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Abstract: Although research has shown that proper nutrition is associated with improved physical health, eating healthfully is a challenge for many individuals because caloric restriction is not well-tolerated on a long-term basis. The purpose of this study was to assess the effects of the Daniel Fast—a biblically-based, *ad libitum,* vegan eating plan—on physical health as measured by weight and metabolism. 22 subjects (females; 18-22 years) completed a 28-day Daniel Fast following guidelines provided. Subjects reported to the lab following an overnight fast for pre-fast evaluations. After 21 days of fasting, they reported to the lab for post-fast evaluations during the final week of the fast. Resting heart rate, resting metabolism, and anthropometric variables were measured and a dietary survey was administered. Dietary records were kept for 3 days prior to the fast and during the final week of the fast. The following variables were significantly ($p<0.05$) lower following the fast: resting heart rate, weight, resting energy expenditure, protein, sodium, cholesterol, and diet score. Fiber intake increased ($p=0.0085$). No significant difference was noted for fat oxidation ($p>0.05$) and these changes varied among subjects. A 28-day period of dietary restriction in accordance with the Daniel Fast is well-tolerated by young women on a university campus, promotes moderate weight loss, and may impact changes in metabolism.

Research has shown that the type of fuel chosen to nourish the body relates to how well the body functions and how much at risk it is for disease (Fraser, 2003). Researchers also have found indications that a proper diet is probably the most powerful weapon humans have against disease and sickness (Campbell & Campbell, 2004, p. 3). When Campbell, Ph.D. and Campbell II, M.D. examined the relationship between animal product consumption and chronic illness, their study led to the authorship of one of the most popular books on modern nutritional science. Through what is now commonly known as The China Study, these researchers found that people eating a plant-based, whole foods diet minimizes and may even reverse the development of certain chronic diseases (Cummings, 2012).

Eating fruits and vegetables at least five times a day is one of the top four modifiable health behaviors related to disease and well-being; however, research has also shown that only 23.3% of American actually choose to follow this behavior (Reeves & Rafferty, 2005). Even though proper nutrition has been shown to be one of the most powerful influences on physical health, it seems to remain excluded from lifestyle choices of many people, thereby preventing them from experiencing the potential benefits of a healthy diet.

One way to encourage proper dietary choices is through religious fasting. Fasting has been defined in these investigations as “partial or total abstention from all foods, or a select abstention from prohibited foods” (Trepanowski & Bloomer, 2010, p. 1). Three types of fasts have been studied specifically—caloric restriction, alternate-day, and dietary restriction fasts. A caloric restriction fast reduces the caloric intake by a certain percentage of normal consumption, an alternate-day fast consists of a feasting period and a fasting period, and a dietary restriction fast involves restricting the content of dietary intake with little or no reduction in total calories consumed (Trepanowski & Bloomer, 2010). When these types of fasts were examined in a religious context, each was found to promote great improvement in physical health while also fostering sustainable healthy lifestyle choices and spiritual growth (Trepanowski & Bloomer, 2010).

One specific type of dietary restriction fast known as the “Daniel Fast” has become especially popular during recent years. Also practiced because of spiritual benefits, the fast typically lasts 21 days, with many Christians choosing to fast for longer or shorter periods of time. This religious fast is popular because instead of involving total abstention from food, the content of the diet is modified while the quantity of food remains unlimited. This characteristic qualifies the Daniel Fast as what is scientifically referred to as an *ad libitum* diet—it allows for unlimited intake of food as long as the type of food is restricted to fruits, vegetables, whole grains, legumes, nuts, and seeds, and excludes sweeteners, additives, refined food, white flour, caffeine, dairy, eggs, and meat. No sugars, meats, or wines are allowed during the fast. The restriction to unlimited quantities of plant-based, nutrient-dense foods allows individuals to experience enjoyment and satisfaction during the fasting experience.

The guidelines for the Daniel Fast are derived from the biblical story of Daniel’s exile to Babylon, found in the first and tenth chapters of the book of Daniel. In Daniel 1:8-9, the Bible says, “Daniel resolved not to defile himself with the royal food and wine, and he asked the chief official for permission not to defile himself this way. Now God had caused the official to show favor and sympathy to Daniel, but the official told Daniel, ‘I am afraid of my lord the king, who has assigned your food and drink. Why should he see you looking worse than the other young men your age? The king would then have my head because of you’” (NIV). Because the guard was hesitant to agree to his request, Daniel suggested that the guard test him and his three friends for 10 days and then compare their appearance to that of the other young men who continued to eat the food and wine assigned by the king. After the 10 days, Daniel and his friends were found to be not merely acceptable, but exceptional before the king (Daniel 1:19). After eating only “pulse” (food grown from seed) and water instead of the royal food and wine, Daniel and his friends looked healthier and better nourished than those who indulged in the royal food (Bloomer et al., 2010).

Another instance of Daniel’s dietary discretion and restriction is found in the tenth chapter of Daniel. This time, he mourned for three weeks, or 21 days, during which he “ate no choice food; no meat or wine touched [his] lips…” (Daniel 10:2-3, NIV). God rewarded Daniel’s efforts to honor Him and Daniel benefitted from his choices spiritually, mentally, and physically

(Daniel 10). The modern-day Daniel Fast was developed as a 21-day fast based on this biblical foundation. It is now well-known, widely practiced, and increasingly supported by scientific research.

Background

Research on the Daniel Fast has found that individuals with metabolic and cardiovascular diseases can experience improvements in disease prognosis if they implement the dietary habits of the fast (Bloomer et al., 2010). Although centered on a spiritual purpose, the Daniel Fast utilizes principles of good nutrition as a foundation and provides an opportunity to explore the impact of whole foods and religious fasting on the body.

A common theme for many "diets" is the goal to lose a certain amount of weight by restricting caloric intake and achieving negative energy balance—consuming fewer calories than are expended. Diets, along with certain types of fasting, allow dieters to choose any food option as long as the amount is restricted. This is based on the assumption that the quantity of calories is more important to health than the quality of those calories (Bloomer et al., 2010).

The assumption that caloric restriction is most important may not be true in all instances, however. One drawback to caloric restriction is that the metabolism can slow down if not enough calories are consumed. The resting metabolism may be repressed by as much as 20% when an individual begins to follow a diet that restricts energy intake drastically (Kinucan & Kravitz, 2006). The body perceives energy deficiency as a threat and reacts by burning fewer calories to preserve energy. This can eventually lead to positive energy balance and weight gain because when food is consumed without restriction again, the metabolism has already slowed down and must adjust in order to burn the additional calories. Studies examining energy expenditure in subjects who restrained eating versus subjects who did not restrain eating found that those who restrained food intake also restricted calories significantly which could cause the metabolism to slow down and result in weight gain when dieting stopped (Manore et al., 1991). This cycle, which often results from dieting, can prove discouraging to individuals trying to achieve and maintain weight loss.

Even though the total amount of energy consumed as calories is an important consideration, studies have shown that the type of food consumed may be just as important to consider (Bloomer et al, 2010). For this reason, Dr. Fuhrman, M.D., sought to look past quick-fix diets to find a more satisfying and scientifically sound weight loss program. He has developed a diet based on the formula Health=Nutrients/Calories (Fuhrman, 2002) which means that when the ratio of nutrients to calories is high, body fat will decrease more quickly. The more nutrient dense the calories are—the higher the quality of the type of food consumed—the more satisfaction and satiety occurs with fewer calories. His research has even found that cravings for fatty and processed foods will disappear over time, making the pattern of eating more enjoyable and more sustainable long-term (Fuhrman, 2002).

In accordance with Dr. Fuhrman's research, the Daniel Fast differs from many diets on this point: the goal is not a certain amount of weight loss via the quantitative restriction of calories. Instead, the Daniel Fast allows *ad libitum* intake of whole, nonprocessed foods—the type of food is restricted while the amount of food consumed is left to the discretion of the individual. As a result, previous studies on the Daniel Fast have shown reductions in total caloric intake, protein, total fat, saturated fat, trans fat, and cholesterol, and increases in carbohydrate and fiber (Bloomer et al., 2010). For the average participant in a Daniel Fast, processed, fried, and non-nutrient dense foods are included in dietary intake prior to beginning the fast, and the elimination of such lower quality foods results in decreased caloric consumption and the improvement of metabolic and anthropometric health factors (Bloomer et al., 2010).

Because the Daniel Fast does not restrict caloric intake, it has the potential to help individuals avoid cyclic dieting. Thus, the fast also has the potential to balance emotional satisfaction from food with energy balance and physical benefits. Rather than merely reducing caloric intake the purpose of the Daniel Fast is to restrict the type of food consumed, thereby increasing the quality of the fuel the body receives in a way that is sustainable as a lifestyle rather than as a temporary diet solution.

Metabolism

Before exploring the effects of the Daniel Fast on the body, a foundational understanding of metabolism is necessary. The most basic measurement of metabolism is known as the resting energy expenditure (REE)—the amount of energy in the form of calories—required to maintain all physiological functions while the body is in a state of rest (Manore, Berry, Skinner, & Carroll, 1991). This amount of energy required to keep the processes of the body performing at rest is also known as the resting metabolic rate (RMR) and accounts for 60-65% of the total daily energy expenditure used during a 24-hour period (Kinucan & Kravitz, 2006). The REE is also a primary indicator of whether or not the body is efficient in using food for energy.

Every food consumed contains energy units called calories and the goal of metabolism is to achieve energy balance with these energy units. Energy balance occurs when the number of calories used is equal to the number of calories consumed, resulting in the canceling out of calories and maintenance of weight. Energy balance is important because the more that caloric intake exceeds expenditure, the more energy tends to be stored as fat resulting in weight gain which can be a contributing risk factor for lifestyle diseases (Goris & Westerterp, 2007). When the calories consumed are put to good use instead of being stored, they are being utilized efficiently.

Beyond the complexity of caloric intake and the efficient use thereof, metabolism includes another very important component: the Respiratory Quotient (RQ), a number that provides a quick indication of what the body actually uses for energy. The body can use different types of fuel—also referred to as substrates—and the two primary options are fat and carbohydrate (CHO). The RQ is a ratio of carbon dioxide output to oxygen consumed and is used to analyze fuel utilization by estimating the percentage of energy metabolism taken from CHO and fat (Powers & Howley, 2012). A measured RQ of 0.70 indicates exclusive metabolism of fat, and an RQ of 1.0 indicates metabolism of solely CHO. A measured RQ of 0.85 indicates an equal contribution from both fat and CHO as energy substrates. The exploration and study of RQ is important because some studies indicate that the inability of the body to oxidize dietary fat is a risk factor for positive energy balance leading to weight gain (Goris & Westerterp, 2007).

Purpose

The Daniel Fast was implemented as a wellness ministry at Southern Adventist University (SAU). Details of the SAU Daniel Fast were closely modeled after the principles set forth in *The Daniel Fast* written by Gregory (2010). Although Gregory's book and most previous studies are based on 21-day Daniel Fasts, research has shown that as people adjust to a nutrient-dense and plant-based diet, they may potentially develop sustainable eating patterns that, unlike temporary diets, lead to both short-term and long-term improvements in health (Fuhrman et al., 2010). To this end, a fourth week was added to the SAU Daniel Fast in order to encourage the development of sustainable dietary and spiritual lifestyle habits.

The specific aim of this study was to investigate the effects of dietary intake changes on the metabolism and anthropometric variables in order to determine if the Daniel Fast can have a positive impact on physical health. The following questions were proposed as the main focus of the study: Does weight loss occur during a Daniel Fast? Does the metabolism of fat increase as a result of the Daniel Fast? It was hypothesized that each subject would experience a moderate decrease in weight. And because researchers suggest that diet manipulation can make the body more likely to burn fat, it was also hypothesized that metabolism of fat would increase as a result of fasting in accordance with Daniel Fast guidelines (Kiens, Alsted, & Jeppesen, 2011).

Research Design

Due to the nature of this Daniel Fast, this study involved a pre-post assessment and did not include a randomized assignment. The participants were not limited to females with known risk factors because the goal was to observe the effects of a spiritually-based eating plan on all types of young female students at SAU. The observed sample of females represents the potential effects of the Daniel Fast on other young women in the population.

Subjects and screening. The subjects for this study were females between the ages of 18 and 22 years (n=22) who attend SAU (Figure 1). Thirty-three subjects were initially recruited to participate and 31 subjects were enrolled. Twenty-two subjects completed the fast and testing procedures. The majority of subjects were either African American or White (Figure 2). Using BMI, 14 subjects were classified as normal body weight (BMI 18.5-24.9 kg/m^2), five were classified as overweight (BMI 25-29.9 kg/m^2), and three were classified as obese (BMI $\geq$ 30 kg/m^2) (Centers for Disease Control and Prevention, 2011). The weight range was also wide (109.5-195 lbs.) and subjects practiced a variety of exercise and dietary habits prior to the fast. Baseline characteristics for this study are described in Table 1.

Potential subjects were screened prior to participation using a standard questionnaire. Prior to joining the study, all fasting subjects were informed of all procedures and requirements in accordance with University Institutional Review Board for Human Research Subjects guidelines (H10-06). Participants were recruited using advertisements and female students volunteered to be a part of the metabolic testing without any promised incentive.

The Daniel Fast design. In the process of planning this study, previous research on the Daniel Fast was consulted, including the first known scientific investigation of the Daniel Fast. The study, conducted by Dr. Bloomer (2010), involved a 21-day *ad libitum* fasting period using the same dietary restrictions used in the current study. Gregory's book *The Daniel Fast* (2011) also provided specific guidelines on how the diet should be restricted. The current study slightly modified these guidelines by not allowing textured vegetable protein (vegetarian meat substitutes) to be eaten during the fast. The food list was provided to all subjects for easy access and the research coordinator, a registered nurse, and an exercise physiologist were available to field any questions during the fast.

Variables. In accordance with earlier investigations, the independent variable in this study was the change in dietary intake during the first 21 days of the Daniel Fast (Bloomer et al., 2010). Initial testing was conducted 2 weeks before the fast began. Subjects were also instructed to record 3 days of pre-fast dietary intake. The second evaluation was performed during the fourth week of the fast after at least 21 days of fasting had been completed. The dependent variables included REE, RQ, weight, body composition, perceived effects, and a dietary survey score. Changes in caloric intake, fat oxidation, and body weight would be attribute to the dietary restrictions.

Methods

The initial, pre-fast evaluation included measurement of the following: 1) resting metabolic rate, 2) weight, and 3) body composition. All laboratory measurements were performed in the early morning after an overnight total fast. A dietary survey was also used to compare the current diet to fasting guidelines.

Anthropometric Measurements

Body composition was analyzed via bioelectrical impedance analyzers. Bioelectrical impedance determines percentage of body fat (%BF) using a low-voltage current, which alternates through the body. The current is conducted more readily by lean tissue, while fat and bone are less conducive (Zarowitz & Pilla, 1989). This method has been used by researchers, compared to other more invasive and time-consuming measures of body composition, and validated as a safe and efficient method for measuring body composition. Weight was measured using a calibrated medical scale. Body mass index was calculated as weight divided by height and was found using the bioelectrical impedance device.

Resting Metabolic Rate Testing

Following an overnight fast of at least 10 hours, subjects reported to the Human Performance Lab for the measurement of RMR. Each subject was to lie quietly for 20 minutes in a neutral temperature environment and was told not to listen to music or to fall asleep. Breath-by-breath oxygen and carbon dioxide analysis was performed using the ParvoMedics Metabolic Analyzer®. Average oxygen consumption was calculated and was used to determine the calories burned at rest (REE) and the percentage of those calories from carbohydrate or fat.

Dietary Records

Before the fast began, subjects were given Daniel Fast dietary guidelines. The amount of processed foods allowed in the plan was very limited, but a list of acceptable processed foods was provided to the subjects and included unsweetened milk substitutes, tofu, and certain types of pre-made whole grain bread. The subjects were asked to keep a log of dietary intake for 3 days before the fast and for 6 days during the final week of the fast. The websites LiveStrong.com and MyPlate.gov were used by subjects to record dietary intake.

Dietary Survey

All participants in the Daniel Fast were asked to complete a dietary survey using an online survey engine. The questions included inquiries about the amounts of certain foods eaten, time of day for meals, frequency of snacks, amount of sugar consumed, and classification of diet (vegetarian, pescatarian, etc.). These surveys were quantified so that a greater diet "score" indicated a larger divergence between the current diet and the guidelines of the Daniel Fast. A post-fast dietary survey was also prepared, distributed, and quantified. The comparison of these dietary scores was used as a tool to look at the change in dietary intake as a result of the fast. A greater change in score indicated a greater change in diet as a result of the fast.

Physical Activity

Prior to this study, the subjects did not maintain any certain diet and may or may not have exercised regularly. Subjects were instructed to maintain whatever exercise regimen they had been using before the fast in order to eliminate exercise as a variable in the study.

Data Collection and Statistical Analysis

Data was collected confidentially with numbers assigned to each subject. The testing results were kept in a locked file box, accessible only to the research coordinator and lab assistants. The data was then entered according to subject number into a spreadsheet and analyzed using the T-test statistical method.

Results

Thirty-one subjects were initially enrolled in the research study. Twenty-two subjects completed the fast while remaining eligible for data analysis.

Subjective Results

Individual perceptions of satiety (satisfaction with food) varied with individual adaptation to whole foods during the fast. Some subjects complained that they did not feel satisfied while others claimed complete satisfaction. Many subjects noted that they enjoyed Daniel Fast food choices and appreciated the *ad libitum* design. Subjects also said they "felt lighter" and "felt great," and several reported more "strength" and "endurance" during their normal exercise routines. Some subjects said they would continue to incorporate some of the food choices into their dietary style after the fast.

Anthropometric Results

Previous research studies on the Daniel Fast have not shown large differences in weight, BMI, body composition, or RHR (Bloomer, 2010). As hypothesized in this study and in accordance with previous research, moderate changes were observed. Changes included a moderate decrease in average body weight (3.58 lbs, p=0.00001). Weight changes varied from as much as 8.0 pounds lost to 2.5 pounds gained, and eight subjects lost greater than 5 pounds and two subjects gained less than 3 pounds. There was also a slight decrease in BMI (0.87, p=0.001), a small decrease in %BF (1.19%, p=0.004), and an unexpected decrease in RHR by an average of 7.41 beats per minute (p=0.00015) (see Table 2).

Metabolic Results

The REE decreased as expected during the fast (p=0.00005) (see Tables 3 and 4). The change in average RQ was 3.63% in the direction of increased CHO burn. The average percentage of fat oxidized at rest (%FAT) decreased, and the average percentage of CHO oxidized at rest (%CHO) increased. However, this change in substrate oxidation was not significant for %FAT (p=0.095, NS) or %CHO (p=0.095, NS). Relative to individual subject data, 52% of subjects either increased or maintained the same fat burning levels while 48% burned more CHO. These results split the sample almost exactly in half between increased %FAT and increased %CHO (see Figures 3 and 4).

Dietary Results

Only 12 of the subjects completed food logs both pre-fast and during the final week of the fast. As expected, daily dietary intake from pre-fast to the final week of the fast changed in several areas. Average total calories consumed per day decreased by 9.05% (p=0.069, NS). There was also a decrease in cholesterol and sodium consumption, with a change of 91.7% (p=0.0015) and 53.5% respectively (p=0.00014). Carbohydrate intake (measured as a percentage of macronutrient) intake increased by 7.40% (p=0.321, NS) and intake of protein (PRO) decreased significantly ($p<0.01$). Intake of fiber per day also increased by 172.2% (p=0.0085) (see Table 5). Pre-fast dietary surveys indicated an average change in diet of 60.4% ($p<0.01$). This change indicates that all subjects changed their diet during the fast to be closer to Daniel Fast guidelines.

Discussion

Results from the present study indicate that 28 days of a Daniel Fast 1) reduce cholesterol and sodium intake and increase carbohydrate and fiber intake, 2) promote moderate weight loss and change in body composition, 3) promote decreased resting energy expenditure, 4) may or may not directly affect the metabolism of fat or carbohydrate, 5) are well-tolerated due to the *ad libitum* nature, and 5) may be useful for encouraging the development of healthy lifestyle habits that are long-lasting and beneficial for physical health.

Dietary Intake

Dietary records are important for evaluating whether or not subject eat within recommendations for a healthy diet during the Daniel Fast. According to the Center for Nutrition Policy and Promotion (CNPP, 2011), recommended guidelines for a balanced diet for women of this age are <300 mg cholesterol, <2300 mg sodium, 45-65% CHO, 10-35% PRO, 20-35% fat, and 1800-2000 calories. During the fast, six of the 12 subjects who completed food logs were in the recommended range for CHO consumption—the other half were slightly over the recommended amount. Protein and fat were within the recommended proportion of diet with 66.7% of subjects consuming the recommended amounts.

The CNPP (2011) has set the Adequate Intake (AI) for dietary fiber for women at 25 grams per day, and most subjects exceeded this amount significantly after the fast with the average increasing from 18 grams per day to 28 grams per day ($p=0.0085$). This increase in dietary fiber is significant and may be one of the largest benefits to the Daniel Fast eating plan. According to research and set guidelines, naturally occurring dietary fiber is thought to reduce the risk of cardiovascular disease, obesity, and type 2 diabetes (CNPP, 2011). Thus, consuming higher amounts of fiber during a Daniel Fast could promote physical health and well-being.

The reason for the change in fiber intake can be attributed to the change in the content of the diet during the Daniel Fast. Dietary fiber is the form of carbohydrates that occurs naturally in plants and, due to its non-digestible nature, helps to provide feelings of fullness and satiety. The best sources include beans, peas, vegetables, whole grains, nuts, and some fruits (CNPP, 2011). All of these foods were included in the whole foods acceptable during the Daniel Fast. Refined flours and processed foods contain significantly lower amounts of naturally occurring dietary fiber and thus, replacing the intake of such foods with more fibrous foods during the Daniel Fast caused a significant increase in the dietary fiber consumed by subjects (CNPP, 2011).

Interestingly, total average calories decreased even though subjects could eat unlimited amount of food. As seen in previous research on the Daniel Fast, this indicates that when eating nutrient-dense foods with more fiber, satiety increases and thus the intake of calories is reduced (Bloomer et al., 2010). Another recent study found that a nutrient-dense diet makes the experience of hunger less unpleasant even though fewer calories are consumed (Fuhrman et al., 2010). In accordance with this research, it is likely that subjects consumed a higher volume of nutrient-dense foods that provided satisfaction without providing as many calories even though they were allowed to consume as many calories as they desired.

Changes were also observed in the consumption of less desired nutrients—cholesterol and sodium. During the final week of the fast, every subject consumed less than the recommended maximum for both cholesterol and sodium. Because cholesterol is only found in animal foods, the Daniel Fast guidelines eliminate the possibility of consuming cholesterol. Additionally, sodium content of foods comes mostly from salt added during food processing, thereby making processed foods a major contributor to high amounts of sodium (CNPP, 2011). Eliminating animal foods as a source of cholesterol and processed foods as a source of sodium is the most likely cause of the decrease in cholesterol and sodium during the Daniel Fast. Because high sodium and high cholesterol can be contributors to lifestyle diseases such as high blood pressure, diabetes, and heart disease, adopting a dietary lifestyle that maintains healthy levels of both sodium and cholesterol could be beneficial to overall health and even reduce the risk for cardiovascular disease (CNPP, 2011).

Overall, the Daniel Fast dietary intake seems to follow the recommended guidelines set forth for Americans by the CNPP (2011): decreasing dietary cholesterol and sodium intake, decreasing the consumption of refined grains, solid fats, and added sugars, and increasing intake of dietary fiber, vegetables, fruits, whole grains, healthy fats, and lean protein. Although not all of these components were measured during the fast, the fasting guidelines set forth clear principles that are in line with recommendations.

Weight Loss

The speculation that subjects would lose a moderate amount of weight was supported by the amount of weight loss observed. The average decrease in weight was moderate, but changes varied among subjects (see Figure 5). As subjects ate a diet more similar to the Daniel Fast principles there was a slight trend for more weight loss, with 14.9% of the variation in weight being explained by the variation in diet (R^2=0.149) (see Figure 6). This indicates that the Daniel Fast provides guidelines for a balanced diet that can positively influence weight—not necessarily for weight *loss* but rather the maintenance of a healthy weight.

Body Composition

Although BMI has become one of the most foundational ways to classify healthy weight levels, this measurement cannot show how fat and muscle are distributed throughout the body (Ainsworth, 2004). For this reason, body composition is also important because it analyzes beyond the number on the scale and measures the components of that number. The variations in weight seen during the Daniel Fast call for an exploration into these components. Looking at these factors is crucial because if weight is lost in the form of lean body mass, it can carry a health risk rather than health benefit (Kingsland, 2005). In the case of this Daniel Fast, there was no strong relationship between the amount of dietary change and decreased %BF (R^2=0.017). A greater change in diet did not necessarily result in a more significant loss of weight or body fat.

Weight loss and body composition changes may have occurred based on the changes in eating style, but the Daniel Fast alone does not ensure that the weight lost is not lean body mass.

Research shows that physical activity added to initial diet intervention is important because it provides the most effective reduction in fat cell size (You, Murphy, Lyles, Demons, Lenchik, & Nicklas, 2006). Additional research has shown that the only way to increase fat burn other than consuming more fat is to increase physical activity (Goris & Westerterp, 2007). Because physical activity is an important consideration when eating healthfully—it helps to preserve lean body mass during weight loss—participants in the Daniel Fast should be encouraged to maintain healthy exercise habits in addition to dietary changes.

Metabolism

According to previous research, when body weight or body composition changes, the total number of calories necessary to maintain energy balance changes as well (Manore et al., 1991). The observed changes in body composition and weight during this Daniel Fast influenced total need for calories measured as REE. In this study, the REE decreased as expected ($p<0.05$), but this was just one component of the metabolic activity. Varying changes in substrate oxidation call for more comprehensive discussion and further research.

It was hypothesized that fat oxidation would increase as a result of the Daniel Fast, but this hypothesis was not supported by the results. During the final week of the fast it was found that %FAT had increased, decreased, or remained unchanged (see Table 4). There were no direct correlations or consistent changes in RQ—some subjects shifted towards higher %CHO while others shifted towards higher %FAT. This split may indicate that simply changing dietary habits is not the sole factor in determining substrate oxidation. Weight loss, decreased %BF, and changes in dietary intake are other potential factors that deserve attention.

In regards to weight loss, no correlation was found between the amount lost and the change in RQ (R^2=0.003). The majority of subjects were in one of two groups: one group increased CHO oxidation with a change in weight and the second group increased fat oxidation with a change in weight. The shift towards burning CHO or fat could occur simultaneously with the loss of weight. However, the change in RQ tended to be larger for subjects whose %CHO increased. In other words, a shift towards fat oxidation had a lower percent change—less displacement—than a shift towards CHO oxidation. Despite this observation, no significant relationship can be found between the loss in body weight and the change in substrate oxidation based on the results in the current study (see Figure 7).

The relationship between RQ and body composition can be explored as well. Some research studies have hypothesized that subjects with a higher %BF would naturally burn more fat while other studies have proposed that higher %BF may actually decrease fat oxidation, making lean body mass more desirable for increased fat burn (Kriketos et al., 2000). However, one study explored this relationship between %BF and change in substrate oxidation, and found that fat oxidation in women is not related to body fat or lean body mass (Kriketos et al., 2000). In accordance with this research, subjects in the current study with a higher %BF at the beginning of the fast did not necessarily have a greater change in metabolism toward or away from fat oxidation. These findings, along with past studies, suggest that REE and substrate oxidation may not be directly related to body composition.

The final possible factor measured in this study was the dietary intake during the fast. There was a slight trend with 22.4% of the change in RQ being explained by the diet based on the diet survey scores (R^2=0.224). The RQ was more likely to change as the significance of dietary change increased. Increases in fat oxidation were also slightly higher for subjects with greater dietary change **(**see Figure 8).

During the Daniel Fast, average CHO intake slightly increased which could potentially have affected the percentages of substrate oxidized. A study done on the factors regulating fat oxidation found that using dietary intake to manipulate stores of glycogen—a form of CHO found in muscle—could increase or decrease fat oxidation (Kiens et al., 2011). Lower CHO intake and lower glycogen levels would promote higher fat oxidation. When carbohydrates are controlled, insulin does not need to increase dramatically because there is less sugar in the bloodstream and the body is able to burn the fat consumed rather than depositing it**.**

According to these previous studies, the current study's average increase in CHO intake of 7.4% could have either increased glycogen stores or increased the body's blood sugar, decreasing the ability to oxidize fat. However, as stated, this was not the case for every subject because although CHO intake increased for 66% of subjects who completed a food log, %FAT and %CHO oxidation changed indirectly. Only 1.8% of the change in RQ was explained by the change in CHO consumption (R^2=0.0183) (see Figure 9). As with carbohydrates, the average intake of fat increased during the fast based on the food logs completed by subjects. However, no correlation was found between the amount of change in fat intake and the change in RQ (R^2=0.0002). Because no correlation was found between either macronutrient—neither fat nor carbohydrate—macronutrient consumption was not found to be the primary cause for the metabolic shifts observed.

In addition to weight loss, body composition, and dietary change, the physical activity and physical fitness could have had an impact on metabolism and substrate oxidation. Previous studies have found both that high physical fitness levels tend to yield higher rates of fat oxidation and that fat oxidation is higher in sedentary individuals with a higher body fat mass (Kriketos, Sharp & Seagle, 2000). Further research suggests that this increased fat oxidation affects the body during both exercise and at rest, meaning that it would affect the resting metabolic rate (Kriketos et al., 2000). Subjects were instructed to maintain the same exercise habits as they had been practicing before the fast. However, these exercise habits were neither quantified nor monitored. Some of the subjects began the fast as "physically active" individuals, while others were quite "sedentary." It is possible that the rate of fat oxidation changed based on pre-fast fitness level or type of activity, but further research is needed to determine how fitness and activity levels affect subjects participating in a Daniel Fast.

As discussed, none of the measured factors in the current study completely explain the variety of metabolic shifts observed—half of subjects burning more fat and half of subjects burning more CHO. The increase in %CHO is not necessarily an adverse effect of the Daniel

Fast, however. Research has found that fat oxidation may actually have negative physical effects. For example, increased fat oxidation can potentially impair glucose uptake by metabolic feedback, decreasing insulin sensitivity (Kiens et al., 2011). Thus, higher fat oxidation may not always be ideal for the body. The metabolism as a whole, however, remains an important consideration when looking at the indicators for overall health. Science has established that the body works to achieve energy balance and equilibrium and may be using specific substrates in different amounts in order to achieve this balance. What is yet to be determined are the specific variables affecting equilibrium and the timing of metabolic changes.

Discussion Summary

Previous studies report a wide variation in findings on metabolism related to body composition, dietary intake, and physical activity, and this study is no exception (Kriketos et al., 2000). Although future research is necessary to determine the cause of the metabolic "shift" observed, this study on the Daniel Fast presents many avenues with which to proceed in this endeavor. Despite the variation in findings, all subjects reported perceived feelings of well-being indicating that health benefits could be present irrespective of the direction of metabolic shift. Other health factors such as weight loss, decreased %BF, decreased BMI, and reported decreased acne, decreased perceived hunger, etc. were also observed irrespective of the change in metabolism. This indicates that the Daniel Fast does have benefits and that fat oxidation may not be the primary indicator for physical health.

Limitations and Application

During the study, limitations created several inconsistencies that could be prevented in the future. First, two different machines were used to test the resting metabolism of subjects. Ideally, each subject should have been tested before and after the fast using the same machine to ensure more efficient data collection. The discrepancy between the two machines, if any exists, is unknown. Second, some subjects were instructed not to fall asleep or to listen to music during the test while others were not given this guidance. Lastly, the largest limitation was a machine malfunction. During the post-fast testing, four subjects were tested on a machine that had a hole in one of the tubes leading to the analyzer. The data from these four tests was excluded from analysis of resting metabolism results. The subjects could not be re-tested due to the final test being done on the last day of the fast.

Although lab resources were limited, testing was done as efficiently as possible. However, if this study could be redesigned from the beginning, a more structured environment for testing would be ideal. More lab resources would be needed to ensure every test was completed with precisely the same process and on the same machine for each subject. Additionally, a closely monitored control group would be necessary for valid comparison to the data of fasting subjects.

In addition to these procedural limitations, the nature of the Daniel Fast creates limitations in the study design. For example, because subjects are free to partake of unlimited amounts of food, they are on a type of honor system. The subjects were only required to keep track of intake using the baseline 3-day food log and a 6-day log during the fast. Although the guidelines were thoroughly explained and emphasized to all subjects before and during the fast, the understanding of these guidelines may have varied from subject to subject. Therefore, the actual compliance of subjects to the fast could not be measured and ensured.

Overall, the current design of the Daniel Fast is not an ideal method for studying the metabolism, weight loss, or change in body composition. Due to the number of variables involved, precise determination of which specific dietary component is responsible for the metabolic shift and weight loss observed is difficult. In order to truly narrow the possibilities and find conclusive evidence, the focus of the study must be narrowed. Dietary consumption, fitness level and exercise, and consistency of macronutrient proportions should be monitored more closely. Unmonitored variables could have caused the metabolic rate to fluctuate during the fast and these variables should also be addressed in future studies.

Because further research is needed to determine the cause of the metabolic shift, the study design could be modified to reduce the variables potentially affecting the substrate oxidation. First, the design could include multiple tests throughout the fast to determine if weight or metabolism fluctuated during the fast or showed a constant trend. Another modified design could explore the impact of the macronutrient content of specific meals prior to testing by using multiple metabolic tests and by specifying the exact content of the meals. Further research should also take physical activity and physical fitness into account when designing a Daniel Fast study. Metabolism may be affected by the type of exercise subjects choose or by their fitness level prior to beginning the fast. The current study was limited in that it did not measure or quantify these exercise habits and therefore could not examine the impact. Finally, the design could be modified to include increased dietary intake monitoring and a measure of compliance to ensure subjects were following all guidelines accurately.

Conclusion

This investigation sought to discover the effects of a 28-day Daniel Fast on weight and the metabolism. Results showed changes in weight, body composition, dietary intake, and metabolism but with no highly significant relationships between different variables. Despite limitations, results regarding weight loss supported the hypothesis that moderate weight loss would occur. Results of metabolic testing did not support the prediction that subjects would burn greater amounts of fat, however. These findings identify the need for much more in-depth study to determine the precise variables causing changes in substrate oxidation. However, although the metabolic shift was not precisely explained, this study successfully provided a variety of ideas which could aid in designing future studies on the Daniel Fast.

This study also successfully found a method of encouraging young females at Southern Adventist University to develop enjoyable and sustainable dietary habits. Only the type of food was restricted, allowing each subject to focus on the spiritual experience while also enjoying healthful, whole foods (Trepanowski & Bloomer, 2010). Subjects became more aware of the food they consumed, gained knowledge about healthy food choices, and expressed a desire to continue eating according to the fasting guidelines after the fast was complete. If continued intentionally, such habits could develop into lasting lifestyle choices that have the potential to positively impact both perceived and measured physical health.

Tables and Figures

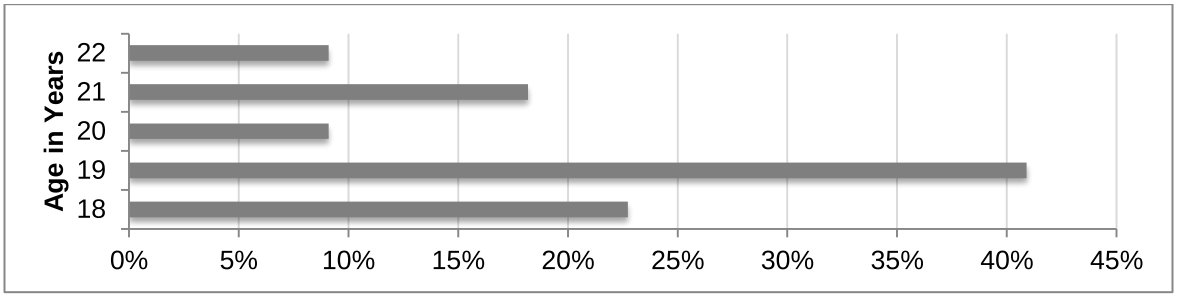

***Figure 1*. Subject age in years. Out of the subjects in this study, 41% of subjects were age 19. All subjects were between the ages of 18 and 22.**

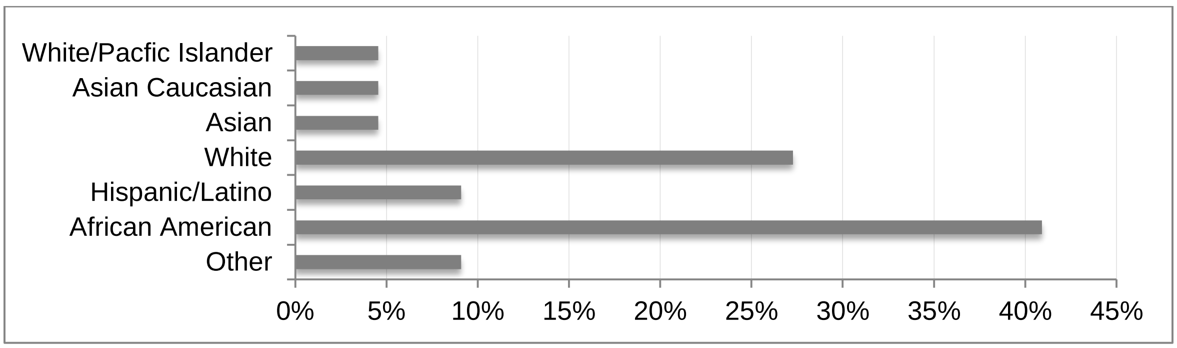

***Figure 2.* Subject race. As surveyed, subjects in this study indicated the race they identified with most. Of the 22 subjects, the majority were African American and White. The subjects were not stratified into groups based on race.**

Table 1

Pre-fasting baseline characteristics

	Weight (lbs)	BMI	Body Fat (%)	REE (kcal)	FAT burn (%)	Diet Score
Mean	147.72	24.79	26.25	1578.4	81.8	23.3
SEM	± 31.49	± 0.82	± 1.43	± 47.9	± 3.4	±1.5
N	22	22	21	21	21	18

Table 1. Baseline characteristics recorded at the time of pre-fast testing. Prior to the fast, weight was measured in pounds. Average BMI was in the "normal" range. The body composition was measured by bioelectrical impedance to find %BF. REE was 1578.38 kilocalories per day and average %FAT was 81.8%. According to the dietary survey taken pre-fast, average score was 23.3, indicating a high deviation from a vegan, whole food dietary lifestyle such as the Daniel Fast. All values are mean ± SEM.

Table 2

Anthropometric data of subjects pre and during final week of fast

Variable	Pre	Post	% Change
Weight (lbs.)	147.72 ± 31.49	144.14 ± 30.73	-2.43 ± 0.52
BMI (kg.m-2)	24.79 ± 0.82	23.92 ± 0.72	-3.28 ± 0.71
Body Fat (%)	26.25 ± 1.43	25.05 ± 1.34	-4.10 ± 0.02

RHR (bpm)	71 ± 6.7	63 ± 7.5	-10.2 ± 8.86

Table 2. Anthropometric data of subjects before and during the final week of a 28 day Daniel Fast. This table shows the mean values for each variable pre and post-fast ± SEM. The percent change was calculated as a relative value.

Table 3

Metabolic changes

Variable	Pre	Post	% Change
REE (kcal)	1578.4 ± 47.9	1412.8 ± 38.0	-9.88 ± 0.02
CHO burn (%)	18.2 ± 3.43	29.6 ± 6.72	N/A
FAT burn (%)	81.8 ± 3.43	70.6 ± 6.71	N/A
RQ	0.76 ±0.01	0.78 ± 0.02	3.63 ± 0.03

Table 3. Metabolic data of subjects before a 28 day Daniel Fast and during the final week of the fast. All values are mean ± SEM. REE decreased by an average percent change of 9.88%. RQ *increased* by 3.63% meaning that the number approached more carbohydrate burn. The distribution of values varied greatly from subject to subject. 52% of subjects had higher %FAT at the end of the fast while 48% had higher %CHO, splitting the sample almost exactly in half.

Table 4

Change in percentage fat burn at rest

Subject	Pre (%)	Post (%)	Change (%)
	61	27	-34
	54	98	44
	100	45	-55
	90	59	-31
	97	36	-61
	100	100	0
	99	64	-35
	60	100	40
	95	100	5
	100	100	0
	70	89	19
	60	100	40
	100	21	-79
	95	56	-39
	89	100	11
	80	100	20
	66	96	30
	85	25	-60
	76	95	19
	74	48	-26
	67	23	-44
Mean	**81.8 ± 3.43**	**70.6 ± 6.71**	**-11.2 ± 8.07**

Table 4. Change in percentage fat burn at rest. This table shows the raw data for subject fat oxidation. Those with a negative change decreased in %FAT while those with a positive change increased. Eleven of the 21 subjects either increased or remained the same. The mean values show that overall there was a decrease in %FAT, but the raw data shows that only about half of the subjects actually decreased in fat oxidation. All values are mean ± SEM.

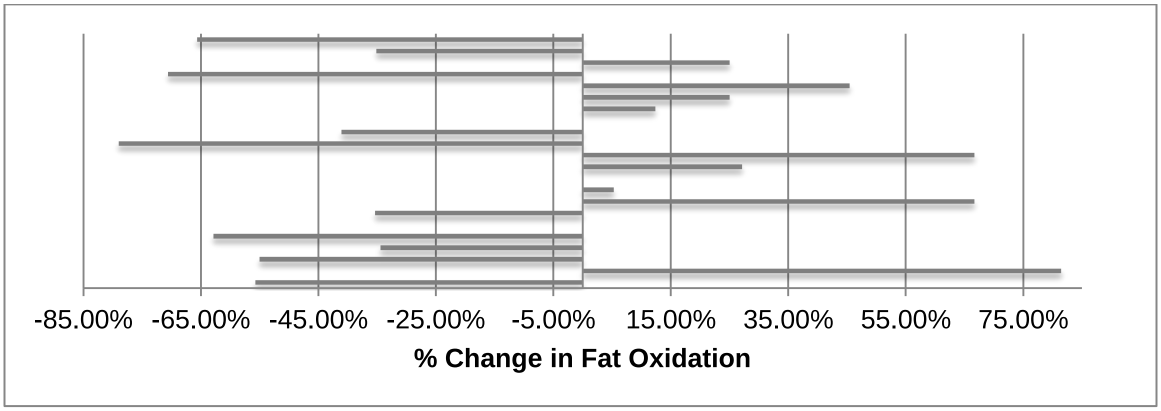

Figure 3. **Distribution of changes in percent fat oxidation. The percent change in fat oxidation from pre-fast to the final week of the fast was widely distributed: 52% of subjects increased fat oxidation while 48% of subjects burned less fat near the end of the fast.**

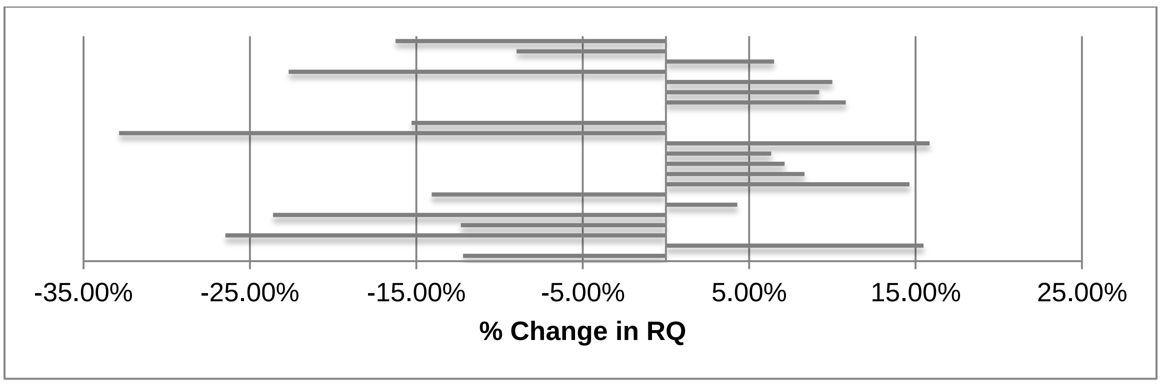

Figure 4. **Distribution of changes in respiratory quotient. This figure shows the percent changes in RQ during from pre-fast to the final week of the fast. 52% of subjects had an positive change, indicating an increase or maintenance of %FAT. 48% of subjects had a negative change indicating an increase in % CHO.**

Table 5

Dietary intake value comparison

Variable (mean)	Pre Fast	Post Fast	Control
Calories (kcal)	1490	1253	2264
Cholesterol (mg)	103	8	84
Sodium (mg)	2304	1003	3702
Carbohydrate (%)	59.17	61.52	63.00
Fiber (g)	18	28	32
Diet Score	23.3 ± 1.46	8.7 ± 0.61	19.0

Table 5. Dietary intake value comparison. From pre-fast to during the final week of the fast caloric, CHO, and fiber intake increased. Cholesterol and sodium intake decreased. The control group only completed one food log and the comparison to this food log can be seen: calories, cholesterol, sodium, CHO, and fiber were all higher than subjects during the final week of the fast. The diet score for subjects decreased as a result of the fast, and was appropriately lower than that of the control. Diet score values are ± SEM.

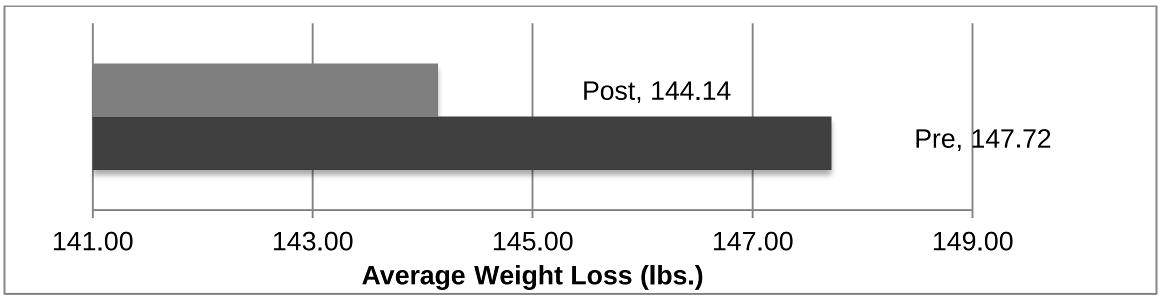

Figure 5. **Average body weight pre-fast and during final week of fast. The average loss of body weight was 3.58 lbs.. Only two subjects gained weight during the fast.**

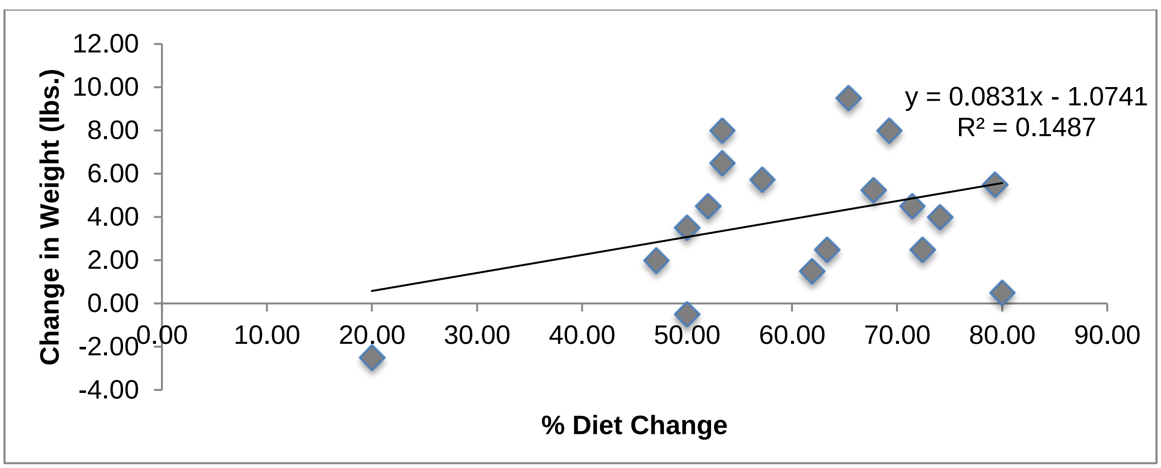

Figure 6. **Change in diet compared with loss of weight. As subjects ate a diet more similar to the Daniel Fast guidelines there was a slight trend for more weight loss with 14.9% of the variation in weight being explained by the variation in diet (R=.149).**

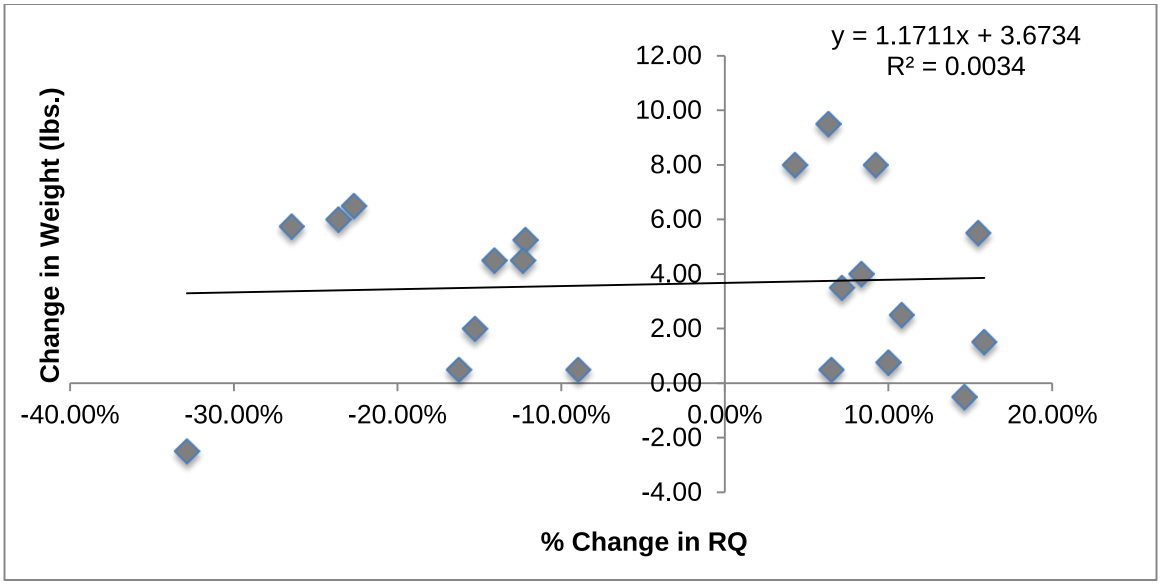

Figure 7. **Change in metabolic RQ compared with loss of weight. As RQ decreased, fat burn increased. About half of subjects had an decrease in RQ but this was not necessarily related to the amount of weight lost. Only .34% of the RQ change was explained by the change in weight.**

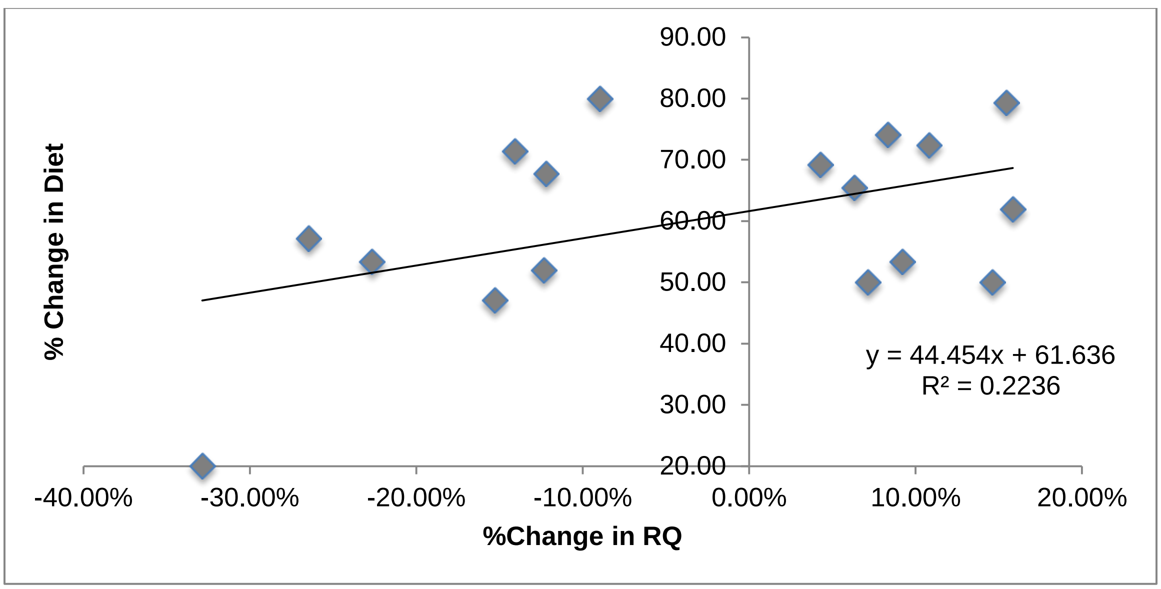

Figure 8. **Change in metabolic RQ compared with change in dietary survey score. As RQ decreased the change in diet was likely to be higher. The relationship was not extremely strong but there was a slight trend with 22.4% of the change in metabolic RQ being explained by the change in diet (R=.2236).**

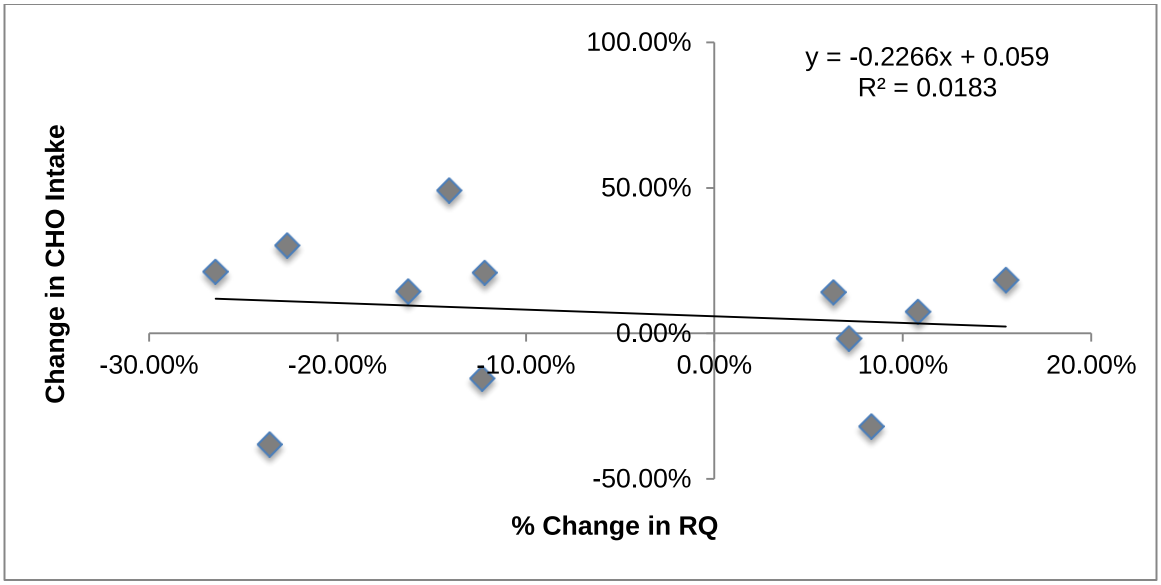

Figure 9. **Change in metabolic RQ compared to change in CHO intake. Only 1.8% of the change in metabolic RQ was explained by the change in CHO (which was an average increase of CHO intake).**

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