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Analysis of How a Carbohydrate or Protein Breakfast Influences Caloric Intake at Lunch

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Abstract

Obesity is a rising epidemic in the United States and the type of macronutrients consumed at breakfast serves an important role to decrease the statistics. This study analyzed whether a carbohydrate or protein breakfast affected the amount of calories consumed during an *ad libitum* lunch buffet. Both boys and girls, aged 8 to 12, were screened to participate. Each participant consumed either a carbohydrate or a protein breakfast on two separate occasions. The subject was then presented with an *ad libitum* lunch buffet and was instructed to eat until they were full. The food consumed was weighed and logged. The results of this study determined that there was no significant difference in the amount of calories consumed during lunch, after a carbohydrate or protein breakfast.

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Introduction

Obesity is a growing epidemic in the United States. There are many health risks associated with obesity. Health risks consist of higher rates of type 2 diabetes, early symptoms of vascular dysfunction and subclinical atherosclerosis (Mitka, 2013). Studies found that middle-to-late adolescence is the highest period of susceptibility of obesity; these children are more likely to remain obese in upcoming years (Ogden et al., 2006; Leidy & Racki, 2010). Targeting adolescent obesity may help decrease onset of diseases later on in their lives. Adolescents exhibit the poorest dietary patterns compared to all other ages (Pelletier, Graham & Laska, 2014). Approximately 34% of the adolescent population is currently overweight or obese (Huh, Stice, Shaw & Boutelle, 2011). Over the past two decades childhood obesity has increased by nearly 50% (Lifshitz, 2008), along with an increase in children skipping breakfast (Leidy & Racki, 2010). Skipping breakfast correlated with an increase in body mass index (BMI) in young people (Leidy & Racki, 2010). The adolescent population should be targeted to consume breakfast that will increase satiety throughout the day.

A well-balanced diet contributes to managing a healthy weight. The typical Western diet consisted of 50% carbohydrates, 35% fats, and 15% of daily energy from protein (Brennan et al., 2012). Complex carbohydrates with a slower digestion rate are more efficient than simple carbohydrates in increasing satiety (Alviña & Araya, 2003). A lunch high in carbohydrates, in comparison to fat, decreased the caloric intake later in the day (Blundell & Noury, 2001). High-protein meals, consisting of 45% protein, resulted in a decrease in caloric consumption (Brennan et al., 2012). A comparison of a high-protein breakfast to a high-carbohydrate breakfast, found less calories were consumed later in the day after the protein breakfast in men (Ratliff et al.,

2010). Studies regarding breakfast composition in children are limited in quantity especially, when comparing proteins and carbohydrates.

This study aimed to determine whether a carbohydrate or protein breakfast would reduce caloric intake at lunch. It was hypothesized that a protein breakfast would result in fewer calories consumed during lunch compared to the carbohydrate breakfast.

Review of Literature

Obesity is a growing epidemic. The percentage of children in the United States who are overweight or obese continues to rise (Ogden et al., 2006; Huh et al., 2011). Statistics indicate that adolescent obesity has more than tripled from the 1960s (Huh et al., 2011). It is estimated that nearly 34% of young people are either overweight or obese (Huh et al., 2011). In 1999-2000 the prevalence of overweight female adolescents was 14% and increased to 16% in 2003-2004 (Ogden et al., 2006). Similarly the increase in prevalence was found in male adolescents from 14% to 18% in the time frame previously stated (Ogden et al., 2006). The trend of obesity will continue to rise. Knowledge of when the adolescent population is at its highest risk of obesity is instrumental in implementing measures to thwart the rising statistics.

Adolescents who are overweight or obese are more susceptible to weight gain at certain ages. Distinguishing incidence and remission in overweight and obese adolescents highlights the time periods for greater risk of onset and opportunities for intervention (Huh et al., 2011). A year-long study, conducted with participants aged 5-13, examined the onset and remission of obesity (Huh et al., 2011). Results concluded that younger children in comparison to the older children were more likely to become obese and remain obese over the 1-year follow up, implying an continuance of obesity throughout later years (Huh et al., 2011). Preventing obesity in younger children will decrease their risk of becoming obese in the future.

Adjusting adolescent's dietary patterns is one factor that could decrease weight gain. Increasing evidence supports that adolescents have similar dietary patterns to those around them (Pelletier et al., 2014). Eating meals as a family is beneficial to adolescents since it is a time period that their future health habits are formed (Pelletier et al., 2014). Adolescents who regularly eat with their families consume fewer sweetened drinks, and more fruits, vegetables,

and calcium-rich foods (Larson, Story, Eisenberg & Neumark-Sztainer, 2006; Pelletier et al., 2014). Larson, Story, Eisenberg and Neumark-Sztainer (2006) believed that social interaction at home between parents and children had a strong influence regarding the food served at meals as well as the food purchased. In a longitudinal study, preparing meals at home, was associated with improved diet quality (Pelletier et al., 2014). The dietary patterns continued to mold their eating behaviors into young adulthood (Pelletier et al., 2014). Eating with family and establishing healthy eating habits at a young age was beneficial for years to come after they leave home (Pelletier et al., 2014).

Digestion rates are known to be different between macronutrients. Simple carbohydrates break down faster in the body than complex carbohydrates (Alviña and Araya, 2003). Alviña and Araya (2003) conducted a study that compared the digestion rates of carbohydrates found in traditional Chilean meals. There were 48 overweight and normal weight participants in the study, aged 3-6 years. The results determined children were more satiated from the meal with a slow digestion rate of carbohydrates rather than the meal with a rapid digestion rate (Alviña & Araya, 2003). The carbohydrates with slower digestion took longer to breakdown into smaller molecules (Alviña and Araya, 2003). Obese children had a higher energy intake after consuming the carbohydrate meal with a fast rate of digestion (Alviña & Araya, 2003). Carbohydrates with a slower digestion led to a lower energy intake in comparison to carbohydrates with a faster digestion rate.

Fats have a different digestion rate and effect on satiety in comparison to carbohydrates. Fats are less effective than simple carbohydrates in suppressing desires to eat and increasing fullness (Blundell & Noury, 2001). Men either ate a high-fat or high-carbohydrate breakfast; both meals consisted of 440 calories (Blundell & Noury, 2001). The results indicated that

carbohydrates decreased the caloric intake by over 50% compared to the fat lunch (Blundell & Noury, 2001). Carbohydrates can be broken down much faster than fats but fats contain much more energy. Fats have a higher energy density. Individuals who consume meals primarily made up of fats, will, in turn consume more calories throughout the day (Blundell & Noury, 2001). Carbohydrates were less energy dense and caused an increased satiation compared to fats in an individual and decreased caloric intake during later meal times (Blundell & Noury, 2001).

Mentioned previously, lifestyle is composed of numerous factors, one being dietary factors. Diet continues to evolve with time. The current, average Western diet emphasizes carbohydrates more than proteins, which is contrary to the diet of our hunter-gatherer ancestors (Brennan et al., 2012). While carbohydrates suppress appetite and increase satiety more than fats, proteins have a greater effect than carbohydrates on increasing satiation (Brennan et al., 2012). However, the total amount of protein needed to cause the increase in satiation is unknown. Brennan et al. (2012) conducted a study in men to determine whether a carbohydrate or protein breakfast decreased energy intake. Participants consisted of 16 healthy, lean men aged 18-55. The four meals used for this study were: high carbohydrate (60%), high-protein (45%), adequate protein (30%), and low protein (10%) (Brennan et al., 2012). The results revealed the high-protein breakfast reduced energy intake at lunch approximately 14% compared to the high-carbohydrate meal (Brennan et al., 2012). Based on the results, higher protein meals served an essential part in appetite regulation and potential caloric reduction post-prandially (Brennan et al., 2012). Proteins regulated satiety more effectively than fats and carbohydrates.

Altering post-prandial caloric consumption could play a major role in reducing rates of overweight and obesity. A study in which, a protein energy balanced (EB) diet and protein energy (ER) diet were compared against a normal protein diet (Leidy, Bossingham, Mattes, &

Campbell, 2008). A protein EB diet consisted of 18% of total energy from protein and the protein ER diet had 25% of total energy from protein (Leidy et al., 2008). The EB control group contained 11% of total energy from protein and 64% from carbohydrates and the ER group contained 14% protein and 61% carbohydrate (Leidy et al., 2008). The typical American diet only contains about 15% of protein; therefore, the high protein diets should yield results of increased perception of fullness and reductions in appetite. The results were not significant for the high protein EB meal; however, the high protein energy restrictive meal resulted in an increased fullness across a 15-hour time span (Leidy et al., 2008). ER was designed to decrease the normal caloric intake of an individual resulting in weight loss. It can be assumed that if individuals restricted caloric intake and increased the percent of daily dietary protein, there could be a higher success of weight loss.

Breakfast serves an essential role in maintaining good health (Leidy & Racki, 2010). Over the past two decades the amount of people who eat breakfast declined and the rate of reduction paralleled the increase in obesity rates (Leidy & Racki, 2010; Leidy et al., 2008). Breakfast frequency has an inverse correlation with BMI (Leidy & Racki, 2010; Leidy, Ortinau, Douglas & Hoertel, 2013). Not only do breakfast skippers have higher body mass, but they also tend to have poor food choices, represented by an increased snacking on high-fat and processed sugar food and drinks (Leidy et al., 2013). Adolescent's dietary habits are likely to remain unchanged while transitioning into adulthood, thus affecting long-term weight and general health (Leidy & Racki, 2010). Two studies were conducted that analyzed the effect breakfast consumption had in breakfast skippers. Both suggested that the higher amount of protein in breakfast led to a reduction of appetite perceptions (Leidy & Racki, 2010; Leidy et al., 2013). Leidy and Racki's (2010) study concluded subsequent meal intake and overeating during the

evening were both reduced as a result of a high-protein breakfast. The study not only observed differences in calories consumed, but the mechanism of action as well. The authors noted that a breakfast rich in protein affected homeostatic and non-homeostatic reward signals that control the regulation of food intake (Leidy et al., 2013). The importance of a protein breakfast was emphasized to decrease appetite perceptions and caloric intake throughout the day.

Due to reductions in total caloric intake after a high protein meal, protein consumption suggested significant reductions in body weight. Westerterp-Plantenga, Nieuwenhuizen, Tomé, Soenen and Westerterp (2009) observed changes in body weight after consumption of a high-protein diet. In *ad libitum* conditions, food intake and energy were reduced if a high-protein meal was previously consumed (Westerterp-Plantenga, Nieuwenhuizen, Tomé, Soenen, & Westerterp, 2009; Blatt, Roe & Rolls, 2011). Normal weight subjects were given a normal-protein diet (12%) or a high-protein diet (25%). Among individuals that consumed the high-protein meal, satiety was significantly increased compared to the low-protein meal (Westerterp et al., 2009). In addition, energy intake decreased 25% after consuming the high-protein meal (Westerterp et al., 2009). High-protein meals increased satiety and decreased energy intake, which resulted in weight loss.

Many studies were conducted on protein or carbohydrates, however few compared the two. Complex carbohydrates are satiating, however proteins are believed to have prolonged satiating effects (Paddon-Jones et al., 2008; Astrup, 2005). Isocaloric protein and carbohydrate lunches were given to participants on separate occasions (Latner & Schwartz, 1999). The participants had a buffet-style dinner and were instructed to eat as little or as much as they preferred (Latner & Schwartz, 1999). The results concluded that the higher the amount of protein in the meal led to a decreased food intake at dinner (Latner & Schwartz, 1999). The mixture

lunch, carbohydrate and protein, resulted in increased satiety in comparison to the carbohydrate lunch alone (Latner & Schwartz, 1999). Since both carbohydrates and protein were understood to have strong satiating effects then the combination of the two should yield the same result. The addition of carbohydrates in a high-protein meal led to additional reduction of hunger and increased feeling of fullness (Jakubowicz, Froy, Wainstein & Boaz, 2012). When adding a high-carbohydrate snack to breakfast, cravings for sweets, breads, and fast foods were significantly decreased (Jakubowicz et al., 2012). Subjects of this study were either given a breakfast low in carbohydrates or a high carbohydrate and protein-enriched breakfast. Results showed that the low-carbohydrate group failed to maintain their weight reduction goals and during the follow-up period, the subjects gained weight (Jakubowicz et al., 2012). Subjects in the high-carbohydrate and protein-enriched breakfast group continued to lose weight during the study's follow-up period, implying it was a diet that individuals can stick with on a long-term basis (Jakubowicz et al., 2012). The combination of protein and carbohydrate in a meal produced a strong effect on prolonged satiety. However, more studies need to be conducted isolating the two macronutrients during mealtime to determine which one produces the stronger satiety effect.

Methods

Participants

Thirty-two adolescent boys and girls, aged 8 to 12, were recruited from Northwest Arkansas, primarily through flyers and online advertisements. A phone screening determined whether the parent and child came in for an initial consultation. Participants were 8-12 years old to qualify and filled in the weight, height, ethnicity and reading level on a questionnaire. Subjects were excluded if they were diagnosed with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD), on any medication, unwilling to eat to certain foods, or claustrophobic. On testing day, participants were required to sit still while their resting metabolic rate was measured under a hood. Claustrophobia, ADD or ADHD could alter the results if the participants were unable to sit still under the hood. The participants underwent a dual-energy x-ray absorptiometry scan to determine total body composition and BMI was used to determine if they were in the normal-weight or overweight group. The Institutional Review Board approved the study and participants and parents signed informed consent forms. Upon completion of the study, participants received a $100 gift certificate to Wal-Mart.

Materials and Procedure

Participants arrived at the Food Science building at the University of Arkansas at 7:30am, having fasted overnight. Upon arrival, the participant's height and weight were recorded. Either a carbohydrate or protein breakfast was served and must have been consumed in 15 minutes after the first bite occurred. The carbohydrate breakfast consisted of one waffle with syrup. The protein breakfast was one whole egg, two egg whites, and one piece of toast. Both breakfasts were served with orange juice. Both breakfasts were 325 calories and contained 11 grams of fat. The protein breakfast consisted of 18 grams of protein and 38.5 grams of carbohydrates, while

the carbohydrate breakfast consisted of 4 grams of protein and 52.5 grams of carbohydrates. Details of breakfast consumption are represented in Table 1. Baseline for time was when the participant ate their first bite. Lunch was set up buffet-style and included a variety of low to high nutritional quality food items. A salad and yogurt were two foods considered to have higher nutritional quality, while chicken nuggets and ice cream were considered lower nutritional quality items. The plate was weighed after each food item and weighed after the participant was finished. The participant was instructed to stop eating once they felt full.

Table 1

Breakfast Composition

Parameter	**PRO Breakfast**	**% Energy**	**CHO Breakfast**	**% Energy**
Energy (kcal)	325		325	
Protein (g)	18	22	4	5
Carbohydrate(g)	38.5	48	52.5	65
Fat (g)	11	30	11	30

Statistical Analysis

A repeated-measures analysis of variance was performed with one between-subject's factor (weight classification) to determine differences in total calories consumed during the *ad libitum* lunch between the weight groups as well as the breakfast consumed. Results were reported as means plus or minus standard deviation. Statistical significance was set at $p < .05$ for all analyses.

Results

There was no significant difference between carbohydrate or protein breakfast consumption and its effect on calories consumed at lunch. Statistical significance was set at .05. The mean of the total calories consumed after a carbohydrate breakfast was 808.68. The mean of the total calories consumed after a protein breakfast was 902.57. The participants in the normal weight group consumed less calories than the overweight group during lunch. The normal weight participants consumed a mean of 699.98 calories after the carbohydrate breakfast and a mean of 762.98 calories after the protein breakfast. The overweight participants consumed a mean of 953.61 calories after the carbohydrate breakfast and a mean of 1105.60 calories after the protein breakfast.

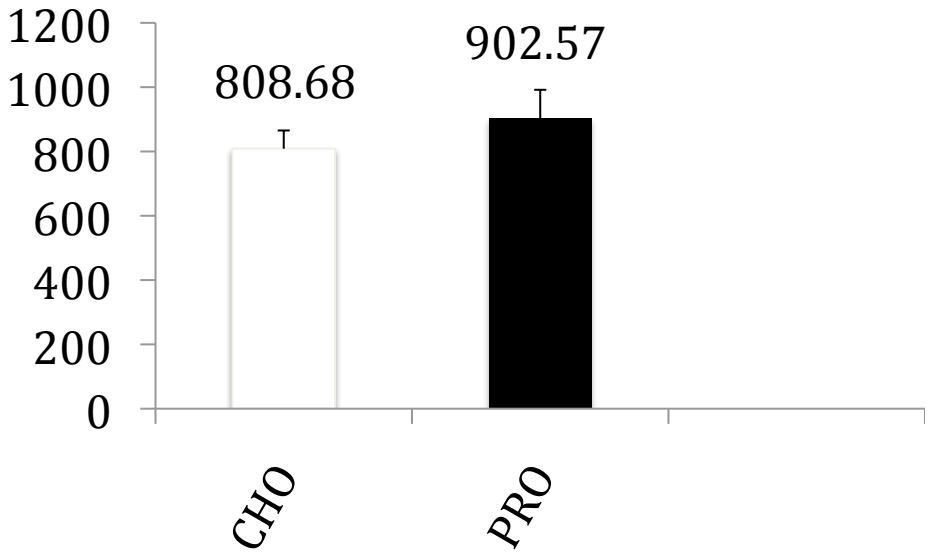

Figure 1. A comparison of the amount of calories consumed at lunch after a carbohydrate or protein breakfast.

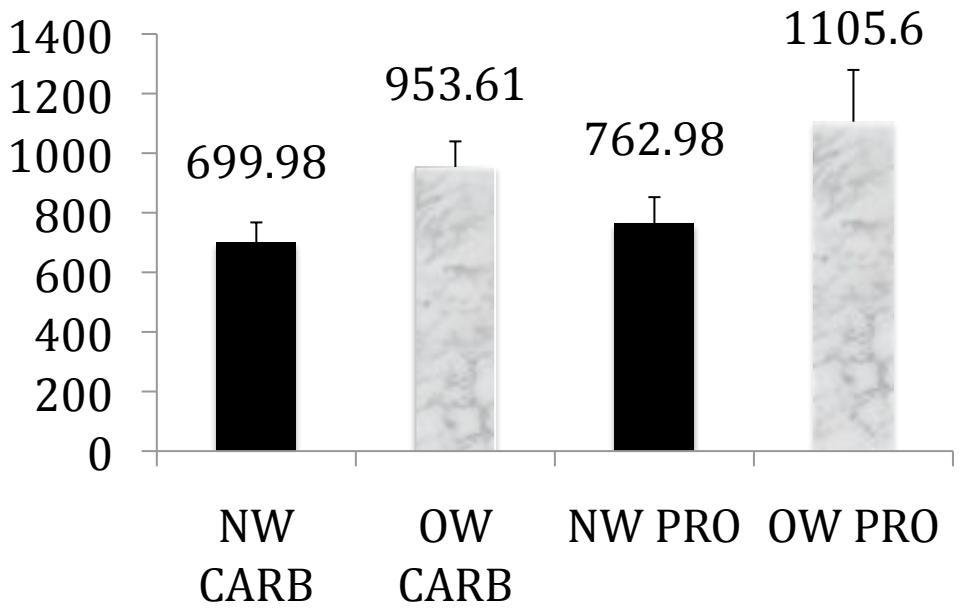

Figure 2. A comparison of the normal weight group and the overweight group and the amount of calories consumed at lunch after either a carbohydrate or protein breakfast.

Discussion

The results stated that a carbohydrate or protein breakfast had similar affects on the amount of calories consumed during lunch. Therefore, after a carbohydrate breakfast, subjects consumed almost as many calories compared to when the subjects ate the protein breakfast.

Previous literature supported that proteins provided longer periods of satiation than carbohydrates (Paddon-Jones et al., 2008; Astrup, 2005). Protein meals also decreased energy intake 25% in comparison to a high carbohydrate meal (Westerterp et al., 2009). Latner and Schwartz (1999) reported similar results. The present study evaluated the effects of the macronutrients served at breakfast. The fat in grams remained constant in the carbohydrate and protein breakfast. Latner and Schwartz (1999) protein and carbohydrate meals were served at midday and the fat in grams varied amongst the protein and carbohydrate lunches, ranging from 9 to 0 grams of fat. Fat content was increased in the protein meal, which led to an increase in satiety in comparison to the carbohydrate meal. Major differences of Latner & Schwartz's (1999) study and the current one were they only had women participants and the meals were in liquid form. These variations in meal composition and participants as well as the discrepancy in fat content and the time of day the meal was given in Latner & Schwartz's (1999) study could have attributed to why the protein breakfast resulted in decreased energy intake. Decreased energy intake was affected by meal composition, liquid or solid, and macronutrient composition, the amount of protein and fat.

Perhaps a cause of the results being insignificant was the buffet style of lunch. Exposure to the *ad libitum* lunch buffet attributed to large amount of calories consumption. Fisher and Birch (2002) stated that even when young girls were not hungry the presence of large portions of food influenced them to keep eating. Although the participants were instructed to quit eating

when satiety was reached, the abundant presence of food could have hindered them from stopping at the appropriate time. Per day, the average caloric consumption for boys and girls, aged 9 to 13, is 1700 kcals (Gidding et al., 2005). The mean caloric consumption after the carbohydrate breakfast was 808.68, which was 47.56% of their daily caloric intake. The mean caloric consumption after the protein breakfast was 902.57, which was 53.09% of their daily caloric intake. After a carbohydrate breakfast approximately 800 calories were consumed at lunch. In a study conducted by Leidy & Racki (2010), 500 calories were consumed during lunch after a carbohydrate breakfast. After a protein-rich breakfast, the approximate caloric intake during the *ad libitum* lunch decreased to 370 calories (Leidy & Racki, 2010). The participants in Leidy and Racki's (2010) study ate significantly less at lunch than the participants in the current study. The protein-rich breakfast in the study conducted by Leidy and Racki (2010) was comprised of 49.1 grams of protein, while the protein breakfast in the current study consisted of 18 grams of protein. The large discrepancy in the amount of protein served during breakfast could have influenced the favorable outcome of the protein-rich breakfast, in the study by Leidy and Racki (2010). The higher the amount of protein served during breakfast caused a lower amount of caloric consumption during lunch.

When the subjects were analyzed by normal and the overweight groups, the difference of total calories consumed at lunch from a carbohydrate and protein breakfast was notable. In normal weight subjects, the difference in the means of the total calories consumed after a protein breakfast and total calories after a carbohydrate breakfast was 63.01 calories. Overweight participants consumed 151.99 calories more during lunch after eating the protein breakfast. Overweight adolescents in comparison to normal weight adolescents consumed more calories per

day (Skinner, Perrin, & Steiner, 2012). The carbohydrate breakfast resulted in lower calories consumed during lunch compared to the protein breakfast.

Alviña and Araya (2004) conducted a study that compared the digestion rates of carbohydrates found in traditional Chilean meals. There were 48 overweight and normal weight participants in the study, aged 3-6 years. The two meals were both primarily comprised of carbohydrates but one was comprised of more starches and greater amounts of simple carbohydrates, while the other consisted of noodles and more complex carbohydrates. The results determined children were more full from the meal with a slow digestion rate of carbohydrates, the spaghetti meal, rather than the meal with a rapid digestion rate, the potato meal (Alviña & Araya, 2003). It was also found that obese children have a higher energy intake after consuming the carbohydrate meal with a fast rate of digestion (Alviña & Araya, 2003). Carbohydrates with a slower digestion led to a lower energy intake in comparison to carbohydrates with a faster digestion rate. Overall these numbers are high. Since a simple carbohydrate was the primary macronutrient in the carbohydrate breakfast it could have affected why there was no significant outcome.

The small sample size was a limitation of the current study. If there was a larger sample size, there could have been a significant difference between the two breakfasts and calories consumed during lunch. An increased number of participants decreased the effect the outliers had on the means. In regards to the protein breakfast, participants consumed between 353.07 calories and 2529.15 calories. The sampling error was smaller for larger sample sizes, resulting in a greater statistical power (Lipsey & Hurley, 2009). The limitation would be great to explore during future research.

Conclusion

Protein and carbohydrate breakfasts do not affect caloric intake at lunch. In comparison, neither macronutrient substantially prolonged satiety in children. The rising obesity rates cannot be thwarted from simply picking a carbohydrate or protein breakfast. More research should be conducted to determine which macronutrient leads to the least amount of calories consumed at lunch.

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