The Influence of Diet Recommendations on Exercise Performance, Specifically Single and Multi-Nutrient Effects

Samuel Maurer
sjmaure@clemson.edu

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THE INFLUENCE OF DIET RECOMMENDATIONS ON EXERCISE PERFORMANCE, SPECIFICALLY SINGLE AND MUTLINUTRIENT EFFECTS

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Food, Nutrition, and Culinary Science

by
Samuel J. Maurer
May 2023

Accepted by:
Dr. Elliot Jesch, Committee Chair
Dr. Greg Batt
Dr. William Bridges
ABSTRACT

Objectives: The main question in this study was “Do nutrients present within the MyPlate and Paleo dietary patterns affect exercise parameters in a positive way?” An auxiliary question was “Do nutrients present within these two diets reduce comorbidities of chronic diseases?”

Methods: This study analyzed secondary data collected from a previous diet and exercise study. Dietary records were analyzed for correlations between nutrient intake and exercise performance in both diet groups. Further stratification by VO2 peak performance was done to analyze nutrient intake differences between high and low performing individuals.

Results: The MyPlate eating pattern increased body fat percentage, blood pressure, and resting heart rate, while the Paleo eating pattern decreased these variables. The Paleo group consumed less carbohydrates, fats, and protein, and more B-vitamins, amino acids, omega-3 fats, and other water- and fat-soluble vitamins. Calcium, zinc, iron, and thiamine were positively correlated with an increase in diastolic blood pressure. Peak minute ventilation and relative VO2 peak at baseline were statistically significant in the Paleo group, while the MyPlate group had a lowered peak respiratory exchange ratio.

Conclusion: Decreasing total fat mass and increasing total lean mass through a dietary pattern that focuses on the intake of vegetables, fruits, lean meats, eggs, wild game, seafood, and nuts and seeds with limited intake of refined foods and added sugars is beneficial for exercise performance and overall health outcomes for sedentary weight stable females aged 19-28 not currently following a structured diet in Clemson, South Carolina.
DEDICATION

To my wife and family
ACKNOWLEDGEMENTS

I would like to thank my wife for supporting me through my 2 years of graduate school. I want to thank my advisor, Dr. Jesch, for the tremendous support and guidance. To Dr. Bridges, for the statistics support and guidance through difficult parts of my project. Thank you to Dr. Batt for the insights, unique perspectives, and push to achieve a journal worthy paper. I would like to thank Dr. Corbett for her guidance through my assistantship and dietetic application. Finally, I would like to thank Clemson University for educating me for 6 years through undergrad and graduate school.
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CHAPTER ONE

INTRODUCTION

Human nutrition is constantly changing with new research directing evidence-based practice. Recommendations are not the same today as they were five years ago. The United States Department of Agriculture (USDA), in tandem with the Department of Health and Human services (HHS), publishes updated health and fitness recommendations every five years, entitled the Dietary Guidelines for Americans (DGA). These recommendations are an attempt to synthesize scientific research from different fields of nutrition into a concise report. Print materials such as infographics summarizing key nutrient intakes are made for medical professionals and consumers. The goal of the DGA is to increase the health status of Americans by distributing accurate and up to date information about healthy eating patterns as well as provide healthcare personnel and consumers with coherent nutrition recommendations. (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020) (Locke, Schneiderhan, & Zick, 2018).

It is not the goal of the DGA to make exercise recommendations. The Physical Activity Guidelines for Americans (PAGA; U.S. Department of Health and Human Services, 2021) are based on current scientific research concerning exercise and health. These recommendations are meant to promote health and prevent the risk of chronic diseases through evidence-based research on physical activity and health outcomes (Chaput et al., 2020). This research is synthesized by a panel of experts using high quality academic research. Updates such as long-term benefits of exercise, risk of sedentary behavior, and guidelines for preschool-age children have been made since the initial document was published in 2008 (U.S. Department of Health
and Human Services, 2021). Additional revisions are due to new research methodologies and scientific findings related to exercise and health.

Early texts reviewing the emergence of exercise science found that most research was directed towards muscle strengthening (Nuzzo, 2021); strength and conditioning research incorporation into practice was not standardized until approximately 1979 by the National Strength and Conditioning Association (Shurley, Todd, & Todd, 2017). The first appearance of local muscular endurance on human subjects was in 1979 (Conlee & Fisher, 1979). Earlier studies were done on muscular morphological changes (Reitsma, 1969; Schumann, 1967), but these studies were performed on rats. Simple cardiorespiratory fitness research in disease populations first appeared in the 1950’s (BRUCE, LOVEJOY, YU, & McDOWELL, 1950). Later texts studying the relationship between fitness testing and lung capacity appeared in the 1960’s (Shephard, 1966; Shephard et al., 1968) with the first mention of maximal oxygen capacity being used as a marker for cardiorespiratory fitness in 1966 (Shephard et al., 1968). While strength and conditioning were the popular methodology for exercise research, Moritani and deVries (1979) studied neural adaptations to resistance training. In their paper, fifteen individuals underwent strength training for 8-weeks. The results showed that initial resistance gains were due to a brain-muscle connection with overall muscle hypertrophy becoming the major contributor after 3 to 5 weeks. Current exercise and physiology research includes advanced methods such as 3D modeling, biopsy techniques, and modern conditioning equipment. The dynamic nature of exercise science is not contained within the physiology field. The fields of cardiology, biomechanics, and psychology all utilize exercise science as a means of treatment (James Madison University, 2022). Nutrition research remains prevalent in both the exercise field and among the populous.
Relevant research in nutrition began in the early 20th century (Mozaffarian, Dariush, Rosenberg, & Uauy, 2018). Studies were focused on the identification and synthesis of vitamins and their effects in rat models. In the 1920’s, vitamins A, C, and D appeared in the literature (Heaton, 1922; Sherman, La Mer, & Campbell, 1921). The B vitamin complex and other water-soluble vitamins did not appear in the research until the 1930’s and 1940’s (Vitamin B1 & B5 1934; B2 1935; K 1936; B7 1939; B3 & B9 1943; B12 1948) (Day & Darby, 1938; György, 1935; Palmer, 1934; Parkhurst, 1927; Tauber, 1937; West & Wilson, 1939; Wright & Welch, 1943). Academics and governmental bodies focused on food fortification (adding nutrients at a higher level than occurring naturally) and/or enrichment (replacing nutrients lost in production) to prevent diseases caused by nutrient deficiencies such as beriberi (thiamine deficiency) (Fulgoni, Keast, Bailey, & Dwyer, 2011). Keats et al. (2019) and Spohrer et al. (2013) reported that foods fortified with iron, iodine, and vitamin A in developing countries led to a 34% reduction in anemia, a 74% reduction in the odds of goiters, and 41% reduction in the odds of neural tube defects.

In the middle of the 1900’s, nutrition research centered around fats and protein. Analysis of underdeveloped nations and low-socioeconomic status citizens within developed countries found a clear gap between the recommended amount of protein intake and the amount individuals were consuming (Mozaffarian, D., Rosenberg, & Uauy, 2018). Diseases caused by low-protein intake, such as marasmus and kwashiorkor, were noted. Marasmic-kwashiorkor is seen in individuals consuming low amounts of protein or overall calories and usually presents with ascites, generalized edema, poor wound healing, and failure to thrive. This disease can be detrimental to skeletal muscle content and vital fat stores (Titi-Lartey & Gupta, 2022). Modern

Nutrition and exercise are frequently studied among academics. The relationship between the two is noted by numerous authors (Richard & Koehle, 2019; Staples et al., 2011; Wackerhage & Rennie, 2006). The first relevant application of nutrition integrated into exercise studies appeared in the literature in the 1940’s and 1950’s (BANKS & REED, 1948; Haldi & Wynn, 1946; LERICHE, 1956); these studies used whole food products to enrich participant’s diets. The first mention of supplements other than food in research was in 1946 and included clinical patients recovering from hernial repair (KEETON & COLE, 1946). These early clinical trials were likely not the beginning of supplement research, rather they were part of an ongoing body of science using nutrient fortification in diets to alter either health outcomes or exercise performance. The safety and efficacy of performance enhancing dietary supplements is still not fully understood (Bailey, Gahche, Miller, Thomas, & Dwyer, 2013; Lentjes, 2019) as the production and evaluation of dietary supplements is not regulated by the Food and Drug Administration (FDA), which is the basis for the lack of data on dietary supplements. The use of dietary intake to increase ergogenic compounds is of particular interest due to its safety via food regulation by governmental bodies (i.e., FDA, USDA, EPA) and support of healthy eating habits.

As previously mentioned, dietary supplements such as creatine, multi-nutrient mixtures, or BCAAs are not regulated by governmental agencies; therefore, research surrounding nutrients present within the diet and their effect on exercise is a relevant topic in the field of exercise physiology and dietetics. There are numerous studies that explore the effect of nutrients in the diet on exercise (Amorim et al., 2018; Chin A Paw, M. J. M., de Jong, Schouten, van Staveren, & Kok, 2002; Gwin et al., 2021; Kysel et al., 2020; Nilsson et al., 2020; Telford, Catchpole,
Deakin, Hahn, & Plank, 1992). Gwin et al. (2021) supplemented essential amino acid (EAA) enriched whey protein to explore the effect of diets containing foods with high EAA concentrations on muscle protein synthesis (MPS). Their team found that compared to an iso-nitrogenous, iso-caloric control group, the diet groups receiving increased EAA concentrations had overall higher MPS rates. Chin A. Paw et al. (2002) and Telford et al. (1992) used micronutrient supplements to look at activities of daily living (ADL) and athletic performance, respectively. The former researchers did not find a significant change in ADL among elderly patients; however, there were slight but significant correlations between vitamin intake and ADL that warrant a longer study. The latter team found increases in body weight, sum of skin folds, and jumping ability in female basketball players consuming the recommended dietary intake (RDI) for all micronutrients. Kysel et al. (2020) and Nilsson et al. (2020) observed improvements in muscle strength, fiber size, and endurance performance among young men on a calorie restrictive diet and elderly patients consuming high amounts of whey, micellar casein, vitamin D3, creatine, and DHA/EPA.

There are numerous studies that highlight exercise performance and body compositional changes from altering dietary macronutrients (Kerksick et al., 2010; Lehtisalo et al., 2017; Volek et al., 2004; Wroble et al., 2019; Zajac et al., 2014). Kerksick et al. (2010) and Volek et al. (2004) altered macronutrients (i.e., carbohydrates, protein, and fat) and found decreased body weight and fat mass following increased consumption of protein foods in addition to caloric restriction. Wroble et al. (2019) observed a lower peak and average power following a Wingate test among participants on a ketogenic diet. Furthermore, Zajac et al. (2014) observed an increase in relative VO2max and VO2 at lactate threshold among participants following a ketogenic diet.
One of the more common compounds consumed but is not considered a macronutrient is caffeine. Caffeine’s presence throughout the literature is prolific. Researchers have been exploring the effects of this compound since approximately 1945 (BISCHOFF, 1945). Since then, there have been a multitude of caffeine-focused studies and an increase in its usage among athletes and active individuals (Giráldez V. et al. 2023; Graham, 2001; Guest et al., 2021; Richardson & Clarke, 2016; Wang, Qiu, Gao, & Del Coso, 2022). Giraldez V. et al. (2023) reviewed 189 experimental studies which included a total of 3,459 participants to determine the most popular dosing and route of administration of caffeine. Their data suggested that capsules (51.9%) and beverages (41.3%) were the most common. In line with this conclusion, Richardson & Clark (2016) included one capsule form of caffeine administration and three beverages. In this study, the researchers found that the addition of anhydrous caffeine to decaffeinated coffee increased the amount of weight lifted during resistance exercise. This result suggests that the mode of administration is influential in caffeine’s effect on exercise. Although these authors found a significant effect of caffeine, there is still debate in the literature regarding how caffeine increases exercise capacity. Graham T. (2001) hypothesizes that caffeine does not influence endurance exercise directly. Instead, he suggests that caffeine allows for a more favorable ionic environment within the muscle motor units, allowing for greater force production. There is currently limited evidence to suggest that caffeine has an effect in resistance exercise as most studies are focused on endurance or maximal force modalities.

These results taken together show a clear link between the nutrients consumed in the diet and exercise outcomes. A challenge faced in most of these studies is determining to what extent the nutrients are affecting exercise versus losses in body weight, for example, or an effect of erroneous randomization causing a confounding variable to influence results. Additionally,
following specific dietary patterns to achieve a result may prove futile. While Zajac et al. (2014) observed increases in aerobic exercise performance, participants’ ability to complete anaerobic exercise decreased likely due to the low consumption of carbohydrates and muscle glycogen depletion. Therefore, the goals of the individual should be weighed against the pros and cons for altering dietary consumption of specific nutrients; however, the psychology of dietary behavior is outside the scope of this study and will not be presented herein.

Background

The following paragraphs will overview the project, review the background to the current study, describe, in detail, the research problem, present specific research aims and objectives as well as questions followed by the study’s significance and limitations.

The MyPlate recommendations are like the Dietary Approaches to Stop Hypertension (DASH) and Mediterranean diet. These eating patterns emphasize intake of vegetables, fruits, whole grains, fat-free dairy products, lean meats, beans, and nuts and seeds. The Paleolithic recommendations include pre-agrarian foods such as vegetables, fruits, lean meats, eggs, wild game, seafood, and nuts and seeds (Popp, 2016). The difference in the Paleolithic diet being the omission of refined or processed foods such as cereal grains, dairy products, legumes, refined sugars, fats, and added salt.

Overconsumption of nutrients can affect exercise performance. In competitive sports, ingestion of high amounts of dietary fats can lead to GI distress. Consumption of large amounts of dietary fiber before an exercise bout can lead to increased peristaltic motion and overactive bowels. However, the nutrient consumption in “regular” diets does not have this extreme effect. The reasoning for this lessened response is multifaceted. One explanation is that individuals in our study were not competitive athletes. Therefore, increased consumption of a single, or group
of, nutrients did not have a strong response. A more likely explanation is that the degree to which nutrients were altered both between and within diet groups were not to the severity that would cause drastic exercise performance changes. However, the goal of this study was never to explore drastic change regarding physical activity. Most of the world’s population falls under the “un-trained” category. Therefore, conducting a study that focused on the niche group of overly active individuals would have limited generalizability. The more reasonable application of this study is to determine nutrients’ effect on regular physical activity performed by “un-trained” peoples. As a secondary application, the changes in risk factors for diseases such as diabetes, metabolic syndrome, and other inflammatory conditions (i.e., blood pressure, BMI, waist circumference), and how these risk factors can be improved by consuming certain nutrients and physical activity, can be seen in this study.

The main research question in this study was “Do nutrients present within these two dietary patterns affect exercise parameters in a positive way?” An auxiliary question was “Do nutrients present within these two diets reduce comorbidities of chronic diseases?” To answer our primary research question, participant dietary data will be analyzed versus various exercise parameters with the focus on VO2 peak, respiratory exchange ratio (RER) peak, and select resistance exercise criteria. The auxiliary question will be answered by analyzing participant alignment to USDA diet standards versus their prescribed diet and quantifying whether a greater, lesser, or no deviation leads to a reduction in anthropometric risk factors. Therefore, we have adopted the hypothesis from the previous study which is that the Paleolithic diet would lead to increased aerobic and resistance exercise performance and reduce the risk factors associated with negative health outcomes.
CHAPTER TWO

METHODS

The methodology of this study was to analyze diet records and exercise outcomes to look for any interactions between single and multiple nutrients. The data was collected from a previous study (Popp, 2016). For the purposes of this paper, methods will be described based on the collection and analysis of the diet and exercise results, attempting to avoid any unnecessary redundancies presented in the previous study.

Original research

The original study focused on analyzing the correlations between exercise performance between two separate diet groups (Popp, 2016). Briefly, the diet groups assigned were MyPlate and Paleolithic, with MyPlate acting as a control. The original author hypothesized that the reduction of processed foods and saturated fats in both the MyPlate and Paleolithic diets, in combination with exercise, will improve metabolic syndrome markers such as insulin sensitivity, waist circumference, fasting plasma glucose, blood pressure, and blood lipids as well as increase aerobic fitness, upper and lower body strength, and anaerobic power.

Participants were recruited via email, flyers, and word of mouth in the Clemson, SC area and on Clemson University’s campus. However, it was not required to be a student at Clemson University to take part in the trial. Participants were included into the study if they met the following criteria: female, body fat percentage >20 and <40%, <=150 minutes per week of exercise at >=4.5 METs, not pregnant or lactating, non-smokers, not currently or previously (within past 3 mos.) participating in a resistance training program, no dieting within the past 3
mos., no allergies or dietary restrictions, and were weight stable (+/- 10 lbs.) within the past 3 mos.

The research was an 8-week longitudinal study that included screening, baseline, midway, and final measurements for select variables. Diet records were completed at baseline, midway, and final time points while exercise tests, body composition, and various activity measures were completed at baseline and final only. Additionally, bi-weekly weigh-ins for each participant were completed to track weight lost over the duration of the study.

The original study included aerobic and resistance exercise recommendations. Aerobic training was regulated by heart rate and was to be completed for 30 minutes twice a week; the specific activity was at the discretion of the participant. During the first week, maximal heart rate was to be 55% of the individual’s max heart rate (220-age). Exercise intensity was to be increased by 10% each week and by 5% the final week to complete the trial at 80% max heart rate. Resistance exercise was limited to 45 minutes on non-aerobic training days. The exercises included: leg press, leg curl, chest press, standing push-press, lateral raises, lat pulldowns, tricep pushdowns, bicep curls and, and seated crunches. As a part of the exercise methodology, participants completed a Wingate anaerobic power test and a graded exercise test (Bruce protocol). Briefly, the Wingate test was delivered to estimate peak anaerobic power and anaerobic capacity on a cycle ergometer. The graded exercise test was completed to determine aerobic VO2 peak. These exercise measures were not used as a screening tool, rather they were completed to be used for determining changes in exercise performance pre- and post-treatment.

Exercise outcomes included upper and lower body strength measures. Chest (CP1RM) and leg press 1 repetition maximums (LP1RM) were elucidated from a progressive increase in weight leading to a decrease in repetitions per set. A participant’s 1 repetition maximum was
elucidated within 5 sets. If participants were unable to reach maximal strength output within 5 sets, the individual was instructed to complete as many repetitions as possible during the sixth set and their 1 repetition maximum was estimated.

**Present research**

The main goal of this study was to describe the effect of individual, and a combination of, nutrients on exercise performance. A secondary goal was to explore the relationship between these nutrients and health markers such as blood pressure, weight, and fat mass. The objective of the original study was to describe the effects of the MyPlate and Paleolithic diets on exercise. The key difference in our study was shifting the focus to individual, and combinations of, nutrients and their effect on exercise and health parameters. In this study, our hypothesis was consistent with the original paper stating that the Paleolithic diet would lead to increased aerobic and resistance exercise performance and reduce the risk factors associated with negative health outcomes.

Diet records, body composition, and exercise results were collected from print logs and a digital master template. This template included demographic information, participant screening results, Monark and Bruce protocol outputs, body composition and SenseWear Armband values, and bi-weekly weigh-in weights for each participant and time point.

Participant 4-day diet records completed at baseline and at the final period were inputted into Cronometer (Cronometer, 2022), a diet analysis software. Output from the diet analysis software was used for the analysis in this study. Time points from each 4-day record were averaged to form two main groups: baseline and final. The midway measurement was not included because the focus of this paper is on the effect of nutrients on exercise measures across an 8-week period.
Exercise outcomes including chest (CP1RM) and leg press 1 repetition maximums (LP1RM) as well as Monark and Bruce protocol outputs were collected from the original template. The outputs were imported in the data analysis software and matched to each participant. SenseWear Armband data used to record various daily activities was imported in the data analysis software. Relative VO2 peak was used to establish high and low performing participants between both diet groups.

Popp (2016) notes that exercise adherence could not be checked due to improper completion of the exercise log. For this reason, the exercise subgroups were combined with their parent groups for this study.

**Study Limitations**

Upon reviewing the methodologies of the original project, some limitations were noted. Two of the variables of interest were maximal power and power decrement during the cycle ergometer Wingate test. The completed warmup for this test was done with no load on the machine, which may be inadequate for exercise preparation. Adherence to the diet recommendation was another point of limitation. Although participants were encouraged to eat within the bounds of their treatment group, complete diet adherence may have been an issue. Because of the complexity in the food records and non-standardized foods, the adherence could not be determined post hoc. Adherence was also a problem for the exercise recommendations. Resistance exercise recommendations were given to participants and a progressive increase in load was expected throughout the trial. However, few individuals increased their resistance load.
**Statistical analysis**

All data was analyzed using JMP Pro (Version 17. SAS Institute Inc., Cary, NC, 1989–2021.). Data was inputted into JMP after select participants were excluded due to missing or failure to complete the study. Figure 1 shows the exclusion criteria and total number of participants used for data analysis.

![Exclusion diagram](image)

*Figure 1 Exclusion diagram for the total number of participants used for the data analysis. Incomplete data included incomplete or missing food records. Participants were not excluded for incorrect or incomplete resistance exercise records. One participant did not complete the final measurement and dietary record; their baseline data was included.*

Differences between diet groups were first analyzed without consideration to exercise parameters. A large multivariate fit Y by X was performed with the nutrients as the dependent variable and diet group and the independent. Statistical significance was accepted at a p-value less than or equal to 0.05. Variables that were statistically different between diet groups were extracted from the original data table for further analysis.
Exercise parameters were analyzed without consideration to the significantly different nutrients between diet groups. The same large multivariate fit Y by X was performed for exercise outcomes between diet groups. Statistically significant variables were extracted from the original data table for further analysis.

To explore any possible difference between high and low performers among diet groups, a large fit Y by X was performed, fitting all variables measured by each performance group. The variables that were statistically different (p < 0.05 for difference in slopes unless otherwise stated) between performance groups in the Paleo diet group were total fat mass, physical activity level, lean mass – right arm, minimum power, total distance, absolute VO2 peak, relative peak power, relative and absolute chest press 1 repetition max, percent power drop, and average power.

Significantly different variables from both the nutrient and exercise analysis were used to explore commonalities between the two groups. All pairwise combinations of exercise and nutrient variables were explored graphically for any apparent correlations. Simple statistics were then calculated, and 95% confidence intervals were derived to elucidate statistically significant correlations. Simple linear regression and multivariate regression analysis were then performed to extract significant relationships between individual, and combinations of, variables. Principal components analysis (PCA) was used to represent multi-nutrient effects on exercise parameters. Individual components from the PCA were graphed and linear regression was used to determine the extent of the effect on exercise.
CHAPTER THREE

RESULTS

Participant Demographics

Participants demographics are reported in Table 1. There were no significant differences between time points within diet groups. Excluding time points from the analysis revealed that MyPlate had a greater total fat mass (TFM; kg) and percent body fat (%BF) (p value = 0.0155, 0.0073, respectively). Overall, Paleo had a greater total lean mass to fat mass ratio (TLM:TFM) (p value = 0.0095). Weight (Wt; kg) and body mass index (BMI) did not reach statistical significance; however, the Paleo group had an approximately 9.1 kg lower Wt and a 3 index point lower BMI than the MyPlate group. These results were almost significant (p value = 0.0973 and 0.0745, for Wt and BMI versus diet group). Height (Ht; cm) and total lean mass (TLM; kg) were not different between time points or overall, between diet groups. Slight deviations in Ht measures between time points were likely due to measurement errors.

Table 1 Participant mean (SD) demographics. P value is for comparison of overall group mean regardless of time point.

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<tr>
<td></td>
<td>Baseline</td>
<td>Final</td>
<td>Baseline</td>
<td>Final</td>
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<td>Ht (cm)</td>
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<td>166.73 (6.91)</td>
<td>165.93 (8.14)</td>
<td>166.01 (8.02)</td>
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<td>Wt (kg)</td>
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<td>74.61 (18.48)</td>
<td>67.69 (8.95)</td>
<td>65.05 (8.57)</td>
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<tr>
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<td>26.78 (5.90)</td>
<td>24.57 (2.59)</td>
<td>23.61 (2.74)</td>
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<tr>
<td>TFM</td>
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<td>27.43 (7.43)</td>
<td>22.94 (4.36)</td>
<td>21.54 (4.89)</td>
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<tr>
<td>TLM</td>
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<td>45.68 (11.77)</td>
<td>42.91 (5.45)</td>
<td>41.85 (5.44)</td>
</tr>
<tr>
<td>TLM: TFM</td>
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<td>1.69 (0.24)</td>
<td>1.91 (0.31)</td>
<td>2.01 (0.45)</td>
</tr>
<tr>
<td>%BF</td>
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<td>36.52 (3.43)</td>
<td>33.66 (3.62)</td>
<td>32.73 (4.81)</td>
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</table>

VO2max Test Performance

To explore the commonality between high performing participants (relative VO2max greater than 37.5 ml/kg/min, i.e., above 75th percentile), individuals were stratified based on their relative VO2max values and diet group. The greatest number of high performers were in the...
Paleo group, while one participant was contained within the MyPlate group (Table 2).

Categorical data analysis on the probabilities of achieving above the 75th percentile in the Paleo group revealed an insignificant difference (p > 0.05) from a hypothesized proportion of 0.5 (50% probability of achieving above or below 75th percentile).

Table 2 Performance of Individuals in MyPlate and Paleo Groups. Note: table count does not add to 14 as some individuals did not have a final VO2 peak measurement. * Signifies statistical difference in means (p < 0.05). ^ indicates outlier based on diet group and performance.

<table>
<thead>
<tr>
<th>Diet Group</th>
<th>Count</th>
<th>Avg. VO2max L-P</th>
<th>H-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleo</td>
<td>3</td>
<td>32.90*</td>
<td>39.64*</td>
</tr>
<tr>
<td>MyPlate</td>
<td>4</td>
<td>29.65</td>
<td>41.60^</td>
</tr>
</tbody>
</table>

Participants in the Paleo treatment group had a significantly higher relative VO2max compared to the MyPlate group (p < 0.05; Figure 2). This difference was not present in the absolute VO2max results (Figure 2). To elucidate high VO2max test performance from all diet groups combined, individuals who achieved a relative VO2max of 37.5 ml/kg/min or greater were labeled as “high performers.” This cutoff was established as the 75th percentile of the data. There were 3 high performers in the Paleo group and 1 in the MyPlate.
Exercise

There was a significant overall effect from the PCA components (caffeine (mg), copper (mg), and monounsaturated fat (mg)) on peak respiratory quotient (RERp) (p < 0.001; Figure 3). Stratifying data revealed a significant difference between diet groups (p < 0.05). The MyPlate group had a significantly lower RERp than the Paleo group (p < 0.05). The mean (95% CI) of the response for the Paleo group was approximately 1.24 (1.21, 1.28). This mean was significantly greater than the MyPlate group (1.17 (1.13, 1.21); p < 0.05). The means of the two groups decreased from baseline to final measurement. This decrease, however, was not significant (p = 0.786). There was a small overlap of confidence intervals at each time point (Paleo, baseline = 1.25 (1.20, 1.30); Paleo, final = 1.24 (1.18, 1.29); MyPlate, baseline = 1.19 (1.14, 1.24); MyPlate, final = 1.16 (1.10, 1.22)).

The Paleo group had a significantly greater intake of caffeine (p < 0.05 and p < 0.001, respectively; Appendix A). There was no significant difference between diet groups for monosaturated fat intake (p = 0.373). The mean intake of caffeine in the MyPlate and Paleo groups were 32.91 mg (4.11, 61.71) and 71.34 mg (35.02, 107.66), respectively, across the duration of the study. Among the Paleo group, most of the individuals (71.43%) were consumers.
of caffeine throughout the study. Similarly, in the MyPlate group most of the individuals (58.33%) consumed caffeine throughout the study. The difference between proportion of consumers and non-consumers was greater in the Paleo group (delta = 42.85%) compared to the MyPlate group (delta = 16.66%). Of those in the Paleo group, only a small percentage (7.14%) were low consumers.

Copper intake was greater in the Paleo group (1.19 mg (0.95, 1.44)) than in the MyPlate group (0.89 mg (0.69, 1.00)). The difference between the Paleo and MyPlate participants was almost significant (delta = 0.298 (-0.011, 0.608); p = 0.0578). Participants in the MyPlate group consumed approximately 2 grams (20.31 g (14.34, 26.27) less monosaturated fat on average compared to the Paleo group (22.83 g (15.86, 29.79)).
Figure 3 Peak RER versus PCA components (A; \( R^2 = 0.42 \)), PCA components stratified by diet group (B; \( R^2 = 0.11, 0.60 \) for MyPlate and Paleo), diet group (C) time point (D). Figures (A), (C), and (D) are inclusive of all data points, regardless of time point. *Statistically different (\( p < 0.05 \)). Monounsaturated fatty acids (MUFA), peak respiratory exchange ratio (RERp); principal components analysis (PCA).
There was a significant effect of the PCA components (caffeine (mg), copper (mg), and fats (g; MUFA, PUFA, total fat)) and diet group on peak minute ventilation (VEp (L/min); p < 0.0001; Figure 4). Stratifying the data based on diet groups reveals a statistical difference (p < 0.01). The paleo group had a significantly greater VEp compared to the MyPlate group (p < 0.01). There was a non-significant effect of time point on VEp (p > 0.05). The mean VEp for the MyPlate and Paleo groups was 79.01 L/min (71.40, 86.65) and 92.34 L/min (85.87, 98.81), respectively. The mean VEp at baseline measurement was 77.65 L/min (68.29, 87.02) for the MyPlate group and 93.49 L/min (84.32, 102.66) for the Paleo group. There was a small overlap in the confidence intervals between the MyPlate group and Paleo group at baseline. The mean of the response at the final measurement for the two groups was 80.37 L/min (68.32, 92.43) and 91.19 L/min (82.07, 100.32) for the MyPlate and Paleo groups, respectively. There was a non-significant increase in VEp in the MyPlate from baseline to final (delta = 2.72) (p = 0.7125). There was a non-significant decrease in the Paleo group (delta = -2.3) (p = 0.7131).
Figure 4 Peak Minute Ventilation (VEp) versus principal components analysis (PCA) (A; \( R^2 = 0.35 \)), PCA stratified by diet group (B; \( R^2 = 0.20, 0.62 \) for MyPlate and Paleo), diet group (C), and time point (D). Figures (A), (C), and (D) are inclusive of all data points, regardless of time point. *Statistically significant \( (p < 0.01) \).
Average metabolic equivalents (METs – exercise intensity) were significantly correlated with physical activity level (p < 0.0001, $R^2 = 0.52$; Figure 5). The inclusion of the diet groups in the analysis also produced a significant interaction (p < 0.001, $R^2 = 0.53$); however, there was not a significant reduction in error (RMSE = 0.095 and 0.092 for the full and reduced model, respectively). Additionally, there were no significant differences in reduction of error when the performance groups were included in the analysis (p > 0.05).

Figure 5 Average metabolic equivalents (METs) versus physical activity level. Data is inclusive of all time points. The correlation between average METs and physical activity level was significant (p < 0.0001; $R^2 = 0.52$).
There is no significant overall trend in the carbohydrate versus the absolute/relative leg press 1 repetition max data. However, an apparent trend in the data appears in the relative 1 repetition max data. Stratifying the data based on performance group revealed a significant overall effect of carbohydrate intake on relative leg press 1 repetition max (Rel LP 1RM; kg/kg lean mass; p < 0.01; Figure 6). The high-performance group had a significant effect on Rel LP 1RM with respect to carbohydrate intake (p < 0.01). There was a strong negative correlation between carbohydrate intake and Rel LP 1RM with increases in 1 repetition maximum leading to less carbohydrate consumption ($R^2 = 0.98$). Subsequent data stratification based on the performance groups revealed a non-significant effect of carbohydrate intake on Rel LP 1RM in the low performing group (p = 0.3973).
Figure 6 Relative leg press 1 repetition max (Rel LP 1RM; kg/kg lean mass) versus carbohydrate intake (A; $R^2 = 0.08$) and stratified by performance group (B; $R^2 = 0.99, 0.04$ for High performer and Low performer). Leg press 1 repetition max (LP 1RM; kg) versus carbohydrate intake (C; $R^2 = 0.04$) and stratified by performance group (D; $R^2 = 0.79, 0.01$ for High performer and Low performer). All data is inclusive of both time points. **Statistically different than Low performance group ($p < 0.01$).
The total lean mass to total fat mass ratio (TLM:TFM) was significantly higher in the high performing group across all time points ($p < 0.0001$; Figure 7). There were no MyPlate participants in the high performing group at baseline measurement. At final measurement, there was one high performing MyPlate participant. There was a slight increase in the TLM:TFM in the Paleo group from baseline to final measurements ($\delta = 0.04 (-0.337, 0.4207)$). This difference was not statistically significant.

There was an overall slight decrease in total fat mass in both diet groups. Neither decrease reached statistical significance ($p = 0.7687$; $\delta = 2.10 \text{ kg} (-5.28, 9.47)$, $1.40 \text{ kg} (-5.34, 8.13)$ for the MyPlate and Paleo groups). There was a non-significant decrease in total lean mass between time points for the Paleo group ($p = 0.8162$; $\delta = 1.06 \text{ kg} (-8.28, 10.40)$). The MyPlate group experienced a slight and non-significant increase in total lean mass between time points ($p = 0.9411$; $\delta = 0.37 \text{ kg} (-10.6, 9.86)$).

There was a similar trend for the high and low performance groups. The total fat mass of the low performing group was significantly greater than the high performers ($p < 0.01$; $\delta = 8.05 \text{ kg} (2.68, 13.43)$). There was a significant difference between performance groups relative to total fat mass between time points ($p < 0.05$). Both the high and low performance groups experienced a significant decrease in their total fat masses ($p < 0.05$; $\delta = 8.23 \text{ kg} (-0.40, -16.07)$, $7.88 \text{ kg} (-0.51, -15.24)$ for the high and low groups, respectively). The high performing individuals had a slightly lower total lean mass than low performing participants; however, this difference was not statistically significant ($p = 0.7439$; $\delta = 1.27 \text{ kg} (-9.19, 6.66)$). At baseline measurement, both the high and low performance groups had a total lean mass of approximately $44 \text{ kg} (44.15, 43.97$ for the high and low groups). The low performers did not decrease their total
lean mass between timepoints (delta = 0.08 kg (-8.16, 8.32)). The decrease in total lean mass for the high-performance group was not significant (p = 0.7513; delta = 2.10 kg (-15.64, 11.450)).

There was a significant difference between lean mass to fat mass ratio between performance groups with the high performing group having a greater overall ratio of total lean mass (p < 0.0001, delta = 0.614 kg; **Figure 8**). There was a significant overall effect of lean mass to fat mass ratio on relative LP1RM (p < 0.0001). However, the individual parameters and interaction terms were not significant; the interaction of performance and relative LP1RM almost reached statistical significance (p = 0.0655). Stratifying the analysis by performance group revealed a non-significant effect in the high performing group and a significant effect in the low performing group (p = 0.6224, p < 0.05 for the low and high performing group, respectively).
Interestingly, an increase in lean mass tended to increase relative LP1RM in the high performing group ($R^2 = 0.05$), while a decrease in lean mass also tended to increase relative LP1RM in the low performing group ($R^2 = 0.31$). The correlation between lean mass to fat mass ratio and relative LP1RM only reached statistical significance in the low performing group ($p < 0.05$).
Figure 8: Total lean mass versus absolute leg press 1 rep max (A; $R^2 = 0.48$) and stratified by performance group (B; $R^2 = 0.03, 0.65$ for High performer and Low performer).

Total lean mass versus relative leg press 1 rep max stratified by performance group (C; $R^2 = 0.07, 0.09$ for High performer and Low performer) and TLM:TFM by relative leg press 1 rep max stratified by performance group (D; $R^2 = 0.05, 0.31$ for High performer and Low performer). **Statistically different than High Performer group for regression line slopes ($p < 0.0001$).
The effect of lean mass to fat mass ratio on relative CP1RM was like that of relative LP1RM. The full model including the individual model terms and the interaction between performance group and relative CP1RM was overall statistically significant (p < 0.0001). While the reduced model did not yield statistically significant effects, the effect of lean mass to fat mass ratio on CP1RM tended to follow the trend of an increase in lean mass to fat mass ratio led to an increase in relative CP1RM among high performing individuals while a decrease in lean mass to fat mass ratio led to an increase in the low performance group (Figure 9).
Figure 9 Total lean mass versus absolute chest press 1 rep max (A; $R^2 = 0.543$) and stratified by performance group (B; $R^2 = 0.34, 0.63$ for High performer and Low performer). Total lean mass versus relative chest press 1 rep max (C; $R^2 = 0.31, 0.00$ for High performer and Low performer) and TLM:TFM by relative chest press 1 rep max stratified by performance group (D; $R^2 = 0.03, 0.10$ for High performer and Low performer). **Statistically different than High performance group for regression line slopes ($p < 0.0001$).
There was a significant overall effect of energy intake on relative CP1RM ($p < 0.0001$). Analysis of the full model yielded a significant effect for all individual variables and the interaction between relative CP1RM and performance group ($p < 0.0001, p < 0.001$ for the performance and interaction term and relative CP1RM, respectively). The correlations between variables were elucidated in the reduced model and yielded a strong negative linear correlation between energy intake and relative CP1RM with an increase in relative CP1RM decrease in energy intake in the high performing group ($R^2 = 0.97$; Figure 10). Likewise, there was a weak to moderate positive correlation in the low performing group ($R^2 = 0.36$).

There was no overall effect of trans-fat on relative CP1RM ($p = 0.3092$). The intake of trans-fat did not lead to a change in the low performing group but was significantly correlated with relative CP1RM in the high performing group ($R^2 = 0.95, R^2 = 0.02$ for the high and low performing group, respectively). A decrease in trans-fat intake led to a significant increase in relative CP1RM ($p = 0.0001$).

![Figure 10](image)

*Figure 10* Relative chest press 1 rep max by energy ($A; R^2 = 0.99, 0.04$ for High performer ad Low performer) and trans-fat ($B; R^2 = 0.83, 0.23$ for High performer and Low performer). Data is inclusive of all time points. * Signifies statistical significance for regression line slopes ($p < 0.001$)

There was a significant difference between diet groups for systolic blood pressure (SBP) ($p < 0.05$; *Figure 11*). The MyPlate group had a significantly higher SBP compared to the paleo
group. Subsequent analysis of thiamine and calcium, diet groups, and time point showed a significant difference between diet groups for the baseline time point (p < 0.05). There were no significant differences between any of the variables for the final time point. Increased calcium consumption tended to increase SBP in the MyPlate group and decrease SBP in the Paleo group. These correlations were very weak ($R^2 = 0.105$ and 0.005, respectively). Increased consumption of thiamine had a weak effect on SBP ($R^2 = 0.104$, p = .3708; $R^2 = 0.069$, p = 0.3873 for the MyPlate and Paleo groups).

Figure 11 Systolic blood pressure versus diet group. Data is inclusive of all time points. ** Signifies statistically different than Paleo for group means (p < 0.05).
There was a significant effect of the PCA variables on DBP (p < 0.05). These variables consisted of thiamine, riboflavin, folate, calcium, iron, and zinc. Increased iron consumption tended to increase DBP in both the MyPlate and Paleo diet groups (R^2 = 0.65 and 0.052, respectively; Figure 12). The increase in the MyPlate group was statistically significant (p < 0.01). Increased calcium consumption tended to increase DBP in the MyPlate group and decrease DBP in the Paleo group (R^2 = 0.33 and 0.033, respectively). The effect of increased calcium consumption in the MyPlate group reached statistical significance (p < 0.05). Increased thiamine consumption tended to increase DBP in the MyPlate and Paleo groups (R^2 = 0.835 and 0.080). The effect of thiamine on DBP in the MyPlate group was statistically significant (p < 0.0001; Figure 13). Increased consumption of zinc tended to increase DBP in both the MyPlate and Paleo groups (R^2 = 0.658 and 0.050, respectively). The only group to reach statistical significance from increased zinc consumption was the MyPlate group (p < 0.01; Figure 13). Interestingly, lying duration had a significant effect on DBP (p < 0.05; Figure 14). This effect was only seen in the MyPlate group.
Figure 12 Diastolic blood pressure versus principal components analysis variables (thiamine, riboflavin, calcium, iron, and zinc). Data is inclusive of all time points. * Signifies statistical significance for regression line slope ($p < 0.05$; $R^2 = 0.84, 0.02$ for MyPlate and Paleo).
Figure 13 Diastolic blood pressure versus calcium (A; $R^2 = 0.33, 0.03$ for MyPlate and Paleo), thiamine (B; $R^2 = 0.84, 0.08$ for MyPlate and Paleo), iron (C; $R^2 = 0.65, 0.05$ for MyPlate and Paleo), zinc (D; $R^2 = 0.65, 0.05$ for MyPlate and Paleo) stratified by diet group. Data is inclusive of all time points. *Signifies statistically significant for regression line slopes ($p < 0.05$).
There was a significant overall effect of calcium, diet group, and their interaction on RHR (Figure 15). The individual effects showed an insignificant effect of calcium and diet group (p = 0.6031, p = 0.0663). The MyPlate group had a significantly greater intake of calcium compared to the Paleo group (p < 0.05). There was a significant overall effect of diet group, time point, and calcium on RHR. However, individual analysis of variables showed only a significant effect from diet group and the interaction between diet group and calcium (p < 0.05, p < 0.01).

The mean RHR from the MyPlate and Paleo groups were 85.67 (73.08, 98.26) and 64.59 (46.96, 82.22). The confidence intervals at the baseline time point were considerably overlapped. However, the final measurements had a mean RHR of 91.70 (73.35, 110.04) and 54.21 (24.48, 83.93) for the MyPlate and Paleo groups, respectively. Increased calcium consumption tended to increase RHR in the MyPlate group and decrease RHR in the Paleo group ($R^2 = 0.28$ and 0.32, respectively). The effect of increased calcium consumption was almost significant in the MyPlate group ($p = 0.0752$) and reached statistical significance in the Paleo group ($p < 0.05$).

There was a significant effect of lying duration on resting heart rate ($p < 0.05$); as lying duration increased, so did RHR.
Figure 15 Resting heart rate versus calcium intake (A: $R^2 = 0.28$, $0.33$ for MyPlate and Paleo), diet group stratified by time point (B), performance group(C), and diet group (D). Figures (A), (C), and (D) include data inclusive of all time points. *Statistically different ($p < 0.05$).
Total fat mass was not statistically different between diet groups (p = 0.0778; **Figure 16**). However, there was an approximately 4-kilogram decrease from MyPlate to Paleo participants. There was a statistically significant difference between the total fat masses of the individuals in the high and low performance groups. The high performing group had a significantly lower overall total fat mass (p < 0.05, delta = 6.4 kg). The overall mean for the high performing group was 20.68 kg (16.19, 25.17). The low performing group had a mean total fat mass of 27.08 kg (24.53, 29.64).
Figure 16 Total fat mass versus performance group stratified by diet group (A) Body fat percentage versus performance group stratified by diet group (C). Data is inclusive of all time points. *Statistically significant difference for group means (p < 0.05).
There were no differences between active time or sleep efficiency in either MyPlate or Paleo groups (Figure 17). There was an almost statistically significant overall effect of sleep efficiency on sedentary time (p = 0.08). However, this effect reached significance for lack of fit (p < 0.05). Stratifying the data based on the diet group did not yield any significant results (p = 0.15 for both groups). While there was no statistically significant effect from sleep efficiency on sedentary time in the full or reduced model, the data was weakly positively correlated ($R^2 = 0.25$). There appeared to be a slight increase in sedentary time from an increase in sleep efficiency; however, there were no apparent effects on sleep efficiency itself with increases in sedentary time.

There was not a significant overall effect of active time on sedentary time or vice versa (p = 0.1287; Figure 17). The data appeared to be weakly negatively correlated ($R^2 = 0.22$). Stratifying the data by the diet group revealed a significant overall effect between active time and sedentary time in the Paleo group only (p < 0.001). These data also appeared to be moderately negatively correlated ($R^2 = 0.70$) with an increase in activity leading to a subsequent decrease in sedentary time. The data in the MyPlate group were not significant; however, there was an apparent weak negative correlation ($R^2 = 0.11$).

There was a weak positive correlation between active energy expenditure and physical activity level ($R^2 = 0.13$; Figure 18). This correlation almost reached overall statistical significance (p = 0.070). There were no apparent differences among data stratification by diet group, time point, or performance group.
Figure 17 Active time (A; $R^2 = 0.19, 0.16$ for MyPlate and Paleo) and sleep efficiency (B; $R^2 = 0.11, 0.72$ for MyPlate and Paleo) by diet group and time point. Sedentary time by sleep efficiency (C) and active time (D). Data in figures (C) and (D) is inclusive of all time points. *Statistically significant ($p < 0.001$)
Figure 18 Active energy expenditure versus physical activity level ($R^2 = 0.13$). Data is inclusive of all time points.

**SenseWear Armband**

There were no significant differences in the time participants wore the SenseWear Armband (SWA). The time worn tended to increase in the MyPlate group ($p = .12$) from baseline to final and decreased in the Paleo group ($p = .73$). There was a significant increase in active energy expenditure in the MyPlate group from baseline to final ($p < 0.05$) when outliers were controlled. The overall increase was approximately 80 kcal (+/- 35 kcal). There was a significant effect of time point ($p < 0.05$) and an interaction between time point and diet grouped ($p < 0.05$) on average METs. The final time point in MyPlate was significantly different from baseline ($p < $
There was a significant difference between MyPlate final and paleo final (p < 0.05), but no different between both baseline measurements. The interaction between time point and diet grouped on physical activity level was almost significant (p = 0.09). Between baseline and final, the MyPlate activity level was significantly different (p < 0.05). The MyPlate group’s final activity levels were significantly higher than paleo (p < 0.05). There was no significant effect of time point or diet group on steps; however, steps tended to increase from baseline to final in both groups with the increase being greater in the MyPlate group. There was no effect on total distance; however, the MyPlate group tended to increase total distance from baseline to final. There was no effect on lying duration from time point and diet grouped; however, lying duration tended to decrease from baseline to final in the MyPlate group and increased in the Paleo group. There was no effect on sleep duration from time point and diet group; however, sleep duration tended to decrease in the MyPlate group and increase in the Paleo group. There was no effect on sedentary time from time point and diet grouped; however, the MyPlate group had a significantly lower sedentary time compared to baseline. This lower sedentary time was not significantly different than the Paleo group. The Paleo group was 42 minutes (+/- 22.332) more sedentary than the MyPlate group (no significant difference). There was no effect on moderate activity time from time point and diet group; however, the MyPlate group tended to have an increased time compared to baseline. This difference was approximately 15.8 minutes (+/- 8.21; not significant). There were no tendencies in the paleo group. These results are presented in Appendix A and B.
**Diet adherence**

To quantify participant’s deviation from USDA diet recommendations, standards were derived from the Dietary Guidelines for Americans and were compared to the actual intake for each nutrient. Averages were taken for each nutrient across all time points. Both diet groups had greater than 10% deviation from USDA standards across all macronutrients with the only exception being the MyPlate group’s consumption of fats (~10% below recommended).

![Graph showing deviation from USDA diet recommendations for macronutrients. Zero represents absolute adherence and data labels are percent over/under the recommended intake. Data is inclusive of all time points.](image)

**Figure 19** Deviation from USDA diet recommendations for macronutrients. Zero represents absolute adherence and data labels are percent over/under the recommended intake. Data is inclusive of all time points.

Deviation from DGA recommendations for all other nutrients measured are presented in **Figure 20**. Most of the nutrients outside +/- 10% of the recommendations. The only exceptions were folate, pantothenic acid, thiamine, tyrosine, saturated fatty acids, vitamin K, and potassium.
for the Paleo group. Methionine, phenylalanine, calcium, and copper were within 10% of the recommendations for the MyPlate group.

Figure 20 MyPlate and Paleo group deviation from the Dietary Guideline for Americans (DGA) standards. Data is inclusive of all time points. Data labels on individual bars represent percent deviation on a scale from 0-1 (0% to 100% deviation). Data labels nearing zero should be interpreted as closer adherence to DGA recommendations.
CHAPTER FOUR

DISCUSSION

The intake of caffeine, copper, and monounsaturated fatty acids (MUFAs) appeared to correlate with peak respiratory quotient (RER). This suggests that there may be a significant effect of increasing consumption of stimulants, minerals, and fats on nutrient metabolism. The contribution of caffeine to the overall variation between caffeine, copper, and MUFA was the lowest of the three variables. This suggests that copper and MUFAs describe the data more efficiently than caffeine. All three factors were positively associated with peak RER. Out of the three, caffeine and MUFAs have the most direct effect on exercise as they both can influence metabolism and fuel availability.

There is conflicting evidence in the literature regarding caffeine’s effect on exercise. A study that supplemented matcha green tea found a slight decrease in RER following treadmill walking (Willems, Şahin, & Cook, 2018). However, it is difficult to determine whether this effect was solely from the intake of caffeine or some synergistic effect from the catechins also present in matcha green tea powder. Similarly, there were numerous studies that supplemented caffeine within the range of 2-7 mg/kg and noted a slight to moderate decrease in RER following submaximal and maximal exercise (Collado-Mateo, Lavín-Pérez, Merellano-Navarro, & Coso, 2020; Glaister & Gissane, 2018; Harty et al., 2020). Furthermore, there is a lack of concrete evidence surrounding the effect of minerals on RER. Johnson H. et al. (1988) supplemented participants with sports drinks and noted an increase in RER. However, the increased RER in specific groups was likely due to carbohydrates instead of minerals present in the drinks. Zajac A. et al. (2014) noted an increase in peak VO2 and VO2 at lactate threshold from fat intake via a ketogenic diet but no effect on RER. The increase in peak RER in our data is possibly due to the sensitivity of untrained individuals to caffeine, as noted by Mateo D. et al. (2020).
Monounsaturated fatty acids were positively correlated with peak RER. This correlation was present for both time points in the Paleo group but was absent at baseline in the MyPlate group. The correlation between MUFAs and peak RER suggests that MUFAs increase an individual’s exercise capacity by increasing metabolizable fuel reserves. Increased fatty acids in the circulation may increase the endurance capacity of aerobic exercise as the body preferentially metabolizes free fatty acids during low intensity activities.

Copper’s observed correlation with peak RER was stronger overall than caffeine and MUFAs. The correlation was also stronger for the Paleo group versus the MyPlate group. This data suggests that copper is involved in the regulation of nutrient metabolism. Copper has been documented to reduce antioxidant activity and reactive oxygen species. Adenan M. et al. (2020) observed an increase in oxidative stress after cardiopulmonary exercise testing (CPET) among obese women. Furthermore, Husain K. (2004) documented increased Cu-Zn superoxide dismutase after 8-weeks of exercise training in rats. These results taken together suggest that copper may reduce oxidative stress and thus provide a protective effect in exercising individuals. It is impossible to equivocally prove causality in this study; therefore, we cannot conclude that increased copper intake increased peak RER. In our data, there was a slight increase in the correlation of copper and peak RER between baseline and final measurements. The foods suggested in the dietary patterns may have contributed to increases in copper intake which in turn influenced peak RER by reducing oxidative stress and increasing exercise capabilities.

Caffeine, copper, and overall fat consumption influenced peak minute ventilation (VEp). Glaister M. and Gissane C. (2018) noted an increase in VE following a 3-6 mg/kg caffeine dose and submaximal exercise. This increase was likely exacerbated by the untrained participants in
the analysis. Increased consumption of these nutrients may increase an individual’s ventilatory capacity, leading to a possible increase in exercise duration, intensity, or recovery.

In our data, there was a significant correlation between average METs, active energy expenditure, and physical activity level. This result is consistent with other data as increasing exercise intensity leads to an increase in metabolic equivalents (METs) and energy burned during the activity (AEE). Interestingly, decreased carbohydrate intake increased relative leg press 1 repetition max (r-LP1RM) in the high performing group only. Kerksick C et al. (2017) and Tipton K. and Wolfe R. (2001) reported an increase in carbohydrate consumption leading to increases in intramuscular triacylglycerol, which in turn influences resistance exercise. The rationale for this result in our data is unknown and is most likely due to a confounding variable that was not measured in this study.

The correlation between average METs and physical activity level is consistent with exercise physiology as physical activity level likely corresponds to METs. Likewise, active energy expenditure (i.e., energy burned while doing activity) increased with physical activity level which implies that as the level of activity increases, the number of calories burning also increases.

Increased lean mass to fat mass ratio increased r-LP1RM in the low performing group only. The r-LP1RM was determined by dividing the absolute 1 repetition max by the participant’s lean mass. As lean mass increases, the r-LP1RM increases. The apparent increase in r-LP1RM is most likely due to a decrease in fat mass rather than an increase in lean mass. This is still a “good” result as losing fat mass, in general, imparts positive health outcomes on individuals.
Another interesting result is the decreased energy intake correlating with an increase in relative chest press 1 repetition max (r-CP1RM) in the high performing group only. This result is likely a coincidence as a decreased energy intake would not correlate with a decrease in fitness performance. However, there may be some variable that was not measured that could have hindered participant’s performance in subsequent tests. Decreased lean mass to fat mass ratio correlated with an increase in r-CP1RM in the low performing group only. Lean mass remained stagnant, and participant fat mass increased, there could be an excess amount of fuel to increase fitness performance. This result is likely what occurred in our data. There was an interesting change in the lean mass and fat mass between time points and performance groups. There was a nonsignificant decrease in total fat mass between both performance groups. This is counter intuitive to the previously explained rationale. However, there may have been a decrease in total lean mass that could have partially explained the increase in r-CP1RM. There was one participant between time points in the low performing group that did not change their total lean mass. This participant influenced the results to remove an apparent change in total lean mass between time points. Briefly excluding this participant revealed a decrease in total lean mass. Therefore, the original hypothesis of an increase in total fat mass with a stagnation of total lean mass may have been a greater decrease in total lean mass than fat mass, leading to a decrease in the lean mass to fat mass ratio.

The effect of mineral and thiamine intake of diastolic blood pressure is likely consistent with the effects of excess minerals in the plasma on blood pressure seen in the literature. Along with the increase in diastolic blood pressure, increased calcium intake correlated with an increase in resting heart rate. These data suggest that there may be a correlation between mineral intake and cardiovascular functionality. Interestingly, increased lying duration was correlated with
increased diastolic blood pressure. This increase in diastolic blood pressure may be, however, may be an indirect effect of lying duration. An individual in a lying position encounters less circulatory resistance from gravity. The heart may become accustomed to this lessened resistance and, upon standing, raise blood pressure to counteract the unconditioned change in circulatory resistance. This conclusion is further represented in participant resting heart rate. Lying duration was correlated with an increase in resting heart rate. This result is likely due to the same rationale as for DBP. The increased time spent in the prone position lowers cardiac muscular resistance and allows the heart to pump at a lower rate. Upon standing, the heart encounters resistance from gravity and must increase both peripheral resistance and heart rate to maintain cardiac output.

Body fat percentage and total fat mass were lower in the high performing group. The individuals in the high performing group were mostly consuming the Paleo diet. Consuming this dietary pattern might lead to a decrease in body fat percentage and total fat mass compared to a MyPlate diet.

There were no differences in active time between diet groups. This is somewhat surprising as most of the Paleo participants performed well on the VO2 peak test. Since the participants did not complete the exercise logs accurately, there is no way to determine if this increase in VO2 peak was correlated with increases in a certain exercise type. A decrease in active time was correlated with an increase in sleep efficiency. Since the participants were not “trained” individuals, participating in this study, and being required to exercise to a certain extent may have been slightly detrimental to sleep. Therefore, decreasing active time would lead to an increase in sleep efficiency. Furthermore, there was a correlation between sedentary time and sleep efficiency suggesting that decreased active time and increased sedentary time would lead to overall improvements in sleep efficiency in our study population.
CHAPTER FIVE

CONCLUSION

General healthful eating is important to reduce weight, cholesterol, blood pressure, and non-communicable diseases preceded by these factors. This study examined the eating patterns of two specific diets: MyPlate and Paleolithic. The MyPlate diet emphasizes intake of vegetables, fruits, whole grains, fat-free dairy products, lean meats, beans, and nuts and seeds. The Paleolithic recommendations include pre-agriculture foods such as vegetables, fruits, lean meats, eggs, wild game, seafood, and nuts and seeds. Both eating patterns provide nutrients in sufficient quantities to support a healthy lifestyle.

The main question in this study was “Do nutrients present within these two dietary patterns affect exercise parameters in a positive way?” An auxiliary question was “Do nutrients present within these two diets reduce comorbidities of chronic diseases?”

The exercise parameters that were statistically significant in the Paleo group included peak minute ventilation and relative VO2 peak at baseline. The MyPlate group had a lowered peak respiratory exchange ratio (RERP). The apparent difference in nutrient consumption between the two diet groups led to a disparity in exercise performance. The Paleo group had such a higher number of high performing individuals on the VO2 peak assessment that the high performing group could be considered synonymous with the Paleo group. In line with this conclusion, most MyPlate participants were in the low performing group. The high performing group had an increased total lean mass to total fat mass ratio (TLM:TFM) which increased relative chest press 1 repetition max (Rel CP 1RM) and relative leg press 1 repetition max (Rel LP 1RM). The low performing group had an increase in TFM, Rel LP 1 RM, and Rel CP 1 RM with a decrease in TLM:TFM. This phenomenon is likely due to the MyPlate group increasing their TFM without a concomitant TLM increase, thus TLM:TFM was reduced. However, since
this increase in fat mass increased energy reserves, the low performer’s Rel CP 1 RM and Rel LP 1 RM still increased.

Disease comorbidities assessed in this study include body fat percentage (%BF), blood pressure (systolic (SBP) and diastolic (DBP); mmHg), weight (wt; kg), body mass index (BMI), total fat mass (TFM; kg), total lean mass (TLM; kg) and resting heart rate (RHR; bpm). The MyPlate eating pattern in this study increased TFM, SBP, and %BF. The Paleo eating pattern decreased Wt, TFM, and BMI (clinically significant). The Paleo group participants consumed less carbohydrates, fats, and protein than the MyPlate group. These individuals’ fat consumption was even less than that recommended by the Dietary Guidelines for Americans (DGA). Additionally, the Paleo group consumed approximately more B-vitamins, amino acids, omega-3 fats, other water- and fat-soluble vitamins. The Paleo group also consumed less calcium and sodium than the MyPlate group.

Regardless of diet intake patterns, individual and combinations of nutrients still influenced exercise and health parameters. Calcium, zinc, iron, and thiamine were positively correlated with an increase in DBP. Additionally, lying duration was positively correlated with DBP. Calcium intake increased RHR in the MyPlate group and decreased RHR in the Paleo group. Caffeine, copper, monounsaturated fatty acids (MUFA) were positively correlated with RERp. Peak minute ventilation was positively correlated with caffeine, copper, and overall fat intake. Increased Rel LP 1RM correlated with a decrease in carbohydrate intake in the high performing group. Increased Rel CP 1RM correlated with decreased energy and trans-fats intake in the high performing group only.

In our study population of sedentary weight stable females aged 19-28 not currently following a structured diet, consuming less calcium and sodium along with a lower amount of
fat, carbohydrates, and protein lead to increased exercise performance. Additionally, limiting the intake of B-vitamins, iron, and zinc from dietary supplements decreased DBP. A major affecter may also be weight and fat mass. Thus, decreasing total fat mass and increasing total lean mass through a dietary pattern that focuses on the intake of vegetables, fruits, lean meats, eggs, wild game, seafood, and nuts and seeds with limited intake of refined foods and added sugars is beneficial for exercise performance and overall health outcomes.
Table 3 Caffeine, copper, and monosaturated fat intake. Percentages in “consumption” and “consumption level” represent row percentages of both groups. *, ** Signifies statistically different.

<table>
<thead>
<tr>
<th>Diet Group</th>
<th>Consumption Caffeine (mg)</th>
<th>Consumption Level</th>
<th>Consumption Level</th>
<th>Consumption Level</th>
<th>Consumption Level</th>
<th>Consumption Level</th>
<th>Consumption Level</th>
<th>Copper (mg)</th>
<th>Monounsaturated (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myplate</td>
<td>32.92 *</td>
<td>58.33%</td>
<td>41.67%</td>
<td>33.33%</td>
<td>25.00%</td>
<td>41.67%</td>
<td>0.9***</td>
<td>20.31</td>
<td></td>
</tr>
<tr>
<td>Paloo</td>
<td>71.34 *</td>
<td>71.43%</td>
<td>26.57%</td>
<td>64.29%</td>
<td>7.14%</td>
<td>26.57%</td>
<td>1.2**</td>
<td>22.83</td>
<td></td>
</tr>
</tbody>
</table>
Figure 21 Duration on body (minutes)(A), active energy expenditure (kcal)(B), METS (C), physical activity level (PAL)(D), lying duration (minutes)(E), steps (F) versus diet group stratified by time point.
Figure 22 Sedentary time (minutes)(A), moderate activity time (minutes)(B), sleep duration (minutes)(C), total distance (miles)(D), and activity level versus diet group stratified by time point.
References


Poole, D. C., & Jones, A. M. (2017). Measurement of the maximum oxygen uptake $\dot{V}O_{2}\text{max}$

$\dot{V}O_{2}\text{peak}$ is no longer acceptable. *Journal of Applied Physiology (Bethesda, Md.: 1985)*, 122(4), 997-1002. doi:10.1152/japplphysiol.01063.2016


