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Cover Page Footnote

I would like to thank Dr. Cathy Anstrom for her unending support and guidance throughout the research process. Without her, I could not have successfully completed my research. Additionally, I would like to express my gratitude to Dr. Beth Schurman for walking with me through the steps necessary to perform an Honors research project from start to finish. I would also like to thank Dr. Alison Young Reusser for helping me with the statistical analysis of my data. Last but not least, I would like to thank the Olivet Nazarene University Honors Program for the opportunity to accomplish this project and for the funding necessary to make it possible.

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ABSTRACT

Learning outcome
To understand the relationship between the amount of black coffee consumed and Body Mass Index (BMI) in individuals 18 years and older.

Background
Researchers have debated the relationship between weight status and coffee consumption with conflicting results. Lee, Kim, & Kim (2017) found a positive trend exists between the amount of coffee consumed and BMI. Conversely, Grosso et al. (2015) found an inverse trend between coffee consumption and BMI.

Methods
Quantitative design was used. A researcher constructed questionnaire was piloted through SNAP Survey at a small Midwestern university receiving 939 complete responses. Three questions were included on the pilot study questionnaire soliciting feedback regarding question wording, ordering, and comprehension. The questionnaire was revised for validity and clarity. The revised questionnaire for the main study was administered through Amazon Mechanical Turk. Fifty-seven complete questionnaires were received. Eighty-four participants from the pilot study who reported only black coffee consumption were included in the main study data analysis. The two samples were combined to increase statistical power (n=141). BMI (kg/m2) was calculated for each participant.

Results
An ANCOVA was performed to examine the relationship between BMI and black coffee consumption (oz.) per day (scale was 4 oz. to 40 oz.). The results showed no correlation between the two variables, $F(1, 138)= 0.65$, $p < 0.001$. Unlike the previous studies, this quantitative study controlled for additives (such as cream, sugar, and milk) as confounding factors so that the relationship between black coffee and weight status were studied solely.

Conclusions
Amount (ranging from ½ to 5 cups) of black coffee consumed per day was not correlated to BMI in this sample of adults.

Keywords: coffee, Body Mass Index, black coffee, weight status

INTRODUCTION

Coffee is one of the most consumed beverages worldwide. In an analysis of the responses from 22,513 adults from the National Health and Nutrition Examination Survey (NHANES) from 2003 to 2012, researchers found that 52.8% of participants consumed coffee (defined as caffeinated coffee, decaffeinated coffee, or coffee substitutes) (An, 2016).

Obesity is defined as having a Body Mass Index of 30 or higher, which puts an individual at greater risk for chronic disease states such as diabetes mellitus, cardiovascular

disease, and some cancers. Per the Centers for Disease Control and Prevention (2018), 39.8% of U.S. adults in 2015-2016 are obese. Therefore, about 93.3 million adults in the United States are considered obese and at risk for major health conditions.

Coffee and energy intake

An (2016) examined the correlation between coffee consumption and changes in energy intake. Based on the NHANES data from 2003 to 2012, coffee consumption was associated with an, on average, 108 kcal increase in total energy intake per day. More specifically, the consumption of coffee was related to a 60.7 kcal increase in daily energy intake of energy-dense, nutrient-poor foods. This number was highest among young and middle-aged adults (An). In other words, individuals who consumed coffee were more likely to also consume foods high in calories and low in nutrition.

Additionally, researchers have found a statistically significant difference between energy intake changes in normal-weight and overweight/obese individuals (Gavrieli et al., 2013). In normal-weight individuals, coffee consumption amount is not statistically significantly associated with a change in dietary intake or appetite (Gavrieli et al.). In overweight and obese individuals, moderate coffee consumption (1 cup) is associated with lower calorie consumption in the next meal as well as lower calorie consumption for the rest of the day (Gavrieli et al.). That is to say that biological mechanisms in coffee could be related to decreased appetite, possibly resulting in weight loss.

The amount of coffee consumed also has an impact on daily energy intake. In a study conducted by Grosso et al. (2015) that analyzed the results of the Polish arm of the Health, Alcohol and Psychosocial factors in Eastern Europe (HAPIEE), individuals who consumed three or more cups of coffee per day were more likely to have a higher total energy intake than those who consumed fewer than three cups of coffee per day. Future research is required to determine causality for this association. Furthermore, the consumption of three or more cups of coffee per day is associated with a lower exercise rates in Korean women (Lee, Kim, & Kim, 2017). With exercise quantity closely associated with weight status, this association would further indicate that the consumption of three or more cups of coffee per day could be related to higher weight status. In a study conducted on mice, coffee consumption was positively associated with food intake (Rustenbeck et al., 2014). When applied to a human population, this could suggest that with a larger amount of coffee consumed, the calories consumed increases as does weight status.

Coffee and clinical indicators

Many studies (Cai, Ma, Zhang, Liu, & Wang, 2012; Cowan et al., 2014) have examined the relationship between coffee consumption and variables such as blood lipid value and blood pressure. In a meta-analysis of twelve studies with a total of 1017 participants, coffee consumption was correlated with an increase in total cholesterol, low-density lipoprotein cholesterol, and triglyceride levels. This effect was more pronounced in those who drank higher amounts of coffee (Cai et al.). This relationship has been debated due to conflicting results. In a study performed on rats fed a high-fat diet, coffee had a protective effect against liver triglycerides (Cowan et al.). This provides an opposing conclusion than in the study performed by Cai et al.

Coffee and weight change

Current research shows that regular consumption of coffee has been associated with decreases in body weight (Pan et al., 2013). Caffeine increases metabolic rates in humans, which could be responsible for some of the weight loss, but similar effects on weight have been observed in those who drink decaffeinated coffee, showing that other constituents of coffee could be responsible as well (Bakuradze et al., 2014). Following an intervention of Special Blend coffee that consisted of high amounts of roast products such as N-methylpyridinium and a small amount of light roast that is high in green bean constituents, body weight of participants was statistically significantly decreased. Body fat was decreased after an intervention of the Special Blend as well as after the intervention of the Market Blend (consisting of five commercially sold coffees, to represent the typical blend of coffee). Components of coffee such as chlorogenic acids and green coffee bean extracts may be responsible for stimulating metabolic rate (especially in the catabolism of internal body fat) (Bakuradze et al., 2014). In support of this finding, in a synthesis of three cohort studies on coffee intake and weight within a four-year period, researchers found that for each additional serving of coffee consumed per day, 0.14 kg of weight was lost (Pan et al., 2013).

Researchers (Cowan et al., 2014; Moy & McNay, 2013; Rustenbeck et al., 2014) have studied mice and rat populations to examine the relationship between coffee and weight changes more closely. Cowan et al. fed a group of rats a high-fat diet with a water treatment and another group a high-fat diet with a coffee treatment. Rats who were fed a high-fat diet in conjunction with the coffee treatment had less weight gain and body fat gain than those fed a high fat diet with the water treatment. In a similar study that focused on caffeine in coffee, Moy and McNay (2013) found that the consumption of caffeine by rats fed a high-fat diet eliminated the weight that the non-caffeinated rats gained from the same diet. A similar result can be seen in mice. Rustenbeck et al. examined the effect of high coffee consumption on weight gain in mice. They found that coffee eliminated the weight gain in the normal-fed mice but just decreased it (not eliminated completely) in the high-fat fed mice. In other words, the presence of caffeine in the animal's diet when fed a high-fat diet decreases the amount of resultant weight gain. This concept is a potential mechanism of coffee in a human population. Though the current study is not examining the fat levels in participants' diets, further research should be conducted to determine if this effect exists in coffee.

Coffee and weight status

Researchers (Fathi, Ahari, Amani, & Nikneghad, 2016; Kim & Park, 2017; Lee et al., 2017) often disagree on coffee's relationship to weight status. In a meta-analysis performed by Fardet and Boirie (2014), they concluded that high levels of coffee consumption are associated with an increased risk of obesity (especially in women). More specifically, individuals who consume three or more cups of coffee per day are at an even higher risk of obesity. Additionally, coffee consumption of four or more cups per day is associated with an increase in all-cause mortality and adverse health effects (Kim & Park). In the study by Fathi et al. in which researchers surveyed physicians in Ardabil City, they found that coffee intake is a risk factor for overweight and obesity. Lee et al. studied Korean women and found that a positive trend exists between the

amount of coffee consumed and BMI. The consumption of three or more cups of coffee was positively associated with a BMI of 30 or higher (indicative of obesity).

On the other hand, many researchers (Grosso et al., 2015; Mogre, Nyaba, & Aleyira, 2014) have found the opposite to be true. In the analysis of the results from the Polish arm of the HAPIEE study, Grosso et al. found a statistically significant inverse trend between coffee consumption and BMI. Also, Mogre et al. found that in the adult students from a university in Ghana, the refraining from drinking coffee increased the risk of both general and abdominal obesity.

Current study

Studies by Lee et al. (2017) have investigated the relationship between coffee consumption and the risk for obesity in a population of Korean female adults and found a positive correlation between coffee consumption with additives (such as sugar, cream, milk, etc.) and the occurrence of obesity in the participants, but the mechanism responsible for this relationship is still unknown. In the current study, the coffee additives as a confounding factor are eliminated so that black coffee and weight status can be studied solely. Additionally, the current study measured the amount of black coffee consumed in participants who consume only black coffee daily to further examine whether a statistically significant relationship exists between black coffee consumption and weight status.

Research hypothesis/research question

The purpose of the current study was to explore the relationship between daily black coffee consumption on weight status (through Body Mass Index). The current study was directed by the following research hypothesis and research question.

Null hypothesis: There is no relationship between the amount of black coffee consumed daily and an individual's BMI.

Alternative hypothesis: There is a relationship between the amount of black coffee consumed daily and an individual's BMI.

Research question 1: What is the relationship between the amount of black coffee consumed daily and an individual's BMI?

METHODS

A quantitative study was conducted in which the researcher collected data that included the amount of black coffee each participant consumed on an average day and week. Data was also collected that included participant self-reported age, weight, and height in order for the researcher to calculate BMI.

Pilot study

A researcher constructed survey was piloted to 939 participants recruited from the undergraduate student body at a private Christian university in the Midwest (see Appendix A). An email was sent campus wide. The online survey was administered through SNAP technology. Participants provided feedback on question ordering, wording, and

comprehension through three additional questions at the end of the research survey (see Appendix B). Based on feedback received, the survey was revised to improve clarity (see Appendix C). All participants received a link to the informed consent document. Once completed, participants were directed with a link to the survey tool on SNAP. Directions advised participants to read each question carefully. They answered questions that covered coffee consumption, weight, height, age, exercise, and demographical information (year in school, race, gender). The survey was estimated to take approximately five to ten minutes to complete.

Main study

One hundred participants were obtained from Amazon Mechanical Turk to take the revised survey. The study participants included only those who solely drink black coffee. An attention-check question was included that asked the participants to select a certain response to ensure they were accurately completing the questionnaire. The question read, "Please select '24 oz (3 cups)' below." If they did not select the correct response, they were screened out and their responses were disqualified. Additionally, if, based on the responses, the participant did not fit the qualifications of the study (solely drinking black coffee), their responses were disqualified. After removing the responses that did not solely drink black coffee or did not correctly answer the attention-check question, 57 participants remained.

DATA ANALYSIS

From the data collected for each participant's height and weight, a BMI value was calculated by dividing weight (in kilograms) by height (in meters) squared. This data was then run in the data analysis along with average amount of coffee consumed per day. Of the 939 participants in the pilot study, 84 reported that they consume only black coffee and were included into the analysis with the main study participants ($n = 84$ for the pilot study and $n = 57$ for the main study for a total of $n = 141$).

An ANCOVA was run with ounces of black coffee and sample type (pilot study or main study) as predictors to examine the relationship between Body Mass Index (kg/m2) and ounces of black coffee consumption per day. For responses of "Less than 8 oz. (1 cup)" black coffee consumed per day, a value of four ounces was used in the calculation. For responses of "Greater than 32 oz. (4 cups)" black coffee consumed per day, a value of 40 ounces was used in the ANCOVA.

RESULTS

The results showed no correlation between the ounces of black coffee consumed per day and body mass index, $F(1, 138) = 0.65$, $p < 0.001$. A scatterplot summarizes these results **(Figure 1)**. Overall, ounces of black coffee consumed per day is not a statistically significant predictor of BMI in adults.

Additionally, an effect of the sample type (pilot study or main study) was found, $F(1,138) = 17.05$, $p < 0.001$. In other words, the two samples had statistically significant differences between them. Specifically, the pilot sample had a lower average BMI ($M = 23.93$, $SE = 0.58$) compared to the main sample ($M = 27.68$, $SE = 0.702$).

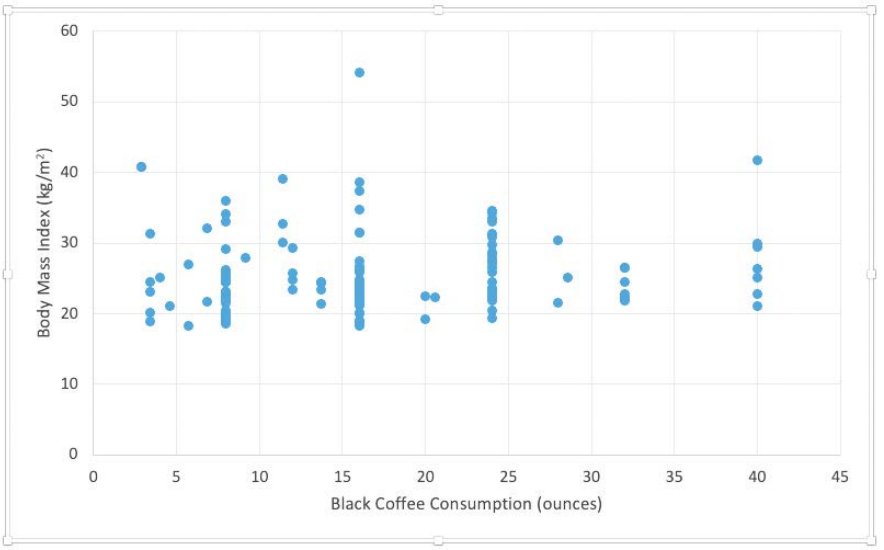

Figure 1: Scatterplot of black coffee consumption and Body Mass Index. There is no relationship between the amount of black coffee consumed and weight status (n=141). This figure includes results from the pilot study and the main study

DISCUSSION

The current study was directed by the following research hypothesis and research question:

Null hypothesis: There is no relationship between the amount of black coffee consumed daily and an individual's BMI.

Alternative hypothesis: There is a relationship between the amount of black coffee consumed daily and an individual's BMI.

Research question 1. What is the relationship between the amount of black coffee consumed daily and an individual's BMI?

The purpose of this study was to examine the relationship between black coffee consumption and weight status in an adult population. The main conclusion of this study is that there is no statistically significant relationship between the amount of black coffee consumed and weight status as measured by Body Mass Index. This is particularly interesting due to the strong correlations found in previous studies such as those by Fathi et al. (2016) and Lee et al. (2017). Though a meta-analysis performed Fardet and Boirie (2014) of all coffee consumption studies stated that high levels of coffee consumption are associated with increased risk of obesity, there are studies that show just the opposite, such as those by Grosso et al. (2015) and Mogre et al. (2014).

Data collection and analysis for the current study leads the researcher to fail to reject the null hypothesis. To answer the research question, there was no relationship found between the amount of black coffee consumed daily and an individuals' BMI.

A strength of the current study is the isolation of black coffee as a variable rather than combining black coffee drinkers with coffee drinkers who also consume coffee with additives (such as cream, sugar, or milk). Previous research does not specify the type of coffee that is consumed or whether additives are present. The current study eliminated coffee additives as a confounding variable to weight status to show that, while prior research suggests a relationship exists between coffee consumption and weight status, no statistically significant relationship exists between specifically black coffee consumption and weight status in the population studied. This further suggests that the coffee additives may play a large role in accounting for the relationship to weight status.

The current study was limited by the sample size. While the study began with one hundred participants through Amazon Mechanical Turk, twenty-one responses were eliminated because the participant reported to drink the black coffee less than seven days a week, one response was eliminated because the participant failed to correctly answer the attention-check question, and forty-two responses were eliminated because the participant reported to either sometimes or always drink coffee with additives (such as cream, sugar, etc.) or because the participant did not fully or correctly answer the questionnaire (i.e., putting height in feet and inches instead of inches like instructed). After all the invalid responses were eliminated, a sample size of fifty-seven remained. I recommend repeating this study with a larger sample size, enabling the results to be more adequately generalized.

Additionally, a limitation of the current study was the self-reported nature of the data collected. In the current study, all information, including height, weight, and coffee consumption, was collected through an online survey. Therefore, the data relies on the accuracy of the information self-provided by the participant. Specifically, the height and weight are variables that the participant could have estimated so I suggest repeating this study with a laboratory-measured height and weight to increase the accuracy of the data collected.

The current study adds to the body of knowledge that black coffee consumption may not be associated directly or inversely with weight status. Further research should be conducted to determine the extent to which coffee additives impact weight status in comparison to black coffee. Also, further research could be done to determine factors that influence coffee intake and the effect of daily coffee consumption versus coffee consumption less than seven days a week.

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APPENDIX A – PARTICIPANT SURVEY

1. What year are you in school? Freshman (1st year), Sophomore (2nd year), Junior (3rd year), Senior (4+ year)

2. What is your age?

3. What is your gender? Male, Female

4. What is your race? White or Caucasian, Black or African American, Hispanic or Latino, Asian or Asian American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Another race

5. What is your height in inches?

6. What is your weight in pounds?

7. Do you: I drink all coffee black, I sometimes drink coffee black and I sometimes drink coffee with additives (cream, sugar, etc.), I drink all coffee with additives (cream, sugar, etc.), I do not drink coffee, Other

8. On average, how many cups (8 oz. = 1 cup) of black coffee (without sugar, cream, milk, or any other additive) do you consume per day? 0 cups, 1 cup, 2 cups, 3 cups, 4 cups, 5 cups or more

9. Of the number of cups stated in Question 1, how many are decaffeinated? 0 cups, 1 cup, 2 cups, 3 cups, 4 cups, 5 cups or more

10. How many minutes per WEEK (on average) do you exercise? 0 mins/wk, 1-30 mins/wk, 31-60 mins/wk, 61-90 mins/wk, 91-120 mins/wk, 121-150 mins/wk, Greater than 150 mins/wk

11. How many calories per DAY (on average) do you consume? 1200-1500 calories, 1501-1800 calories, 1801-2100 calories, Greater than 2100 calories

12. How long have you been drinking coffee? Less than 1 year, 1-5 years, 6-10 years , >10 years

APPENDIX B – PILOT STUDY QUESTIONS

Were there any questions in this survey that were hard to understand? If so, which one(s) and why?

Did the order of the questions in this survey make sense? If not, explain.

Do you have any other general comments about this survey?

APPENDIX C – REVISED PARTICIPANT SURVEY

1. What is your age?

2. What is your gender? Male, Female, Prefer not to say

3. What is your race? Select all that apply. White or Caucasian, Black or African American, Hispanic or Latino, Asian or Asian American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Another Race

4. What is your height in INCHES? (1 foot=12 inches)

5. What is your weight in POUNDS?

6. Please select the option that most describes you. I drink all coffee black, I sometimes drink black coffee and I sometimes drink coffee with additives (cream, sugar, milk, non-dairy creamer, etc.), I drink all coffee with additives (cream, sugar, milk, non-dairy creamer, etc.), I do not drink coffee, Other

7. On average, how many days a week do you drink coffee? 0 days per week, 1 day per week, 2 days per week, 3 days per week, 4 days per week, 5 days per week, 6 days per week, 7 days per week

8. On average, how many ounces (8 oz. = 1 cup) of black coffee (without sugar, cream, milk, non-dairy creamer, or any other additive) do you consume per day? If do not drink coffee every day, answer the amount you would consume on a day you do drink coffee. 0 cups, Less than 8 oz (1 cup), 8 oz (1 cup), 12 oz (1.5 cups), 16 oz (2 cups). 20 oz (2.5 cups), 24 oz (3 cups), 28 oz (3.5 cups), 32 oz (4 cups), Greater than 32 oz (4 cups)

9. Of the number of ounces stated in the question above, how many are decaffeinated? 0 cups, Less than 8 oz (1 cup), 8 oz (1 cup), 12 oz (1.5 cups), 16 oz (2 cups). 20 oz (2.5 cups), 24 oz (3 cups), 28 oz (3.5 cups), 32 oz (4 cups), Greater than 32 oz (4 cups)

10. How long have you been drinking only BLACK coffee? Less than 1 year, 1-5 years, 6-10 years, >10 years

11. How many minutes per week (on average) do you exercise? 0 mins/wk, 1-30 mins/wk, 31-60 mins/wk, 61-90 mins/wk, 91-120 mins/wk, 121-150 mins/wk, Greater than 150 mins/wk