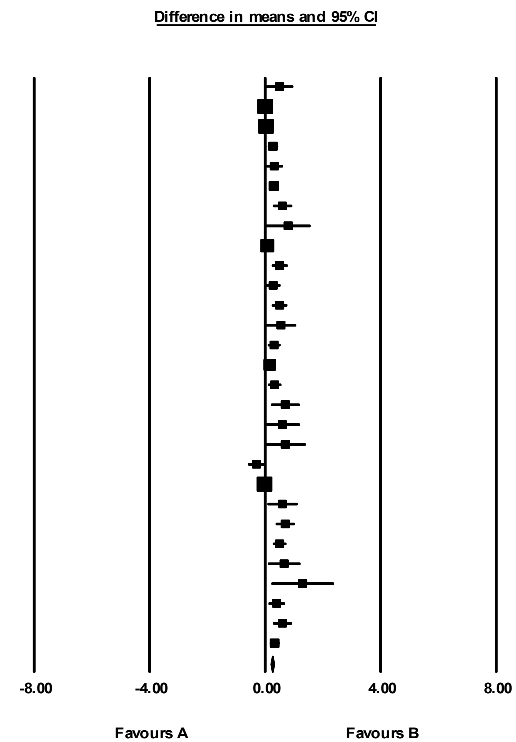



**Meta Analysis**

*Figure 11*. Forest plot of unstandardized weight change freshman year

## BMI change freshman year

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Boyce & Kuijer, 2014 | Both | 0.500 | 0.250 | 0.009 | 0.991 |
| Brock et al., 2015 (Group 1) | Both | 0.008 | 0.004 | -0.000 | 0.016 |
| Brock et al., 2015 (Group 2) | Both | 0.031 | 0.016 | -0.001 | 0.062 |
| Butler et al., 2004 | Female | 0.270 | 0.101 | 0.072 | 0.468 |
| Calitri et al., 2010 | Both | 0.320 | 0.161 | 0.004 | 0.636 |
| Deliens et al., 2013 | Both | 0.300 | 0.088 | 0.127 | 0.473 |
| Delinsky & Wilson, 2008 | Female | 0.600 | 0.179 | 0.250 | 0.950 |
| Edmonds et al., 2008 | Female | 0.800 | 0.404 | 0.008 | 1.592 |
| Finlayson et al., 2012 | Both | 0.080 | 0.042 | -0.003 | 0.163 |
| Gillen & Lefkowitz, 2011 (Group 1) | Both | 0.500 | 0.148 | 0.209 | 0.791 |
| Gow et al., 2010 | Both | 0.280 | 0.137 | 0.011 | 0.549 |
| Hajhosseini et al., 2006 | Both | 0.500 | 0.146 | 0.215 | 0.785 |
| Jung et al., 2008 | Female | 0.550 | 0.277 | 0.007 | 1.093 |
| Kapinos & Yakusheva, 2014 (Female) | Female | 0.310 | 0.120 | 0.075 | 0.545 |
| Kapinos & Yakusheva, 2014 (Male) | Male | 0.160 | 0.062 | 0.039 | 0.281 |
| Kasperek et al., 2008 | Both | 0.330 | 0.127 | 0.081 | 0.579 |
| Levitsky et al., 2004 | Both | 0.700 | 0.263 | 0.185 | 1.215 |
| Lloyd-Richardson et al., 2009 Study 2 (Female) | Female | 0.600 | 0.317 | -0.022 | 1.222 |
| Lloyd-Richardson et al., 2009 Study 2 (Male) | Male | 0.700 | 0.369 | -0.023 | 1.423 |
| Meisel et al., 2015 | Both | -0.300 | 0.159 | -0.611 | 0.011 |
| Middleton & Perri, 2014 | Female | -0.020 | 0.010 | -0.040 | 0.000 |
| Mifsud et al., 2009 (Male) | Male | 0.600 | 0.275 | 0.060 | 1.140 |
| Provencher et al., 2009 (Female) | Female | 0.700 | 0.179 | 0.348 | 1.052 |
| Provencher et al., 2009 (Male) | Male | 0.500 | 0.128 | 0.249 | 0.751 |
| Timko et al., 2010 (Female) | Female | 0.660 | 0.296 | 0.079 | 1.241 |
| Timko et al., 2010 (Male) | Male | 1.300 | 0.562 | 0.199 | 2.401 |
| Webb, 2012 | Female | 0.400 | 0.152 | 0.103 | 0.697 |
| Wengreen & Monocur, 2009 (Female) | Female | 0.600 | 0.177 | 0.253 | 0.947 |
| Wengreen & Monocur, 2009 (Male) | Male | 0.330 | 0.095 | 0.144 | 0.516 |
| | | 0.220 | 0.027 | 0.168 | 0.273 |

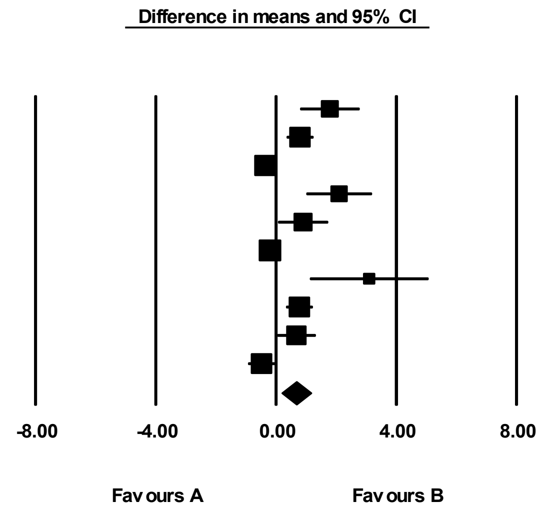



**Meta Analysis**

*Figure 12.* Forest plot of unstandardized BMI change freshman year

## Percent fat mass change freshman year

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| | | Statistics for each study | | | |
| Butler et al., 2004 | Female | 1.790 | 0.514 | 0.783 | 2.797 |
| Deliens et al., 2013 | Both | 0.800 | 0.236 | 0.338 | 1.262 |
| Graham & Jones, 2002 | Both | -0.360 | 0.179 | -0.711 | -0.009 |
| Hajhosseini et al., 2006 | Both | 2.100 | 0.567 | 0.990 | 3.210 |
| LeCheminant et al., 2011 | Both | 0.900 | 0.433 | 0.050 | 1.750 |
| Mfsud et al., 2009 (Female) | Female | -0.200 | 0.098 | -0.393 | -0.007 |
| Mfsud et al., 2009 (Male) | Male | 3.100 | 1.015 | 1.111 | 5.089 |
| Morgan et al., (2012) | Both | 0.780 | 0.236 | 0.318 | 1.242 |
| Poddar et al., 2009 (Group 1) | Both | 0.680 | 0.335 | 0.023 | 1.337 |
| Poddar et al., 2009 (Group 2) | Both | -0.480 | 0.237 | -0.945 | -0.015 |
| | | 0.649 | 0.244 | 0.170 | 1.128 |

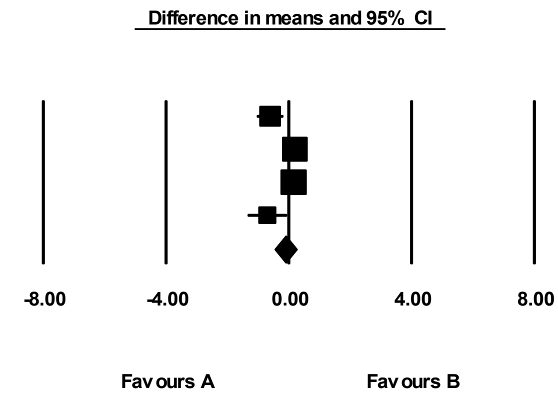



**Meta Analysis**

*Figure 13*. Forest plot of unstandardized percent body fat change freshman year

## Fat-free mass change freshman year

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Butler et al., 2004 | Female | -0.610 | 0.228 | -1.057 | -0.163 |
| Deliens et al., 2013 | Both | 0.200 | 0.105 | -0.006 | 0.406 |
| Finlayson et al., 2012 | Both | 0.160 | 0.084 | -0.005 | 0.325 |
| Mifsud et al., 2009 (Male) | Male | -0.700 | 0.337 | -1.361 | -0.039 |
| | | -0.129 | 0.178 | -0.477 | 0.219 |



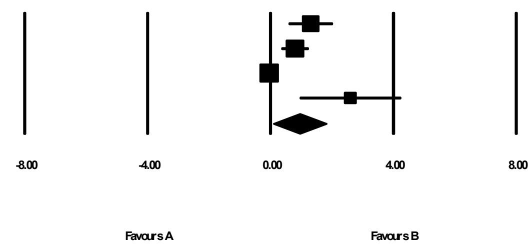

**Meta Analysis**

*Figure 14.* Forest plot of unstandardized fat-free mass change freshman year

# Absolute fat mass change freshman year

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit | QualityRatings | Year |
|---|---|---|---|---|---|---|---|
| Butler et al., 2004 | Female | 1.310 | 0.376 | 0.573 | 2.047 | 4 | 2004 |
| Deliens et al., 2013 | Both | 0.800 | 0.236 | 0.338 | 1.262 | 4 | 2013 |
| Finlayson et al., 2012 | Both | -0.040 | 0.021 | -0.081 | 0.001 | 4 | 2012 |
| Mifsud et al., 2009 (Male) | Male | 2.600 | 0.851 | 0.932 | 4.268 | 4 | 2009 |
| | | 0.924 | 0.437 | 0.068 | 1.781 | | |

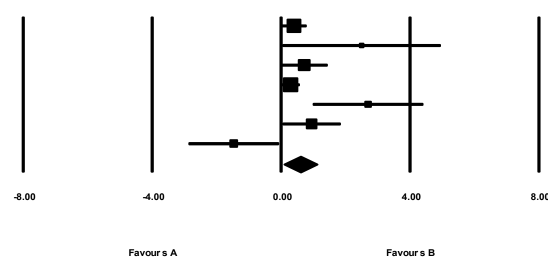
Difference in means and 95% CI




# Waist circumference change freshman year

| Subgroup within study | Difference in means | Standard error | Variance | Lower limit | Upper limit | Z-Value | p-Value | QualityRating | Study |
|---|---|---|---|---|---|---|---|---|---|
| Both | 0.400 | 0.210 | 0.044 | -0.012 | 0.812 | 1.902 | 0.057 | 4 | Deliens et al., 2013 |
| Female | 2.500 | 1.262 | 1.593 | 0.026 | 4.974 | 1.981 | 0.048 | 6 | Edmonds et al., 2008 |
| Both | 0.720 | 0.379 | 0.144 | -0.023 | 1.463 | 1.899 | 0.058 | 4 | Finlayson et al., 2012 |
| Female | 0.300 | 0.147 | 0.022 | 0.011 | 0.589 | 2.034 | 0.042 | 4 | Mifsud et al., 2009 (Female) |
| Male | 2.700 | 0.884 | 0.781 | 0.968 | 4.432 | 3.055 | 0.002 | 4 | Mifsud et al., 2009 (Male) |
| Both | 0.950 | 0.468 | 0.219 | 0.032 | 1.868 | 2.028 | 0.043 | 4 | Poddar et al., 2009 (Group 1) |
| Both | -1.470 | 0.726 | 0.527 | -2.893 | -0.047 | -2.024 | 0.043 | 4 | Poddar et al., 2009 (Group 2) |
| | 0.576 | 0.261 | 0.068 | 0.065 | 1.087 | 2.210 | 0.027 | | |

Difference in means and 95% CI




**Meta Analysis**

*Figure 16*. Forest plot of unstandardized waist circumference change freshman year

**Subgroup Analysis by Study Length –Freshman Year**

**Weight.** For freshman year, studies ranged from 10 weeks to eight months. The study duration was evaluated for the potential impact on body composition changes. Length of study was stratified by ten weeks to four months, which represents a semester, and five to eight months, until the end of the freshman year. For studies four months or less, the average weight gain was higher (1.44 kg, CI: 0.73-2.15) than those examining changes five months to eight months (0.64 kg, CI: 0.46-0.82). Comparison analyses found a significant difference between studies of shorter versus longer duration (Hedge's $g = 0.20$, $z = 8.03$, $p < 0.001$).

**BMI.** We found that studies examining BMI change that collected follow-up data at four or less months had a mean change of 0.33 $kg{\cdot}m^{-2}$ (CI: 0.05-0.62, $I^2 = 91.4\%$). Studies collecting follow-up data for BMI change at five to eight months had a mean change of 0.25 $kg{\cdot}m^2$ (CI: 0.16-0.33, $I^2 = 87.2\%$). A statistically significant difference was found for study duration (Hedge's $g = 019$, $z = 6.879$, $p < 0.001$).

**Percent body fat.** Only one study examining percent body fat change with a follow-up of four months of less was available. The mean increase was 2.1% (CI: 0.99-3.21, $I^2$ = NA). Therefore, a comparison analysis was not available. Six studies examined percent body fat change with a follow-up of five to eight months and had a mean increase of 0.33% (CI: -0.14-0.80, $I^2 = 87.2\%$).

**Fat-free mass.** Three studies that evaluated fat-free mass collected follow-up information between five to eight months. A pooled mean change of -0.33 kg (CI: -0.99-0.34, $I^2 = 86.7\%$) was observed. A comparison analysis to shorter follow-up studies was not possible due to the limited available studies.

**Absolute fat mass.** For follow-up of absolute fat mass data collected during freshman year, three studies had duration of five to eight months. Of these, we observed a mean change of 1.20 kg (CI: 0.51-1.90, $I^2$ =53.3%). Comparison analysis to other studies was not available.

**Waist circumference.** Four studies examining waist circumference change had a follow-up period of five to eight months. We observed a mean change of 0.38 in (CI: -0.13-0.89, $I^2$ = 62.1%) in these studies. There were no available studies evaluating waist circumference change that had duration of four or less months, so a comparison analysis was not conducted.

**Subgroup Analysis of Studies Freshman Versus Four Years**

**Weight.** A comparison analysis was conducted in studies occurring over freshman year to studies examining weight change over all four years. A statistically significant (Hedge's $g = 0.17$, $z = 8.59$, $p < 0.001$) difference was found for studies (n = 27) over freshman year (0.75 kg, CI: 0.58-0.93) and over four years (n = 6; 0.90 kg, CI: 0.49-1.32).

**BMI.** A significant (Hedge's $g = 0.15$, $z = 6.33$, $p < 0.001$) difference was found for studies conducted only freshman year (0.21 $kg{\cdot}m^2$, CI: 0.16-0.27) and studies conducted over the course of college (0.24 $kg{\cdot}m^2$, CI: -0.03-0.50).

**Percent body fat.** Studies conducted over four years (1.0%, CI: 0.38-1.62) reported significantly (Hedge's $g = 0.18$, $z = 5.34$, $p < 0.001$) different percent body fat change than those over only freshman year (0.64%, CI: 0.12-1.15).

**Fat-free mass.** Only two studies were available for reported fat-free mass over four years. A subgroup analysis of studies revealed a non-significant (Hedge's $g = 0.00$,

$z = 0.03$, $p = 0.97$) difference between studies occurring over freshman year (-0.13 kg, CI: -0.48-0.22) and four years (0.28 kg, CI: -0.39-0.94).

**Subgroup Analysis by Gender –Freshman Year**

**Weight.** From the 55 studies included in the meta-analysis, twelve studies were conducted only with females while none of the studies were conducted only with males. Twenty-four studies stratified reported weight change by gender. Females and males were evaluated separately for mean weight change. Nineteen studies examining females found a gain of 1.31 kg (CI: 0.86-1.76, $I^2 = 87.7\%$) and ten studies with males found a weight gain of 1.47 kg (CI: 0.90-2.05, $I^2 = 63.9\%$). A significant difference was found between genders for weight gain (Hedge's $g = 0.18$, $z = 9.06$, $p < 0.001$).

**BMI.** Eleven studies were available to examine BMI change in females whereas six studies had data for males. A statistically significant difference was found for genders and BMI change (Hedge's $g = 0.17$, $z = 5.69$, $p < 0.001$). Females had a mean BMI change of 0.45 kg·m$^2$ (CI: 0.23-0.67, $I^2 = 87.3\%$), whereas males had a BMI change of 0.39 kg·m$^2$ (CI: 0.20-0.59, $I^2 = 61.3\%$).

**Subgroup Analysis by Location –Freshman Year**

**Weight.** Weight change in freshman year was further analyzed by location of the study. Nineteen studies were conducted in the United States, four studies in Canada, and one study each in the United Kingdom, New Zealand, and Belgium. Due to the small sample of studies, inference cannot be made for the United Kingdom, New Zealand, and Belgium. However, in these studies, the United Kingdom (0.23 kg, CI: -0.01-0.47) had an observed lower weight change than the United States, whereas Belgium had a slightly higher weight change (1.00 kg, CI: 0.42-1.58). Studies from the United States (0.86, CI:

0.64-1.09, $I^2 = 87.2\%$) and Canada (0.81 kg, CI: -0.17-1.80, $I^2 = 77.2\%$) significantly differed ($z = 8.02$, $p < 0.001$, Hedge's $g = 0.21$). Studies from North America (0.86 kg, CI: 0.65-1.08) to studies from other continents (0.67 kg, CI: 0.03-1.32) significantly differed ($z = 8.90$, $p < 0.001$, Hedge's $g = 0.22$).

**BMI.** A total of 14 studies from the United States, with a pooled estimate of 0.17 kg·m$^2$ (CI: 0.11-0.23), 3 studies from the United Kingdom (0.04 kg·m$^2$, CI: -0.23-0.31), 4 studies from Canada (0.58 kg·m$^2$, CI: 0.40-0.76), and one study each from Belgium (0.30 kg·m$^2$, CI: 0.13-0.47) and New Zealand (0.50 kg·m$^2$, CI: 0.01-1.00), examined BMI change over freshman year. We found a significant difference between studies from the United States and Canada ($z = 8.03$, $p < 0.001$, Hedge's $g = 0.19$). A significant difference between reported BMI in studies from North America (0.22 kg·m$^2$, CI: 0.17-0.28) and studies from other continents (0.16 kg·m$^2$, CI: -0.04-0.35) was also found ($z = 7.09$, $p < 0.001$, Hedge's $g = 0.21$).

**Percent body fat.** For percent body fat change freshman year, six studies came from the United States, with a pooled mean of 0.67% (CI: 0.02-1.32), one study from Canada (-0.17%, CI: -0.37-0.03), and one from Belgium (0.80%, CI: 0.34-1.26). Because of the available studies with necessary data provided, subgroup analyses by location were not possible.

**Fat-free mass.** One study each from the United States (-0.61 kg, CI: -1.06- -0.16), the United Kingdom (0.16 kg, CI: -0.01-0.33), Canada (-0.70 kg, CI: -1.40-0.00), and Belgium (0.20 kg, CI: -0.01-0.41) examined fat-free mass change. A subgroup analysis examining studies from North America (-0.64 kg, CI: -1.01- -0.27) and Europe

(0.17 kg, CI: 0.05-0.31) did not reveal a significant ($p > 0.15$) difference in reported fat-free mass change.

**Absolute fat mass.** The United States (1.31 kg, CI: 0.57-2.05), the United Kingdom (-0.04 kg, CI: -0.08-0.00), Canada (2.6 kg, CI: 0.76-4.44), and Belgium (0.80 kg, CI: 0.34-1.26) each had one study evaluating absolute fat mass change. A significant difference ($p < 0.05$) in absolute fat mass change was found between studies from North America (1.73 kg, CI: 0.55-2.91) and Europe (0.35 kg, CI: (-0.47-1.17) with an effect of Hedge's $g = 0.44$.

**Waist circumference.** For waist circumference change, two studies came from the United States, with a pooled mean of -0.19 in (CI: -2.56-2.17), two studies from Canada (1.06 in, CI: -0.91-3.04), and one each from the United Kingdom (0.72 in, CI: -0.02-1.46) and Belgium (0.40 in, CI: -0.01-0.81). A non-significant difference was found for studies in the United States (-0.20 in, CI: -2.57-2.17) and Canada (1.62 in, CI: -0.28-3.52). A comparison between studies in North America (0.75 in, CI: -0.28-1.80) and Europe (0.48 in, CI: 0.12-0.84) revealed a significant difference in reported waist circumference change (Hedge's $g = 0.19$, $p < 0.05$).

**Subgroup Analysis by Measurement Method –Freshman Year**

**Weight.** In freshman year, measurement method based on self-report and objective measurement was further analyzed. For weight gain, 5 studies used self-report and 19 studies used objective measures to collect data. The self-report studies had a pooled mean of 0.96 kg (CI: 0.67-1.24), whereas the objective studies had a pooled mean of 0.55 kg (CI: 0.36-0.73). A statistically significant difference between the two methods and weight change was found ($z = 9.13$, $p < 0.001$, Hedge's $g = 0.17$).

**BMI.** For BMI change freshman year, 8 studies used self-report, with a pooled mean of 0.23 kg·m$^2$ (CI: 0.14-0.32), and 14 studies, with a pooled mean of 0.28 kg·m$^2$ (CI: 0.16-0.41), used objective measures to examine changes. This revealed a statistically significant difference ($z = 6.75$, $p < 0.001$, Hedge's $g = 0.19$).

**Subgroup Analysis by Study Retention Rate –Freshman Year**

Analyses were conducted to evaluate whether weight and body composition changes differed in studies of high (> 80%) or low (≤ 20%) retention rate.

**Weight.** For those examining weight change and reported the necessary information, 11 studies had high retention rate while 14 studies had low retention. Studies of high retention had significantly higher reported weight gain (1.19 kg, CI: 0.63-1.75) than studies of low retention (0.52 kg, CI: 0.32-0.71; $z = 7.47$, $p < 0.001$, Hedge's $g = 0.22$).

**BMI.** Over freshman year studying changes in BMI, 10 studies had high retention and 13 studies had low retention rate of its sample. In BMI change, there was significant difference (Hedge's $g = 0.18$, $z = 6.51$, $p < 0.001$) between studies of high retention (0.41 kg·m$^2$, CI: 0.19-0.62) and low retention (0.19 kg·m$^2$, CI: 0.12-0.27).

**Percent body fat.** For studies measuring percent body fat change in freshman year and that reported retention rates, two studies had high retention while four had low retention rates. A non-significant difference was found between these studies ($z = 1.24$, $p > 0.21$).

**Fat-free mass.** In those studies measuring fat-free mass, two had high retention rates and two had low retention rates in their sample. A non-significant difference was found between the rates of retention and fat-free mass ($z = 1.41$, $p > 0.15$).

**Absolute fat mass.** Two studies each for high and low retention rates were observed for studies measuring absolute fat mass change over freshman year. A non-significant difference was found between these studies ($z = -1.32$, $p > 0.18$).

**Waist circumference.** For studies examining waist circumference change, two had high retention rates in their sample and three had low rates of retention. A significant difference was found in that high retention studies (1.62 in, CI: -0.28-3.52) had reported greater waist circumference change than studies with low retention rates (0.35 in, CI: -0.33-1.02; $z = 3.757$, $p < 0.001$).

**Subgroup analysis by Quality of Study –Freshman Year**

Overall, the quality of the studies included in the meta-analysis for freshman year of college was adequate with approximately 67% considered medium to high. Specifically, seven studies met criteria for high quality (6-7 points), 30 studies of medium quality (4-5 points), and 18 studies of low quality (3 or less points).

**Weight.** Study quality ratings were examined to determine whether it affected the reported weight change. The meta-regression showed that quality scores of the studies did not significantly differ in reported weight change ($z = 0.28$, $p > 0.78$).

**BMI.** A non-significant difference was found for the quality rating of studies and reported BMI change during freshman year of college ($z = -0.27$, $p > 0.79$).

**Percent body fat.** For percent body fat change, a non-significant difference was found for studies of different quality ratings ($z = -0.97$, $p > 0.33$).

**Waist circumference.** A non-significant difference was found for waist circumference change and study quality ratings ($z = 1.46$, $p > 0.14$).

**Subgroup Analysis of Year of Publication**

**Weight.** A meta-regression was conducted to determine whether year of publication for studies examining weight change over freshman year affected the reported weight change. The results indicated a non-significant effect of publication year ($z$ = 0.97, $p$ = 0.33). For studies reporting weight change over four years of college, a non-significant effect ($z$ = -1.41, $p$ = 0.16) was also found.

**BMI.** In studies examining BMI change over freshman year, the meta-regression analysis indicated a significant ($z$ = -6.53, $p$ < 0.001) difference across publication dates, with earlier studies reporting slightly higher BMI change. For studies occurring over four years, a non-significant ($z$ = -1.78, $p$ > 0.75) difference was found.

**Percent body fat.** A non-significant ($z$ = 0.24, $p$ > 0.80) difference was found for studies examining percent body fat freshman year and the year of publishing. Because only three studies were available for percent body fat over college, a meta-regression of publication year could not be conducted.

**Fat-free mass.** For studies evaluating fat-free mass change over freshman year, a significant ($z$ = 3.46, $p$ < 0.001) difference was found for study year of publication, with earlier studies reporting greater decreases in fat-free mass. Due to limited studies being available, a meta-regression for studies examining fat-free mass over four years was not possible.

**Absolute fat mass.** Absolute fat mass change over freshman year was not significantly affected by publication year of the study ($z$ = -1.03, $p$ > 0.30). Only one study was available for absolute fat mass over the course of college so a meta-regression could not be conducted.

**Mean Weight Change Over Four Years**

To be included in the meta-analysis over four years of college, studies must have reported the mean weight change from the beginning of freshman year to the end of senior year of college, sample size, and the *p*-value of the weight change. From this information, the CMA software is able to calculate the effect size. Of the 12 studies examining body composition changes over four years, only six studies reported the necessary data to include in the weight change analysis. Due to the high heterogeneity observed in this sample, a random effects model was used ($Q$ statistic = 190.33, $I^2$ = 90.5%). A final sample of 9,565 students comprised this analysis, with a statistically significant weight gain of 0.90 kg (CI: 0.49-1.32); ($p < 0.001$). The results indicate a small effect size (Hedge's $g = 0.09$, $z = 2.75$, $p < 0.05$). With Kawada and colleagues (2015) removed, a mean difference of 2.13 kg (CI: 1.02-3.25, $Q = 16.70$, $I^2 = 76.1\%$, $p < 0.001$; Hedge's $g = 0.17$, $z = 3.88$, $p < 0.01$) was found – more than doubling the observed change.

**Mean BMI Change Over Four Years**

Six studies evaluated BMI change over the course of attending college. A statistically significant increase of 0.26 kg·m$^2$ (CI: 0.01-0.52, $I^2 = 89.1\%$, $p < 0.05$) was observed in a sample of 6,110 students. Hedge's $g = 0.06$ ($z = 1.50$, $p = 0.13$), indicating a non-significant small effect size. Not including Kawada and colleagues (2015), a significant mean BMI change of 0.48 kg·m$^2$ (CI: 0.16-0.80, $I^2 = 81.7\%$, $p < 0.001$) was found with a Hedge's $g$ of 0.16 ($z$ =3.45, $p < 0.001$).

**Mean Percent Body Fat Over Four Years**

Over the four years of college, three studies examined mean percent body fat change. In a sample of 847 students, we found a statistically significant increase of 1.69% (CI: 0.46-2.92, $I^2 = 74.7\%$, $p < 0.05$), with a Hedge's *g* of 0.19 ($z = 4.49$, $p < 0.001$).

**Mean Fat-Free Mass Over Four Years**

For fat-free mass change in four years, two studies reported the necessary data. We observed a non-significant change of -0.09 kg (CI: -0.76-0.59, $I^2 = 92.6\%$, $p = 0.79$) and a Hedge's *g* of 0.03 ($z = 0.19$, $p = 0.85$).

**Mean Absolute Fat Mass Over Four Years**

Only one study examined absolute fat mass change over the course of college. This study had a mean change of 3.20 kg (CI: 1.34-5.06, $I^2$ = NA) with a medium effect size (Hedge's $g = 0.29$, $z = 3.30$, $p < 0.001$).

**Subgroup Analysis by Gender –Four Years**

**Weight.** Six studies were available to examine differences between males and females and reported weight change over four years. A significant difference (Hedge's $g = 0.12$, $z = 3.75$, $p < 0.001$) was found between females (0.89 kg, CI: 0.26-1.51) and males (1.00 kg, CI: 0.47-1.52). Without Kawada and colleagues (2015) a significant difference (Hedge's $g = 0.20$, $z = 5.17$, $p < 0.001$) was found between females (1.42 kg, CI: 0.69-2.14) and males (2.89 kg, CI: 0.78-4.99).

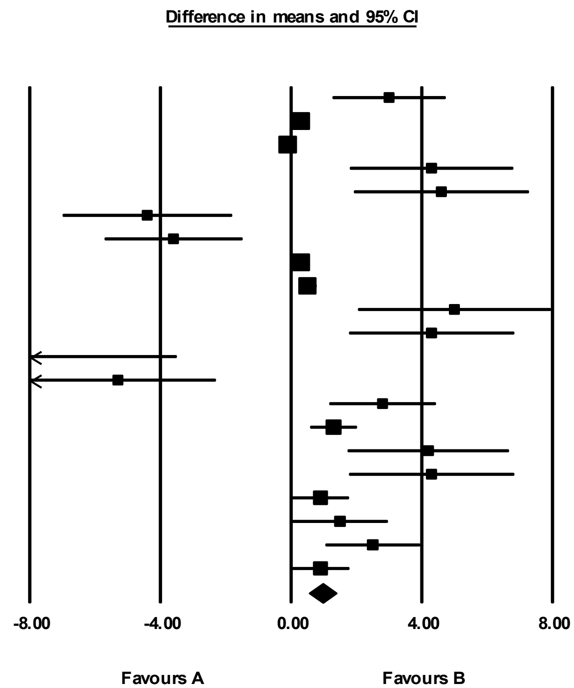
**BMI.** Over four years of college, five studies reported the necessary data for BMI change. A small significant (Hedge's $g = 0.08$, $z = 1.99$, $p < 0.05$) difference was found between females (0.21 kg·m$^2$, CI: -0.21-0.63) and males (0.40 kg·m$^2$, CI: -0.12-0.92). A significant mean difference (Hedge's $g = 0.49$, $z = 5.70$, $p < 0.001$) was found without Kawada and colleagues (2015) between females (0.47 kg·m$^2$, CI: 0.30-0.64) and males (0.99 kg·m$^2$, CI: 0.13-1.85).

**Percent body fat.** Only two studies separating gender were available for percent body fat subgroup analysis. Although it is difficult to infer patterns due to the limited number of studies, a significant effect was found (Hedge's $g = 0.26$, $z = 5.37$, $p < 0.001$) between females (1.71%, CI: -0.33-3.76) and males (2.75%, CI: -1.54-7.03).

**Fat-free mass.** For fat-free mass change over four years, only two studies reported the necessary data for analysis. A significant (Hedge's $g = 0.25$, $z = 2.46$, $p < 0.05$) difference was found for females (-0.24 kg, CI: -1.12-0.64) and males (0.81 kg, CI: 0.05-1.58), though the few number of studies available limits inferences.

# Weight change four years

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Gropper et al., 2012 | Both | 3.000 | 0.891 | 1.254 | 4.746 |
| Kawada et al., 2015, Group 1 (Male) | Male | 0.300 | 0.090 | 0.123 | 0.477 |
| Kawada et al., 2015, Group 1 (Female) | Female | -0.100 | 0.053 | -0.204 | 0.004 |
| Kawada et al., 2015, Group 2 (Male) | Male | 4.300 | 1.284 | 1.783 | 6.817 |
| Kawada et al., 2015, Group 2 (Female) | Female | 4.600 | 1.373 | 1.909 | 7.291 |
| Kawada et al., 2015, Group 3 (Male) | Male | -4.400 | 1.333 | -7.012 | -1.788 |
| Kawada et al., 2015, Group 3 (Female) | Female | -3.600 | 1.086 | -5.728 | -1.472 |
| Kawada et al., 2015, Group 4 (Male) | Male | 0.300 | 0.091 | 0.122 | 0.478 |
| Kawada et al., 2015, Group 4 (Female) | Female | 0.500 | 0.151 | 0.203 | 0.797 |
| Kawada et al., 2015, Group 5 (Male) | Male | 5.000 | 1.514 | 2.033 | 7.967 |
| Kawada et al., 2015, Group 5 (Female) | Female | 4.300 | 1.298 | 1.755 | 6.845 |
| Kawada et al., 2015, Group 6 (Male) | Male | -8.500 | 2.557 | -13.511 | -3.489 |
| Kawada et al., 2015, Group 6 (Female) | Female | -5.300 | 1.537 | -8.312 | -2.288 |
| Kawada et al., 2015, Group 7 (Male) | Male | 2.800 | 0.840 | 1.154 | 4.446 |
| Kawada et al., 2015, Group 7 (Female) | Female | 1.300 | 0.373 | 0.569 | 2.031 |
| Lloyd-Richardson et al., 2009, Study 1 (Female) | Female | 4.200 | 1.267 | 1.716 | 6.684 |
| Lloyd-Richardson et al., 2009, Study 1 (Male) | Male | 4.300 | 1.299 | 1.754 | 6.846 |
| Meckel et al., 2011 (Female) | Female | 0.900 | 0.453 | 0.012 | 1.788 |
| Meckel et al., 2011 (Male) | Male | 1.500 | 0.754 | 0.022 | 2.978 |
| Racette et al., 2008 | Both | 2.500 | 0.749 | 1.033 | 3.967 |
| Yamane et al., 2014 | Both | 0.900 | 0.459 | 0.001 | 1.799 |
| | | 0.938 | 0.207 | 0.533 | 1.343 |



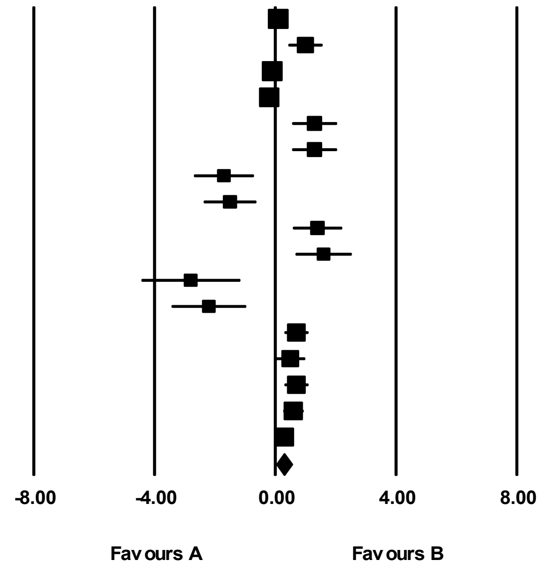

**Meta Analysis**

*Figure 17*. Forest plot of unstandardized weight change over four years

## BMI change four years

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Ekuni et al. | Both | 0.100 | 0.053 | -0.004 | 0.204 |
| Gropper et al., 2012 | Both | 1.000 | 0.297 | 0.418 | 1.582 |
| Kawada et al., 2015, Group 1 (Male) | Male | -0.100 | 0.053 | -0.204 | 0.004 |
| Kawada et al., 2015, Group 1 (Female) | Female | -0.200 | 0.106 | -0.407 | 0.007 |
| Kawada et al., 2015, Group 2 (Male) | Male | 1.300 | 0.388 | 0.539 | 2.061 |
| Kawada et al., 2015, Group 2 (Female) | Female | 1.300 | 0.388 | 0.540 | 2.060 |
| Kawada et al., 2015, Group 3 (Male) | Male | -1.700 | 0.515 | -2.709 | -0.691 |
| Kawada et al., 2015, Group 3 (Female) | Female | -1.500 | 0.452 | -2.386 | -0.614 |
| Kawada et al., 2015, Group 5 (Male) | Male | 1.400 | 0.424 | 0.569 | 2.231 |
| Kawada et al., 2015, Group 5 (Female) | Female | 1.600 | 0.483 | 0.653 | 2.547 |
| Kawada et al., 2015, Group 6 (Male) | Male | -2.800 | 0.842 | -4.451 | -1.149 |
| Kawada et al., 2015, Group 6 (Female) | Female | -2.200 | 0.638 | -3.450 | -0.950 |
| Kawada et al., 2015, Group 7 (Male) | Male | 0.700 | 0.210 | 0.289 | 1.111 |
| Kawada et al., 2015, Group 7 (Female) | Female | 0.500 | 0.260 | -0.010 | 1.010 |
| Racette et al., 2008 | Both | 0.700 | 0.210 | 0.289 | 1.111 |
| Racette et al., 2010 | Both | 0.600 | 0.180 | 0.246 | 0.954 |
| Yamane et al., 2014 | Both | 0.300 | 0.153 | 0.000 | 0.600 |
| | | 0.264 | 0.128 | 0.012 | 0.516 |

Difference in means and 95% CI



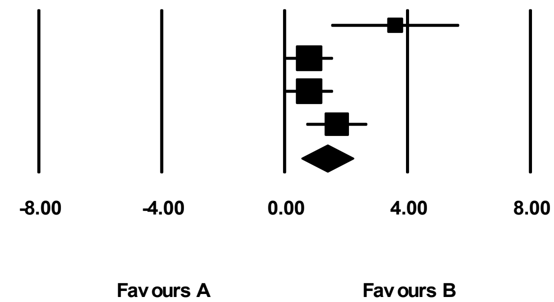

**Meta Analysis**

*Figure 18*. Forest plot of unstandardized BMI change over four years

## Percent fat mass change four years

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Gropper et al., 2012 | Both | 3.600 | 1.069 | 1.504 | 5.696 |
| Meckel et al., 2011 (Female) | Female | 0.800 | 0.403 | 0.011 | 1.589 |
| Meckel et al., 2011 (Male) | Male | 0.800 | 0.402 | 0.012 | 1.588 |
| Morgan et al., (2012) | Both | 1.700 | 0.514 | 0.693 | 2.707 |
| | | 1.361 | 0.425 | 0.528 | 2.195 |

Difference in means and 95% CI




**Meta Analysis**

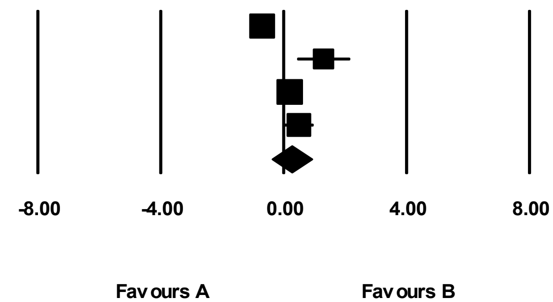
*Figure 19.* Forest plot of unstandardized percent body fat change over four years

## Fat-free mass change four years

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Gropper et al., 2012 (Female) | Female | -0.700 | 0.172 | -1.037 | -0.363 |
| Gropper et al., 2012 (Male) | Male | 1.300 | 0.449 | 0.421 | 2.179 |
| Meckel et al., 2011 (Female) | Female | 0.200 | 0.105 | -0.006 | 0.406 |
| Meckel et al., 2011 (Male) | Male | 0.500 | 0.251 | 0.007 | 0.993 |
| | | 0.239 | 0.329 | -0.406 | 0.884 |

Statistics for each study

Difference in means and 95% CI




**Meta Analysis**

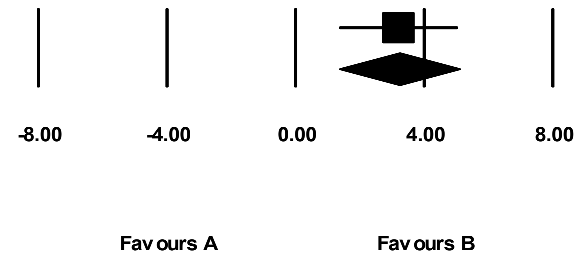
*Figure 20.* Forest plot of unstandardized fat-free mass change over four years

## Absolute fat mass change four years

| Study name | Subgroup within study | Difference in means | Standard error | Lower limit | Upper limit |
|---|---|---|---|---|---|
| Gropper et al., 2012 | Both | 3.200 | 0.950 | 1.337 | 5.063 |
| | | 3.200 | 0.950 | 1.337 | 5.063 |

Statistics for each study

Difference in means and 95% CI




**Meta Analysis**

*Figure 21.* Forest plot of unstandardized absolute fat mass change over four years

**Subgroup Analysis by Location –Four Years**

**Weight.** Three studies from the United States measuring weight change over four years had a pooled mean of 3.16 kg (CI: 2.15-4.17). Two studies were from Asia, with a pooled mean of 0.99 kg (CI: 0.41-1.57). A comparison analysis of studies from the United States to studies from Asia revealed a significant difference in reported weight change over four years of college (Hedge's $g = 0.21$, $z = 4.65$, $p < 0.001$).

**BMI.** Studies in the United States measuring BMI change had a pooled mean of 0.71 kg·m$^2$ (CI: 0.46-0.95). A pooled mean for studies in Japan indicated a 0.14 kg·m$^2$ (CI: -0.13-0.41) change in BMI. A statistically significant difference (Hedge's $g = 0.13$, $z = 4.47$, $p < 0.001$) was found between studies reporting BMI change in the United States (0.71 kg·m$^2$, CI: 0.46-0.95) and Japan (0.14 kg·m$^2$, CI: -0.13-0.41).
Without Kawada and colleagues (2015), a significant ($p < 0.001$) mean change of 0.15 kg·m$^2$ (CI: -0.02-0.32) was found with a small Hedge's $g = 0.11$ ($z = 5.15$, $p < 0.001$) comparing BMI change in the United States and Japan.

**Percent body fat.** The two studies from the United States examining percent body fat change had a pooled mean of 2.42% (CI: 0.61-4.23) whereas the study from Israel had a mean change of 0.80% (CI: 0.24-1.36). Although no strong inferences could be made based on the available studies, a significant difference (Hedge's $g = 0.20$, $z = 3.89$, $p < 0.01$) was found in studies from the United States and Israel, with a pooled mean of 2.42% (CI: 0.85-4.23).

**Subgroup Analysis by Study Retention Rate –Four Years**

**Weight.** For studies examining weight change over four years, with the necessary reported data, three studies had high retention rate (> 80%) whereas three had low (≤

20%) retention rates in their sample. A statistically significant difference was found in that studies with high retention reporting lower weight gain (0.57 kg, CI: 0.17-0.98) than studies with low retention (3.16 kg, CI: 2.15-4.17; Hedge's $g = 0.13$, $z = 4.77$, $p < 0.001$). Without Kawada and colleagues (2015), a statistically significant difference ($p < 0.01$) was found between studies of high retention (0.99 kg, CI: 0.41-1.57; Hedge's $g = 0.18$, $z = 5.21$, $p < 0.001$).

**BMI.** A significant difference (Hedge's $g = 0.13$, $z = 4.47$, $p < 0.001$) was found between the three studies with high retention rate (0.14 kg·m$^2$, CI: -0.13-0.41) versus the three studies with low retention (0.71 kg·m$^2$, CI: 0.46-0.95) for BMI change. A significant difference (Hedge's $g = 0.11$, $z = 5.15$, $p < 0.001$) was also found without Kawada and colleagues (2015) in studies with high retention (0.15 kg·m$^2$, CI: -0.02-0.32) and with low retention.

**Percent body fat.** Only one study for high and two studies for low retention were available for analysis. Although no inferences can be made, the study with high retention (0.80%, CI: 0.24-1.36) had significantly lower (Hedge's $g = 0.20$, $z = 3.89$, $p < 0.001$) reported percent body fat over the studies with low retention rates (2.42%, CI: 0.61-4.23).

Table 2
*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Mean weight change | Weighted on sample | 27 | 6,389 | 0.74 kg (CI: 0.56-0.92) | 201.89 | $P < 0.001$ | 86.6% |
| Subgroup analysis | By location | 19 | 5,856 | USA: 0.86 kg (CI: 0.64-1.09) | 138.996 | $P < 0.001$ | 87.2% |
| | | 1 | 120 | UK: 0.23 kg (CI: -0.01-0.47) | 0.00 | NA | NA |
| | | 4 | 330 | Canada: 0.81 kg (CI: -0.17-1.80) | 13.185 | $P < 0.01$ | 77.2% |
| | | 1 | 101 | Belgium: 1.00 kg (CI: 0.42-1.58) | 0.00 | NA | NA |
| | | 1 | 54 | New Zealand: 1.1 kg (CI: 0.00-0.50) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 5 | 4,652 | Self-report: 0.96 kg (CI: 0.67-1.24) | 5.06 | $P > 0.05$ | 21.0% |
| | | 19 | 1,473 | Measured: 0.55 kg (CI: 0.36-0.73) | 124.98 | $P < 0.001$ | 84.0% |
| Subgroup analysis | By study length | 5 | 234 | ≤ 4 mths: 1.44 kg (CI: 0.73-2.15) | 17.94 | $P < 0.05$ | 72.1% |
| | | 22 | 7,142 | 5-8 mths: 0.64 kg (CI: 0.46-0.82) | 157.86 | $P < 0.001$ | 86.1% |

Table 2

*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By gender | 19 | 4,083 | Females: 1.31 kg (CI: 0.86-1.76) | 146.34 | $P < 0.001$ | 87.7% |
| | | 10 | 2,736 | Males: 1.47 kg (CI: 0.90-.05) | 24.91 | $P < 0.05$ | 63.9% |
| Mean BMI change | Weighted on sample | 23 | 7,033 | 0.21 kg·m$^2$ (CI: 0.16-0.27) | 186.71 | $P < 0.001$ | 87.7% |
| Subgroup analysis | By location | 14 | 3,653 | USA: 0.17 kg·m$^2$ (CI: 0.11-0.23) | 118.27 | $P < 0.001$ | 88.2% |
| | | 3 | 532 | UK: 0.04 kg·m$^2$ (CI: -0.23-0.31) | 7.88 | $P < 0.05$ | 74.6% |
| | | 4 | 1,569 | Canada: 0.58 kg·m$^2$ (CI: 0.40-0.76) | 0.33 | $P > 0.05$ | 0% |
| | | 1 | 101 | Belgium: 0.30 kg·m$^2$ (CI: 0.13-0.47) | 0.00 | NA | NA |
| | | 1 | 65 | New Zealand: 0.50 kg·m$^2$ (CI: 0.01-0.99) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 8 | 4,252 | Self-report: 0.23 kg·m$^2$ (CI: 0.14-0.32) | 80.14 | $P < 0.001$ | 90.0% |
| | | 14 | 1,766 | Measured: 0.28 kg·m$^2$ (CI: 0.16-0.41) | 86.32 | $P < 0.001$ | 84.9% |

Table 2

*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By study length | 5 | 326 | ≤ 4 mths: 0.33 kg·m$^2$ (CI: 0.05-0.62) | 46.75 | $P < 0.001$ | 91.4% |
| | | 13 | 2,946 | 5-8 mths: 0.25 kg·m$^2$ (CI: 0.16-0.33) | 101.23 | $P < 0.001$ | 87.2% |
| Subgroup analysis | By gender | 11 | 3,426 | Females: 0.45 kg·m$^2$ (CI: 0.23-0.67) | 78.72 | $P < 0.001$ | 87.3% |
| | | 6 | 2,329 | Males: 0.39 kg·m$^2$ (CI: 0.20-0.59) | 12.90 | $P < 0.05$ | 61.3% |
| Mean % body fat change | Weighted on sample | 8 | 891 | 0.65% (CI: 0.17-1.13) | 66.79 | $P < 0.001$ | 88.4% |
| Subgroup analysis | By location | 6 | 761 | USA: 0.67% (CI: 0.02-1.32) | 49.20 | $P < 0.001$ | 87.8% |
| | | 1 | 29 | Canada: -0.17% (CI: -0.37-0.03) | 0.00 | NA | NA |
| | | 1 | 101 | Belgium: 0.80% (CI: 0.34-1.27) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 8 | 891 | Measured: 0.54% (CI: 0.08-1.00) | 66.79 | $P < 0.001$ | 88.0% |

Table 2

*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By study length | 1 | 27 | ≤ 4 mths: 2.1% (CI: 0.99-3.21) | 0.00 | NA | NA |
| | | 6 | 322 | 5-8 mths: 0.33% (CI: -0.14-0.80) | 42.71 | $P < 0.001$ | 87.2% |
| Subgroup analysis | By gender | 2 | 70 | Females: 0.73% (CI: -1.22-2.68) | 14.47 | $P < 0.001$ | 93.1% |
| | | 1 | 13 | Males: 3.1% (CI: 1.11-5.09) | 0.00 | NA | NA |
| Mean fat-free mass change | Weighted on sample | 4 | 288 | -0.13 kg (CI: -0.48-0.22) | 16.68 | $P = 0.001$ | 82.0% |
| Subgroup analysis | By location | 1 | 54 | USA: -0.61 kg (CI: -1.06 - -0.16) | 0.00 | NA | NA |
| | | 1 | 120 | UK: 0.16 kg (CI: -0.01-0.33) | 0.00 | NA | NA |
| | | 1 | 29 | Canada: -0.70 kg (CI: -1.40-0.00) | 0.00 | NA | NA |
| | | 1 | 101 | Belgium: 0.20 kg (CI: -0.01-0.41) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 4 | 288 | Measured: -0.13 kg (CI: -0.48-0.22) | 16.68 | $P = 0.001$ | 82.0% |
| Subgroup analysis | By study length | 3 | 168 | 5-8 mths: -0.33 kg (CI: -0.99-0.34) | 15.07 | $P < 0.001$ | 86.7% |

Table 2
*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By gender | 1 | 54 | Females: -0.61 kg (CI: -1.06 - -0.16) | 14.59 | $P < 0.001$ | 86.3% |
| Mean fat mass change | Weighted on sample | 4 | 288 | 0.92 kg (CI: 0.07-1.78) | 34.83 | $P < 0.001$ | 91.4% |
| Subgroup analysis | By location | 1 | 54 | USA: 1.31 kg (CI: 0.57-2.05) | 0.00 | NA | NA |
| | | 1 | 120 | UK: -0.04 kg (CI: -0.08-0.00) | 0.00 | NA | NA |
| | | 1 | 29 | Canada: 2.60 kg (CI: 0.76-4.44) | 0.00 | NA | NA |
| | | 1 | 101 | Belgium: 0.80 kg (CI: 0.34-1.26) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 4 | 288 | Measured: 0.92 kg (CI: 0.07-1.78) | 34.83 | $P < 0.001$ | 91.4% |
| Subgroup analysis | By study length | 3 | 184 | 5-8 mths: 1.20 kg (CI: 0.51-1.90) | 4.28 | $P > 0.05$ | 53.3% |
| Subgroup analysis | By gender | 1 | 54 | Females: 1.31 kg (CI: 0.57-2.05) | 0.00 | NA | NA |
| | | 1 | 13 | Males: 2.60 (CI: 0.07-1.78) | 0.00 | NA | NA |
| Mean waist circumference change | Weighted on sample | 5 | 442 | 0.58 in (CI: 0.05-1.09) | 18.71 | $P < 0.05$ | 67.9% |

Table 2
*Summary of Meta-Analysis Estimates by Type of Analysis –Freshman Year (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By location | 2 | 89 | USA: -0.19 in (CI: -2.56-2.17) | 7.59 | *P* < 0.05 | 86.8% |
| | | 1 | 120 | UK: 0.72 in (CI: -0.02-1.47) | 0.00 | NA | NA |
| | | 2 | 145 | Canada: 1.06 in (CI: -0.91-3.04) | 2.84 | *P* > 0.05 | 64.8% |
| | | 1 | 101 | Belgium: 0.40 in (CI: -0.01-0.81) | 0.00 | NA | NA |
| Subgroup analysis | By body weight measurement method | 5 | 442 | Measured: 0.58 in (CI: 0.05-1.09) | 18.71 | *P* < 0.05 | 67.9% |
| Subgroup analysis | By study length | 4 | 322 | 5-8 mths: 0.38 in (CI: -0.13-0.89) | 10.57 | *P* < 0.05 | 62.1% |

Table 3

*Summary of Meta-Analysis Estimates by Type of Analysis –Four Years*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Mean weight change | Weighted on sample | 6 | 9,565 | 0.90 kg (CI: 0.49-1.32) | 190.33 | $P < 0.001$ | 90.5% |
| Subgroup analysis | By location | 3 | 1,239 | USA: 3.16 kg (CI: 2.15-4.17) | 2.25 | $P = 0.325$ | 11.1% |
| | | 2 | 8,152 | Japan: 0.69 kg (CI: 0.25-1.13) | 164.35 | $P < 0.01$ | 90.9% |
| | | 1 | 174 | Israel: 1.06 kg (CI: 0.30-1.82) | 0.00 | NA | NA |
| Subgroup analysis | By gender | 6 | 3,586 | Females: 0.89 kg (CI: 0.26-1.51) | 86.63 | $P < 0.001$ | 90.8% |
| | | 6 | 5,979 | Males: 1.00 kg (CI: 0.47-1.52) | 64.22 | $P < 0.001$ | 87.5% |
| Mean BMI change | Weighted on sample | 6 | 6,110 | 0.26 kg·m$^2$ (CI: 0.01-0.52) | 146.70 | $P < 0.001$ | 89.1% |
| Subgroup analysis | By location | 3 | 5,485 | Japan: 0.14 kg·m$^2$ (CI: -0.13-0.41) | 127.42 | $P < 0.001$ | 89.0% |
| | | 2 | 335 | USA: 0.71 kg·m$^2$ (CI: 0.46-0.95) | 0.68 | $P = 0.409$ | 0.00% |

Table 3
*Summary of Meta-Analysis Estimates by Type of Analysis –Four Years (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By gender | 4 | 3,087 | Females: 0.21 kg·m$^2$ (CI: -0.21-0.63) | 51.87 | $P < 0.001$ | 90.4% |
| | | 4 | 5,400 | Males: 0.40 kg·m$^2$ (CI: -0.12-0.92) | 58.29 | $P < 0.001$ | 91.4% |
| Mean % body fat change | Weighted on sample | 3 | 847 | 1.69% (CI: 0.46-2.92) | 7.91 | $P < 0.05$ | 74.7% |
| Subgroup analysis | By location | 2 | 673 | USA: 2.42% (CI: 0.61-4.23) | 2.57 | $P = 0.109$ | 61.0% |
| | | 1 | 174 | Israel: 0.80% (CI: 0.24-1.36) | 0.00 | NA | NA |
| Subgroup analysis | By gender | 2 | 178 | Females: 1.71% (CI: -0.33-3.75) | 4.88 | $P < 0.05$ | 79.5% |
| | | 2 | 127 | Males: 2.75% (CI: -1.54-7.03) | 7.60 | $P < 0.05$ | 86.8% |
| Mean fat-free mass change | Weighted on sample | 2 | 305 | -0.09 kg (CI: -0.76-0.59) | 13.52 | $P < 0.001$ | 92.6% |
| Subgroup analysis | By location | 1 | 131 | USA: -0.44 kg (CI: -0.76 - -0.13) | 0.00 | NA | NA |
| | | 1 | 174 | Israel: 0.25 kg (CI: 0.06-0.43) | 0.00 | NA | NA |

Table 3
*Summary of Meta-Analysis Estimates by Type of Analysis –Four Years (continued)*

| | Specification | N studies | N students | Pooled estimate | Q statistics | *P*-Value of heterogeneity | $I^2$ |
|---|---|---|---|---|---|---|---|
| Subgroup analysis | By gender | 2 | 178 | Females: -0.24 kg (CI: -1.12-0.64) | 20.00 | $P < 0.001$ | 95.0% |
| | | 2 | 127 | Males: 0.81 kg (CI: 0.05-1.58) | 2.42 | $p = 0.120$ | 58.7% |
| Mean fat mass change | Weighted on sample | 1 | 131 | 3.20 kg (CI: 1.34-5.06) | 0.00 | NA | NA |
| Subgroup analysis | By gender | 1 | 89 | Females: 2.30 kg (CI: 0.96-3.64) | 0.00 | NA | NA |
| | | 1 | 42 | Males: 4.90 kg (CI: 2.05-7.75 | 0.00 | NA | NA |

## Discussion

The present meta-analysis added to the previous meta-analytic reviews of weight change over the freshman year of college, by increasing the number of studies and examining other body composition changes that occurred during college attendance. In addition, to our best knowledge, this is the first meta-analysis examining body composition changes over four years of college attendance, rather than relying exclusively on studies investigating the freshman year. Examining differences in body composition changes in studies targeting freshman year compared to all four years may provide a more complete picture of the changes and potential health risks that occurs for college students.

This meta-analysis found that over the course of the freshman year, students gained an average of 0.74 kg (1.63 lbs). Furthermore, there were increases in BMI (0.21 $kg{\cdot}m^2$), percent body fat (0.54%), absolute fat mass (0.92 kg), and waist circumference (0.58 inches), whereas fat-free mass decreased (-0.13 kg). These findings support the first hypothesis of expected overall direction of changes in weight and body composition. Compared to Vadeboncoeur and colleagues (2015; 1.21 kg) and Vella-Zarb and Elgar's (2009; 1.75 kg) meta-analyses, however, the observed weight change in the present meta-analysis was smaller than anticipated. It is possible this finding may be due to the inclusion/exclusion criteria and the studies used within the analyses. For instance, Vadeboncoeur and colleagues (2015) included studies that collected follow-up data at a minimum of four weeks whereas the current study's minimum follow-up period was at least ten weeks. The present study also expanded the review to an additional five studies more than Vadeboncoeur and colleagues' (2015) meta-analysis.

The observed weight gain (0.74 kg; 1.63 lbs) from our data did not align with the supposed "Freshman 15". When considering only the students who gain weight their first year (over 60%), we found a mean gain of 3.43 kg (7.56 lbs), which is much higher than the gain observed in the overall student population – though still considerably below the "Freshman 15". The present meta-analysis supported previous findings of weight gainers with additional studies compared to Vadeboncoeur and colleagues (2015), who found weight gain in gainers to be 3.38 kg (7.45 lbs). Clearly, there is some reason for concern and a need to further evaluate and assist those students who are gaining more notable amounts of weight. Importantly, we know the range of weight student's gain can vary greatly, upwards towards 20.9 kg (46.08 lbs; Racette et al., 2008). Future studies should continue to present data on the group of weight gainers and examine potential predictors for this subgroup of college students.

Beyond the first year of college, students continue to gain observable weight. We found an overall mean change of 0.90 kg (1.98 lbs) at the end of senior year, supporting the second hypothesis of continued weight gain throughout college attendance. This meta-analysis also revealed an increase in BMI (0.26 $kg{\cdot}m^2$), percent body fat (1.69%), and fat mass (3.2 kg), as well as a decrease in fat-free mass (-0.09 kg). When comparing body composition changes in studies gathering data freshman year and those collecting data until the end of college, a significant difference was found. In weight, BMI, and percent body fat, studies taking data through all four years of college attendance had higher reported changes. For the measures of fat-free mass, absolute fat mass, and waist circumference, limited analyses were possible due to the few number of studies available. Therefore, more attention may need to be given to college students throughout their education experience, in addition to the freshman year. Further examination of the potential predictors and moderators of body composition changes in college students may clarify the reasons behind the changes we observed.

A goal for this study was to examine whether gender differences emerged in college freshmen as well as during all four years of college. Individual studies have observed significant gender differences in body composition changes (Bodenlos et al., 2015; Cluskey & Grobe, 2009; Gropper et al., 2012). Vadeboncoeur and colleagues (2015) did not find an overall significant difference between genders while Vella-Zarb and Elgar (2009) found a small significant difference. For the freshman year of college, the present analysis also found differences in weight and BMI change between genders. Gender differences at the conclusion of college also were observed in the our findings, with males showing reliably greater gains in weight, BMI, percent of fat, and percent of fat-free mass. This finding suggests that although males appear to gain muscle mass and mature over this period, they also increase in adiposity in greater amounts than did females. Given the relatively few studies available in this area, further attention to long-term gender differences is warranted and could provide greater clarity as to the potential mechanism at play and how these may differentially impact males and females over the entire course of college.

Our results indicated that studies from North America reported greater changes in weight, BMI, and absolute fat mass than countries in Europe and Asia, which supports the sixth hypothesis regarding regional/national locations. These differences were observed in studies taking place over freshman year and four years. Analyses in North America revealed that in studies over the freshman year, students in the United States

(0.86 kg) had statistically significant greater increases in weight over students in Canada (0.81 kg). However, students in Canada had greater increases in BMI than students in the United States. Vadeboncoeur and colleagues (2015) did not find a significant difference in weight gain between the United States (1.32 kg) and Canada (1.71 kg). Variables related to attending college in the United States compared to Canada, the United Kingdom, Belgium, Israel, and Japan, should be more closely evaluated to determine the reasons behind the difference in weight change.

Studies included in the analyses collected weight and BMI changes through either self-report or objective measurements. Only studies that had consistent methods of collecting data were included for analysis, due to the potential inconsistencies in results (McCabe et al., 2001). In the analysis of studies occurring during the freshman year, an unexpected significant difference was found for weight change; self-reported weight gain was higher than objectively measured weight change. Vadeboncoeur and colleagues (2015) did not find a difference in weight change in studies using self-report versus objective measurements, though Vella-Zarb and Elgar (2009) did find a statistically significant yet small effect of self-report data being higher than objective measurements. These differences may speak to young adults' lack of accuracy in estimating their actual body composition, and perhaps somewhat their belief in the myth of the "Freshman 15".

Over the freshman year, studies varied in their follow-up duration. Results comparing studies with shorter follow-up, occurring only over the first semester, to studies with longer follow-up, collecting data at the end of the year, showed a significant difference in weight and BMI change. Studies that took place over the first semester showed significantly higher weight and BMI change than studies that occurred over the entire academic year. It seems as though the first semester is a higher risk time for weight changes in college freshman. Interestingly, in Vella-Zarb and Elgar (2009) and Vadeboncoeur and colleagues' (2015) meta-analyses, greater weight gain was found in studies with a longer duration. This difference in the present study and the past studies may be accounted for by the additional studies that were included in this analysis. We also found that over all four years of college, students had significant increases in weight, BMI, and percent body fat, though not at the same rate as observed during the first semester of college. Therefore, our results would indicate that although weight gain for students throughout their collegiate experience is of importance, it appears the freshman year may be a more critical time to consider for intervening and prevention of weight gain.

We also examined how study retention rate may affect the amount of body composition and adiposity changes reported. In freshman year, we found that studies with high retention reported significantly greater increases in weight, BMI, and waist circumference. Over the four years of college, studies with low retention reported greater changes in weight, BMI, and percent body fat. We considered retention rate when scoring quality ratings for each study and did further analysis on the potential effects. We found no significant differences for any body composition measures between studies with different quality ratings. Despite having only 67% of the studies meeting criteria for medium or high quality, it did not affect the changes observed in college student body composition.

The present meta-analysis included a total of 55 studies (though no more than 27 studies were included in any particular analysis) and is the first review to examine other measures of body composition, including BMI, percent body fat, fat-free mass, fat mass, and waist circumference. Evaluating these additional measures of body composition changes are important for assessing a more nuanced form of weight change that occurs. That is, these measures allow us to assess potential convergence of weight gain outcomes as well as allow for efforts to disentangle weight gain due to increased adiposity and/or fat-free mass (e.g., increased muscle mass). Thus, increases in weight, percent body fat, fat mass, and waist circumference and a decrease in fat-free mass would suggest more negative body/health changes. However, increases in fat-free mass, may suggest changes associated with more positive/healthful body composition.

Because young adults attending college are at higher risk for weight gain compared to young adults living at home or not attending college, it is crucial that future research be conducted, so that potential mechanism of body composition change are determined and interventions may be more effectively developed (Deforche et al., 2015; Hovell et al., 1985; Kapinos & Yakusheva, 2011; Kapinos, Yakusheva, & Eisenberg, 2014; Levitsky, Halbmaier, & Mrdjenovic, 2004; Pliner & Saunders, 2008; Provencher et al., 2009). These interventions may help to prevent the trend of weight gain that we currently observe in students during their college years, and place young adults on a longer term trajectory of reduce weight gain and better health outcomes later in life.

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## Appendix A: PRISMA Checklist

| Section/topic | Checklist item |
|---|---|
| **TITLE** | |
| Title | Identify the report as a systematic review, meta-analysis, or both. |
| **ABSTRACT** | |
| Structured summary | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. |
| **INTRODUCTION** | |
| Rationale | Describe the rationale for the review in the context of what is already known. |
| Objectives | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). |
| **METHODS** | |
| Protocol and registration | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. |
| Eligibility criteria | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. |
| Information sources | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. |
| Search | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. |
| Study selection | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). |
| Data collection process | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. |
| Data items | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. |
| Risk of bias in individual studies | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. |
| Summary measures | State the principal summary measures (e.g., risk ratio, difference in means). |
| Synthesis of results | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. |

| Section/topic | Checklist item |
|---|---|
| Risk of bias across studies | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). |
| Additional analyses | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. |
| **RESULTS** | |
| Study selection | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. |
| Study characteristics | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. |
| Risk of bias within studies | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). |
| Results of individual studies | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. |
| Synthesis of results | Present results of each meta-analysis done, including confidence intervals and measures of consistency. |
| Risk of bias across studies | Present results of any assessment of risk of bias across studies (see Item 15). |
| Additional analysis | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). |
| **DISCUSSION** | |
| Summary of evidence | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). |
| Limitations | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). |
| Conclusions | Provide a general interpretation of the results in the context of other evidence, and implications for future research. |
| **FUNDING** | |
| Funding | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. |

*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed10000

## Appendix B: Search Syntax

Names of Databases: PsycINFO, PubMed, Web of Science, SPORTDiscus, Health Source, Scopus, Cochrane Review
Dates: October 2015

Initials of person who ran search: HL

1. Student OR freshmen OR freshman AND university OR college OR higher education AND weight change OR weight gain OR weight increase OR BMI OR body mass index OR adiposity

Delimited to: peer-reviewed journal articles, published in English

Total hits: 18, 912

References of studies subject to full review for potential studies to be included

**Appendix C: NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE COHORT STUDIES (and no-treatment control group from RCT)**

Note: Studies are assessed on a total score of seven stars. Scores of six and above are considered high quality, four and five average quality, and three or lower are low quality. A study can be awarded a maximum of one star for each numbered item within the Selection, Outcome, and Bias Assessment categories.

**Selection† (maximum 2 stars)**

1) Student population
   a) representative of the average student in college ❋
   b) representative of the student body at that particular college ❋
   c) selected group of users (e.g. volunteers, convenience pool, health class, only female/male sample)
   d) no description of the derivation of the cohort

2) Recruitment
   a) Performed at a university wide level ❋
   b) For *no-treatment control group from randomized intervention*: drawn from the same college as the exposed cohort and used both *active* (e.g., email to newly admitted freshmen who attended summer advising sessions at the university, enlisted resident advisors from each dormitory to personally invite residents to attend a group information recruitment session, recruitment incentives were used to both recruit and retain study participants) and *passive* (e.g., posted study fliers in dormitories and word-of-mouth) recruitment strategies ❋
   c) drawn from a different source
   d) no description of the derivation of the non-exposed cohort

†Cohort representative of a normal student population with males and females sampled, recruitment was performed to give equal chance to participate to everyone.

**Outcome (maximum 4 stars)**

1) Method of outcome
   a) objective with a measuring protocol ❋
   b) self-report only
   c) no description

2) Time of first measurement
   a) baseline data was collected within 2 weeks of the onset of first semester ❋
   b) baseline data was collected prior to onset of college, but no earlier than 4 weeks before start of semester
   c) baseline data was collected after onset of college, but no later than 4 weeks after start of semester

3) <u>Was follow-up long enough for outcomes to occur (for "freshmen 15")</u>
   a) yes (follow up period of at least one academic year; 7 months) ✵
   b) no

4) <u>Retention rate reported /adequacy of follow up of cohorts</u>
   a) complete follow up - all subjects accounted for ✵
   b) subjects lost to follow up unlikely to introduce bias - small number lost $\leq$ 20 % to follow up, or description provided of those lost ✵
   c) follow up rate of 50-79% and no description of those lost
   d) problematic follow-up rate (<50%) or no statement about retention

**Bias Assessment (maximum 1 star)**

1) <u>Conducted analyses of bias</u>‡
   a) comparability between respondents and non-respondents characteristics is established and/or reported that any missing data at follow-up missing at random (MAR) ✵
   b) reported that missing data was not missing at random
   c) reported crucial limitation, or some limitations for multiple areas sufficient to lower ones confidence in the study
   d) did not conduct or report analyses of bias

‡ Statistical comparison between those lost to follow-up and those who did not

**Appendix D: Cohen's Kappa Agreement for Coders (Article exclusion/inclusion)**

| | Investigator 1 (HL) | Investigator 2 (RL) |
|---|---|---|
| Include | 21 | 18 |
| Exclude | 1382 | 1385 |

Overall Cohen's kappa = 0.71

$N$ = 1403