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Association of dietary behaviors, macro-nutrients and energy intake with body fat percentage, lean mass, and bone mineral density.

Makayla Goggins

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Makayla Goggins

University of Arkansas

Primary Investigator: Erin Howie

Committee Members: Erin K. Howie, Ph.D., Michelle Gray, Ph.D., Kate Walker

Project assisted by Bryce Daniels, Jordan Means, and Lauren Lyons.

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Abstract:

Background: Due to the obesity epidemic, many studies have compared nutrient intake to human body composition. However, previous studies have not used gold standard measures of body composition in a college population. **Purpose**: The purpose of this study is to examine how dietary behaviors, overall energy intake, and macronutrient intake are associated with the body composition factors measured in a dual-energy x-ray absorptiometry (DXA) scan. We hypothesize higher body fat percentage will be associated with higher fat and carbohydrate intake, but not total energy intake. **Methodology**: This was a cross-sectional study done as part of Exercise is Medicine® On Campus initiative. It was a convenience sample of subjects that had to be connected to the University of Arkansas as a student, faculty, or a staff member, and at least 18 years old. Body composition was measured using a DXA scan, which measured total body lean tissue, fat mass, and bone mineral density. Participants completed an online survey on dietary habits. 24-hour dietary recalls will be used to determine nutrient intake for each subject. Results from the recalls will be entered into Nutritionist Pro™ to obtain macronutrient levels and overall energy intake. Descriptive statistics were calculated and linear regression adjusted for sex and age compared the dependent variables of body composition by independent variables of dietary behaviors. **Results:** Survey: There were a total of 47 participants (n=29 women), with a mean age of 29.2 (SD 12.5, range 19.1 to 66.0). Preliminary results found average percent body fat of 33.9% (SD 8.6) for women and 21.8% (SD 7.3) for men, lean mass of 39.5 kg (6.2) for women and 59.0 kg (5.8) for men, bone mineral density of 1.2 (0.1) for women and 1.3 (0.1) for men. Eight participants (17%) drank milk at least daily and of those that consumed milk at all, 11 (26.2%) primarily consumed whole milk. Additionally, 19 (41%) participants consumed fruit at least daily. In models adjusted for age and sex, there were no differences in percent body fat (β 2.5, p=.435), lean mass (β 0.6, p=.806), or bone mineral density (β .004, p=.925) in those who consumed milk daily compared to those who consumed milk less than daily. There was no difference in percent body fat (β 2.3, p=.368) between those who consumed fruit daily compared to those who consumed less than one serving of fruit daily. Dietary Recalls and DXA: there was no association between total fat percentage and total energy intake (β 0.1, p=.124), carbohydrate intake (β=-0.1, p=.268), protein intake (β=0.1, p=.637), or fat intake (β=0.1, p=.439). The same is true for android fat percentage, gynoid fat percentage, and lean mass percentage. There was an association between total energy (Kcal) intake and bone mineral density (β=.002, p=.039). Bone mineral density was not associated with carbohydrate intake (β=0.0, p=.979), protein intake (β=-.003, p=.089), or fat intake (β=.002, p=.092). **Discussion**: Results from the survey indicate that there is not an association between body composition and dietary behaviors. Results from dietary recalls indicate there is no association between body composition and macronutrients, but there is an association between bone mineral density and total energy intake. Further studies for combatting the epidemic of obesity should also look at other behaviors such as exercise and lifestyle.

Introduction:

The modern epidemic of obesity is continuing to grow, with the global presence close to double what it was just 30 years ago (Pasco et al., 2014). In 2016, the World Health Organization stated that there were 650 million obese adults over the age of 18, and 39% of the world's adult population is overweight (WHO, 2018). Obesity is linked to many dangerous diseases including hypertension, insulin resistance, dyslipidemia, and cardiovascular disease, which can all be combined to be classified as metabolic syndrome (Saklayen, 2018). The risks from obesity extend far beyond having a high body weight and are compromising lives in populations. Being overweight or obese in childhood or adolescent years is a very strong predictor of having obesity as an adult (Biro & Wien, 2010). College students are typically in the transition from adolescence to adulthood, and whether they are obese, overweight, or healthy weight, many decide during this time what lifestyle they will adapt as adults (Von Ah et al., 2004). Many students continue to live unhealthy lives by being sedentary or consuming a poor diet (Cluskey and Grobe, 2009). The American College of Sports Medicine recognizes that college campuses are a place that these behaviors can be studied and need to be improved. Research needs to be continued to be done on college populations, both young and old, to see what the barriers to healthy lifestyles are. A way to currently assess the situation of this population is to look at their current body composition and lifestyle, and try to prevent growing numbers of obesity.

Obesity can be defined as an excess of body fat, but it is measured in individuals with their body mass index (BMI). The Centers for Disease Control classifies a healthy BMI between 18.5-24.9 kg/m^2. It classifies 'overweight' as a BMI greater than 25.0 kg/m^2, and 'obese' as a BMI greater than 30.0 kg/m^2 (CDC, 2016). However, a person's body composition is not always indicated by their BMI. It has been found in recent years that BMI can actually underestimate the

adiposity level of an individual (Pasco et al., 2014). This has been causing researchers to look further to accurately assess a person's health in regards to their body composition. This includes using a DXA scan.

Dual energy x-ray absorptiometry (DXA) was originally created to test bone mineral density to aid in diagnosis of osteoporosis (Miller, 2017), but is now used to also test bone mineral content, fat-free mass, and estimates of body fat (Clasey et al., 1997). Studies have found that DXA scans provide much more accurate estimates of body fat percentage than a BMI score (Taylor et al., 2002). Although a person might appear to be in the healthy range from the outside (BMI), it's possible they could still be classified as obese from their body fat percentage (DXA).

The disconnect of BMI and body fat percentage could be from what the individual is consuming and/or how much they exercise. It was found several years ago that amount of fat in the body is linked with composition of the person's diet and their exercise habits, rather than their overall energy intake (Miller et al., 1990). They found a higher correlation to body fat percentage with the macronutrients of fat and carbohydrates compared to protein, alcohol, and sugar. This may mean that it matters more what the food is composed of rather than how much energy (kcals) it actually is. In the previous study, they used hydrostatic weighing to determine body fat percentage. Although this is an accurate way to measure body fat, there is still a benefit to using the DXA scan instead. The results from the DXA scan show body composition in different regions of the body, and hydrostatic weighing only gives one overall value. High prevalence of adipose tissue in the abdominal area (android fat) poses a much greater threat than adipose tissue distributed other places throughout the body (even with the same BMI) (Snijder et al., 2005). Knowing the locations in the body with the highest fat percentages can make a difference in what risks the individual could be facing. It's also possible that there are trends in

diet and exercise that cause some people to have less fat than others in different areas. The DXA scan will also analyze bone mineral density, another component not available through hydrostatic weighing. Multiple studies have been done comparing bone mineral density with a person's micronutrient intake (New et al., 1997). However, there is very little found comparing macronutrient intake with bone mineral density.

The purpose of this study was to examine how dietary behaviors, overall energy intake and macronutrient intake are associated with the body composition factors measured in a DXA scan. Many studies have compared nutrient intake to human body composition, but previous studies have not used gold standard measures of body composition in a college population. We hypothesized the following: that higher body fat percentage will be associated with higher fat and carbohydrate intake when looking at the macronutrients of fats, carbohydrates, and protein, that overall energy intake will not associate with body fat percentage as highly as macronutrient fat, and that bone mineral content will have some correlation with intake of macronutrients instead of just overall energy intake.

Methods:

Exercise is Medicine® (EIM) On Campus, managed by the American College of Sports Medicine, is an initiative brought to college campuses to work towards increasing physical activity across all populations – including students, teachers, and staff of all ages. The goal is to get these groups in the mindset that physical activity is necessary to live their best quality of life. This initiative has now been brought to the University of Arkansas, and research is being done alongside of it. This study was a small component of the larger EIM research that is happening. There were two parts to this study. First, there was a survey taken online that asked about

behaviors and results were compared to body composition. Then, a series of test were done on a smaller group of the survey takers, which included a 24-hour dietary recall. Results were again compared to body composition. The study was approved by University of Arkansas' Institutional Review Board (IRB Approval #1808138910).

Participants. Participants included anyone that the larger Exercise is Medicine research study was recruiting, which includes all students, teachers, and staff at the University of Arkansas Fayetteville age 18 or older. Exclusion criteria included those who could not complete the questionnaire in English, and those that had any physical or mental limitations (including pregnancy) that would prevent them from completing all of the assessments. Participants did not complete the maximal testing if the health screening they completed was contraindicative to the American College of Sports Medicine guidelines.

Measures.

Survey: The survey was formed using Qualtrics. Participants could access the survey using a link from any online device. The survey asked many lifestyle questions, including habits of exercise, sleep, and diet. Results for this study were compared between those who consumed milk daily and those who did not, and those who consumed fruit daily and those who did not.

Diet. Upon arrival, participants first completed a 24-hour dietary recall. The recall involved the researcher writing answers and prompting the subject throughout it. Visual aids and hand measurements were used to help determine exactly what and how much of something was consumed. The recall used was "Appendix D, Population-based Food Consumption Survey of the People of Hong Kong 2005-07," which was "Conducted for the Food and Environmental Hygiene Department by the Chinese University of Hong Kong." All information from the recall was put into the program Nutritionist Pro™ – Diet Analysis & Nutrition Food Labeling

Software. The University of Arkansas Exercise Science Research Center already owned this program. Once the data from the recalls was entered, the program calculated values of macronutrients, micronutrients, and overall energy intake.

Body Composition. After the dietary recall was finished, the subjects underwent a series of fitness tests done by other researchers in the Exercise is Medicine study, and during this section they had the DXA scan. Results from the DXA scan included total body lean mass, total fat %, android fat %, gynoid fat %, and bone mineral density. Results were also given based off of region in the body, including left and right arm, left and right leg, left and right trunk, a left total, a right total, and combined arms, legs, and trunk total, but that part of information was saved for future studies.

Statistical Analysis.

Survey Dietary Behaviors and DXA. Descriptive statistics were calculated and linear regression adjusted for sex and age examined associations between the dependent variables of body composition with independent variables of dietary behaviors.

Dietary Recalls and DXA. Descriptive statistics were also calculated for the macronutrients and body composition. We specifically examined the association between intake of the macronutrients fats, carbohydrates, and protein with total body fat percentage and if bone mineral content has any correlation with any of the macronutrients. Linear regressions were used to test these associations, with the diet macronutrient intake as the independent variable and body composition variables as the dependent variables and adjusted for gender and age.

Results.

Survey – Dietary behaviors:

A survey over dietary behaviors was taken by n=47 participants, 29 being female. Results from the survey include the following:

Eight participants (17%) drank milk at least daily and of those that consumed milk at all, 11 (26.2%) primarily consumed whole milk. Additionally, 19 (41%) participants consumed fruit at least daily. In models adjusted for age and sex, there were no differences in percent body fat (β 2.5, p=.435), lean mass (β 0.6, p=.806), or bone mineral density (β .004, p=.925) in those who consumed milk daily compared to those who consumed milk less than daily. There was no difference in percent body fat (β 2.3, p=.368) between those who consumed fruit daily compared to those who consumed less than one serving of fruit daily.

Dietary Recalls and DXA scans:

A 24-hour recall was recorded for n=37 participants.

Table 1: Summary of macronutrients, n=37

	Female (n=29)	Male (n=8)
Total Kcal	1,839.7 (1,241.4)	1,832.8 (1,046.0)
Carbohydrates (%)	44.8 (12.6)	44.9 (14.3)
Fat (%)	36.2 (13.3)	37.5 (7.4)
Protein (%)	16.7 (7.5)	17.0 (6.3)

Average total energy intake (kcals) were comparably close between males and females, with 8 males consuming a mean of 1,832.8 kcals, and 29 females consuming a mean of 1,839.7 kcals. When looking at all three macronutrients, the means were all within less than 1% of each other when comparing male intake with female intake.

Table 2: Linear regression associations between macronutrients and body composition outcomes (adjusted for age and sex), n=37.

	Total Fat (%)		Android Fat (%)		Gynoid Fat (%)		Lean Mass (%)		Bone Mineral Density (g/cm^3)	
	B (95%CI)	p-value	B (95%CI)	p-value	B (95%CI)	p-value	B (95%CI)	p-value	B (95%CI)	p-value
Total Kcal (100 kcals)[a]	0.1 (-.03, 0.3)	.124	0.2 (-0.05 (0.4)	.124	.05 (-0.1, 0.2)	.502	-.001 (-.003, .0003)	.108	.002 (.0001, .005)	.039
Carbohydrates (%)	-0.1 (-0.3, 0.1)	.268	-0.04 (-0.3, 0.2)	.738	-0.1 (-0.2, 0.1)	.242	0.00 (-0.001, .002)	.280	0.00 (-.002, .002)	.979
Protein (%)	-0.1 (-0.4, 0.2)	.637	-0.3 (-0.7, 0.1)	.177	0.01 (-0.3, 0.3)	.949	.001 (-.002, .004)	.554	-.003 (-.007, .001)	.089
Fat (%)	0.1 (-0.1, 0.2)	.455	0.1 1(-0.1, 0.3)	.439	.04 (-0.1, 0.2)	.591	-.001 (-.002, .001)	.406	.002 (-0.00, .004)	.092

Results show there was no association between total fat percentage and total energy intake (β 0.1, p=.124), carbohydrate intake (β=-0.1, p=.268), protein intake (β=0.1, p=.637), or fat intake (β=0.1, p=.439). The same is true for android fat percentage, gynoid fat percentage, and lean mass percentage (seen in table 2). There was, however, an association between total energy (Kcal) intake and bone mineral density (β=.002, p=.039). Bone mineral density was not associated with carbohydrate intake (β=0.0, p=.979), protein intake (β=-.003, p=.089), or fat intake (β=.002, p=.092).

Discussion.

Before obtaining these results, we hypothesized that there would be an association between macronutrients (including fat, carbohydrates, and protein) and body composition factors (including total body fat, lean mass, and bone density), with the strongest association being between fat and carbohydrate intake and body fat percentage. We also hypothesized that body fat percentage would have a stronger association with macronutrients than with total energy intake, and that macronutrients are associated with bone mineral density. The results from this study did not confirm these hypotheses.

Dietary Behaviors

After surveying participants on dietary behaviors, there were no differences in percent body fat, lean mass, or bone mineral density in those who consumed milk daily compared to those who consumed milk less than daily, and no differences between those who consumed fruit daily and those who consumed less than one serving of fruit per day. This contraindicates results found in a previous study that determined premenopausal women had lower bone mineral density when they had consumed low amounts of fruit and milk in their early adulthood years (New et al., 1997). Future investigating should be done to determine if it is only in younger years that these specific nutrition components have an effect on bone mineral density. Further, it has been shown in previous studies that increased calcium intake in developmental years is associated with higher bone mineral density (Cadogan et al., 1997). It was also seen in an observational study that 12-yr-old females had a higher bone mineral density when consuming higher amounts of fruit and vegetables (McGartland et al., 2004). This study, however, did not find the same results for males, or for 15-yr-old females. Because the average college population is aged 18-22 years old, which is just past developmental years for some and still at the end of developmental years for others, further investigating on daily milk and fruit consumption and bone mineral density should be done on this age group specifically, instead of any adult over the age of 18. If previous studies are finding results at an adolescent age group, just past adolescence should be considered to compare. Gender should still be considered separately, since fruit consumption could potentially only have an impact on bone mineral density in females. Other questions asked in this survey should also be examined and compared to body composition, including those on exercise habits, sleep habits, and lifestyle factors.

Dietary Recalls

After testing the hypothesis further with the dietary recalls, there appeared to be no association between macronutrients and body composition in the current study. There was also no association between macronutrients and lean mass, or macronutrients and bone mineral density. There was, however, an association between total energy (Kcal) intake and bone mineral density. This discovery is one that has been seen in previous studies (Trichopoulou et al., 1997), but a majority of studies have either focused on different age groups (Ilich et al., 2003), or looked specifically at calorie restriction and how that is related to *lower* bone mineral density (Villareal et al., 2006; Sukumar et al., 2010). The association between higher bone mineral density and increased energy intake in this study was consistent with findings in previous ones mentioned, but uses the gold standard of measurement in a college population.

Since previous studies (Miller et al., 1990) have confirmed that there is an association between macronutrients and body composition, there are several factors that could have contributed to why we did not get the results that were hypothesized. The factors we hypothesize that contributed the most was underreporting of food consumed and an inconsistency with the environment of the participant when reporting. Underreporting has proven to be an issue in many cases (Johansson et al., 2007; Poppitt et al., 1998; Moran et al., 2018). A sign of underreporting in this study can be seen when looking at the mean of total kcals consumed in males vs females. The values were extremely close. Men and women typically have different basal metabolic rates, which can be define in the Merriam-Webster Dictionary as the amount of kcals needed to sustain energy on a daily basis. The value for males should have likely been higher than the value for females (Arciero, Goran, & Poehlman, 1993). This could indicate that during the 24-hour dietary recalls, participants of both genders were reporting what they think the societal norms are for

calorie consumption. Differences such as the sex of the researcher and the number of people in the room at the time likely caused some inconsistencies in this area as well. For example, because the concept of food can be a sensitive subject for some people, participants could have felt more judgment or uncomfortableness if a researcher of the opposite sex was recording their information. At times throughout this data collection, there were multiple people in the room while the dietary recalls were happening, and at other times it was just the researcher and participant. This also could have effected the level of comfort the participant had in being completely honest in their answers.

Other Limitations.

Limitations included the type of dietary recall used. Although every type has pros and cons, some studies have shown that the most accurate form is a 7-day recall (Ouellette et al., 2014), (Stuff et al., 1983). Another limitation was the actual sample of participants. Although this study was open to any person at the University of Arkansas campus, a majority of the participants doing the dietary recalls were faculty or staff, instead of students. This meant that although they were a part of a college population, they were not within the normal college aged range (18-22) that we were expecting.

Conclusion.

When comparing dietary intake and behaviors with body composition, the only association made was between a higher energy (kcal) intake and a high bone mineral density. A major obstacle to overcome in future studies is subjects reporting accurate amount of foods they consumed. Further studies for combating the epidemic of obesity should also look at other behaviors such as

exercise and lifestyle, as this epidemic is one that still needs much attention and extensive research.

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