Holistic perspectives for optimizing dietary quality

by

Jessica Mick Phelan

B.G.S., Fort Hays State University, 2017
M.S., Fort Hays State University, 2019

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Food, Nutrition, Dietetics and Health
College of Human Ecology

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Abstract

The purpose of this dissertation was to use a holistic perspective to better understand overall dietary quality for practical application. Key concepts used to guide each of the studies included "meeting people where they are," and best practices for maximizing dietary quality. Chapter two, study one, was a critical review that sought to provide a theoretical framework to determine how dietary quality assessment might be translated into practice across different socio-ecological levels to increase the effectiveness of evidence-based practices. A five-step holistic dietary quality assessment process was created to guide public-health officials and clinicians in identifying barriers or facilitators to optimizing dietary quality. In doing so, this study identified potential social and environmental factors that might be present for individuals or populations that affect dietary quality. Examples of these factors include, but are not limited to, food accessibility, socioeconomic status, cultural factors, and food safety/regulation. Study two, chapter three, sought to investigate the potential for maximizing the dietary quality of the most popular "fad diets" in the United States. First a definition of "fad diet" was created, and Google Explore© was used to determine the dietary patterns that were searched for most frequently. Inclusion and exclusion criteria were applied, and nine dietary patterns were included for analysis, where one-week menus were created attempting to maximize dietary quality while staying within the parameters of each fad dietary pattern. Results showed that some of the current popular fad dietary patterns have the potential to achieve a relatively high Healthy Eating Index (HEI) dietary quality score ranging from 77.1-89.1 out of 100 points, potentially surpassing the average American HEI dietary quality score. This study proposed an alternative approach to improving dietary quality by "meeting people where they are." Ultimately, this type of approach may lead to better adherence and better sustainability of a higher quality diet.

Finally, study three, chapter four, was a systematic review that sought to determine the associations between overall dietary quality and the non-clinical mental health outcomes of stress, anxiety, and/or depression among college students, with a secondary aim of determining the association between overall dietary quality and academic performance. Twelve relevant articles met the a priori selection criteria, where ten studies pertained to overall dietary quality and non-mental health outcomes, and two pertained to overall dietary quality and academic performance. The systematic review revealed that very few relevant studies had been conducted that included both non-clinical mental health and academic outcomes in the college student population. Given the prevalence of mental health issues in this population and the intersection between mental health and academic performance, this is an area where research is needed. Results of the meta-analysis indicated weak and moderate associations between overall dietary quality and non-clinical mental health outcomes in college students, and though very limited, based on the two studies included, results showed weak associations with academic performance. Altogether, the three studies included in this dissertation suggest that a holistic paradigm may be beneficial when used to better understand dietary quality for practical application. Future research is needed to help to elucidate the factors that should be considered when working toward improving the quality of the dietary intake of individuals and populations.

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Dedication

I dedicate this dissertation to my support system. I have been blessed to have my husband, parents, and siblings that support me in any and all of my endeavors; their encouragement allows me to dream big and live loudly. They are there to share in my victories, but mostly, they are steadfast when I need help, love, and someone to count on. There is no one else that I want on my team.

Chapter 1 - Introduction

Dietary Quality

The term “dietary quality” is sometimes used interchangeably with the terms “healthy diet” or “high-quality diet,” which may contribute to difficulty regarding a shared understanding of dietary quality. Rather than a strict definition, it may be beneficial to consider dietary quality conceptually. What do we mean when we use the term “dietary quality?” How can it be measured? How would be use and apply outcomes related to dietary quality assessment? Published research literature suggests that a high-quality diet should encompass a safe food supply that has the nutritional composition to support human growth and development to prevent disease (Alkerwi, 2014). Depending upon the social, environmental, or biological factors present, the necessary requirements of obtaining a high-quality diet might range due to the specific population being studied.

A high-quality diet may be achieved in many ways through the intake of a variety of foods, and dietary patterns can be either health-promoting or health-compromising (Dietary Guidelines Advisory Committee, 2020), pg. 478). Dietary patterns thought to be generally health-promoting include high intake of fruits, vegetables, fatty acids, fibers, and low intake of added sugars, sodium, saturated fats, and trans-fats. Examples of dietary patterns that meet these criteria include the Mediterranean Diet and the Dietary Approaches to Stop Hypertension (DASH) diet, as well as others that adhere to the DGAs. Conversely, the Westernized Diet, generally considered to be health-compromising, comprises large portion sizes and is characterized by low intake of fruits and vegetables, and high intake of calories, fats, sodium, and sugars (Rakhra et al., 2020).

Dietary Quality Measurement

Objectively, dietary quality is measured through a quantitative assessment of nutrient content of foods consumed against recommendations that are health promoting. The quantitative assessment of dietary quality is determined using mathematical algorithms according to different dietary quality indices, to arrive at a score that represents the overall quality of the diet or dietary pattern as compared to the highest score achievable (Poyatos Guerrero & Pérez-Rodríguez, 2017). As the importance of dietary quality has been determined, many dietary quality indices have been created within the last three decades. Brugaff and colleagues reviewed existing dietary indices and concluded that there were at least 57 major indices (Burggraf et al., 2018). Some of the indices used more frequently in published research include the Healthy Eating Index (HEI), the Diet Quality Index, the Healthy Diet Indicator, and the Mediterranean Diet Score, as well as modifications of these primary indices (Waijers et al., 2007). Each of the primary indices use predefined recommendations and allocate different scores per nutrient or food group consumed, usually summing to 100 points. For example, the HEI uses the Dietary Guidelines for Americans (DGAs) as the standard for comparison and allocates points for adequacy (total and whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein, seafood and plant protein, and fatty acids), and moderation components (refined grains, sodium, added sugar, and saturated fats) (National Institutes for Health, 2002). A diet containing more foods within the adequacy component and less foods within the moderation component is assigned a higher score, indicating greater dietary adherence to the DGAs. Higher scores, indicating better adherence to DGAs are associated with positive health outcomes and reduction various of non-communicable chronic diseases (Schwingshackl et al., 2018).

The Case for Holistic Dietary Quality

According to the most recent release of the DGAs, HEI scores have remained consistently low, around 60 points out of 100, throughout the last 15 years (Dietary Guidelines for Americans, 2020-2025, n.d.) indicating poor adherence to the DGA recommendations for a healthful diet. In the United States, 31.9% (CI 31.6-32.3; N=353,841) of adults are classified as having obesity and 34.8% (CI 34.5-35.2, N=353,841) are classified as having overweight, as of 2020 (Centers for Disease Control and Prevention, 2022). Overweight and obesity, cardiovascular diseases, and type II Diabetes Mellitus are associated with poor dietary quality and high levels of sedentary behaviors. The four primary risk factors for non-communicable diseases, which account for almost 70% of deaths world-wide, are tobacco use, physical inactivity, inappropriate alcohol use, and improper nutrition (World Health Organization, 2022). These data suggest that despite continual efforts toward improving dietary quality, dietary quality is an area where efforts for improvement are needed. The incidence of preventable, non-communicable chronic diseases, indicates the necessity to further explore different avenues for improving dietary quality, using both holistic and reductionist approaches on multiple fronts.

Reductionism vs. Holism

The reductionist paradigm is a philosophical method that approaches explaining a scientific phenomenon, not by looking at the phenomenon as a whole, but rather by breaking it into parts and analyzing the individual components (Fardet & Rock, 2018; Hoffmann, 2003). Conversely, the holistic paradigm views a scientific phenomenon as a whole, suggesting that the "whole is more than the sum of its parts (Fardet & Rock, 2015)," or 1+1>2. As applied to nutrition sciences, the reductionist view focuses on individual nutrients and their effects, while the holistic view focuses on whole foods and dietary patterns. Throughout history, both approaches have provided valuable insights contributing to the health of the population, though the reductionist paradigm has predominated nutritional sciences.

Scrinis divided the history of nutrition sciences into three specific periods (Scrinis, 2015). During the first period, “Quantifying Nutritionism (1850–1950),” scientists focused on dissecting the components of food and determining their actions within the body. The British Medical Journal identifies the 1920s–1950s as the “Era of Vitamin Discovery” (Mozaffarian et al., 2018). Nutritional adequacy was the focus of dietitians, and in the 1940s, the Recommended Dietary Allowances were created (Institute of Medicine, 2003). In the next period “Good-and-Bad Nutritionism (1960’s–1990’s),” studies were largely based on determining which nutrients were “bad” and which nutrients were “good.” In this period, a dieting culture flourished, and diets, such as the Atkins diet, were popularized. During this time, people in developed countries became more sedentary, ate more, and started showing signs of overnutrition, thereby shifting the focus of nutrition sciences to chronic diseases (Mozaffarian et al., 2018). Finally, during the period of “Functional Nutritionism (1990’s–present),” nutrients known for their positive effects were added to foods through enrichment and fortification processes. Foods that were once considered to be “bad” had “good” nutrients added to them, thereby making them “good” again. Refined grains, for example, have bran and germ removed through the milling process, but nutrients such as iron, iodine, niacin, thiamin are then added back to the products that include refined grains (Preedy et al., 2011). These food processing efforts have been economically beneficial for the food industry and have produced some improvements to population health, thereby, reinforcing the dominant reductionist view. It was not until the last few decades that a more holistic view of nutrition began to emerge.

As a response to the steady increase in non-communicable chronic diseases (World Health Organization, 2022), researchers, for example the Dietary Guidelines Advisory Committee, have suggested that a different approach be taken, a holistic approach, to potentially understand dietary patterns that influence health. Though the reductionist approach has contributed much to the field of nutritional sciences, both overnutrition and undernutrition are evident around the world, suggesting that a shift in paradigms might provide additional and valuable contributions to the field of nutrition sciences and to the health of the global population. For the purpose of the current dissertation, the holistic view encompasses more than examining intake of specific foods and dietary patterns, but also takes into consideration biological, social, and environmental factors that influence nutrition and health (*2005 - The Giessen Declaration.Pdf*, n.d.).

Therefore, the overall aim of the current dissertation was to explore the concept of dietary quality from a holistic perspective. The first study, a critical review (chapter two), used a public-health perspective to consider the barriers that populations may have to achieving a high-quality diet and to conceptualize how dietary quality scores might be translated into for use in practice. This study used a global perspective and provided examples of how the critical framework might be applied to different levels of influence. The second study, (chapter three) used a holistic approach to analyze popular fad dietary patterns in the United States by creating sample menus that maximized the potential nutrients included within the parameters of each dietary pattern. The purpose of this study was to harness the positive aspects of the popular eating patterns among Americans. Finally, the third study, a systematic review (chapter four) investigated dietary quality and the relationship it may have to mental health outcomes and academic performance among college-aged students. The systematic review included studies from around the world, and a holistic perspective was used to determine the variables used, to determine whether overall dietary quality is associated with outcomes that are relevant to and important for college-aged populations.

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Chapter 2 - Holistic Framework to Contextualize Dietary Quality Assessment: A Critical Review

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Abstract

Numerous dietary quality indices exist to help quantify overall dietary intake and behaviors associated with positive health outcomes. Most indices focus solely on biomedical factors and nutrient or food intake and exclude the influence of important social and environmental factors associated with dietary intake. Using the Diet Quality Index- International as one sample index to illustrate our proposed holistic conceptual framework, this critical review seeks to elucidate potential adaptations to dietary quality assessment by considering—in parallel—biomedical, environmental, and social factors. Considering these factors would add context to dietary quality assessment, influencing post-assessment recommendations for use across various populations and circumstances. Additionally, individual and population-level evidence-based practices could be informed by contextual social and environmental factors that influence dietary quality to provide more relevant, reasonable, and beneficial nutritional recommendations.

Keywords: dietary quality; reductionism; holism; dietary quality index; dietary quality measurement; social factors; environmental factors

Introduction

According to the World Health Organization, around 41 million or 71% of annual global deaths are due to noncommunicable diseases (NCD). Diseases that are often related to poor dietary quality and sedentary lifestyles, such as cardiovascular diseases (CVD), respiratory diseases, and diabetes, account for 17.9, 3.9 and 1.6 million deaths, respectively (World Health Organization, 2021). As the burden of NCDs continues to increase to a greater extent in lower-income countries and populations (Centers for Disease Control and Prevention, 2020), the importance of understanding the factors that influence dietary quality becomes more pronounced. Dietary quality assessment should consider contextual factors influencing the quality of dietary intake in order to translate such assessments into post-assessment recommendations and potential interventions.

To quantitively determine dietary quality, mathematical algorithms—in the form of dietary quality indices—have been created based upon adherence to pre-defined nutritional guidelines such as the Dietary Guidelines for Americans that are thought to enhance health, support growth, and reduce diet-related diseases (Poyatos Guerrero & Pérez-Rodríguez, 2017). Reviews of the most common indices of dietary quality show that higher scores are associated with a lower incidence of chronic disease. Some studies aimed at reviewing dietary indices, including the Healthy Eating Index (HEI) and the Alternative Healthy Eating Index (AHEI), have shown unclear results regarding specific health outcomes, such as CVD risk factors, risk of developing abdominal obesity, and gender-specific weight loss (Aljuraiban et al., 2019; Asghari et al., 2017). Other reviews have indicated that better adherence to dietary guidelines is associated with reduced risk of all-cause mortality, CVD mortality, and cancer mortality (Onvani et al., 2017; Schwingshackl et al., 2018). A meta-analysis assessing adherence to the DASH diet in relation to all-cause and cause-specific mortality suggests more uniform results, where even modest scores are associated with lower all-cause and cause-specific mortality (Soltani et al., 2020).

Waijers et al. (Waijers et al., 2007) suggested that to critically evaluate a dietary quality index, the main questions that need to be considered are why the index was created in the first place, and what health outcome was the index created to address? As mentioned above, the most common indices have been shown to predict health status or risk when dietary quality scores are either high or low. In order to determine the utility of a particular index, however, the purpose behind the creation of the index should be considered (Alkerwi et al., 2015; Chiuve et al., 2012). Additionally, individual and population-level evidence-based practices should include contextual considerations, such as social and environmental factors. These factors influence the translatability of dietary quality scores for post-assessment nutritional recommendations across differing populations. Such contextual considerations clearly do not alter actual nutrient needs; however, they could be added as metrics for the interpretation of an existing dietary index or used to create entirely new indices. Although as many as 57 major indices of dietary quality exist, the Diet Quality Index-International (DQI-I) is among the most commonly used indexes due to its applicability for international use (Burggraf et al., 2018). The DQI-I was used in the present paper to provide an example index from relevant literature (Aljuraiban et al., 2019; Asghari et al., 2017; Burggraf et al., 2018), showing that the DQI-I is appropriate for cross-cultural application.

Using the Giessen Declaration ("The Giessen Declaration," 2005) as a guide to broaden the science of nutrition into a more integrative discipline inclusive of the challenges of the twenty-first century, the current critical review seeks to elucidate relevant biomedical, social, and environmental factors in order to foster a more holistic contextual understanding of dietary quality assessment. First, a brief review of the concepts of reductionism and holism will be provided. Next, utilizing the DQI-I as one example index to illustrate this conceptual framework, the current review considers social and environmental factors that contribute to dietary quality in various populations and contexts.

Reductionism vs. Holism

Historically, nutrition sciences have largely been focused on gaining knowledge about foods and nutrients in relation to health. In 2015, Scrinis wrote "*Nutritionism: The Science and Politics of Dietary Advice*", a book that summarizes how nutritional advice has changed throughout recent history, with a focus on reductionism (Scrinis, 2015). The concept of reductionism can be thought of simply as science that reconstructs reality by its parts (Fardet & Rock, 2018; Hoffmann, 2003). With this viewpoint, medicine has approached nutrition in a similar manner to pharmacology, as a treatment for individuals who are unhealthy, rather than as a way to prevent nutrition-related diseases in order to keep people healthy (Fardet & Rock, 2015). While reductionism has a history of improving the world's health—for example, the eradication of scurvy, pellagra, and rickets from all but the poorest of areas—it has also directed scientists to examine the intake of single nutrients or foods, rather than the impact of a pattern of food intake as a whole. For example, antioxidants are known to "decrease oxidative stress"; therefore, many studies have been conducted to determine specifics about their benefits. Many studies have used "supra-physiological" doses of antioxidant vitamins, taken as supplements extrinsic to foods naturally high in vitamin content. Unexpectedly to the researchers, some results have shown an increased risk of cancers at these doses (Fardet & Rock, 2014). Other studies have shown that isolated nutrient supplementation may not be beneficial, and relevant health outcomes are more likely to be associated with the overall dietary pattern (Jacobs et al., 2009). There is now an increased recognition of the importance of whole food consumption, and not just individual nutrients, thus introducing the more holistic concept of food synergy (Fardet & Rock, 2015; Jacobs et al., 2011).

Conceptually, food synergy means that in most cases, foods are interactive in their effects on health (Jacobs et al., 2011). Similar to the idea of Gestalt theory, 1 + 1 > 2, or "the whole is more than the sum of its parts (Fardet & Rock, 2015)". To illustrate this, in 2018, Fardet, Lakhssassi, and Briffaz conducted a study that provided insights regarding how to classify foods based upon their structures as well as their nutrient compositions, keeping in mind the concept of food synergy (Fardet et al., 2018). Fardet and colleagues indicated that foods with identical nutrient compositions could have differential effects on health, likely due to the bioavailability of the nutrients in the compared foods as well as their satiating effects; therefore, one calorie of a food did not necessarily equal one calorie of another. For example, 100 calories of two carbohydrate-containing foods, such as jellybeans and grapes, do not provide equal nutrition. In the study, 280 generic foods most widely consumed by French men and women aged 65 years and older were tested to determine how quantitative and qualitative aspects of food, such as texture, water activity, shelf life, glycemic response, and satiety related to levels of food processing. Results showed that minimally processed foods such as cooked lamb, brussels sprouts, hard eggs, broccoli, and pink shrimp, to name a few, were more satiating, more nutritionally dense, less hyperglycemic, had a shorter shelf-life, and in a compression test, had lower maximum stress—meaning they were deformed with less compression than ultra-processed foods (Fardet et al., 2018). Based on the study results, Fardet and colleagues concluded that foods should first be classified based upon the degree of processing, then nutrient composition, and that food and diet should be looked at as a whole and should include the matrix effect, and then should be looked at according to its component pieces.

Diet Quality Index-International: Diet Index from a Holistic Perspective

An important aspect to consider in the assessment and translation of dietary quality in practice is measurement: how is overall dietary quality measured? Most dietary indices use records of food consumption over a specified time-period using 24 h recalls, food frequency questionnaires, or daily food logs, and then generate scores indicating high or low adherence to pre-determined population-level dietary guidelines. Dietary indices differ from one to the other, each emphasizing differing aspects of dietary quality. Generally, all indices have been created to emphasize the analysis of the biomedical factors and/or health outcomes associated with food consumption rather than incorporating other social and environmental factors—reflecting the reductionist view. The current review provides an overview of the DQI-I, using it as one sample dietary quality index to illustrate the holistic conceptual framework provided herein. We acknowledge that there are many additional dietary indices that may also be suitable for use.

In order to address the need for a more holistic measurement tool, the Diet Quality Index-International (DQI-I) was developed in 2003 and was used in a cross-national study that compared dietary quality between the United States and China (Kim et al., 2003). Kim and colleagues claimed that prior to their study, no cross-national research on dietary quality had been conducted because there was no way to ensure the validity of an existing index for use in a different country or context. Therefore, the reasoning behind creating the DQI-I was to provide a measurement tool for assessing dietary quality that would apply to diverse populations in a comprehensive manner, using the average of two to three 24 h recalls and addressing overnutrition as well as undernutrition. To illustrate this concept, studies from various countries, such as Iran (Alipour Nosrani et al., 2022), Korea (Cho et al., 2021), and Canada (Setayeshgar et al., 2017), to name a few, have used the DQI-I as a measurement tool to assess dietary quality and have investigated associations between DQI-I scores and various outcomes, such as obesity and cardiovascular diseases in adults and body fat among children.

The major constructs assessed within the DQI-I are variety, adequacy, moderation, and overall dietary balance. These categories are included based upon the understanding that both foods and individual nutrients are valuable aspects of dietary quality when comparing heterogeneous dietary cultures. Kim and colleagues (Kim et al., 2003) stated that other previously developed indices often combined both adequacy and moderation into one category, making it difficult to determine the cause of a low score and, more specifically, the impact of a dietary component on an outcome of interest, as shown in Table 1.

Table 2.1.

Comparison of Index Scoring Components: Adequacy and Moderation

Dietary Quality Index-International Separate Scoring of Moderation and Adequacy						Other Index Combined Scoring of Moderation and Adequacy		
Undernutrition	⟶	Low adequacy score	⟶	Low Overall Dietary Quality	⟵	Low adequacy OR moderation score	⟵	Undernutrition
Overnutrition	⟶	Low moderation score	⟶				⟵	Overnutrition

As an example of how under or overnutrition may both lead to low overall dietary quality scores, a country with substantial undernutrition in its population could have a low score due to insufficient food sources, thereby indicating poor adequacy. On the other hand, a country known for overnutrition could have a low DQI-I score due to the overconsumption of food, indicating poor moderation. However, both countries would potentially have low overall dietary quality scores if adequacy and moderation were combined into one category, and the reason behind the score would be uncertain. Further information about the DQI-I, its components, and its scoring may be found in the original publication by Kim and colleagues (Kim et al., 2003).

Holistic Conceptual Framework for Dietary Quality Assessment

Utilizing the DQI-I as one sample dietary quality index, this section of the review elucidates how social and environmental factors related to dietary quality would add important context for the improved translation of research into practice. Examples of the biomedical, social, and environmental factors in the holistic conceptual framework are shown in Table 2. Additionally, selected sub-factors are discussed in further detail that potentially add novel and current contextual considerations. Well-established factors, such as religion, culture, climate, seasonality, and natural phenomena, remain relevant but are not the focus of this manuscript. Although sub-factors are grouped into social and environmental categories, we acknowledge that many of the sub-factors are multi-faceted and do cross into other factors and sub-factors. Further, biomedical factors will not be discussed in detail in this review, as they are typically already discussed within dietary quality index considerations.

Table 2.2.

Holistic Factors Contributing to Translation of Dietary Quality

Holistic Factors Contributing to Contextual Translation of Dietary Quality		
Biomedical Factors	**Social Factors**	**Environmental Factors**
Health/Disease Status	Culture	Climate/Seasons
Genetics	Socioeconomics	Pollution/Contamination
Anthropometrics	Religion	Land Availability
Energy Balance	Food Preparation	Food Accessibility
Developmental Status	Food Processing	Food Safety/Regulation
Personal Attributes	Meal Patterns	Topography

Social Factors

Social factors are integral to the relationship that human beings have with food and are critical to our understanding of food intake behaviors. Food is interwoven into social events, such as weddings and parties, and it is part of religious celebrations, such as Lent and Ramadan (Pilcher, 2012). For example, Eastern Orthodox Christian Church members abstain from eating olive oil, meat, fish, eggs and dairy every Wednesday and Friday, and they employ four fasting periods throughout the year (Mazokopakis & Samonis, 2018). Jewish people have specific food laws (Kosher) and dietary regulations that they abide by (Regenstein et al., 2003; Tieman & Hassan, 2015). For spiritual purposes, Buddhists avoid eating specific vegetables, alcohol, and all animal products except milk (Persynaki et al., 2017). Food is a sign of love and compassion in some cultures; in others, food is a reminder of economic status (Fonseca et al., 2019). Social factors influence food choice and dietary consumption, thereby affecting dietary quality.

Socioeconomics and Food Processing

Although the proportion of people living in poverty has never been lower than it is now, economic disparities throughout the world are as prevalent today as they were 100 years ago. According to the Food and Agriculture Organization of the United Nations, moderate to severe food insecurity affects around 2 billion people worldwide, and from that total, 1.04 billion are in Asia, 676 million are in Africa, and 188 million are in Latin America (*The State of Food Security and Nutrition in the World 2021*, 2021). Conversely, the obesity epidemic has continued to worsen and has now surpassed 650 million cases in adults worldwide (World Health Organization, 2021b). Economics influence dietary quality and food choice drastically, often times influencing individuals to rely on ultra-processed foods or no food at all rather than fresh, less processed food choices, affecting adequate micronutrient intake (Bouis et al., 2011; Darmon & Drewnowski, 2008). Sometimes, ultra-processed foods are cheaper, have a longer shelf life, and are more easily obtained than fresh, nutrient-dense foods. These factors not only make eating nutritious meals more costly and burdensome, but also make obtaining all essential nutrients difficult for segments of populations, or entire populations.

Socioeconomic factors have influenced food consumption throughout history because, in some instances, food has been a symbol of social status. Historically, the ability to purchase a plethora of food coupled with the possibility of surplus led to greater food consumption among the wealthy, resulting in increased body weight. Excess body weight was a sign of wealth and beauty (Ferris & Crowther, 2011). Today, over-consumption of food has been linked to negative health outcomes and increased risk for non-communicable diseases, but prestige-seeking behaviors are still exhibited in food selection, regardless of nutritional value (Palma et al., 2017). Wealthier people purchase and consume prestigious foods perceived to be a symbol of social status, and people with a lower socioeconomic status seek to purchase these same foods in order to be seen as members of as wealthier class, regardless of nutritional value (Palma et al., 2017). This is just one example of how social factors influence food consumption and dietary quality.

Environmental Factors

Environmental factors, such as climate, season, natural phenomena, food safety, land availability, rainfall, sunlight, topography, and food accessibility—to name a few—influence dietary quality substantially, especially in developing countries. Organizations such as the FAO have been established to help increase food accessibility and safety around the world through the implementation of sustainable food and agriculture missions, food systems, and more (FAO, 2021). Both developing and developed countries also face many environmental challenges that influence the adequacy of nutrition intake.

Food Accessibility and Land Availability

According to the FAO, in 2018, around 26.4% of people globally were facing food insecurity (*The State of Food Security and Nutrition in the World 2021*, 2021). Moderate food insecurity is defined as "having reduced quality and/or quantity of food and uncertainty about the ability to obtain food due to lack of money or other resources". Severe food insecurity is defined as "having run out of food, and at the most extreme, having gone days without eating". Socioeconomics are involved in the attainment of food, as well as geographical location in relation to sources of food. Mass food production favors the distribution of food products to areas where larger profits may be obtained, thereby neglecting the distribution of foods to lower-income areas (Jackson et al., 2016). Urban sprawl contributes to the increase in the distance between food sources and populations. Generally, as cities expand outward into suburban areas, grocery stores and food sources follow. Land availability is scarce in inner-city neighborhoods, and space is tight, discouraging businesses to build restaurants, grocery stores and super-markets. The relocation of food supply stores is also due, at least in part, to wealthier populations often occupying suburban areas. Therefore, inner-city neighborhoods, particularly low-income areas without access to transportation, are devoid of the local food sources, thereby creating food deserts (Hamidi, 2020). Food deserts are identified as areas with limited access to affordable and nutritious foods (Dutko et al., n.d.). The determination of food deserts varies but usually take into consideration whether the area is urban or rural, the cost of transportation, the price of foods, the distance to the nearest food store, the number of food stores in the area, types of food offered (fresh or preserved) and the nutritional value of the offered foods (Walker et al., 2010). Without close access to food sources, populations located within the food deserts rely on automobile transportation or public transportation. As a result, individuals living in these areas generally consume highly processed foods rather than fresh foods, based upon the expense and availability of the product (Kris-Etherton et al., 2020).

Pollution, Contamination, and Food Safety/Regulation

Pollution, contamination, and food safety are critical factors for populations in all areas of the world. Many countries have advanced regulations regarding sanitation, water treatment, food handling, food production and food regulation. In these areas, measures are taken not only to purify water sources, but also to add different key nutrients to the water supply for the purpose of enhancing health by providing essential micronutrients (Tiemann, 2013). Other countries struggle with supplying adequate clean water and safe food to support human life. Without important regulations, foodborne illnesses and diseases run rampant, resulting in sickness, disabilities, and often early mortality (Kirk et al., 2015). In 2010, an estimated 2 billion illnesses and 1.09 million deaths worldwide were reported from 22 foodborne bacterial, protozoal, and viral diseases, and many likely go unreported (Kirk et al., 2015).

Another important consideration is the effect of pollution. Plastic build-up spans all oceans and seas, potentially harming wildlife and seafood sources. Microplastics found inside whole, sea-dwelling creatures provide the potential for toxicities in humans who consume them (Smith et al., 2018). Crop injury, diminished growth, and reduced agricultural yields are present when agriculture is exposed to toxic air pollutants (Tai & Val Martin, 2017). Agriculturally polluted run-off infiltrates lakes and rivers. Run-off chemicals can have a drastic effect on native fauna, leading to an array of health issues for people that consume them (EPA, n.d.). For example, as a result of intense agricultural practices on the banks of the Racoon River in Central

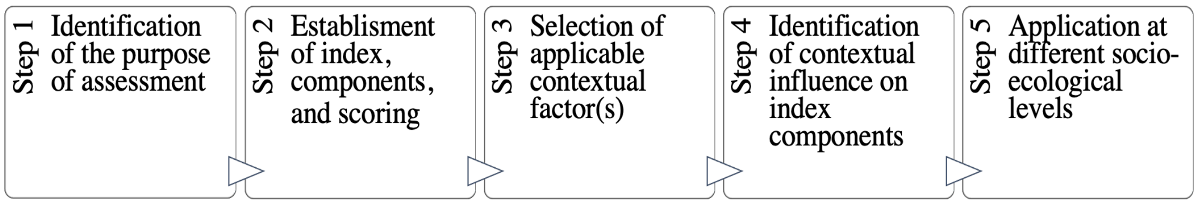
Iowa, nearly three-quarters of the 1.7 million-acre watershed is cultivated. This process requires millions of pounds of fertilizer, pesticides, and other chemicals. Consequently, the rising nitrate level has passed the Environmental Protection Agency's (EPA) legal limit for drinking water (Ridgely, n.d.). These factors contribute to food and water availability by decreasing the amount of clean drinking water and safe food production. Without a proper supply of agricultural products, the adequacy of plant and animal-based foods may not meet population needs, thereby jeopardizing adequacy and balance.

DQI-I: Contextual Translation of Dietary Quality Scores

Some of the most popular dietary indices, such as the HEI, AHEI, and DASH Score indices, are most relevant to high-income countries that have access to plentiful food sources and food imports; therefore, these indices may not be relatable or applicable for low-income countries that struggle with food security (Poyatos Guerrero & Pérez-Rodríguez, 2017). The DQI-I is an index that allows users to customize measurements based upon country-specific guidelines. This customizability provides a foundation for additional considerations that could include other social and environmental contextual factors to provide a more holistic assessment. The DQI-I is used as a focused example index within this critical review, specifically because of its applicability to various contexts. Other indices could also be modified using the conceptual framework suggested to incorporate other holistic factors. The process of how contextual considerations could be incorporated into dietary quality assessment through alterations, exclusions, modifications, and additions to the DQI-I are shown in Figure 1: Holistic Dietary Quality Assessment Process.

Figure 2.1.

Holistic Dietary Quality Assessment Process

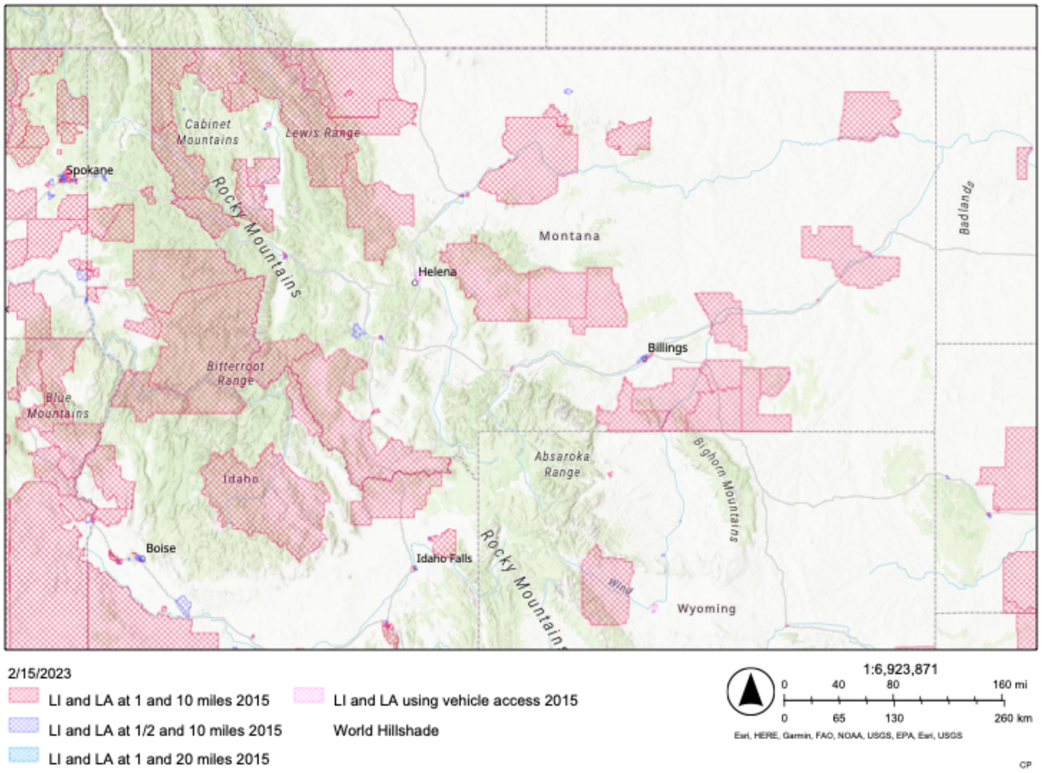


The first step in the conceptual Holistic Dietary Quality Assessment Process is to identify the purpose or goal of the assessment to provide direction for the contextualization of overall dietary quality and how the assessment might be applied. Once the goal of the assessment has been identified, the next step is to select the most appropriate dietary index, including its components and scoring methods. For the examples we have provided, we used the DQI-I due to its applicability to different populations and settings (Kim et al., 2003) where this assessment process might be used (Hennessey, 2010). The next step is to select a contextual factor or factors that are thought to potentially influence overall dietary quality. The factors listed in the assessment process model are nowhere near exhaustive of the biomedical, social, or environmental factors that could be present in a population. Additionally, it is understood that these factors are highly interconnected. Once the contextual factors have been identified for measurement, a critical analysis of each index component should be conducted to determine what aspects of dietary quality may be influenced by the selected contextual factor, whether that be variety, adequacy, moderation, balance, or another index component. In other words, what components of the dietary index are being negatively affected due to the additional social or environmental factors. These considerations may add valuable context for evidence-based practices, allowing for the translation of dietary quality scores to the appropriate post-assessment recommendations based on the social and environmental factors that influence dietary quality.

The following examples are hypothetical illustrations of how this conceptual assessment process might be use in different settings, specifically at the individual and community or societal levels of influence on health (Hennessey, 2010; McCloskey et al., n.d.). Table 3: Holistic Dietary Quality Assessment Process, Example 1: Community or Societal level illustrates an example of a hypothetical community leader identifying potential reasons for poor dietary quality in their respective geographic location. Specifically, we highlight rural areas where accessibility to healthful foods might be lacking and how programming or policy changes might help to improve dietary quality at the community level. In order to determine accessibility, the United States Department of Agriculture: Economic Research Service's "Food Data Atlas" represents one way to identify areas of low income and areas of low accessibility to healthful foods, as seen in Figure 2: Example of the Food Access Research Atlas (USDA: Economic Research Service, 2021). After completing the assessment process steps, the community leader could then determine what feasible, immediate, or minor changes could be made to increase the accessibility of the healthful foods in their community—for example, reducing sales taxes on fresh produce or creating pop-up farmers markets within low-income, low-accessibility areas.

Figure 2.2.

Example of the Food Access Research Atlas Low-Income (LI) Low-Access (LI) Montana



Note. Figure 2 shows a rural location in Montana, USA. Low-income (LI) and Low-access (LA) at 1–10 miles, ½–10 miles, 1–20 miles, and using vehicle access are displayed.

Table 2.3.

Holistic Dietary Quality Assessment Process, Example 1: Community or Societal level

Holistic Dietary Quality Assessment Process Example 1: Community or Societal-level				
Step 1: Identification of Index, Components, and Scoring	**Step 2: Selection of Applicable Contextual Factor/factors**	**Step 3: Identification of Contextual Influence on Index Component**		
Variety: (0-20 pts) Overall variety (0-15 pts) Within-group (0-5 pts)	**Biomedical** Health/ Disease Status Genetics Anthropometrics Energy Balance	**Variety (0-20 pts)**	→	The "within-group" variety for protein might be limited due to not including points for other protein sources such as grains, legumes, seeds, soy, or other geographic-specific protein sources.
Adequacy: (0-40 pts) Vegetable (0-5 pts) Fruit (0-5 pts) Grain (0-5 pts) Fiber (0-5 pts) Protein (0-5 pts) Iron (0-5 pts) Calcium (0-5 pts) Vitamin C (0-5 pts)	Developmental Status Personal Attributes **Social** Culture Socioeconomics Religion Food Preparation	**Adequacy (0-40 pts)**	→	Different types of nutritional data, such as a 24-hour recall, might alter the accuracy of this component due to accessibility issues differing from one day to another. A FFQ might be more appropriate during this context, as it allows the dietary quality score analyze intake over a period of time.
Moderation: (0-30 pts) Total Fat (0-6 pts) Saturated Fat (0-6 pts) Cholesterol (0-6 pts) Sodium (0-6 pts) Empty Calories (0-6 pts)	Food Processing Meal Patterns **Environmental** Climate/Seasons Pollution/Contamination	**Moderation (0-30 pts)**	→	Ready-to-eat foods or highly processed foods might be eaten more regularly due to difficulties accessing fresh produce. These foods are often high in saturated fats, sugars, sodium, and empty calories.
Balance: (0-10 pts) Macronutrient ratio (0-6 pts) Fatty acid ratio (0-4 pts)	Land Availability *Food Accessibility* Food Safety/Regulation Topography	**Balance (0-10 pts)**	→	The types of foods potentially consumed when fresh produce is not readily available, such as foods with a long shelf-life, could contribute to an off balanced fatty acid ratio.

Note. Bold font denotes headings of major index scoring areas and contextual factor groups. Italic font denotes the contextual factor/s identified in the assessment process.

To further demonstrate the assessment process, Table 4: Holistic Dietary Quality Assessment Process, Example 2: Individual level illustrates a hypothetical practitioner helping an individual client who has lactose intolerance and is living in a northern geographic area during winter. Through the identification of barriers to achieving high dietary quality such as decreased Vitamin D intake, the practitioner may focus on strategies to help increase dietary quality, such as switching to lactose-free dairy products, taking a Vitamin D supplement, or focusing on fortified foods. Additionally, by adding contextual factors, the practitioner may identify a "ceiling" for the dietary quality that the client could potentially achieve, considering the factors that are in or out of that client's control. This process could help to determine potential facilitators to improving dietary quality, making achievable recommendations to increase overall dietary quality. The goal would be able to maximize the potential dietary quality, recognizing that some factors would not be controllable and may not be easily modified.

Table 2.4.

Conceptual Holistic Dietary Quality Assessment Process, Example 2: Individual level

Holistic Dietary Quality Assessment Process Example 2: Individual-level				
Step 1: Identification of index, components, and scoring	**Step 2: Selection of applicable contextual factor/factors**	**Step 3: Identification of contextual influence on index component**		
Variety: (0-20 pts)		**Variety (0-20 pts)**	→	Variety score might be low due to low accessibility to in-season fruits and vegetables.
Overall variety (0-15 pts)	**Biomedical**			
Within-group	*Health/Disease Status*			
(0-5 pts)	Genetics			
Adequacy: (0-40 pts)	Anthropometrics			
Vegetable (0-5 pts)	Energy Balance	**Adequacy (0-40 pts)**	→	Special consideration might be given to foods that are plentiful sources of Vitamin D.
Fruit (0-5 pts)	Developmental Status			
Grain (0-5 pts)	Personal Attributes			
Fiber (0-5 pts)				
Protein (0-5 pts)	**Social**			
Iron (0-5 pts)	Culture			
Calcium (0-5 pts)	Socioeconomics			
Vitamin C (0-5 pts)	Religion			
Moderation: (0-30 pts)	Food Preparation			
Total Fat (0-6 pts)	Food Processing	**Moderation (0-30 pts)**	→	Some of the foods that would still contribute to increased health could also contain high amounts of sodium, such as canned vegetables.
Saturated Fat (0-6 pts)	Meal Patterns			
Cholesterol (0-6 pts)				
Sodium (0-6 pts)	**Environmental**			
Empty Calories (0-6 pts)	*Climate/Seasons*			
Balance: (0-10 pts)	Pollution/Contamination			
Macronutrient ratio (0-6 pts)	Land Availability	**Balance (0-10 pts)**	→	Ratios could be off-balanced if the person is unable to consume specific foods.
Fatty acid ratio (0-4 pts)	Food Accessibility			
	Food Safety/Regulation			
	Topography			

Note. Bold font denotes headings of major index scoring areas and contextual factor groups. Italic font denotes the contextual factor/s identified in the assessment process.

Cross-Population Comparisons

The flexibility for dietary quality scoring to be based on country-specific guidelines, when used within the context of a larger, uniform scale, provides a foundation for a holistic conceptual framework for evaluation across different cultures and populations. A more holistic and useful analysis of dietary quality may be possible when evaluation of dietary quality (1) includes contextual, social and environmental factors according to country or region based on their specific dietary guidelines or the Food and Agriculture Organization of the United Nations (FAO) guidelines, and (2) considers variety, adequacy, moderation, and balance. Further, this more contextualized and holistic approach may allow insights into the explanatory mechanisms behind dietary quality differences than are typically gleaned from assessments of dietary quality. For example, if a study were to evaluate the dietary quality of high-income countries (e.g., Canada) or populations where there is access to a large variety of imported foods versus populations from a desert-climate low-income country (e.g., Libya) with few imported food products, dietary intakes and guidelines would likely differ drastically. While it is possible that indices of dietary quality could be modified to add biomedical, social, and environmental factors in order to provide a more holistic assessment, another potential approach would be to utilize previously designed dietary quality indices with minor modifications alongside separate tools that assess social and environmental factors anytime dietary quality is assessed. For example, if a practitioner suspects that a social or environmental factor may be a barrier to achieving high dietary quality scores, this conceptual framework may be used to determine what contextual factors are present, thereby allowing alterations to post-assessment recommendations and potential interventions.

Conclusions

The purpose of the current critical review was not to offer a definitive solution for the problem of poor dietary quality, but rather to shine a light on the need to further inquire about how we might accomplish the inclusion of contextual factors when seeking to understand the barriers and facilitators for optimizing dietary quality. Considering contextual factors alongside adherence to dietary guidelines in dietary quality assessment could strengthen the core of evidence-based practices. Evidence-based practices are essential for providing high-quality care, guiding the development of policies, determining preventive practices, and much more. An improved understanding of individual and population-level goals, expectations, preferences, accessibility, and resources through evidence-based nutrition practices will produce reasonable, applicable, and beneficial nutritional recommendations. A holistic approach to dietary quality assessment may allow nutrition professionals to better identify areas for improvement, such as potential barriers contributing to poor adherence to guidelines within dietary intervention studies, or specific population needs for overcoming barriers to positive health outcomes. If dietary quality is substantially hindered due to social or environmental factors, public health officials could use these data to work toward mitigating barriers to the extent possible. Further, the identification of the populations that are doing well with regard to dietary quality, even while facing social or environmental challenges, could assist nutrition scientists in advising government agency professionals developing future dietary guidelines.

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Chapter 3 - Opportunities for Maximizing the Dietary Quality of Fad Diets

Abstract

Background: The quality of American diets, measured by the Healthy Eating Index (HEI), has remained stable and low since 2005 (*Dietary Guidelines for Americans, 2020-2025*, n.d.). The Dietary Guidelines for Americans 2020–2025 call for research analyzing dietary patterns to determine how guidelines might be altered to increase healthy eating. *Objective:* The current manuscript sought to determine the dietary quality of popular fad dietary patterns among Americans, using Google Explore to determine the top 25 searched diet-related terms. *Methods:* A definition of "fad diet" was determined using scholarly and non-scholarly media sources. Google Explore was then searched for popular diets, using various search terms to determine popular dietary patterns based on the established fad diet definition. Finally, nine dietary patterns were identified for inclusion. One-week sample menus were created for each dietary pattern, maximizing alignment with the DGAs but staying within the dietary pattern parameters, and then scored according to the HEI 2015 to determine the dietary quality. *Results:* Total HEI scores ranging from 26.7 (Carnivore) to 89.1 (Low-FODMAP); the six highest total HEI scores ranged from 77.1–89.1 out of 100 points. *Conclusion:* This analytical approach showed that some of the included popular fad dietary patterns have the potential to attain high dietary quality. Rather than suggesting one "best" diet or dietary pattern, there is opportunity to maximize dietary quality in the context of dietary patterns that are considered to be fad diets.

Introduction

The 2020–2025 version of the Dietary Guidelines for Americans (*Dietary Guidelines for Americans, 2020-2025*, n.d.) revealed that despite continual public health nutrition education, policy, and programmatic efforts, Americans are not adhering to the dietary guidelines (Dietary Guidelines Advisory Committee, 2020). Measured yearly from 2005–2016, scores have ranged from 56–60 out of 100 on the Healthy Eating Index (HEI), which measures dietary quality or healthfulness of dietary patterns based on adherence to the DGAs (U.S. Department of agriculture, 2022). These scores suggest that relatively poor adherence has persisted over a long period of time (Nation Center for Health Statistics, 2022). To determine why Americans have not improved HEI scores over the past several DGA releases, the DGAC suggests that researchers take into consideration existing dietary patterns that influence dietary consumption to better manage and treat diet-related diseases.

Research suggests that the Westernized diet, followed by many Americans, is characterized as high in calories, saturated and trans fats, sugar and sodium, oversized portions; and low in fruits, vegetables, and fibers (Rakhra et al., 2020). Further, around 80% of Americans habitually under consume fruits, vegetables, and dairy/dairy alternatives as compared to the DGA recommendations (*Dietary Guidelines for Americans, 2020-2025*, n.d.). Americans also overconsume refined grains and animal proteins, added sugars, saturated fats, sodium, and alcoholic beverages (*Dietary Guidelines for Americans, 2020-2025*, n.d.). Added sugars and saturated fats account for around 13% and 11% or more of total calories allocated per day, respectively, for the average American, well above the 15% combined total calorie allotment for these types of foods (*Dietary Guidelines for Americans, 2020-2025*, n.d.).

Overall, despite continual refinement of the DGAs to reflect current nutritional needs, adherence to the guidelines remains problematic, and the quality of the American diet is persistently within the “needs improvement” HEI scoring range of 51–80 (Hurley et al., 2009). However, the most popular dietary patterns, sometimes considered as “fads,” reflect the efforts of many to either improve the healthfulness of their diets, and/or to establish a negative energy balance for weight loss. Given the importance of dietary quality for long-term health outcomes, understanding the dietary quality of these fad dietary patterns is critical; determination of the most popular dietary patterns may offer insight into what Americans are actually eating in order to assess areas of poor adherence to dietary guidelines.

Therefore, the primary purpose of the current study was to define and characterize what constitutes a fad diet and to determine the most “popular” fad dietary patterns in the United States. The secondary purpose was to evaluate the dietary quality of the relevant popular fad dietary patterns, assuming that each diet followed the DGAs to the extent possible, according to the rules of the specific pattern. Finally, we synthesized the results across all of the included fad dietary patterns in order to offer insights regarding opportunities for maximizing the dietary quality of Americans, with the understanding that poor adherence to the DGAs is persistent.

Methods

Define Fad Diet: Part 1

For the purposes of this study, we defined the term “dietary patterns” according to the DGA Committee 2020 (DGAC) definition, “the quantities, proportions, variety, or combination of different foods, drink, and nutrients in diets, and the frequency with which they are habitually consumed (Dietary Guidelines Advisory Committee, 2020) pg. 475).” To determine a comprehensive operational definition of a “fad diet,” two independent researchers compiled a database of definitions and diet attributes from peer-reviewed sources (29%); textbooks (21%); and websites, reports, popular books, and blogs (50%), as shown in Table 1. Common themes appearing across numerous database entries were identified as indicated in Table 1. The common themes that appeared the most frequently in database entries included 1) lack of physical activity; 2) rigidity, where intake of certain foods was required; 3) marketing and endorsements by celebrities; 4) restriction, where complete omission of foods or food groups was required; and 5) unrealistic timeframes for weight loss. The frequency of these themes was as follows: lack of physical activity (36%), rigidity (50%), marketing (57%), restriction (64%), and time (92%). Using these themes as a framework, the following working definition of a fad diet was established for the purpose of the current study: a pattern of eating aimed at rapid, unsustainable weight-loss that may severely restrict calories and nutrients, by omitting foods or entire food groups, and/or recommending rigid eating patterns, restricting physical activity, or indicating the lack of necessity for physical activity, where reported results are not evidence based, and are marketed through endorsements from authority figures or celebrities

Table 3.1.

Fad Diet Attributes

Title, Author, Date	**Source Type**	**Fad Diet Attributes**					
		Lack of physical activity	Rigidity	Market-ing	Restrict -ion	Time	Other
Healthy weight, nutrition, and physical activity (Centers for Disease Control and Prevention, 2021)	Website				X		unhealthy, typically fail
Staying Away from Fad Diets (Wolfram, 2021)	Website	X	X			X	
“Weight-loss diets,” 2018	Website		X		X	X	
Fad Diets vs. Healthy Behaviors (Center for Young Women;s Health, 2021)	Website		X	X		X	refers to food as "good" or "bad"
Nutrition for weight loss: What you need to know about fad diets (Fitzgerald, 2022)	Website	X	X	X		X	draw simple conclusions from complex medical research
A Consumer's Guide to Fad Diets (Sizer & Whitney, 2018)	Textbook	X	X	X	X	X	claims individuals can "alter your genetic code" or "rest your metabolism" and fails to mention potential risks

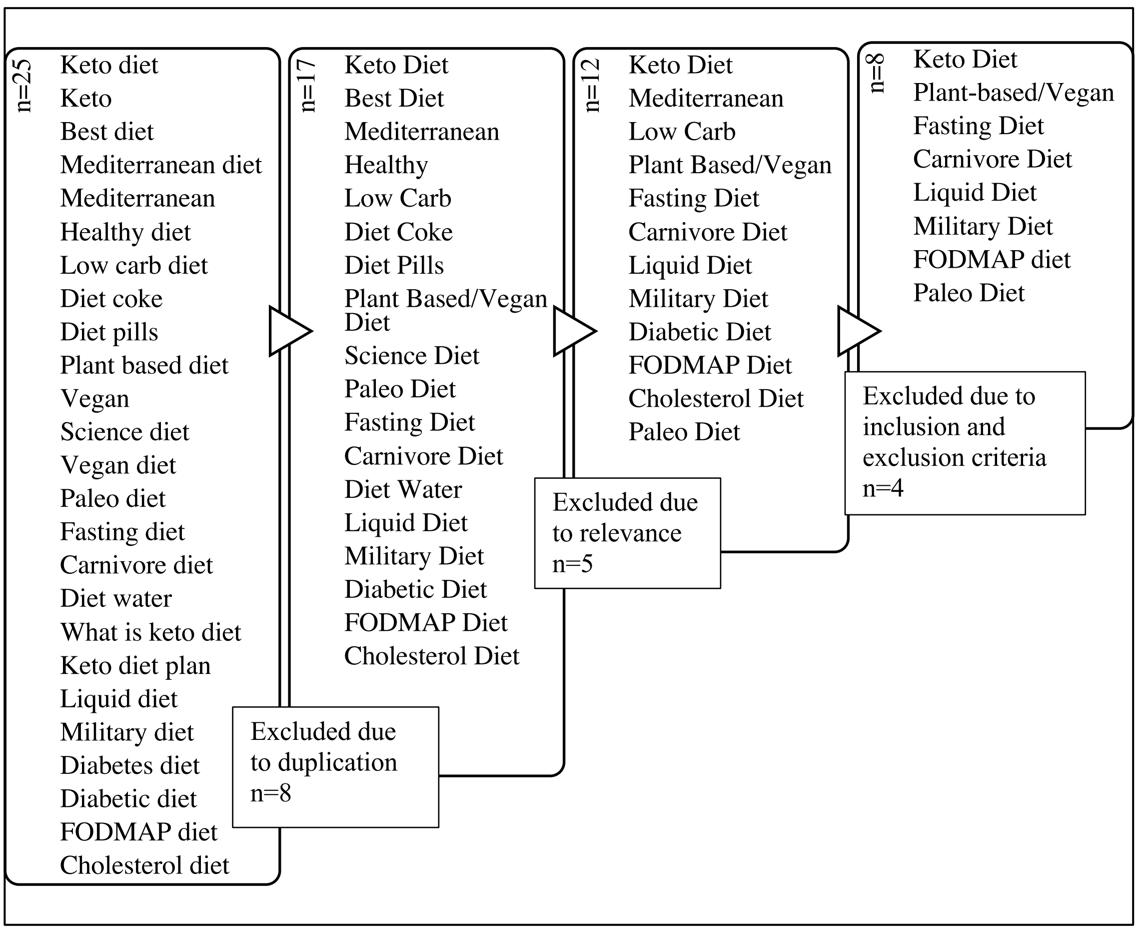
The Latest and Greatest Weight-Loss Diet- Again (Rolfs & Whitney, 2011)	Textbook			X	X	X	recommends liquids rather than foods and fails to inform the client of risks
Fad Diets (Bastin, 2004)	Website	X	X			X	fails to mention health warnings
Fad Diets: Lifestyle Promises and Health Challenges (Khawandanah & Tewfik, 2016)	Journal		X		X	X	may negatively impact health, propelled by ideal body image and low self-esteem, may cause yo-yo dieting, caused from ideal body type portrayed through media influence
Review of Dietary Practices of the 21st Century: Facts and Fallacies (Subhan & Chan, 2016)	Journal		X	X		X	does not take into consideration social and environmental factors relating to dietary consumption, promotes weight loss then health, based on cultural norms of the time
Functional Foods in fad diets; A review (Navaro et al., 2017)	Journal			X		X	
Fad diets: Diet, types, tips (Cleveland Clinic, 2020)	Website		X	X	X	X	
Fad diets: The Slim on good nutrition (Daniels, 2004)	Textbook	X		X		X	
Fad Diets and Obesity - Part IV: Low-Carbohydrates vs. Low-Fat Diets (Moyad, 2005)	Journal				X	X	

Selection of Fad Diets for Analysis: Part 2

Google Explore© was then used to delimit the "popular" dietary patterns, identified from the most widely searched terms or phrases related to fad diets, for inclusion in the current study. First, the term "diet" was searched, and results were filtered to include only those terms or phrases that were searched between January 1st and October 7th of 2020 at 12:30pm. Results showed the top 25 searched terms or phrases (n=25) that included the keyword "diet." To ensure the continued relevance of these fad diets, an identical search was conducted on January 31st, 2022. Results were filtered to include the terms or phrases that were searched between October 7th and January 31st. Results were reviewed to identify any new dietary patterns that were not previously included. Terms or phrases were eliminated due to duplication (n=8) and/or relevance (n=5) where diets were not for human consumption, were not a dietary pattern, or included supplements only. Inclusion and exclusion criteria were derived from the agreed upon definition of "fad diets." The inclusion criteria were dietary patterns that 1) suggested rapid, unsustainable weight loss, 2) severely restricted daily caloric intake, 3) omitted entire food groups or recommended rigid eating patterns outside of the Acceptable Macronutrient Distribution Ranges (AMDRs) for carbohydrates, fats, and protein; 45–65%, 20–35%, and 10–35% of total energy intake, respectively (Food and Nutrition Board Institute of Medicine, 2005), 4) restricted or diminished the importance of physical activity, and/or 5) suggested results that were not supported by peer-reviewed research evidence. Exclusion criteria included any dietary patterns that 1) had accepted credible peer-reviewed evidence available to show sustainable weight loss and/or health benefits, 2) allowed flexibility within the eating pattern, 3) did not severely restrict calories and/or nutrients, 4) suggested physical activity to accompany the dietary pattern. After applying the selection criteria to the remaining 12 terms or phrases, the following dietary patterns (n=8) were included for evaluation and synthesis: Ketogenic Diet, Plant-based/Vegan Diet, Fasting Diet, Carnivore Diet, Liquid Diet, Military Diet, Low-FODMAP Diet, and the Paleo Diet. The process for selecting the final eight dietary patterns is shown in Figure 1. These eight dietary patterns are referred to as popular fad dietary patterns hereafter.

Figure 3.1.

Process for Selecting Included Dietary Patterns



Operationalization of Popular Fad Dietary Patterns: Part 3

In order to operationalize each popular fad dietary pattern for subsequent evaluation and synthesis, an agreed upon/mutual understanding of each popular fad dietary pattern was determined. Two independent researchers identified the parameters of the popular fad dietary patterns from peer-reviewed sources, and when no peer-reviewed sources were available, information was obtained from websites, reports, popular books, or blogs to determine the specifics for each popular fad dietary pattern, as well as potential mechanisms of action related to weight loss and/or health outcomes. Non-peer-reviewed data were used only when peer-reviewed sources were not available. The priority for use of evidence was as follows: peer-reviewed sources; governmental websites and reports; and websites, popular books, and blogs. The popular fad dietary pattern definitions (Table 2) included specific parameters such as calorie limits, micronutrient compositions, dietary components that were restricted, required supplements, required special food products, etc. Any disagreements regarding these parameters were first discussed by two researchers (JP, KR) and additional researchers (SKR, JJ) were included in discussions when needed in order to arrive at one standardized definition for each popular fad dietary pattern.

Table 3.2.

Definition and Parameters for Selected Fad Dietary Patterns

Dietary Pattern	Description
Ketogenic Diet	Dietary pattern characterized by low-carbohydrate intake (< 50g/day), moderate protein intake (~20% of total caloric intake), and high fat intake(~70% of total caloric intake) (Ludwig, 2020).
Plant Based/Vegan Diet	The vegan diet is a plant-only diet that allows no consumption of animal products; the vegetarian diet is a plant- based diet where eggs and dairy may be consumed (Medawar et al., 2019; Melina et al., 2016).
Fasting Diet	Umbrella term used to define dietary patterns where individuals refrain from eating for strategic periods of time followed by normal eating where this process in repeated for potential health effects (Patterson & Sears, 2017) Alternate day fasting: one day fasted followed by a day of eating Alternate day modified fasting: 2 days fasted per week, 5 days of normal eating Periodic fasting: numerous days of consecutive fasting per month Time restricted feeding: restricted eating window to certain hours of the day

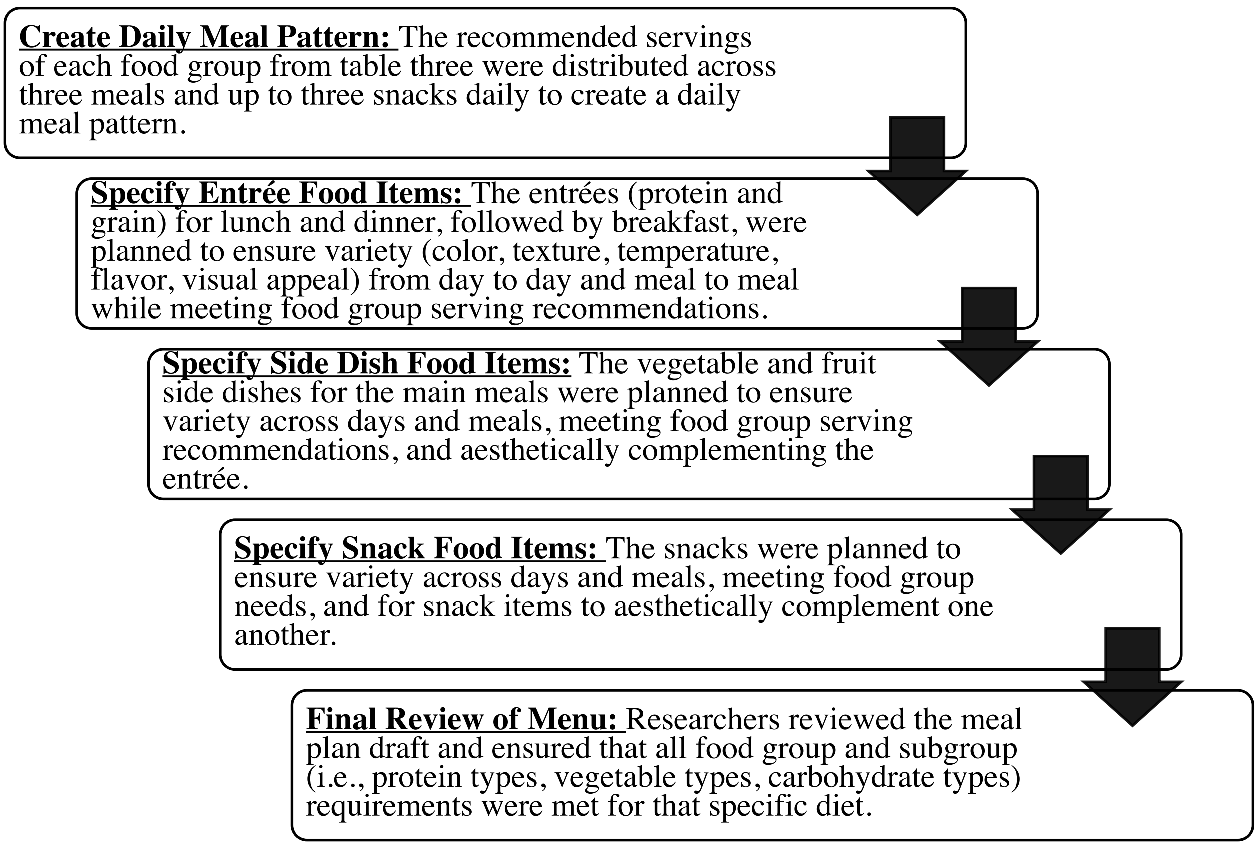
Carnivore Diet	No caloric restriction is necessary, and no fruits or vegetables are acceptable, the only permitted foods are meat, especially fatty cuts, and animal byproducts like bone marrow or bone broth (*How The Carnivore Diet Works How To Start, What To Eat, And More*, 2022).
Liquid Diet	Diet consisting of the following permitted liquids: Water (plain, carbonated, or flavored) Fruit juices without pulp, such as apple or white grape juice Bone broth Miso Strained vegetable juice 100% fruit juice popsicles Generally used for pre-operation situations where an empty colon is required and helps individuals maintain hydration and electrolyte balance (Mayo Clinic, 2020; Oates & Sandeep, 2021; Villines, 2021).
Military Diet	Three-day weight-loss program of rigid eating followed by four days of normal eating; options are available for individuals following a plant-based diet; no other beverages or foods are permitted (*What Is the Military Diet?*, 2022).
Low-FODMAP Diet	Dietary pattern that uses restriction of carbohydrate rich foods -highly fermentable oligosaccharides, disaccharides, monosaccharides, and polysaccharides- to treat IBS, SIBO and other gastrointestinal distress disorders; once symptoms subside, carbohydrate rich foods are reintroduced into the diet as tolerated (Altobelli et al., 2017; Veloso, 2022).
Paleolithic Diet	Dietary pattern that restricts consumption of grains, legumes, peanuts, peas, dairy products, refined sugar, artificial sweetener, salt, potatoes, trans fats, vegetable oil, and highly processed foods and emphasizes intake of fruits, vegetables, lean proteins, seafood, nuts, and seeds (Mayo Clinic Staff, 2020).

Creation of Menus for Analysis: Part 4

One-week menus utilizing the operationalized parameters of the popular fad dietary pattern were created using a process that is similar to a clinical dietitian's process (created by JJ) for creating a meal plan for a patient by using specified food group servings spread out into meals and snacks throughout the day to create a daily meal pattern, followed by menu planning principles to specify food items that fulfill the food group servings in the meal pattern (i.e., start with planning the entrée of the main meals then move on to planning sides and finally snacks, consider varied aesthetic elements like colors and textures across meals and days, ensure foods within meals and snacks complement one another).

Figure 3.2.

Process for Creating Menus for Analysis



As seen in Figure 2, first, the recommended servings of each food group from Table 3 were distributed across three meals and up to three snacks daily to create a daily meal pattern. Second, the entrées (protein and grain) for lunch and dinner, followed by breakfast, were planned to ensure variety (color, texture, temperature, flavor, visual appeal) from day to day and meal to meal while meeting food group serving recommendations. Then, the vegetable and fruit side dishes for the main meals were planned to ensure variety across days and meals, meeting food group serving recommendations, and aesthetically complementing the entrée. Next, the snacks were planned to ensure variety across days and meals, meeting food group needs, and for snack items to aesthetically complement one another. Once the meal plan draft was created, researchers reviewed them and ensured that all food group and subgroup (i.e., protein types, vegetable types, carbohydrate types) requirements were met for that specific diet.

Table 3.3

Dietary Pattern Parameters

Dietary Pattern	Rules	Timeframe for Recommenda-tions	Calorie Intake	Vegetables (cup equivalent)					Fruits (cup equivalent)	Grains (oz equivalent)		Dairy/Dairy Alternatives (cup equivalent)	Protein (oz equivalent)			Oils (g)
				Dark Green	Red Orange	Legumes	Starchy	Other		Whole Grains	Refined		Seafood	Meats, Poultry, Eggs	Nuts, Seeds Soy Products	
HEI/DGA		Daily	2,000			2.5			2	3	3	3		5.5		27
		Weekly	14,000	1.5	5.5	1.5	5	4	14	21	21	21	8	26	5	189
Keto Diet	< 50g of carbs/day 20% calories from protein 70% calories from carbs	Daily	√						< 50g of carbohydrates per day					20% of caloric intake from protein sources		70% of caloric intake from fat sources
		Weekly	√													
Plant Based/Vegan	No meat products	Daily	√			√			√	√	√	√		√ excluding animal sources for vegan; allowing eggs for plant based		√
		Weekly	√	√	√	√	√	√	√	24.5	√	√		24.5 excluding animal sources excluding animal sources for vegan; allowing eggs for plant based		√
Fasting Diet: Time Restricted Feeding	Feeding window- 16hr fast:8hr feeding	Daily	√			√			√	√	√	√	√	√	√	√
		Weekly	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Carnivore Diet	Meat only, mainly red meats	Daily	√						0					All dietary intake from animal meats only, prioritizing red meats		
		Weekly	√													
Liquid Diet	Clear liquids only: Fruit juices without pulp, bone broth, miso, strained vegetable juice, 100% fruit juice popsicles	Daily	√			√ Strained vegetable juice (25cal and 1 serving per ½ cup)			√ Fruit juices or 100% fruit juice popsicles, all without pulp (60cal and 1 serving per ½ cup)		0		Bone broth (80cal and 5g per cup), miso (60)cal and 5g per cup)			-
		Weekly	√	√	√	0	0	√	√							

Liquid Diet	Clear liquids only	Daily	√			√			√	0						
		Weekly	√	√	√	0	0	√	√							
Military Diet	Rigid dietary intake following plan (see meal plan below*) for 3 days followed by normal eating for 4 days	Daily (4 normal eating days)	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Low-FODMAP Diet	Restriction of carbohydrate rich foods -highly fermentable oligosaccharides, disaccharides, monosaccharides, and polysaccharides	Daily	√	restriction of high-FODMAP vegetables: beans, lentils, broccoli, asparagus, garlic, onion inclusion of low-FODMAP vegetables: tomato, eggplant, cucumbers					restriction of high-FODMAP fruits: peaches, apples, pears inclusion of low-FODMAP fruits: blueberries, oranges, limes, lemons, strawberries, pineapples	restriction of high-FODMAP grains: wheat-based products inclusion of low-FODMAP grains: oats, quinoa, rice, gluten free products		restriction of high-FODMAP dairy: milk, yogurts, ice cream, milk-based products inclusion of low-FODMAP dairy: some cheeses, non-dairy based milk products that are calcium fortified	√	√	√	√
		Weekly	√										√	√	√	√
Paleolithic Diet	Restriction of grains, legumes, peanuts, peas, dairy products, refined sugar, artificial sweetener, salt, potatoes, trans fats, vegetable oil, and highly processed foods.	Daily	√			√			√	0	0	0		√		√
		Weekly	√	√	√	0	0	√	√	0	0	0	√	√	√	√

To ensure that menus were created to comply with the DGAs to the extent possible, maximizing dietary quality within the rules of each popular fad dietary pattern, a DGA-compliant meal pattern and menu were first created and were then used as the template for subsequent popular fad dietary pattern menus, and modified according to differences in the food group requirements shown in Table 3. This process helped to reduce potential researcher bias regarding the popular fad dietary patterns that could result in lower dietary quality scores for the popular fad dietary pattern menus. The one-week sample menus are located in Appendix A.

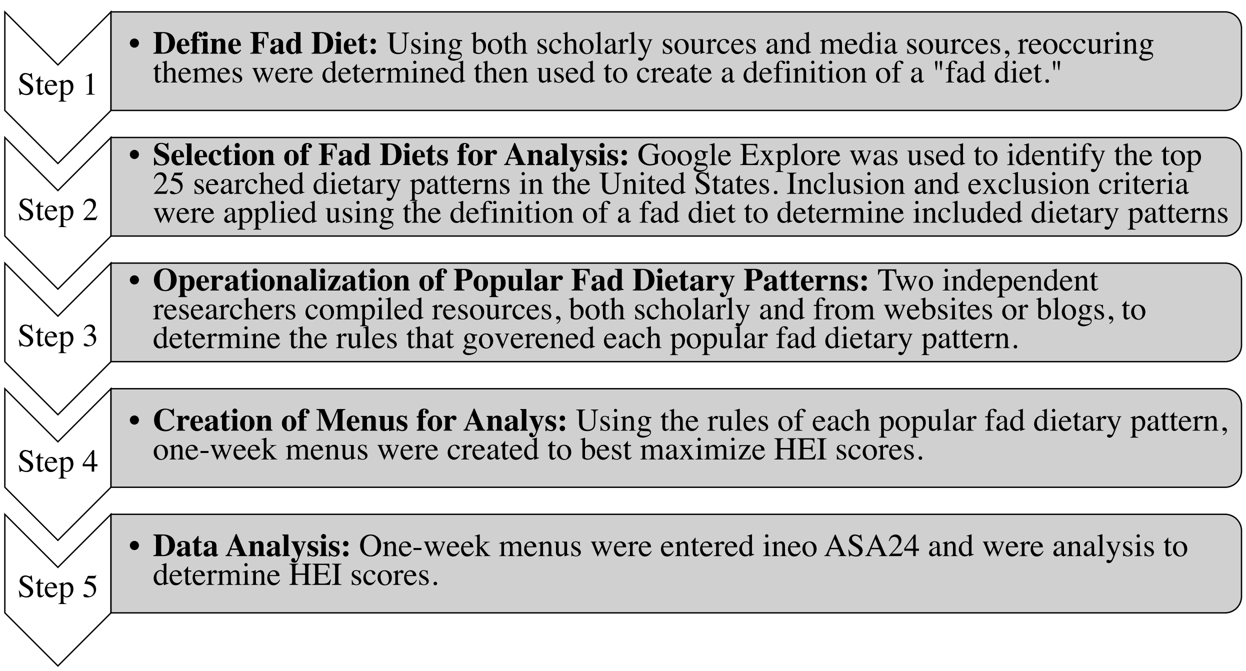
Data Analysis: Part 5

Dietary intake data were analyzed using the Automated Self-Administered 24-hour (ASA24®) Dietary Assessment Tool, version (2021), developed by the National Cancer Institute, Bethesda, MD (National Cancer Institute Division of Cancer Control & Population Sciences, n.d.). Each day of the sample menus was entered in the ASA24® software, and specific foods, portion sizes, and drinks and condiments were indicated. Once each menu was entered, data were extracted and analyzed using the statical software SAS, version 8, copyright © 2022 (*SAS Software Inc.*, 2022). Data were analyzed according to the NCI SAS code provided for all researchers to determine HEI-2015 scores ranging from 0–100 where 0 indicates low adherence to the DGAs and 100 indicates full adherence. The following variables were analyzed: total vegetables, greens and beans, total fruit, whole fruit, whole grain, dairy/dairy alternatives, total protein foods, seafood and plant protein, fatty acid ratio, sodium, refined grains, saturated fat, added sugar, and total HEI-2015 score (National Cancer Institute Division of Cancer Control & Population Sciences, 2022). The outcome variables were analyzed based upon their categorization regarding adequacy (total vegetables, greens and beans, total fruit, whole fruit, while grains, dairy/dairy alternatives, total protein foods, seafoods and plant protein, fatty acid ratio), where higher intake is preferable, or moderation, where lower intake is preferable (sodium, refined grains, saturated fats, and added sugar).

Micronutrient analyses were determined by calculating the means and standard deviations per nutrient, and comparing those with the Dietary Reference Intakes (DRIs): Recommended Dietary Allowances (RDA) (National Institutes for Health, 2022). Recommendations for the 19–50yr age group for both males and females were used for comparisons. The micronutrient recommendations were determined to have been met if the means and standard deviations met or exceeded the RDAs for both males and females.

Figure 3.3.

Methods for Selection of Dietary Patterns to Analysis



Results

Popular Fad Dietary Patterns Definitions

The Ketogenic Diet, Plant-based/Vegan Diet, Fasting Diet, Carnivore Diet, Liquid Diet, Military Diet, Low-FODMAP Diet, and the Paleo Diet, were identified for inclusion in the current study based upon inclusion and exclusion criteria for the fad diet themes. In order to ensure shared understanding of each popular fad dietary pattern, the following operational definitions were determined for each popular fad dietary pattern along with proposed mechanisms of action for weight loss.

Ketogenic Diet

The Ketogenic Diet was popularized in the 1920s by Russell Wilder as a treatment for epilepsy, where restriction of carbohydrates, used as medical nutrition therapy, was used to alter energy metabolism and neurotransmitter function (Masood et al., 2021; Roehl & Sewak, 2017). This diet is characterized by extremely low carbohydrate consumption (< 50 g/day), moderate protein consumption (~20% of total caloric intake/day), and high fat intake (~70% of dietary intake/day) (Ludwig, 2020). Overall, the goal of the Ketogenic Diet is to follow any pattern of food consumption that would result in nutritional ketosis (Roehl & Sewak, 2017). Due to the omission of entire food groups and recommendations of rigid eating patterns outside the AMDRs, the Ketogenic Diet it is considered a popular fad dietary pattern for the purposes of the present study. The Ketogenic Diet has gained popularity due to its metabolic effects and has been repurposed from its original intended use as a medical nutritional therapy for uses a method for weight loss. This restrictive dietary pattern may not be easily maintained over the long-term; therefore, once dietary intake returns back to “normal” and carbohydrates are increased with more typical fat and protein amounts, weight may be regained (Batch et al., 2020).

The mechanism of action for this dietary pattern is centered around ketosis. When carbohydrates are absent from or lacking in the diet, other substrates are used to supply the body with energy. Glucose stores become insufficient for energy needs, thereby influencing energy availability for the central nervous system (CNS) (Kirkpatrick et al., 2019). Insulin production decreases while glucagon production increases, signaling the liver to decrease lipogenesis and increase the synthesis of mitochondrial fatty acids (Kirkpatrick et al., 2019). Ketone bodies, namely acetoacetate and beta-hydroxybutyrate, are formed by the incomplete breakdown of fatty acids due to insufficient amounts of oxaloacetate. As ketone bodies are increased and become the predominant fuel source, nutritional ketosis is achieved. Some published research outcomes associated with a Ketogenic Diet include weight loss, increased insulin sensitivity, potential cancer prevention, and treatment of neurological disorders, as well as negative side effects including muscle cramps, lethargy, micronutrient deficiencies, hepatic insulin resistance, increase in oxidative stress, decreased production of certain gut microbiota, vomiting, abdominal pain, and constipation (Gordon, 2019; Ludwig, 2020; Tuck & Staudacher, 2019). This pattern has been shown to reduce high blood pressure, decrease blood plasma triglycerides, lower glycosylated hemoglobin (HbA1c), reduce postprandial glycemic response, produce an anti-inflammatory effect, and enhance fat oxidation (Batch et al., 2020; Ludwig, 2020).

Plant-Based/Vegan Diet

Plant-based eating is a broad category of eating patterns centered around consuming mostly plant-based foods (McManus, 2021). Generally, plant-based eating comprises diets that are void of animal flesh foods and where the majority of nutrients and calories are from plants (Medawar et al., 2019; Melina et al., 2016). While plant-based diets are generally perceived as healthful, rigidity and restriction and/or omission of foods within the protein food group are present, therefore, they are fit our inclusion and exclusion criteria for a popular fad dietary pattern. Plant-based diets are generally rich in beans, legumes, nuts, soy, fruits, vegetables, and whole grains, as well as fibers, phytochemicals, and healthy fats (Medawar et al., 2019). Increased consumption of predominately unprocessed plant-based foods may be associated with weight control due to overall calorie reduction, increased satiety through increased fiber intake, and greater overall volume of lower calorie/higher water volume content foods. Many other beneficial aspects of a plant-based diet are thought to be due to increased phytochemical, antioxidant, fiber, and micronutrient consumption, as well high nutrient density.

A systematic review of 32 human intervention studies sought to determine the influence of plant-based or vegan diets on metabolism and/or cognitive function (Medawar et al., 2019). Of the 32 included studies, sample sizes ranged from 10–129 participants, duration extended from 5 days to 12 months, and outcomes of interest were centered around both metabolic and cognitive function. In the 26 studies of healthy participants or participants with T2DM, results suggested that as compared to an omnivore diet, a plant-based diet was associated with improved HbA1c levels, greater weight loss, decreased serum low-density lipoproteins (LDL) levels and total cholesterol (Medawar et al., 2019). Overall, this systematic review suggested that evidence was limited regarding the influence of a plant-based diet on cognitive function.

Fasting Diet

The Fasting Diet, also known as intermittent fasting, is an umbrella term used to describe heterogeneous dietary patterns where food is completely restricted for specified periods of time followed by periods of normal/typical eating (Patterson & Sears, 2017). This process is repeated over time until desired health effects are reached. Alternate day fasting consists of one day of fasting followed by one day of eating normally or feasting (Patterson & Sears, 2017; Rynders et al., 2019). Modified fasting, also known as intermittent energy restriction, is based upon the alternate day fasting method of two days of fasting per week followed by five days of normal eating. However, rather than completely abstaining from any caloric consumption, overall intake is limited to ~20–25% if total energy needs on fasting days (Patterson & Sears, 2017) Periodic fasting is characterized by numerous days of consecutive fasting per month ranging from two days to many (Rynders et al., 2019). In some cases, fasting may not mean consuming a balanced and healthful diet, rather it compresses or alters the eating time window.

In other situations, fasting results in omitting entire food groups and extreme caloric reduction. Weight loss resulting from following this dietary pattern may be attributed to reduction in caloric intake and improved insulin sensitivity (Stockman et al., 2018). In a previous review, Rynderes and colleagues sought to identify the current evidence on intermittent energy restriction as treatment for overweight and obesity, reviewing studies (n =11) at least 8-weeks in duration where fasting was compared to a control that included continuous energy restriction. Nine of the 11 included studies suggested that both strategies produced similar weight and fat loss, therefore, authors concluded that both fasting and continuous calorie restriction are potential methods for treatment for overweight and obesity (2019).

Carnivore Diet

The Carnivore Diet, which gained popularity in the late 2010's, is a diet that consists of eating only animal/meat products, namely red meats, without any other sources of food, and without intentional restriction of calories (*How The Carnivore Diet Works How To Start, What To Eat, And More*, 2022). Although this diet suggests strictly eating meat, it is well established that the transition period between other dietary patterns and the Carnivore Diet is difficult; therefore, many diet followers might incorporate other food sources into the diet (*How The*

Carnivore Diet Works How To Start, What To Eat, And More, 2022). There is little to no peer-reviewed evidence over the Carnivore Diet, specifically, and studies where only animal flesh is consumed are absent. The Carnivore Diet suggests omitting entire food groups and has rigid recommendations outside of the AMDRs; therefore, this dietary pattern is considered a popular fad dietary pattern.

Potential mechanistic rationale behind the Carnivore Diet includes evidence that protein intake promotes satiety, thereby encouraging caloric restriction and maintenance of lean tissue during weight loss (Johnstone et al., 2008; Volek et al., 2002). Documented outcomes of high-protein diets, not specific to the Carnivore Diet, include reductions in C-reactive protein, mitigation of sarcopenia in older adults, increased cholesterol levels, decreased HDL/LDL ratio, and increased probability of colon and breast cancer (Lo et al., 2020; Martone et al., 2017).

Liquid Diet

The Liquid Diet is a diet consisting only of liquids, allowing no intake of solid foods (Mayo Clinic, 2020). Examples of foods permitted on a liquid diet are water, fruit juices without pulp, bone broth, miso, strained vegetable juice, and 100% fruit juice popsicles (Cirino, 2019). Generally, Liquid Diets are intended for the short-term, and used pre- and post-surgery, where an empty colon is necessary (Oates & Sandeep, 2021). The Liquid Diet has been used as a quick weight loss method, which is not the original purpose of the diet (Villines, 2021). When used in a weight loss context, a Liquid Diet severely restricts caloric intake, omits entire food groups, has rigid recommendations well outside of the AMDRs, and is not supported by research. Some effects of the Liquid Diet are temporary weight loss due to overall reduction in highly calorically dense foods and absence of food residue in the intestines, low vitamin and mineral intake, potential nutrient deficiencies, and fatigue (Villines, 2021).

Military Diet

The Military Diet is advertised as a low-calorie diet that includes foods designed to increase weight loss without slowing down metabolic processes (What Is the Military Diet?, 2022). This diet consists of three days of planned meals, as shown in Table 4, followed by four days of normal eating until desired results are achieved. Alternate meal plans are provided for those following a plant-based diet. The Military Diet is characterized by extreme caloric reduction and rigid eating patterns outside of the AMDRs. The proposed mechanisms of action are extremely low caloric consumption and low carbohydrate consumption. Low carbohydrate consumption leads to lowered glycogen stores, and since water is stored with glycogen, reduction in glycogen may also lead to lowered body water content (Kreitzman et al., 1992). Therefore, weight-loss tends to occur due to reduced water weight in the initial stages of the diet. Some of the effects of rapid weight loss diets are reductions in fat mass, quick weight loss due to caloric restriction and loss of stored water, and potential reductions in fat-free mass (Ashtary-Larky et al., 2020).

Table 3.4.

Military Diet Meal Plan

Day 1	Day 2	Day 3
Breakfast: 1/2 Grapefruit, 1 Slice of Toast, 2 Tablespoons of Peanut Butter, 1 cup Coffee or Tea (with caffeine) **Lunch**: 1/2 Cup of Tuna, 1 Slice of Toast, 1 cup Coffee or Tea (with caffeine) **Dinner**: 3 ounces of any type of meat, 1 cup of green beans, 1/2 banana, 1 small apple, 1 cup of vanilla ice cream	**Breakfast:** 1 egg, 1 slice of toast, 1/2 banana **Lunch:**1 cup of cottage cheese, 1 hard-boiled egg, 5 saltine crackers **Dinner:** 2 hot dogs (without bun), 1 cup of broccoli, 1/2 cup of carrots, 1/2 banana, 1/2 cup of vanilla ice cream	**Breakfast**: 5 saltine crackers, 1 slice of cheddar cheese1 small apple **Lunch:** 1 hard-boiled egg (or cooked however you like), 1 slice of toast **Dinner**:1 cup of tuna, 1/2 banana, 1 cup of vanilla ice cream

Low FODMAP Diet

The FODMAP Diet, better known as the Low-FODMAP Diet, an acronym for fermentable oligosaccharides, disaccharides, monosaccharides, and polysaccharides, was originally created as a way to control gastrointestinal distress and relieve symptoms related to irritable bowel syndrome (IBS) and small intestine bacteria overgrowth (SIBO) (Veloso, 2022). The Low-FODMAP Diet suggests extreme restriction of highly fermentable oligosaccharides, disaccharides, monosaccharides, and polysaccharides; which are found in carbohydrate-rich foods, such as fruits, vegetables, dairy, and grains; until symptoms of IBS, SIBO, and other gastrointestinal issues subside (Altobelli et al., 2017). Once symptoms have lessened, carbohydrate-rich foods are slowly reintroduced into the diet over time. This type of diet is recommended for those who have symptoms suggestive of gluten or carbohydrate intolerance, as a way to identify foods that provoke problematic symptoms. The Low-FODMAP Diet is sometimes repurposed from its original intent as a quick weight loss diet, omitting entire food groups. The proposed mechanism of action is associated with decreased short-chain carbohydrate consumption, resulting in less fermentation of fibers, subsequently reducing gas production (Veloso, 2022). Additionally, restriction of FODMAP foods may reduce total caloric intake, potentially leading to weight loss. Research outcomes associated with the low-FODMAP diet include treatment of IBS and other IBS-like conditions, reduction of gastrointestinal distress, and short-term weight loss (Gibson, 2017; van Lanen et al., 2021).

Paleolithic Diet

The Paleolithic Diet, sometimes referred to as the “Paleo Diet,” “Cave-Man Diet,” or a hunter-gatherer diet, is a way of eating that emphasizes consuming foods that were readily eaten in the Paleolithic era (Mayo Clinic Staff, 2020). Specifically, the Paleolithic Diet restricts consumption of grains, legumes, peanuts, peas, dairy products, refined sugars, artificial sweeteners, salt, potatoes, trans fats, vegetable oil, and highly processed foods. It also emphasizes intake of fruits, vegetables, lean proteins, seafood, nuts, and seeds (Gunnars, 2018; Mayo Clinic Staff, 2020). The Paleolithic Diet is characterized as a popular fad dietary pattern due to its omission of entire food groups.

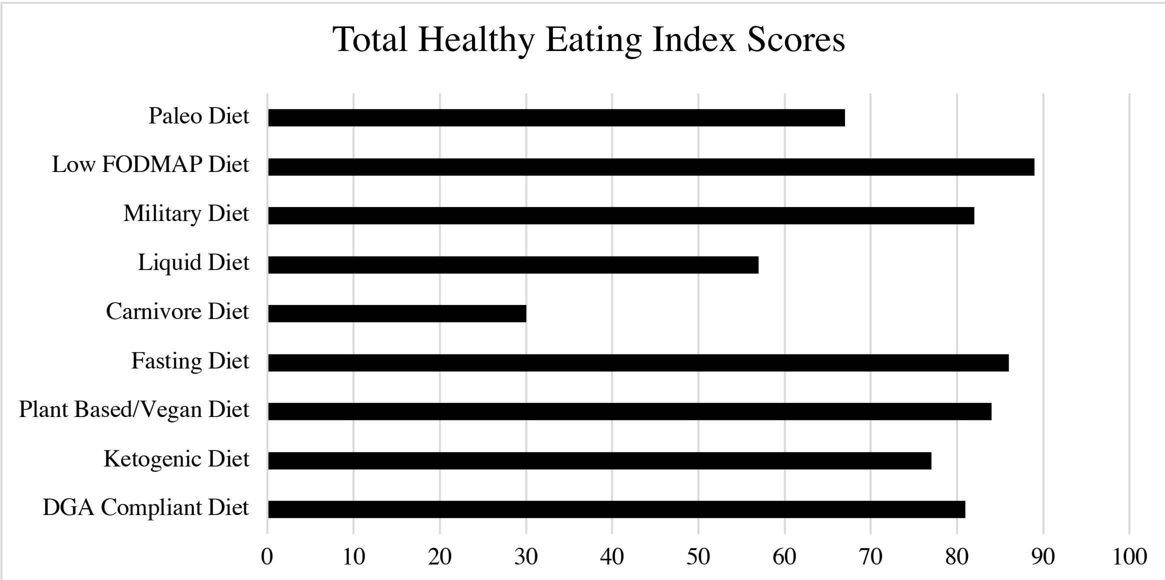
The proposed mechanism of action is through increased intake of nutrient-dense foods and decreased intake of nutrient-poor, ultra-processed foods. In a systematic review and meta-analysis, Ghaedi and colleagues (2019) reviewed eight eligible randomized controlled studies to determine the influence of a Paleolithic Diet on weight, body composition, circulating concentrations of blood lipids, blood pressure, and inflammatory markers. Health outcomes associated with the Paleolithic Diet in comparison to the control diets included lowered bodyweight, BMI, and waist circumference. Additionally, Ghaedi and colleagues suggest that improved blood pressure, circulating cholesterol, triglycerides, LDL cholesterol, C-reactive protein, and increased HDL cholesterol could be associated with the Paleolithic Diet, but that results should be interpreted cautiously (Ghaedi et al., 2019). Another systematic review and meta-analysis over 31 human intervention trials examined the Paleolithic Diet associations to non-communicable diseases, where results indicated improved bodyweight, BMI, and waist circumference when following the Paleolithic Diet as compared with participants not participating in a diet for weight loss (de Menezes et al., 2019).

Healthy Eating Index Scores for Each Dietary Pattern

Analysis of each popular fad dietary pattern, where adherence to the DGAs was maximized, is shown in Figure 4, revealing total HEI scores ranging from 26.7 (Carnivore) to 89.1 (Low-FODMAP). The six highest total HEI scores ranged from 77.1–89.1.

Figure 3.4

Total Health Eating Index Scores



Total calorie provision was the highest in the Liquid Diet (2,143kcal/day), and lowest in the Carnivore Diet (3,102kcal/day). Excluding the Carnivore Diet and Liquid Diet, the remaining seven popular fad dietary patterns total calories ranged from 1,524kcal/day for the Paleo Diet, to 1852kcal/day for the Ketogenic Diet.

Figure 3.5.

Average Daily Calorie Totals

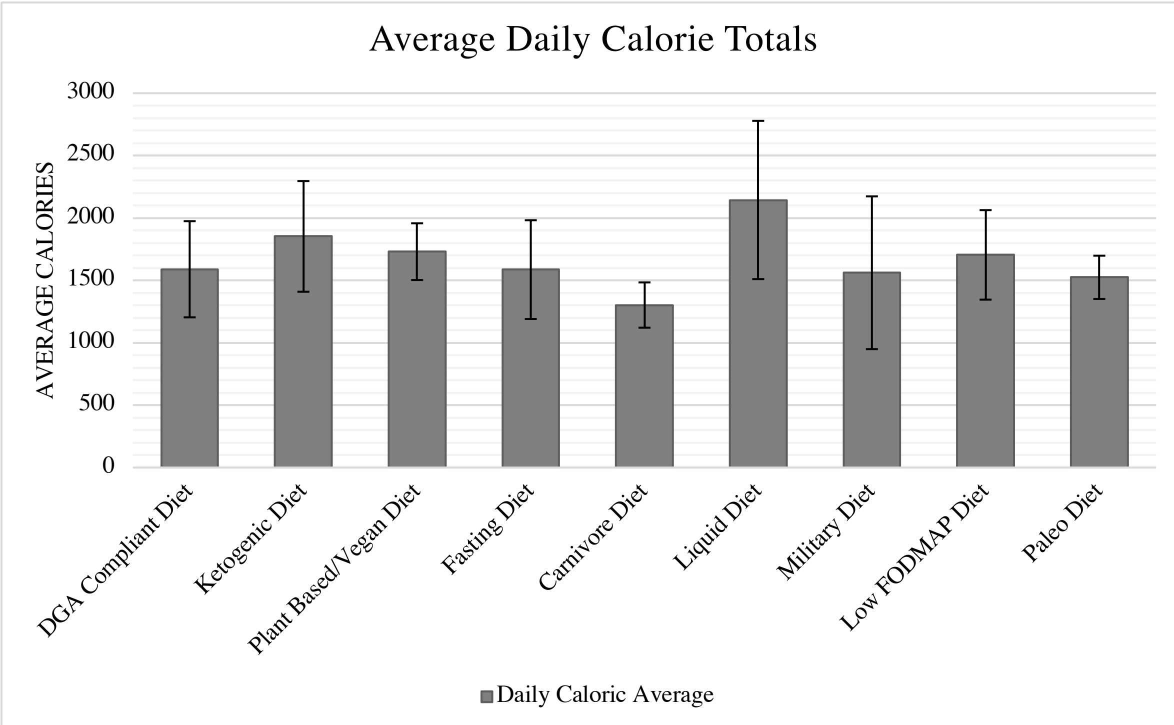


Table 5 illustrates the adequacy component scores that were based upon a 5-point scale where 0 represented non-adherence and 5 represented maximal adherence. Each popular fad dietary pattern, except for the Ketogenic Diet, where carbohydrates were limited, the Carnivore Diet, where plant foods were excluded, and the Liquid Diet, could accommodate the maximal fruit, vegetable, and protein intakes. Overall, adherence was high among the majority of adequacy components for fruits, vegetables, and protein.

Additionally, among the adequacy component scores that were based upon a 10-point scale where 0 represented non-adherence and 10 represented maximal adherence, overall, whole grains were consistently scored low, indicating submaximal adherence among all popular fad dietary patterns. This could be due to how ASA24 classified whole grains versus refined grains per the theoretical menus. Dairy/dairy alternatives was also an area where scores were submaximal among six of the nine poplar fad dietary patterns. The fatty acids ratios of six of the popular fad dietary patterns scored maximal points while the DGA Compliant Diet, the Military Diet, and the Liquid Diet did not.

Also illustrated in Table 5, the moderation component scores that were based upon a 10-point scale where 0 represented non-adherence and 10 represented maximal adherence, sodium scores consistently indicated submaximal adherence among all popular fad dietary patterns, indicating that many of the popular fad dietary patterns provided excessive sodium even when using best practices for minimizing sodium content. Refined grains and added sugars scores were high, representing low consumption. Finally, saturated fats scores were generally high among all popular fad dietary patterns, representing low consumption. Exceptions were for the Ketogenic Diet and the Carnivore Diet, due to high consumption of animal products fats.

Table 3.5.

HEI Scores for Popular Fad Dietary Patterns

HEI Scores for Popular Fad Dietary Patterns										
	Scoring requirements for maximum score per 1,000 kcal	DGA Compliant Diet	Ketogenic Diet	Plant Based/Vegan Diet	Fasting Diet	Carnivore Diet	Liquid Diet	Military Diet	Low FODMAP Diet	Paleo Diet
Adequacy Components (5 pt Scale)										
Total Vegetable	*≥1.1 cup equivalent*	5	5	5	5	0	5	5	5	5
Greens & Beans	*≥0.2 cup equivalent*	5	5	5	5	0	2.1	5	5	5
Total Fruit	*≥0.8 cup equivalent*	5	3.5	5	5	0	5	5	5	5
Whole Fruit	*≥0.4 cup equivalent*	5	5	5	5	0	0	5	5	5
Total Protein	*≥ 2.5-ounce equivalent*	5	5	5	5	5	4.3	5	5	5
Seafood & Plant Protein	*≥0.8-ounce equivalent*	5	5	5	5	5	0	5	5	5
Adequacy Components (10 pt Scale)										
Whole Grains	*≥1.5-ounce equivalent*	6.4	2.9	7.4	5.6	0	0	7.1	8.2	0

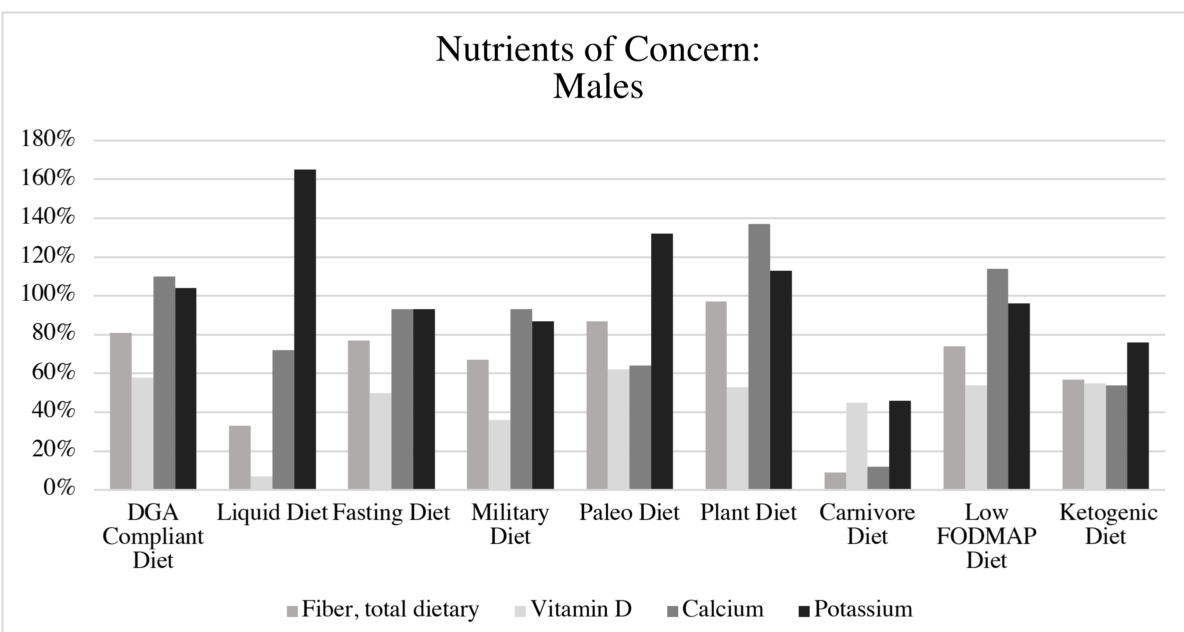
Dairy/Dairy Alternatives	*≥1.3 cup equivalent*	10	3.7	10	10	0.04	0	8.7	7.8	0.4
Fatty Acids Ratio	*(PUFAs + MUFAs) / SFAs Max ≥2.5* *Min ≤1.2*	7.18	10	10	10	10	5.6	2.6	10	10
Moderation Components (10 pt Scale)										
Sodium	*Max: ≤1.1g* *Min: ≥2.0g*	0	7.01	.03	1.3	0	0	5.5	3.09	0
Refined Grains	*Max: ≤1.8-ounce equivalent* *Min: ≥4.3-ounce equivalent*	7.8	10	10	9.6	10	10	10	10	8.5
Saturated Fats	*Max: ≤8% of energy* *Min; ≥16% of energy*	10	4.8	10	10	0	10	8.37	10	8.5
Added Sugars	*Max: ≤6.5% of energy* *Min; ≥26% of energy*	9.8	10	10	9.33	10	10	9.8	9.99	10

Micronutrient Analysis

Figures 6 & 7 illustrate the micronutrient adequacy of each popular fad dietary pattern as compared to the RDAs; specifically, calcium, Vitamin D, potassium, and fiber are highlighted due to the DGAs emphasizing these as nutrients of concern for the American population (*Dietary Guidelines for Americans, 2020-2025*, n.d.) Calcium was adequate for all fad dietary patterns except the Paleo Diet, Carnivore Diet, and Ketogenic Diet, and Vitamin D was only adequate for the Paleo Diet. Potassium was adequate in all but the Ketogenic and Carnivore Diets, while fiber was lacking in the Carnivore, Liquid, and Ketogenic Diets. Overall, the Carnivore and Ketogenic Diets had the potential for more nutritional inadequacies for both vitamins and minerals as compared to the other fad dietary patterns. The remaining seven dietary patterns had, on average, nutritional concerns about over consumption of sodium and inadequate consumption of Vitamin E and Vitamin D.

Figure 3.6.

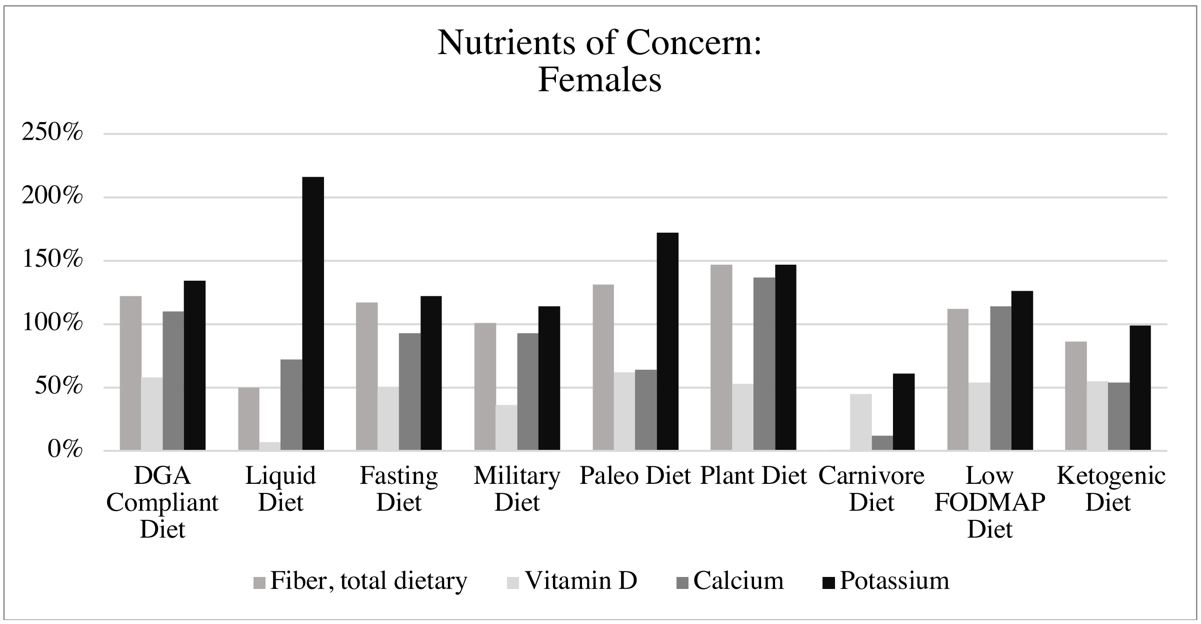
Nutrients of Concern: Males



Note. Each fad dietary pattern was compared to the RDAs were used as the standard where the RDA for fiber, Vitamin D, calcium, and potassium were 38g, 15mcg, 1,000mg, and 3,400mg, respectively. The figure above shows the percentage of attainment of the RDA per nutrient of concern.

Figure 3.7.

Nutrients of Concern: Females



Note. Each fad dietary pattern was compared to the RDAs were used as the standard where the RDA for fiber, Vitamin D, calcium, and potassium were 25g, 15mcg, 1,000mg, and 2,600mg, respectively. The figure above shows the percentage of attainment of the RDA per nutrient of concern.

Discussion

The current study sought to determine the potential for improving dietary quality among popular fad dietary patterns. We first created a working definition of a fad diet based upon both scholarly and non-scholarly sources, then we determined the most popular fad dietary patterns in

America based upon the most searched "diet" term or phrase in Google. A secondary purpose was to evaluate the extent in which the selected popular fad dietary patterns could adhere to the DGAs, as measured but the HEI, staying within the rules of the dietary pattern. Finally, we synthesized common elements from each of the included fad dietary patterns to determine how adherence to the DGAs could be maximized, and therefore maximize the dietary quality of Americans. This evaluation and synthesis showed that some popular fad dietary patterns have the potential for high dietary quality (HEI scores >80) when the fad dietary patterns are planned carefully to follow the DGAs to the extent possible under the rules of the diets. The fad diets that reached the cut point for high dietary quality included the Low FODMAP Diet, Plant Based/Vegan Diet, Military Diet, Fasting Diet, and the DGA Compliant Diet. In comparison to the average HEI scores of the American population (59), the Ketogenic Diet (77), Plant Based/Vegan Diet (84), Military Diet (82), Low FODMAP Diet (89), Fasting Diet (86), and Paleo Diet (69) all have the potential to achieve dietary quality scores that are higher than the current population average, highlighting the importance of understanding that there are many ways to achieve a high-quality diet. Other key findings suggest that nutritional adequacy is potentially problematic in the Carnivore and Ketogenic Diets, although the Ketogenic Diet can achieve a high HEI score. The remaining seven fad dietary patterns can meet most of the RDAs when planned to follow the DGAs.

Table 6 suggests minor alterations that could be made to improve the dietary quality of popular fad dietary patterns that "meet people where they are" as a strategy to improve adherence to dietary patterns that are health promoting. Note these recommendations may not typically be allowed for each popular fad dietary pattern if strict adherence to the parameter is the priority. For this synthesis piece, we grouped the popular fad dietary patterns in the following manner: least restrictive (DGA Compliant Diet, Plant-Based/Vegan Diet, & Fasting Diet), moderately restrictive (Military Diet, Paleo Diet, & Low FODMAP Diet) and most restrictive (Ketogenic Diet, Carnivore Diet, and Liquid Diet).

Table 3.6.

Strategy to Improve Dietary Quality

Areas of concern where HEI scores are consistently low	Modifications made within the study to maximize HEI scores	Popular Fad Dietary Patterns Grouped by Restriction Level (Low, Moderate, and High)	Modifications suggested for future studies to further maximize HEI scores	Example of alterations	Common elements to further maximize scores
High intake of sodium and refined grains; low intake of whole grains.	Where applicable, incorporating different sources of lean proteins and plant-based protein sources, selecting a variety of different plant foods, reducing intake of added sugar and sodium, incorporating different types of mono- and polyunsaturated fats, selecting low-fat dairy/dairy alternative products, and selecting whole grains over refined grains.	DGA Compliant Diet, Plant-Based/Vegan Diet, & Fasting Diet	Selecting low-sodium foods and reducing the amount of refined grains while replacing them with whole grains.	Replacing high-sodium pretzels with either a reduced-sodium option or another non-refined grain.	Select products with low sodium content, incorporate more whole grains, and minimize saturated fat intake.
High intake of sodium, refined grains, and saturated fats; low intake of whole grains and dairy/dairy alternatives.		Military Diet, Paleo Diet, & Low FODMAP Diet	Selecting low-sodium foods, selecting products with limited saturated fats, and including more whole grains* and dairy/dairy alternatives *.	Replacing hot-dogs with a lean protein, substituting ice-cream with yogurt, and adding in whole grains where restricted.	
High intake of sodium, refined grains, and saturated fats; low intake of whole grains, fruits, vegetables, and dairy/dairy alternatives.		Ketogenic Diet, Carnivore Diet, and Liquid Diet	Adding in whole grains* and dairy/dairy alternative products, reducing sodium intake, and balancing fat intake.	Incorporate milk or milk alternatives, selecting a low-sodium broth, substituting bacon for a lean protein, and adding in whole grains where restricted.	

Note. * indicates where recommendations might fall outside of the rules of the popular fad dietary pattern.

A limitation of the current study is that the sample meal plans were not isocaloric; however, the HEI analysis is standardized using foods/nutrients consumed per 1000 calories, and thus adjusts for the differences in calorie provision. However, for some popular fad dietary patterns, for example the Liquid Diet, matching calorie content did not allow for a realistic application of this popular fad dietary pattern. Further, the purpose of the current analysis was to determine how closely each popular fad dietary pattern could adhere to the DGAs to maximize HEI scores; therefore, rather than focusing on creating isocaloric menus for analysis, we determined that creating menus to maximize HEI scores was more aligned with the purpose of this study. Another limitation is that these example menus, designed to maximize dietary quality, potentially do not represent how individuals are following these popular dietary patterns. Rather, they are indicative of the potential for the fad dietary pattern to be considered high in dietary quality.

Directions for Future Research

In alignment with the DGAC recommendations, we suggest that future research determine the dietary patterns Americans are actually consuming, and to what extent they adhere to the rules/restrictions of the identified patterns, so that recommendations might provide practical and reasonable insights, the "low hanging fruit," for improving the dietary quality provided by various dietary patterns. Given that previous studies indicate poor compliance to weight loss diets, future research should also aim to identify opportunities for altering restrictive diets to increase acceptability and adherence. Finally, future analyses should be conducted to determine what dietary patterns are emerging and gaining popularity, such that nutrition professionals can use best practices to help determine how maximal dietary quality and nutrient intake may be achieved within preferred dietary patterns, or potentially with minor alterations that fall outside of the rules that would be acceptable to the client or patient.

Conclusion

This study suggest that there are many approaches to achieving better dietary quality. By using the preferred dietary pattern as a basis for a client/patient, making small changes within the rules or parameters of the dietary pattern might reveal acceptable strategies/components for improvement in dietary quality. Generally, popular fad dietary patterns might be viewed negatively, and there are many misconceptions regarding the “correct” way to eat. A dismissive stance from nutrition and public health professionals may overlook the potential for popular dietary patterns to be health promoting.

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Chapter 4 - The Influence of Overall Dietary Quality on Stress, Anxiety, Depression, and Academic Performance in College Students: A Systematic Review

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Abstract

Objective: The objective of this systematic review was to examine current evidence regarding the associations between dietary quality and mental well-being indicators (stress, anxiety, and/or depression) in college students, with a secondary aim of characterizing the relationship between overall dietary quality and academic performance. **Methods**: Searches were performed, and the PRISMA guidelines were followed for reporting the methods and results. **Results:** Twelve observational studies were included and reviewed showing high dietary quality was associated with: low stress (four studies), *high* stress (one study), and no significant association (two studies); low depression (three studies) and no significant association (two studies) and low anxiety (two studies), *high* anxiety (one study), and no significant associations (two studies). Results showed weak positive associations between overall dietary quality and academic performance. **Conclusions:** These results are consistent with other studies of dietary quality and non-clinical mental health outcomes; more researched is needed to determine potential associations.

Word Count: 150

Dietary Quality, Stress, Anxiety, Depression, Academic Performance, University

Introduction

The transitional period from the late teenage years into early adulthood is often characterized by vast changes and self-discovery (Wood et al., 2018). The *Emerging Adulthood* theory proposes that the life-stage of people aged 18–25 years is developmentally important, as life decisions made during this time have the potential to influence the future (Arnett, 2000). During this time, young people may be contemplating future relationships, career paths, academics, independent living, and other life-altering decisions (Arnett, 2000). Currently, statistics from the United States Department of Education, National Center for Education Statistics, show that in 2018, of the 3.2 million students who graduated from high-school in the U.S., around 2.2 million people, or 69%, enrolled in 2-year or 4-year colleges directly after graduation (National Center for Education Statistics, n.d.). These numbers demonstrate that a substantial proportion of the young adult population is attending higher-education institutions.

There are numerous behavior and environmental changes that can create or exacerbate the stressors associated with attending college, including social activities, sleep, work, dietary habits, high workloads, unfamiliar environments, academics, and changes in living situations (Acharya et al., 2018). These changes may influence perceived stress, anxiety, and depression in these students. These non-clinical mental health indicators have been shown to be negatively associated with academic performance (Tosevski et al., 2010). According to the American College Health Association, 67,972 students spanning over 98 college institutions completed the *National College Health Assessment 2019,* where 33%, 45.3% and 13.4% of college students reported "average stress," "more than average stress," and "tremendous stress," respectively (American College Health Association, n.d.). Furthermore, 24.3% and 20.0% of surveyed students reported being diagnosed and treated for anxiety or depression within the last 12 months, and 16.5% reported having both anxiety and depression (American College Health Association, n.d.). Additionally, students also reported low fruit and vegetable intake with 8.8% reporting consuming no servings per day, 62.7% reporting 1-2 servings per day, 24.1% reporting 3-4 servings per day, and only 4.3% reporting 5 or more servings per day; indicating that many college students are not consuming recommended amounts of fruits and vegetables (American College Health Association, n.d.).

Recently, there has been an increased focus on the psychological well-being of college students, in part due to the COVID-19 pandemic (Rahimnia et al., 2013; UC Santa Cruz, 2022). Efforts to mitigate the ramifications of mental health issues include various coping resources that aim to assist college students with managing the myriad demands that are perceived as creating "overload" and are beyond the perceived capacity of the student for handing these stressors. Some examples of coping resources include optimism, psychological control or mastery, self-esteem, and social support (Taylor & Stanton, 2007). Interestingly, coping resources do not typically include dietary manipulation or nutritional therapy as a method to help reduce stress, anxiety, or depression. When incorporated into a well-balanced, high-quality diet, each of the subsequently highlighted theories and nutrient-specific mechanisms of action, provide insight regarding the potential for dietary manipulation to serve as an effective coping resource.

The Homocysteine Hypothesis of Depression suggests that increased homocysteine levels in the brain, caused by genetic factors and disease, may play a role in depression; Additionally, deficiencies in vitamins B12, folate, and B6 may be influential due to their role in the methionine cycle (Dimov et al., 2021; Folstein et al., 2007; Kennedy, 2016; Schweren et al., 2021). Vitamin B6 plays an important role in the production of serotonin, acting as a cofactor in the brain to help convert tryptophan into serotonin, and when inadequate amounts are present, this results in low serotonin levels (Aly & Engmann, 2020). Magnesium and zinc influence the *hypothalamus pituitary-adrenal (HPA) axis*, by preventing overactivation of this pathway, sometimes found in depressive disorders (Aly & Engmann, 2020; Takeda et al., 2016). Zinc also potentially has a role in inflammation, acting as an antioxidant, reducing reactive oxygen species that affect the brain, playing a role in sleep regulation and reduction of excitotoxicity (Aly & Engmann, 2020; Solati et al., 2015). Finally, numerous amino acids, such as tyrosine, threonine, histidine, and tryptophan, and others, function as precursors to neurotransmitters that influence mood, sleep, balance, and many other bodily functions (Dalangin et al., 2020). The depletion of these monoamine neurotransmitters has also been suggested to contribute to dysregulation of mood, motivation, and other associated behaviors.

The data currently available regarding the associations between dietary quality and non-clinical mental health outcomes, as well as academic performance in various populations, are inconsistent, yet provide some preliminary evidence to support the importance of dietary quality for optimal mental health (Antonopoulou et al., 2020; Dimov et al., 2021; Florence et al., 2008; Molendijk et al., 2018; Quirk et al., 2013; Reuter & Forster, 2021). In children, two studies (Dimov et al., 2021; Florence et al., 2008) with samples sizes of 787 eight- and nine-year-old children and 5,200 children in fifth grader showed positive associations between overall dietary quality and mental health, and overall dietary quality and academic performance, respectively. Likewise, a systematic review (Molendijk et al., 2018) including more than 24 cohorts of adults, indicated that adherence to a high-quality diet was associated with lower risk of depression, but that a low-quality diet was not associated with increased depressive symptoms. Conversely, another systematic review (Quirk et al., 2013), including 25 relevant studies of adults, showed both positive associations between high dietary quality and low depressive symptoms (13 studies), and no significant associations between dietary quality and depressive symptoms (12 studies). In the college population, Solumou and colleagues (2003) conducted a systematic review of 45 relevant studies(Solomou et al., 2023). Results showed that high dietary quality was positively associated with high non-clinical mental health indicators in 36 out of the 45 studies. Finally, results from a study conducted by Reuter and Forster (2021) showed that among college students, dietary quality was not associated with academic performance, with the exception of fast food consumption; increased fast food consumption was associated with poorer academic performance (Reuter & Forster, 2021).

While previous studies have examined the associations between dietary quality and mental health outcomes, most studies have included mental health as an independent variable, and dietary quality as a dependent variable (Choi, 2020; Errisuriz VL et al., 2016; Papier K et al., 2015). In doing so, these studies have sought to determine whether mental health influences food selection. Additionally, these previous reviews have included heterogenous measurement tools for overall dietary quality, proxy measures for fruit and vegetable intake, and some have included non-validated indices of dietary quality, which makes interpretation of results difficult. Results have indicated that high stress is associated with low dietary quality (Choi, 2020; Errisuriz VL et al., 2016; Papier K et al., 2015). In contrast, few studies have tested whether dietary quality influences mental health outcomes. With the above rationale in mind, the purpose of the current systematic review was to examine the available published literature to determine whether overall dietary quality is associated with non-clinical mental health outcomes of stress, anxiety, and depression in college students. A secondary aim was to determine whether there was an association between overall dietary quality and academic performance.

Methods

The Joanna Briggs Institute (JBI) JBI Manual for Evidence Synthesis was used as a guide to conduct this systematic review (Aromataris & Munn, 2020). In addition, the Cochrane Handbook for Systematic Reviews of Interventions was referenced when additional direction was required (Higgins et al., n.d.). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021) guidelines were followed for reporting the methods and results, and the review was registered through the PROSPERO International prospective register of systematic reviews (ID# 284211). All methods were developed a priori and confirmed by three independent researchers.

Information Sources and Search Strategy

A primary and secondary comprehensive literature review was conducted on April 7, 2022 and December 14, 2022, respectively, using the PRISMA guidelines, (Page et al., 2021). PubMed, Cochrane Library, SPORTDiscus (EBSCOhost), Web of Science (Clarivate), Education Full Text (EBSCOhost), SCOPUS, APA PsychInfo (ProQuest), and ProQuest Central, were searched for relevant articles.

A subject specialist librarian (CL) helped in the development of two search strategies using the PICO framework (Richardson et al., 1995) and identification of relevant databases. One was the primary strategy, aimed at study identification pertaining to P: college students, I: high overall dietary quality, C: low overall dietary quality, and O: stress, anxiety, or depression; and the other was aimed at study identification for P: college students, I: high overall dietary quality, C: low overall dietary quality, and O: academic performance. The following Medical Subject Heading (MeSH) terms were searched in PubMed and the Cochrane Library: “diet,” “diet, healthy,” “students,” “universities,” “stress,” “anxiety,” “depression,” “academic performance," and "educational measurement." Additionally, the following key words were searched in the remaining databases: "diet," "dietary quality," "nutrition," "college students," "university," "stress," "anxiety," "depression," and "academic achievement." A detailed search strategy is shown in appendix B.

Eligibility Criteria

Studies were eligible for inclusion if they: 1) were full-text, peer-reviewed articles written in English; 2) were observational and/or experimental studies; 3) included participants enrolled in institutions of higher education, including both undergraduate and graduate programs; 4) used an index or scale to measure overall dietary quality; 5) measured academic performance with grade point average (GPA) or measured stress, anxiety, and/or depression through an index; and 6) examined associations between overall dietary quality as an independent variable, and outcomes including stress, anxiety or depression, or academic performance as dependent variables.

Studies were excluded if they: 1) were originally written in languages other than English; 2) were reviews or dissertations/theses; 3) included adult participants not enrolled in higher education at a university, college, two-year, or four-year institution; 4) used animal models; 5) included participants who were previously diagnosed with a clinical mental disorder as determined by the Diagnostic and Statistical Manual (DSM-5) guidelines; 6) examined the influence of singular foods, nutrients, food groups, or supplements, rather than a dietary pattern; and 7) measured overall dietary quality through methods other than an index or academic performance through methods other than GPA.

Study Selection

Two independent researchers (JP and AE) used the a priori inclusion and exclusion criteria to screen for relevant studies based on the titles and abstracts. Once the initial screening was completed, full-text articles were retrieved and reviewed. The same two researchers made independent determinations of article inclusion, and then met and facilitated conversation until agreement was reached regarding study inclusion.

Assessment of Methodological Quality

The JBI critical appraisal checklist, created by the Joanna Briggs Institute (Munn et al., 2015), was used to formally evaluate risk of bias of the included studies. This risk of bias tool was selected due to its applicability for assessing risk of bias in cross-sectional studies (Ma et al., 2020). The three domains of interest were population, condition, and context. Further information about the risk of bias tool may be found in Table 3. Two independent researchers (JP and AE) completed the risk of bias analysis on the included studies, and any discrepancies were discussed until a mutual agreement was reached regarding evaluation of risk of bias.

Data Collection Process and Data Extraction

Data extraction was completed by the primary researcher (JP) and verified by a second independent researcher (AE). Once data were extracted, the researchers met and confirmed all aspects of the data, and any discrepancies were discussed until a mutual understanding was reached. Extracted data included: sample size; geographic location of the study; study design methods and characteristics; participant characteristics; overall dietary quality measurement tools; non-clinical mental health outcome measurement tools; academic performance measurement tools; data analysis methods; reported associations between overall dietary quality and non-clinical mental health outcomes; and reported associations between overall dietary quality and academic performance.

Data Synthesis

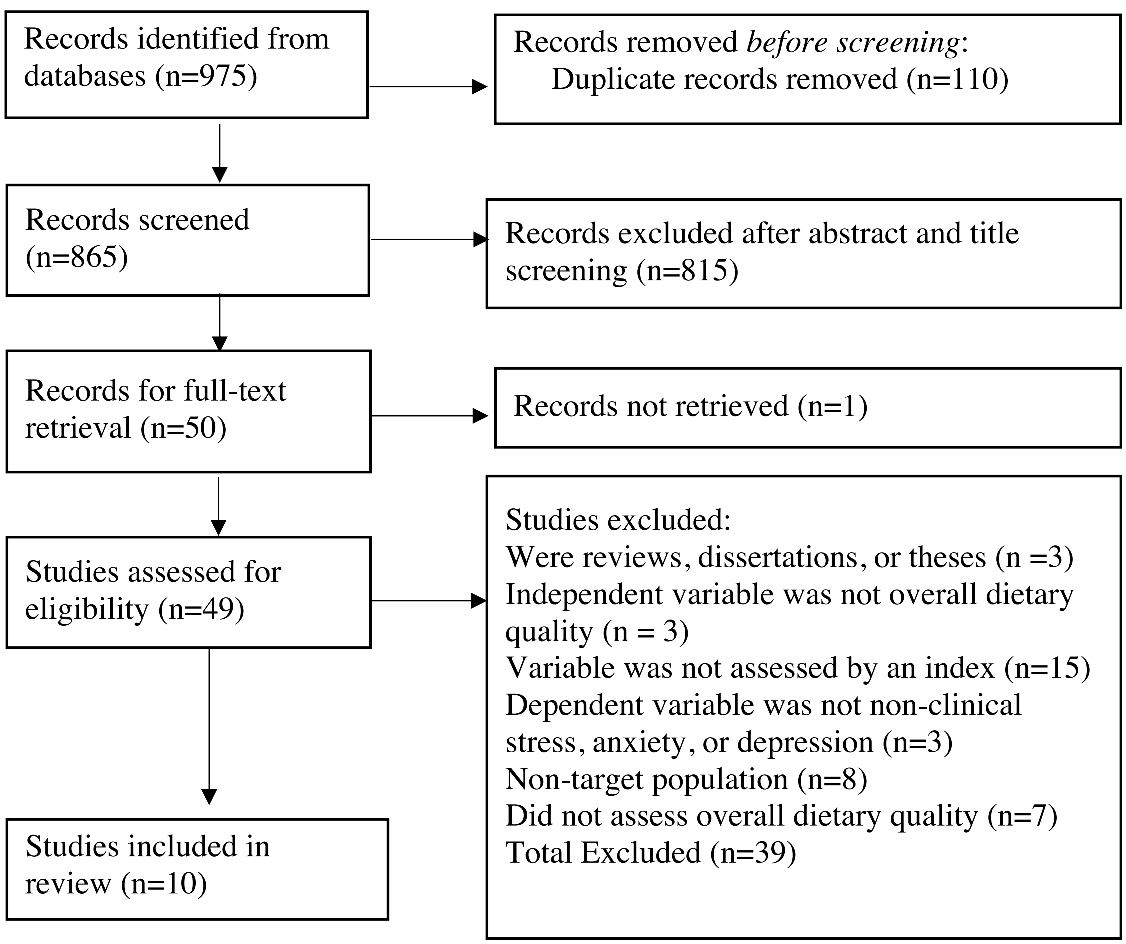
An a priori determination was made that this systematic review was not appropriate for a meta-analytic approach due to the potential heterogeneity of the included study designs, as well as the differing dependent variables of stress, anxiety, depression, and academic performance and their variable measurement methods. Therefore, results were synthesized by grouping similar studies for analysis based on the index used for assessing overall dietary quality, and the type of outcome assessed, such as non-clinical mental health outcomes or academic performance, and their common measurement tools. Results are presented in narrative form using both descriptive statistics from each study as well as interpretation of relevant effect sizes.

Results

After employing the search strategy described above, a total of 975 records were retrieved for initial screening. One-hundred and ten records were excluded due to duplication, leaving 865 articles for review. The first round of screening, based upon the titles and abstracts of the potential studies, eliminated 815 records due to irrelevance. Finally, 50 full-text articles were retrieved and reviewed by two independent researchers based on the a priori inclusion and exclusion criteria, leaving 10 studies for inclusion in the final review synthesis and analysis. Articles were excluded due to lack of relevance, if they were dissertations or theses, if they did not fit the inclusion criteria for the independent and dependent variables, if the population was not college students, and if studies did not measure overall dietary quality using a validated index, as shown in Figure 1. All included studies used a cross-sectional design and were conducted between 2013 and 2021 in ten separate countries, including North American, European, African, and Middle Eastern countries. Sample sizes ranged from 77 to 6,222 college students. Additionally, in all studies but one, females comprised the majority of the population studied.

Figure 4.1.

PRISMA Flow Diagram for Study Inclusion for Overall Dietary Quality and Non-Clinical Mental Health Outcomes



For the secondary search of overall dietary quality and academic performance, a total of 35 records were retrieved for initial relevance screening. Four articles were excluded due to duplication, leaving 31 articles for review. The first round of screening, based upon the title and abstracts of the potential studies, eliminated 23 articles due to lack of relevance. Finally, eight full-text articles were retrieved and reviewed by two independent researchers based upon the *a* *priori* inclusion and exclusion criteria, leaving two studies for inclusion in the final review synthesis and analysis. Articles were excluded due to relevance, publication type, population, inadequate measurement of overall dietary quality, and duplication of the results of the primary search, as shown in *Figure 2*, both included studies used a cross-sectional design, and were conducted between 2017 and 2019 in Australia and Pakistan. Sample sizes ranged from 222 to 278 college students. Additionally, in both studies, females comprised the majority of the study populations at 100% and 71%, respectively.

Figure 4.2.

PRISMA Flow Diagram for Study Inclusion for Overall Dietary Quality and Academic Performance

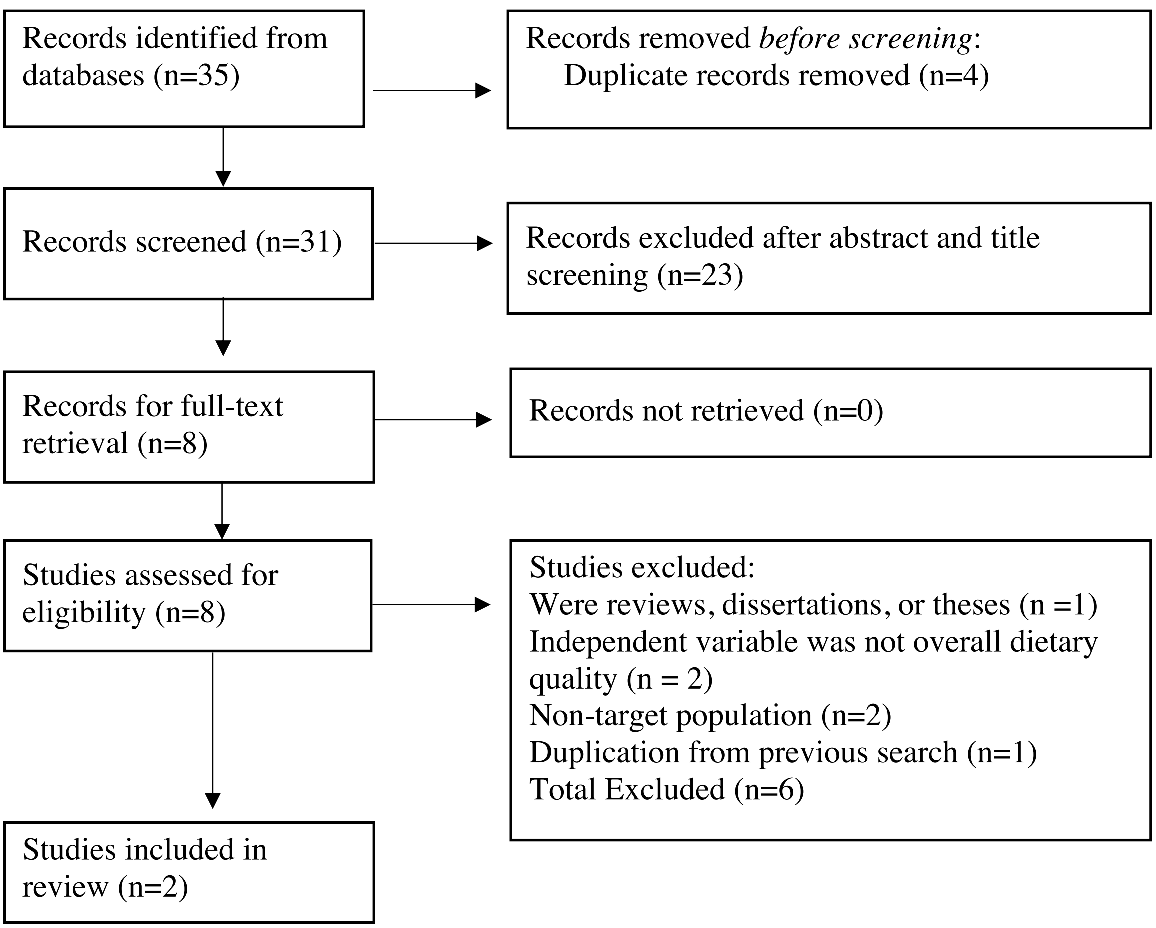


Table 4.1

Study Characteristics

Table 1: Study Characteristics			
(Author, Date)	Geographic Location	Study Design	Participant Characteristics: (n) Total % Female Age range or Mean age (yrs) (SD)
Dependent Variable: Non-clinical Mental Health (Stress, Anxiety, and/or Depression)			
(Carlos et al., 2020)	Spain	Cross-sectional study (survey distributed December 2019 to January 2020)	n = 252 %f = 75.8% Age = 21.4 (4.7)
(Cena et al., 2021)	Croatia, Italy, Lebanon, Poland, Romania, Spain & Turkey	Cross-sectional study (survey distributed between April 2018 and March 2020)	n = 6222 %f = 66.7% Age = 19–24
(Chacón-Cuberos et al., 2019)	Spain	Cross-sectional study (survey distributed in 2017–2018)	n = 515 %f = 49.2% Age = 21.6 (2.3)
(Christensen et al., 2021)	U.S.	Cross-sectional study (survey distributed in August 2020 to January 2021)	n = 77 %f = 100% Age = 18–25
(Fabian et al., 2013)	Puerto Rico	Cross sectional study (survey distributed in August 2011)	n = 275 %f = 67.4% Age = 21–30
(Faghih et al., 2020)	Iran	Cross-sectional study	n = 240 %f = 86.7% Age = 21.5 (1.8)
(Keck et al., 2020a)	United States	Cross-sectional study	n = 225 %f = 61.7% Age = 18.9 (1.5)

(Lo Moro et al., 2020)	Italy	Cross-sectional study (survey distributed in May 2019 to August 2019)	n = 502 %f = 76.1% Age = 21-25
(Quehl et al., 2017)	Canada	Cross-sectional study (survey distributed September 2012 to April 2013)	n =175 %f = 89% Age = 19.1 (1.5)
(Ramón-Arbués et al., 2020)	Spain	Cross-sectional study (survey distributed September 2018 to May 2019)	n =1074 %f = 71% Age = 21.73 (5.1)
Dependent Variable: Academic Performance			
(Khan, 2017)	Pakistan	Cross-sectional study	n= 222 %f= 100% Age= 19–24
(Whatnall et al., 2019)	Australia	Cross-sectional study (distributed from 2017–2018)	n=278 %f= 71% Age= 26.9 (10.5)

Note. Abbreviations: n= total participants in the sample; %f= percentage of females in the sample population; age= age of participants

In order to compare similar outcomes for interpretation, studies were first classified by the type of dependent variable; non-clinical mental health outcomes (n=10), or academic performance (n=2), as indicated in *Table 1*. Next, studies were grouped by the dietary quality index used. These included the “Mediterranean Diet” (n=4), or “Other Indices” (n=8). The following associations were analyzed: “Mediterranean Diet” and non-clinical mental health outcomes; “Other Indices” and non-clinical mental health outcomes; and “Other Indices” and academic performance.

Exposures

Each of the studies included in this systematic review used a validated dietary quality index to determine overall dietary quality. The following indices were used: Mediterranean Diet Quality Index for children and teenagers (KIDMED) test, Mediterranean Diet Serving Score (MDSS), Mediterranean Diet Adherence Screener (MEDAS), Dietary Quality Index (DQI), Healthy Eating Index (HEI), Canadian Health Eating Index (HEI-C), Dietary Approaches to Stop Hypertension score (DASH score), Dietary Quality Index- International (DQI-I), and Australian Recommended Food Score (ARFS). Each of the indices produced an overall score, where a high score indicated high adherence, and a low score indicated low adherence to the predetermined guidelines. Further, high scores were generally indicative of a higher quality diet, and low scores were indicative of a poor-quality diet.

Outcomes

Ten of the included studies assessed areas of stress, anxiety, and/or depression, while the other two assessed academic performance. Non-clinical mental health outcomes were measured by the State Trait Anxiety Inventory (STAI), Perceived Stress Scale-10 (PSS-10), Scale of

Academic Stress, Depression Anxiety Stress Scale (DASS-21), Warwick-Edinburgh Mental Wellbeing Scale (WEMBS), Perception of Course Load & Total Stress Level, Persian General Health Questionnaire (GHQ-12), Generalized Anxiety Disorder-7 item scale (GAD-7), Patient Health Questionnaire 9-item scale (PHQ-9) or the Center for Epidemiologic Studies Depression Scale (CES-D). Each of these scales measured self-reported non-clinical mental health outcomes. Academic performance was measured via Grade Point Average.

Associations Between Exposures and Outcomes

Mediterranean Diet and Non-Clinical Mental Health Outcomes

Four studies examined associations between overall dietary quality, as measured by adherence to the Mediterranean Diet, and stress, anxiety, and/or depression. Carlos and colleagues used the KIDMED index to measure overall dietary quality and its associations with anxiety as both a trait and a state, measured by the State Trait Anxiety Inventory (STAI) (Carlos et al., 2020). Results showed that high KIDMED scores were weakly and positively correlated with high trait anxiety, $r(250)=0.154$, $p<0.05$, but not anxiety as a state $r(250)=0.012$, $p>0.05$. Cena and colleagues used the KIDMED index to measure overall dietary quality and the association with perceived stress using the Perceived Stress Scale-10 (PSS-10) (Cena et al., 2021). Study results indicated that there was not a significant correlation between KIDMED scores and PSS-10 scores, $r(6220) = -0.02$, $p= 0.122$. Conversely, Chacón-Cuberos and colleagues used the KIDMED index to measure overall dietary quality, categorizing participants into high, medium, and low adherence to the Mediterranean diet. The outcome of perceived stress was categorized as: stress pertaining to academic obligations, academic grades and future expectations, interpersonal difficulties, communication of own ideas, and global stress using the Scale of Academic Stress measurement tool (Chacón-Cuberos et al., 2019). Results showed that only in the category of "communicating own ideas," differences in high KIDMED scores vs. low KIDMED scores were present, $F(2,513)=2.801$, $p = 0.045$. Finally, Lo Moro and colleagues used MEDAS scores to measure overall dietary quality and the association with perceived mental health status using the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Lo Moro et al., 2020). Results showed that MEDAS scores were very weakly positively associated with WEMWBS scores, $r(501) = 0.097$, $p = 0.033$. Each of these studies used different dietary quality indices and mental health measurement tools for assessment. Overall, results were inconsistent, as two of the studies showed weak to no correlation with stress, anxiety, and/or depression, and the other two showed weak to moderate positive and negative correlations.

Other Indices and Non-Clinical Mental Health Outcomes

Six studies examined associations between overall dietary quality, as measured by adherence to other predetermined dietary guidelines and their associated indices, and stress, anxiety, and/or depression. Christensen and colleagues used the Healthy Eating Index (HEI) to measure adherence to the Dietary Guidelines for Americans, and its relationship with perceived levels of depression, anxiety, and stress, as measured by the Depression Anxiety Stress Scale (DASS-21) (Christensen et al., 2021). Results revealed that the mean HEI scores of the low stress group ($M=56.1$, $SD=12.4$) were significantly different than those of the high stress group (62.6, $SD=9.5$, $p = 0.015$). Additionally, descriptive statistics suggests that high HEI scores were more present in the high stress group. No significant differences in the means were found in depression and anxiety HEI scores. Fabian and colleagues used the modified Dietary Quality Index (DQI) to measure dietary variety, adequacy, and moderation in Puerto Rican students, and associations with perceived academic stress using the Perception of Course Load & Total Stress Level measurement tool (Fabian et al., 2013). Results indicated that Modified DQI scores, characterized as adequate or inadequate, were not associated with Total Stress Level Perception scores X2 (274)= 0.591, $p>0.05$. Faghih and colleagues examined adherence to the DASH diet and associations with perceived levels of depression, anxiety, and stress, measured by the DASS-21, the ability or inability to carry out normal functions, and the appearance of new and distressing experiences as measured by the Persian General Health Questionnaire (GHQ-12) (Faghih et al., 2020). Results showed that DASH scores, adjusted for energy intake, were inversely associated with the GHQ-12 total score, r(238)= -0.431, $p<0.001$, DASS-21 total score, r(238) = -0.441, $p<0.001$, DASS-21 depression subscale score r(238)= -0.434, $p <0.001$, DASS-21 depression anxiety score, r(238)= -0.325, $p <0.001$, and DASS-21 stress subscale score, r(238)= -0.408, $p <0.001$. Keck and colleagues used the Health Eating Index to determine the associations between dietary quality and depression as measured by the PHQ-9, and/or anxiety as measured by the GAD-7 (Keck et al., 2020). Results showed that HEI scores were not significantly associated with GAD-7 scores (B=0.41, p =0.4) nor PHQ-9 scores (B=0.9, p =0.28). Quehl and colleagues used the Canadian Health Eating Index (HEI-C) to measure adherence to the Canadian dietary guidelines, and the association with depressive symptoms over the past two weeks, using the Center for Epidemiologic Studies Depression Scale (CES-D) (Quehl et al., 2017). Models were created that adjusted for physical activity, BMI, and percent body fat, but results showed that both the adjusted and unadjusted models remained virtually unchanged; therefore, unadjusted models were used. Results showed that HEI-C scores were inversely associated with CES-D scores ($\beta = -0.016$, $p = 0.017$). Finally, Ramone-Arbues and colleagues used the Healthy Eating Index Spanish version to measure adherence to the Spanish dietary guidelines, and the associations with stress, anxiety and depression using the DASS-21 (Ramón-Arbués et al., 2020). Dietary quality was categorized as “good/healthy” if HEI scores were > 80, and as “needs improvement or unhealthy” if scores were < 79. The reference group was “good/healthy diet,” and results showed that “needs improvement or unhealthy diet” significantly increased odds of stress (OR =1.7, 95% CI [1.23, 2.35]), but not anxiety (OR =1.2, 95% CI [0.82, 1.81]), or depression (OR =1.22, 95% CI [0.81, 1.75]). Overall, results were inconsistent, as three of the studies showed very weak associations, two showed weak-to-moderate associations, and one showed inverse associations.

Other Indices and Academic Performance

Of the two studies that determined overall dietary quality, as measured by the Dietary Quality Index-International (DQI-I) and Australian Recommended Food Score, and academic performance as measured by GPA, both showed modest correlations. Khan used the DQI-I to assess dietary variety, moderation, adequacy, and balance, in Canadian students and associations with GPA (Khan, 2017). Results showed that total DQI-I scores were associated with CGPA (B=.006, p=0.037). Further, DQI-I variety scores (B=.026, p=0.009) and DQI-I balance scores were also associated with CGPA (B=.012, p=0.003). Whatnall and colleagues measured adherence to the Australian Dietary Guidelines through the Australian Recommended Food Score (ARFS), and the association with GPA (Whatnall et al., 2019). Study results showed that ARFS was associated with GPA in unadjusted models (β = .019, p= 0.003), additionally, ARFS was associated with GPA in the adjusted models accounting for socio-demographic and student characteristics (β = 0.02, p = 0.011). Both studies used similar measurement tools or GPA that showed weak associations between overall dietary quality and academic performance.

Table 4.2.

Results

Table 2: Results			
(Author, Date)	Overall Dietary Quality Measurement Tool	Non-Clinical Mental Health Outcomes Measurement Tool	Associations between Dietary Quality and Non-Clinical Mental Health Outcomes or Academic Performance
(Carlos et al., 2020)	Mediterranean Diet Quality Index for children and teenagers (KIDMED) test; adherence to the Mediterranean Diet (AMD)	State Trait Anxiety Inventory (STAI); measured both anxiety as a state and anxiety as a trait	High KIDMED scores were associated with high trait anxiety scores High dietary quality was associated with *high* anxiety
(Cena et al., 2021)	Mediterranean Diet Serving Score (MDSS); adherence to the Mediterranean Diet (AMD);	Perceived Stress Scale-10 (PSS-10); levels of perceived stress	Non-significant association
(Chacón-Cuberos et al., 2019)	Mediterranean Diet Quality Index for children and teenagers (KIDMED) test; adherence to the Mediterranean Diet (AMD)	Scale of Academic Stress; perceived stress pertaining to Academic obligations, Academic marks and future expectations, Interpersonal difficulties, & Communication of own ideas	High KIDMED scores were associated with low perceived stress scores in “Communicating own ideas;” High dietary quality was associated with low stress
(Christensen et al., 2021)	Healthy Eating Index (HEI); adherence to the Dietary Guidelines for Americans	Depression Anxiety Stress Scale (DASS-21); perceived levels of depression, anxiety, and stress	High HEI scores were associated with high DASS-21 stress subscale scores, and low HEI scores were associated with low DASS-21 stress subscale scores; while HEI scores were not significantly associated with DASS-21 depression or anxiety scores

			High dietary quality was associated with *high* stress, but not associated with depression or anxiety
(Fabian et al., 2013)	Mediterranean Diet Adherence Screener (MEDAS); adherence to the Mediterranean Diet	Warwick-Edinburgh Mental Wellbeing Scale (WEMBS); perceived mental health status	MEDAS scores were weakly associated with MEDAS scores High dietary quality is associated with high mental wellbeing
(Faghih et al., 2020)	modified Dietary Quality Index (DQI); measured variety, adequacy, and moderation	Perception of Course Load & Total Stress Level; perceived stress from academic load	Modified DQI scores, characterized as adequate or inadequate, were not associated with Total Stress Level Perception scores
(Keck et al., 2020)	DASH score (Fung et al); adherence to the Dietary Approaches to Stop Hypertension Diet (DASH diet)	Persian General Health Questionnaire (GHQ-12); measured the inability to carry out normal functions and the appearance of new and distressing experiences; DASS-21 perceived levels of depression, anxiety, and stress	DASH scores were inversely associated with the GHQ-12 total score, DASS-21 total score, DASS-21 depression subscale score, DASS-21 anxiety subscale score, and DASS-21 stress subscale score High dietary quality was associated with low stress, anxiety, and depression
(Lo Moro et al., 2020)	Healthy Eating Index; adherence to the Dietary Guidelines for Americans	Generalized Anxiety Disorder-7 item scale (GAD-7) measures anxiety symptoms in a medical and primary care setting; Patient Health Questionnaire 9-item scale (PHQ-9) measures depressive symptoms	Non-significant associations
(Quehl et al., 2017)	Canadian Health Eating Index (HEI-C); adherence to	Center for Epidemiologic Studies Depression Scale	HEI-C score were inversely associated with CES-D score

	the Canadian version of the Dietary Guidelines	(CES-D); assesses depressive symptoms over the past two weeks	High dietary quality was associated with low depression
(Ramón-Arbués et al., 2020)	Healthy Eating Index; adherence to the Dietary Guidelines for Americans	DASS-21 perceived levels of depression, anxiety, and stress	HEI scores were significantly associated with stress, but not anxiety or depression Low dietary quality was associated with high odds of stress
[redacted]			
(Khan, 2017)	Dietary Quality Index-International (DQI-I); assess variety, adequacy, moderation, and balance	Canadian Grade Point Average (CGPA)	Total DQI-I scores were associated with CGPA; DQI-I variety scores were associated with CGPA; DQI-I balance scores were associated with CGPA
(Whatnall et al., 2019)	Australian Recommended Food Score (ARFS); adherence to the Australian Dietary Guidelines	Grade Point Average; based upon a seven-point scale	ARFS were associated with GPA in the unadjusted models; ARFS were associated with GPA in the adjusted models accounting for socio-demographic and student characteristics

Note. Abbreviations: n= total participants in the sample; %f= percentage of females in the sample population; age= age of participants

Risk of Bias

Risk of bias scores ranged from zero to eight as shown in Table 3, with eight, zero, and negative eight indicating low, moderate, and high risk of bias, respectively. According to the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies, all scores were moderate- to low-risk of bias based on two independent reviewers' evaluations (JP and AE).

Table 4.3.

Risk of Bias

Table 3: Risk of Bias									
(Author, Date)	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?	Total Score
(Carlos et al., 2020)	-1	1	1	1	0	0	1	1	4
(Cena et al., 2021)	-1	1	1	1	0	0	1	1	4
(Chacón-Cuberos et al., 2019)	1	1	1	1	0	0	1	1	6
(Christensen et al., 2021)	1	1	1	1	0	0	1	1	6
(Fabian et al., 2013)	-1	0	1	1	0	0	1	1	3
(Faghih et al., 2020)	1	1	0	1	1	1	1	1	7
(Keck et al., 2020)	1	1	1	1	0	0	1	1	6
(Lo Moro et al., 2020)	1	1	1	1	0	0	1	1	6
(Quehl et al., 2017)	1	1	1	1	1	1	1	1	8

(Ramón-Arbués et al., 2020)	1	1	1	1	0	0	1	1	6
(Khan, 2017)	1	1	1	1	0	0	1	1	6
(Whatnall et al., 2019)	-1	1	1	1	1	1	1	1	7

Note. Scores above are coded as "no" = "-1," "not clear" = "0," and "yes" = "1." Total scores of eight, zero, and negative eight indicate low, moderate, and high risk of bias, respectively.

Discussion

The current systematic review identified the most relevant published research regarding associations between overall dietary quality and non-clinical mental health outcomes in college students, with a secondary aim of identifying associations between overall dietary quality and academic performance. This review included only homogenous dietary quality measurement tools in comparison to similar systematic reviews where heterogeneous, potentially non-validated measurement tools were used to measure overall dietary quality, making interpretation difficult. Additionally, few studies investigated both mental-wellbeing and academic performance in relation to overall dietary quality. Overall, data were limited, and results were inconsistent, showing weak positive and negative associations between overall dietary quality and non-clinical mental health outcomes. For example, two studies (Carlos et al., 2020; Christensen et al., 2021) showed that high dietary quality was associated with *high* anxiety and stress. Three studies indicated no significant associations between dietary quality and levels of perceived stress (Cena et al., 2021; Fabian et al., 2013; Keck et al., 2020) and four studies showed weak inverse associations between dietary quality and stress and depression (Chacón-Cuberos et al., 2019; Lo Moro et al., 2020; Quehl et al., 2017). Finally, one study indicated moderate positive associations between overall dietary quality using the DASH score and general mental health and depression, anxiety and stress; the only study that used the DASH score as the measurement for dietary quality (Faghih et al., 2020). Results were more consistent, although data were limited, when considering overall dietary quality and academic performance, where two studies suggested weak positive associations between dietary quality and GPA, (Khan, 2017; Whatnall et al., 2019) even when the measurement tools for overall dietary quality were different for the two studies.

Preliminary searching suggested that a large body of literature was available on dietary quality and associations between mental well-being indicators or academic performance, but few studies specifically examined these associations in college students. Upon further investigation, little published research specifically measured dietary quality as the exposure and non-clinical mental health or academic performance as outcomes (Almogbel et al., 2019; Barker ME et al., 2015; Errisuriz VL et al., 2016). Further, results were limited even more when exclusion criteria eliminated studies that focused on a specific nutrient rather than overall dietary quality or did not measure dietary quality using an index. Many of the studies that were ultimately eliminated specifically assessed one or two nutrients or substances or measured dietary quality through proxy questions and their correlations with stress, anxiety, depression, or academic performance (Boozari et al., 2021; Errisuriz et al., 2016; Jaalouk et al., 2019; Pelletier et al., 2016). While this approach may be reasonable in different contexts, the current systematic review viewed dietary quality as a holistic construct, rather than reducing it to a nutrient or individual food, taking into consideration the fact that nutrients are seldom consumed alone (Fardet & Rock, 2014). The Dietary Guidelines Advisory Committee (DGAC) suggests analyzing dietary patterns rather than looking at singular nutrients to gain information about overall dietary quality (Dietary Guidelines Advisory Committee, 2020). This new approach released in the 2020–2025 Dietary Guidelines for Americans alludes to transitioning away from proxy questions about singular foods or nutrients that might limit the depth of information gained from the questions being asked.

Results from the current study are consistent with previous research. A systematic review conducted in 2017 sought to determine the associations between dietary quality and academic achievement in college students (Burrows et al., 2017). Seven studies were included in the analysis, and results showed five studies having small to moderate significant positive associations between dietary quality and academic achievement (Burrows et al., 2017). Similar to our study, most previous studies used cross-sectional or cohort designs, but relied on fruit and vegetable consumption as proxies for overall dietary quality (El Ansari W et al., 2014; El Ansari W & Berg-Beckhoff G, 2015; Liu et al., 2007; Schultchen D et al., 2019; Wald et al., 2014). Wattick and colleagues conducted a cross-sectional study of overall dietary quality and associations with anxiety and depression among college students. Results showed in males that food insecurity and fruit and vegetable intake were predictors of depression, and food insecurity and added sugars were predictors of anxiety; in females, results showed food insecurity was a predictor of depression and, food insecurity and added sugars were predictors of anxiety (Wattick et al., 2018). Overall, the current body of evidence suggests that more high-quality research needs to be conducted to elucidate the associations between overall dietary quality and non-clinical mental health outcomes as well as academic performance.

While we did not exclude any study designs, a key limitation of this systematic review is that all studies that fit our a priori inclusion and exclusion criteria were observational, cross-sectional studies; therefore, these 12 correlational studies do not provide information about causality. In doing so, these studies make it difficult to determine whether dietary quality influences mental health and academic performance, or if mental health and academic performance influence dietary quality. Additionally, few studies accounted for confounding variables such as socioeconomic status or alcohol consumption. Another weakness was the somewhat narrow focus of the non-clinical mental health outcomes of stress, anxiety, and depression. There are many other clinical and non-clinical mental health outcomes that could also be impacted by dietary quality. A strength of this study was the use of homogenous measurement tools for determining overall dietary quality, stress, anxiety, depression, and academic performance. There are many other studies that have sought to determine the associations between dietary quality and non-clinical mental health or academic performance outcomes that use proxy questions as a small part of a larger study, creating difficulty in determining the validity of these associations. The current systematic review serves as a valuable starting point for future research, where there is a need for intervention studies. Such studies are required to determine whether there is a causal relationship between overall dietary quality and non-clinical mental health outcomes or academic performance.

In conclusion, the current systematic review comprises the current state of knowledge pertaining to dietary quality among college students and associations between dietary quality and non-clinical mental health outcomes and academic performance. The results of this systematic review suggest that dietary quality may have weak-to-moderate associations with non-clinical mental health outcomes, and though very limited, potentially also with academic performance in college students. Future research needs to elucidate the relationships between dietary quality and non-clinical mental health outcomes, specifically research with strong methodological designs that allow for determination of causality. Additionally, future research is needed to determine the strength and direction of associations between overall dietary quality and academic performance.

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Chapter 5 - Conclusion

It is well established that dietary quality is an important predictor of health outcomes in populations. The purpose of this dissertation was to use a holistic perspective to better understand overall dietary quality, the role that dietary quality plays in health, and barriers to optimizing dietary quality. A holistic view helps to understand why dietary quality is the way it is to consider the opportunity for improvement wherever the starting point might be. For example, rather than only looking at nutrient data, a holistic approach suggests different avenues regarding how data might be used, and how contextual considerations might help us to understand the factors that contribute to high or low dietary quality.

When considering the optimization of dietary quality, the concepts of "meeting people where they are," and best practices for maximizing dietary quality were used to guide each study. Each chapter comprises one study, and each study used a holistic approach to elucidate predictors of overall dietary quality and associated outcomes. Conclusions from each study included in this dissertation follow, and along with suggestions for future research that is important for moving the field forward.

The first study, chapter two, sought to provide a theoretical framework to determine how dietary quality assessment might be translated into practice across different socio-ecological levels, taking not only dietary intake into consideration, but also the social and environmental factors that are associated with dietary intake. Guided by the Giessen Declaration, biological, social, and environmental factors were incorporated into the proposed framework, where the first step identified was the identification of the purpose behind dietary quality assessment based on the needs of a particular population of focus. The second step was to determine the most relevant and applicable dietary quality index, taking into consideration the heterogeneity of the different available dietary indices, including the purpose behind their creating. Step three was the selection of applicable contextual factors that could influence dietary quality, based on the focus population. Specifically, potential barriers that might hinder the population from achieving a high or optimal dietary quality scores. Step four focused on the identification of the contextual influences on specific components of the selected index, and step five applied the more holistic, contextual understanding to practice or recommendations at the different levels of socio-ecological influence. Study one suggested that quantifying dietary quality through various indices should not be an end point, but rather, a starting place for determining the best ways to optimize dietary quality given the contextual factors that influence the quality of dietary intake.

Study two, chapter three, was guided by a holistic view of food synergy where 1+1>2, or the sum is greater than its parts (Jacobs et al., 2009), and sought to investigate the potential for maximizing the dietary quality of "fad diets." Results showed that some of the current popular fad dietary patterns have the potential achieve a relatively high HEI, dietary quality score ranging from 77.1-89.1 out of 100 points, potentially surpassing the average American HEI dietary quality score of 56–60 out of 100 (Measured yearly from 2005–2016) (U.S. Department of agriculture, 2022). Although many of the current popular fad dietary patterns did not meet all dietary and nutrient recommendations and might be viewed negatively since they do not fit within the current DGAs, it is important to recognize some of the positive aspects within each dietary pattern that may be health promoting and potentially useful for users and practitioners. The idea of "meeting people where they are" and working within the structures of current or preferred dietary patterns, with slight alterations to improve dietary quality, could ultimately improve the dietary quality of the overall population. Given the average dietary quality of the American population, it is clear that dietary guidelines are not being followed by a large percentage of the population, therefore, this study proposed an alternative approach to improvement in dietary quality.

Study three, chapter four, sought to systematically review the association between overall dietary quality and the non-clinical mental health outcomes of stress, anxiety and/or depression among college students, with a secondary aim of determining the association between overall dietary quality and academic performance. After employing a structured *a priori* search strategy, 12 relevant articles met selection criteria and were subsequently reviewed. Ten studies pertained to overall dietary quality and non-mental health outcomes and two pertained to overall dietary quality and academic performance. Results indicated weak and moderate associations between overall dietary quality and non-clinical mental health outcomes in college students, and though very limited, based on the two studies included, results showed weak associations with academic performance as well.

Overall, the three studies included in this dissertation explore holistic aspects of dietary quality, focusing on practical applications. Study one provides a theoretical framework developed to guide practitioners regarding practical applications to optimize dietary quality among different populations. Study two is centered around maximizing the dietary quality of current fad dietary patterns, often thought to be "unhealthy." This study suggests that a preferred dietary pattern may present opportunities for improvement and may confer some positive health outcomes. There is potential for minor modifications to popular fad dietary patterns to improve the quality of that diet while staying within the parameters or "rules" of that fad dietary pattern. Finally, study three summarizes the current knowledge pertaining to dietary quality and its associations with non-clinical mental health outcomes and/or academic performance among college students. Although this area of research is still in its infancy, results suggest that high dietary quality is associated with positive non-clinical mental health outcomes and high academic performance. Therefore, improving dietary quality could provide college students with a practical, low-risk, avenue for improving mental well-being and academic performance. Given the current focus on mental health issues in the United States, this study is relevant and timely. Altogether, these studies suggest that a holistic paradigm may be beneficial when used to better understand dietary quality for practical application.

The following are key points derived from the three included studies:

1. The context of a population's dietary quality is vital to understanding barriers to high dietary quality.
2. "Meeting someone where they are" may offer a practical way to improve dietary quality rather than asserting that there is only one "correct" way of eating and that fad diets are all "bad."
3. High dietary quality is associated with positive mental well-being among college students, but given the limitations of the current research, better quality studies are needed to elucidate this relationship.

Future Research

Adopting a holistic perspective may be beneficial for furthering our understanding of the importance of dietary quality at every level of the socio-ecological model in order to determine the predictors of, and influences of, dietary quality on health and wellbeing. Future research should be conducted to determine whether and how dietary quality is associated with non-clinical mental health outcomes, other indicators of well-being, and academic performance at all levels of education. The vast majority of research surrounding these topics is observational, therefore, the strength of evidence is insufficient for conclusions to be made. Specifically, studies should be well-designed, focusing on measurement tools that are validated in the specific populations being studied. With the recent recognition of the importance of dietary quality for population health and well-being; the recognition of the importance of public health policy, particularly following the COVID-19 pandemic; and the creation of a new National Institutes of Health Office of Nutrition Research, the research comprising this dissertation is relevant and timely.

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Appendix A - One Week Sample Menus

DGA-compliant Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	2 fruits, 1 WG, 1 dairy	2/3 c non-fat vanilla Greek yogurt ¼ c granola 1 c strawberries	¾ c. cheerios 1 c skim milk 1 large banana	2/3 c non-fat vanilla Greek yogurt ¼ c granola 1 c blackberries	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple	¼ c granola 2/3 c non-fat vanilla Greek yogurt 1 c blue berries	¾ c. cheerios 1 c skim milk 1 large banana	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple
Snack	1 grain	1 oz honey chex	1 oz gold fish	1 oz pretzels	1 oz honey chex	1 oz pretzels	1 oz honey chex	1 oz pretzels
Lunch	1.5c veg, 2 WG, 1.5 oz protein	2 tbsp peanut butter (plant pro.) 1.5 c. celery 2 oz pretzels	1.5 oz hard-boiled egg 1.5 c. spinach ¼ c. tomato ¼ c. chick peas 2 oz croutons 2 tbsp Italian dressing	chicken soup (1.5 oz chicken, ¼ c. carrots, ¼ c. corn, ¼ c peas, 2 c broth, 0.5 c egg noddle) 1 oz crackers	4 oz 96% lean beef burger patty 2 oz whole grain bun 0.5 c romaine lettuce (topping) 0.5 c tomato (topping)	0.5 c hummus and 2 oz peta bread (plant pro.) 0.5 sliced bell pepper (dipping) 0.5 baby carrots (dipping)	sandwich with fried egg (1.5 whole egg), whole gain toast (2 oz), low-fat cheddar cheese (1.5 oz), 0.5 c. tomato	chicken salad (1.5 oz chicken, ¾ c. ice burg lettuce ¼ shredded carrots, ¼ tomatoes, ¼ c. corn, ¼ c. black beans) 2 tbsp low-fat ranch

					0.5 c. oven baked sweet potato fries 1 tsp vegetable oil		1 c oven baked home fries 1 tsp vegetable oil	2 oz baked tortilla chips
Snack	1 fruit, 1 dairy	¼ c cottage cheese 0.5 c. peaches	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. pineapple	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. mandarin oranges	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. pineapple
Dinner	1c veg, 2 grain, 4oz protein	4 oz Sirloin steak 1.25 c baked sweet potato 2 oz whole grain dinner roll 2 tsp butter	Stir fry (4 oz skinless chicken breast, ¼ c sugar snap peas, ¼ c. baby corns, ¼ red pepper, ¼ carrots) 2/3 c. brown rice 3 tbsp teriyaki sauce	4 oz salmon fillet 1 c. steamed broccoli (1 tsp vegetable oil) 2/3 c quinoa	2 c. bean chili (includes 1 cup red orange, ¾ c beans/plant pro.) 2 oz corn bread	4 oz pork tenderloin 1 c oven baked red potatoes 1 tsp vegetable oil 2 oz whole grain dinner roll 1 tsp butter	4 oz Rotisserie chicken (no skin, white meat only) 1 c baked beans 2 oz corn bread	4 oz baked cod 0.5 c. butternut squash 0.5 tsp vegetable oil 1 c spaghetti ½ marinara sauce (topping)
Snack	1 fruit, 1 dairy	1 c skim milk 1 small banana	2/3 c non-fat vanilla Greek yogurt 0.5 c mango	1 c skim milk 1 small pear	2/3 c non-fat vanilla Greek yogurt 0.5 c black cherries	1 c skim milk ½ c. strawberries	2/3 c non-fat vanilla Greek yogurt 0.5 c mango	1 c skim milk 1 small banana

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	
	Daily	2,000	2.5					2	3	3	3	5.5			27 (5.5 serv)
	Weekly	14,000	1.5	5.5	1.5	5	4	14	21	21	21	8	26	5	189

Ketogenic Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	1 fruit, 1 full-fat dairy, 4 fats	1c vanilla Greek yogurt, 1c thawed frozen berries, 8 whole pecans (chopped)	¼ avocado mashed, 2 tsp smart balance 1 whole egg pan fried, ½ tbsp smart balance 1 c. strawberries 0.5 c whole milk 1 oz whole brain bread, toasted, ½ tbsp smart balance	Scrambled eggs (1 egg, 1 egg white, 2 tsp canola oil, 1/8 avocado) ¾ c of fresh whole strawberries	Egg omelet (2 whole eggs with 1 tbsp smart balance, 1/8 c cooked diced green bell peppers, 1/8 c mushrooms, ¼ whole tomato) Top with guac (1/4 avocado, 1 tbsp smart balance)	Stuffed red bell pepper (1 red bell pepper, 2 tsp canola oil, 1 tsp garlic, 1.5 oz ground beef, ½ large tomato, 1 tbsp basil, 0.5 oz mozzarella, 1 slice toast + 2 tbsp smart balance)	8 oz yogurt ¼ c blueberries, ¼ c blackberries, ¼ c raspberries ½ avocado	Crustless quiche (1 egg, 3 egg whites, 4 oz whole milk, 2 tbsp parmesan, ¼ tomato, 1/8 c spinach)
Snack	-	-	-	-	-	-	-	-
Lunch	1 veg, 5 med-fat meats, 5 fats	1c romaine salad (free food) with 4oz ground beef (with sodium-free taco seasoning), 1c pico de	Asian beef cabbage soup (3 oz grilled flank steak, ½ c cabbage, 1 tbsp sesame oil, 1 tbsp canola oil, 2	Tex-Mex succotash (1/8 c frozen corn, ¼ c frozen lima beans, ½ large tomato, 1 tbsp canola oil, 1/8	Shrimp "Ceviche" salad (2 oz fresh/frozen pre-cooked shrimp, ¼ avocado, ¼ c red onion, ½ c cucumber,	Strawberry spinach salad (1/4 c strawberries, 6 walnuts, 1 ½ c spinach, 1/8 c red onion, 2 tbsp feta cheese	Tilapia caprese salad (4 oz baked tilapia with 2 tsp canola oil) 1 oz mozzarella ½ tomato	2 beef tacos (2 oz ground beef, ¼ raw tomato, 1/8 c raw onion, ¼ c sliced

		gallo, 3/8 medium avocado, 2 Tbsp ranch dressing	tsp of chili oil) 1 c zucchini ¼ c mushrooms 1.5 c sodium free broth	avocado, 1 oz shredded mozzarella cheese)	1/8 c lime juice, 2 tbsp olive oil, 1 c spinach)	crumble, 2 tbsp clear raspberry vinaigrette with 1 tbsp olive oil)	½ avocado 2 tbsp light Italian dressing basil	cabbage 2 six-inch taco shells, ½ avocado)
Snack	½ grain (WG), 4 fats	1 Tbsp peanut butter on 1/2 slice 100% whole grain toast sprinkled with 2 whole walnuts (chopped)	4 celery sticks ½ tbsp peanut butter mixed with 1 tbsp smart balance 3 whole walnuts	Spicy nut mix blend (2 walnuts, 1 tbsp cashews, 2 pecans, 2 tbsp smart balance)	½ c apples 1 tbsp peanut butter, 1 tbsp smart balance 10 peanuts	4 celery sticks ½ tbsp peanut butter, 1 tbsp smart balance, 10 pecans	1 c popcorn, unsalted and unbuttered (air popped) Spicy nut mix blend	Blueberry and avocado smoothie (4 oz whole milk, ¾ blueberries, ½ avocado, ½ c ice)
Dinner	1 veg, 7 lean meats, 5 fats	5oz sautéed cod with 1 Tbsp olive oil and garlic, 1c sautéed spinach (in same 1 Tbsp olive oil and garlic, free food), 1/2c baked yellow squash (tossed in 2	5 oz grilled salmon, 1 tsp sesame oil 2 whole walnuts (topping) 1.5 c romaine ¼ c halved cucumber slices 2 tbsp sesame salad dressing	Cashew chicken (1 tbsp sesame oil, 4 oz chicken breast, 1 tbsp cashews, ¼ c broiled broccoli with 1 tbsp smart balance) Sauce for chicken (1 tsp lite soy sauce, 1 tsp	Steak dinner (3 oz strip steak, rosemary, 2 tsp canola oil) ½ c cooked asparagus, 2 tsp canola oil ½ c quinoa, 1 tbsp olive oil, ¼ c parsley	4 oz grilled salmon, seasoned with lemon pepper and garlic, 2 tsp canola oil ¼ romaine head, 4 tsp olive oil Garnish with ¼ avocado	3 oz pork loin (boneless, lean), 2 tsp canola oil ½ broccoli and ½ cauliflower blend, 3 tsp olive oil and garlic ¼ c carrots, 2 tsp canola oil and garlic	3 oz pan-seared fish (sea bass, salmon, tilapia, etc.), 2 tbsp olive oil ¼ c zucchini ½ c spinach

		tsp canola oil before baking)	mixed with 1 tbsp canola oil	garlic, 1 tsp white or rice vinegar, ¼ c low sodium chicken broth, 1 tbsp sesame oil)				
Snack	½ grain (WG), 4 fats	Other half of toast with 1 Tbsp PB sprinkled with 2 whole walnuts (chopped)	1 oz whole grain bread ½ tbsp peanut butter 1 tbsp smart balance 3 whole walnuts	Fruit smoothie (1/2 c fresh whole strawberries, 8 oz whole milk, 1/8 avocado, 2 tsp canola oil, 1 c ice)	Berries and avocado frozen smoothie (0.5 frozen avocado, ¼ c strawberries, 4 oz vanilla Greek yogurt, 2 tbsp canola oil, 1 tbsp vanilla extract, 1 tsp lemon juice, 1 c ice	½ c strawberries 2 oz yogurt 4 whole walnuts	1 c popcorn, unsalted and unbuttered (air popped) Spicy nut mix blend	Spicy nut mix blend (4 walnuts, 4 pecans, 2 tbsp cashews, 2 tbsp smart balance)

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Fats/ Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	

<50g carbs/d, 20% cal from protein, 70% cal from fat	Daily	2,000	2 raw/ 1 cooked					0.5	1	0	1 full fat	12 (7 lean, 5 medium-fat/ fish)			155 (22 serv)
	Weekly	14,000			0	0								0	

Plant-based/Vegan Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	2 fruits, 1 WG, 1 dairy	2/3 c non-fat vanilla Greek yogurt ¼ c granola 1 c strawberries	¾ c. cheerios 1 c skim milk 1 large banana	2/3 c non-fat vanilla Greek yogurt ¼ c granola 1 c blackberries	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple	¼ c granola 2/3 c non-fat vanilla Greek yogurt 1 c blue berries	¾ c. cheerios 1 c skim milk 1 large banana	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple
Snack	1 grain	1 oz honey chex	1 oz gold fish	1 oz pretzels	1 oz honey chex	1 oz pretzels	1 oz honey chex	1 oz pretzels
Lunch	1.5c veg, 2 WG, 2 oz protein	2 tbsp peanut butter (plant pro.) 1.5 c. celery 2 oz pretzels	1.5 oz hard-boiled egg 1.5 c. spinach ¼ c. tomato ¼ c. chick peas 2 oz croutons 2 tbsp Italian dressing	navy bean soup (1 c navy beans, ¼ c. carrots, ¼ c. corn, ¼ c peas, 2 c broth, 0.5 c egg noddle) 1 oz crackers	1 black bean burger patty (14 g protein) 2 oz whole grain bun 0.5 c romaine lettuce (topping) 0.5 c tomato (topping) 0.5 c. oven baked sweet potato fries	0.5 c hummus and 2 oz peta bread (plant pro.) 0.5 sliced bell pepper (dipping) 0.5 baby carrots (dipping)	sandwich with fried egg (1.5 whole egg), whole gain toast (2 oz), low-fat cheddar cheese (1.5 oz), 0.5 c. tomato 1 c oven baked home fries 1 tsp vegetable oil	chick pea salad (2 oz low fat cheddar cheese, ¾ c. ice burg lettuce¼ shredded carrots, ¼ tomatoes, ¼ c. corn, ¼ c. black beans) 2 tbsp low-fat ranch 2 oz baked tortilla chips

					1 tsp vegetable oil			
Snack	1 fruit, 1 dairy	¼ c cottage cheese 0.5 c. peaches	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. pineapple	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. mandarin oranges	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. pineapple
Dinner	1c veg, 2 grain, 3.5oz protein	1.25 c baked sweet potato 1 c. black beans 1.5 oz low fat feta cheese 2 oz whole grain dinner roll 2 tsp butter	Stir fry (1.75 c. tofu, ¼ c sugar snap peas, ¼ c. baby corns, ¼ red pepper, ¼ carrots) 2/3 c. brown rice 3 tbsp teriyaki sauce	3.5 oz low fat shredded cheddar cheese 1 c. steamed broccoli (1 tsp vegetable oil) 2/3 c quinoa	2 c. bean chili (includes 1 cup red orange, ¾ c beans/plant pro.) 2 oz corn bread	3.5 scrambled eggs 1 c oven baked red potatoes 1 tsp vegetable oil 2 oz whole toast 1 tsp butter	Red beans and rice 1 ½ c red beans 2/3 c brown rice 2 .5 oz low fat feta cheese	3.5 oz low fat mozzarella cheese 0.5 c. butternut squash 0.5 tsp vegetable oil 1 c spaghetti ½ marinara sauce (topping)
Snack	1 fruit, 1 dairy	1 c skim milk 1 small banana	2/3 c non-fat vanilla Greek yogurt 0.5 c mango	1 c skim milk 1 small pear	2/3 c non-fat vanilla Greek yogurt 0.5 c black cherries	1 c skim milk ½ c. strawberries	2/3 c non-fat vanilla Greek yogurt 0.5 c mango	1 c skim milk 1 small banana

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	
No meat products	Daily	2,000	2.5					2	3	3	3	5.5			27 (5.5 serv)
	Weekly	14,000	1.5	5.5	1.5	5	4	14	21	21	21	0	14	24.5	189

Fasting Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	Fasting	-	-	-	-	-	-	-
Snack	Fasting	-	-	-	-	-	-	-
Lunch	1.5c veg, 2 WG, 1.5oz protein	2 tbsp peanut butter (plant pro.) 1.5 c. celery 2 oz pretzels	1.5 oz hard-boiled egg 1.5 c. spinach ¼ c. tomato ¼ c. chick peas 2 oz croutons 2 tbsp Italian dressing	chicken soup (1.5 oz chicken, ¼ c. carrots, ¼ c. corn, ¼ c peas, 2 c broth, 0.5 c egg noddle) 1 oz crackers	4 oz 96% lean beef burger patty 2 oz whole grain bun 0.5 c romaine lettuce (topping) 0.5 c tomato (topping) 0.5 c. oven baked sweet potato fries 1 tsp vegetable oil	0.5 c hummus and 2 oz peta bread (plant pro.) 0.5 sliced bell pepper (dipping) 0.5 baby carrots (dipping)	sandwich with fried egg (1.5 whole egg), whole gain toast (2 oz), low-fat cheddar cheese (1.5 oz), 0.5 c. tomato 1 c oven baked home fries 1 tsp vegetable oil	chicken salad (1.5 oz chicken, ¾ c. ice burg lettuce¼ shredded carrots, ¼ tomatoes, ¼ c. corn, ¼ c. black beans) 2 tbsp low-fat ranch 2 oz baked tortilla chips
Snack	2 fruit, 2 dairy	2/3 c non-fat vanilla Greek yogurt 1 c strawberries	2 c fat free chocolate milk 1 large pear	2/3 c non-fat vanilla Greek yogurt 1 c blackberries	2 c fat free chocolate milk 1 c grapes	2/3 c non-fat vanilla Greek yogurt 1 c blue berries	2 c fat free chocolate milk 1 large apple	2/3 c non-fat vanilla Greek yogurt 1 c raspberries

Dinner	1c veg, 3 grain, 4oz protein	4 oz Sirloin steak 1.25 c baked sweet potato 3 oz whole grain dinner roll 2 tsp butter	Stir fry (4 oz skinless chicken breast, ¼ c sugar snap peas, ¼ c. baby corns, ¼ red pepper, ¼ carrots) 1 c. brown rice 3 tbsp teriyaki sauce	4 oz salmon fillet 1 c. steamed broccoli (1 tsp vegetable oil) 1 c quinoa	2 c. bean chili (includes 1 cup red orange, ¾ c beans/plant pro.) 3 oz corn bread	4 oz pork tenderloin 1 c oven baked red potatoes 1 tsp vegetable oil 3 oz whole grain dinner roll 1 tsp butter	4 oz Rotisserie chicken (no skin, white meat only) 1 c baked beans 3 oz corn bread	4 oz baked cod 0.5 c. butternut squash 0.5 tsp vegetable oil 1.5 c spaghetti ½ marinara sauce (topping)
Snack (before 8pm)	2 fruit, 1 dairy, 1 WG	1 c skim milk 1 large banana 1 oz graham crackers	2/3 c non-fat vanilla Greek yogurt 0.5 c mango ¼ c granola	1 c skim milk 1 small pear ¾ c honey chex	2/3 c non-fat vanilla Greek yogurt 0.5 c black cherries ¼ c granola	1 c skim milk ½ c. strawberries 1 oz graham crackers	2/3 c non-fat vanilla Greek yogurt 1 c mango ¼ c granola	1 c skim milk 1 large banana ¾ c cheerios

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	

Feeding window-16hr fast:8hr feeding	Daily	2,000	2.5					2	3	3	3	5.5			27 (5.5 serv)
	Weekly	14,000	1.5	5.5	1.5	5	4	14	21	21	21	8	26	5	189

Carnivore Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	7 protein	3 eggs 4 oz sausage	3 eggs 4 thick cut strip bacon	3 eggs 4 oz sausage	3 eggs 4 thick cut strip bacon	3 eggs 4 oz sausage	3 eggs 4 thick cut strip bacon	3 eggs 4 oz sausage
Snack	2 protein	2 oz beef jerky	2 oz turkey jerky	2 oz beef jerky	2 oz turkey jerky	2 oz beef jerky	2 oz turkey jerky	2 oz beef jerky
Lunch	7 protein	7 oz rotisserie chicken	7 oz Italian pork sausage	7 oz 90% lean beef patty	7 oz grilled chicken breast	7 oz pork chop	7 oz pot roast beef	7 oz ground chicken patties
Snack	2 protein	2 hard boiled eggs	2 hard boiled eggs	2 hard boiled eggs	2 hard boiled eggs	2 hard boiled eggs	2 hard boiled eggs	2 hard boiled eggs
Dinner	7 protein	7 oz pork tenderloin	7 oz stew beef	7 oz smoked turkey	7 oz pulled pork	7 oz sirloin steak	7 oz ground turkey	7 oz hot pork
Snack	2 protein	4 thick cut strip bacon	2 oz sausage	4 thick cut strip bacon	2 oz sausage	4 thick cut strip bacon	2 oz sausage	4 thick cut strip bacon

<table>
<tr><th rowspan="2">Rules</th><th rowspan="2">Timeframe for Recs</th><th rowspan="2">Calorie Intake</th><th colspan="5">Vegetables (cup equiv)</th><th rowspan="2">Fruits (cup equiv)</th><th colspan="2">Grains (oz equiv)</th><th rowspan="2">Dairy (cup equiv)</th><th colspan="3">Protein (oz equiv)</th><th rowspan="2">Oils (g)</th></tr>
<tr><th>Dark Green</th><th>Red Orange</th><th>Legume</th><th>Starchy</th><th>Other</th><th>Whole Grains</th><th>Refined</th><th>Sea-food</th><th>Meats, Poultry, Eggs</th><th>Nuts, Seeds, Soy Products</th></tr>
<tr><td></td><td>Daily</td><td>2,000</td><td colspan="9">0</td><td colspan="3">27</td><td>-</td></tr>
</table>

Meat only, mainly red meats	Weekly	14,000		0	Red meat mostly, poultry and eggs limited	0	-

Liquid Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	Fruit juice	3 2/3 c. 100 % fruit juice: apple	3 2/3 c. 100 % fruit juice: white grape	3 2/3 c. 100 % fruit juice: pineapple	3 2/3 c. 100 % fruit juice: orange	3 2/3 c. 100 % fruit juice: grape	3 2/3 c. 100 % fruit juice: apple	3 2/3 c. 100 % fruit juice: white grape
Snack	Vegetable juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice	2.5 c.: strained V8 tomato juice
Lunch	Protein juice	3 ¾ c. miso *(4cups)*	3 ¾ c. miso	3 ¾ c. miso	3 ¾ c. miso	3 ¾ c. miso	3 ¾ c. miso	3 ¾ c. miso
Snack	Fruit juice	3 2/3 c. 100% fruit juice: pineapple	3 2/3 c. 100 % fruit juice: orange	3 2/3 c. 100 % fruit juice: grape	3 2/3 c. 100 % fruit juice: apple	3 2/3 c. 100 % fruit juice: white grape	3 2/3 c. 100 % fruit juice: pineapple	3 2/3 c. 100 % fruit juice: orange
Dinner	Protein juice	3 ¾ c. bone broth *(beef broth) (4)*	3 ¾ c. bone broth	3 ¾ c. bone broth	3 ¾ c. bone broth	3 ¾ c. bone broth	3 ¾ c. bone broth	3 ¾ c. bone broth
Snack	Fruit juice	3 2/3 c. 100 % fruit juice: apple	3 2/3 c. 100 % fruit juice: white grape	3 2/3 c. 100 % fruit juice: pineapple	3 2/3 c. 100 % fruit juice: orange	3 2/3 c. 100 % fruit juice: grape	3 2/3 c. 100 % fruit juice: apple	3 2/3 c. 100 % fruit juice: white grape

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)	Fruits (cup equiv)	Grains (oz equiv)	Dairy	Protein (oz equiv)	Oils (g)

			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined	(cup equiv)	Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	
Clear liquids diet	Daily	2,000	2.5c juice Strained vegetable juice (25cal and 1 serving per ½ cup)					11c juice Fruit juices or 100% fruit juice popsicles, all without pulp (60cal and 1 serving per ½ cup)	0		0	7.5c Bone broth (80cal and 5g per cup), miso (60 cal and 5g per cup)			-
	Weekly	14,000	Achieved based on available varieties of strained vegetable juices					22 serv				38.5oz equiv			

Military Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	2 fruits, 1 WG, 1 dairy	½ grapefruit, 1 slice toast, 2 T peanut butter, 1c coffee	1 egg, 1 slice toast, ½ banana	5 saltine crackers, 1 slice cheddar cheese, 1 small apple	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple	¼ c granola 2/3 c non-fat vanilla Greek yogurt 1 c blue berries	¾ c. cheerios 1 c skim milk 1 large banana	½ c oatmeal (made with 0.5 c skim milk) 0.5 skim milk for drinking or topping 1 large apple
Snack	1 grain	-	-	-	1 oz honey chex	1 oz pretzels	1 oz honey chex	1 oz pretzels
Lunch	1.5c veg, 2 WG, 1.5oz protein	1/2c tuna (packet) 1 slice toast 1c coffee	1c cottage cheese, 1 hard-boiled egg, 5 saltine crackers	1 hard-boiled egg, 1 slice toast	4 oz 96% lean beef burger patty 2 oz whole grain bun 0.5 c romaine lettuce (topping) 0.5 c tomato (topping) 0.5 c. oven baked sweet potato fries 1 tsp vegetable oil	0.5 c hummus and 2 oz peta bread (plant pro.) 0.5 sliced bell pepper (dipping) 0.5 baby carrots (dipping)	sandwich with fried egg (1.5 whole egg), whole gain toast (2 oz), low-fat cheddar cheese (1.5 oz), 0.5 c. tomato 1 c oven baked home fries 1 tsp vegetable oil	chicken salad (1.5 oz chicken, ¾ c. ice burg lettuce¼ shredded carrots, ¼ tomatoes, ¼ c. corn, ¼ c. black beans) 2 tbsp low-fat ranch 2 oz baked tortilla chips

Snack	1 fruit, 1 dairy	-	-	-	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. mandarin oranges	1 c fat free chocolate milk 0.5 c grapes	¼ cottage cheese 0.5 c. pineapple
Dinner	1c veg, 2 grain, 4oz protein	3oz grilled chicken, 1c green beans, ½ banana, 1 small apple, 1c vanilla ice cream	2 hot dogs, 1c broccoli, 1/2c carrots, ½ banana, 1/2c vanilla ice cream	1c tuna (packet), ½ banana, 1c vanilla ice cream	2 c. bean chili (includes 1 cup red orange, ¾ c beans/plant pro.) 2 oz corn bread	4 oz pork tenderloin 1 c oven baked red potatoes 1 tsp vegetable oil 2 oz whole grain dinner roll 1 tsp butter	4 oz Rotisserie chicken (no skin, white meat only) 1 c baked beans 2 oz corn bread	4 oz baked cod 0.5 c. butternut squash 0.5 tsp vegetable oil 1 c spaghetti ½ marinara sauce (topping)
Snack	1 fruit, 1 dairy	-	-	-	2/3 c non-fat vanilla Greek yogurt 0.5 c black cherries	1 c skim milk ½ c. strawberries	2/3 c non-fat vanilla Greek yogurt 0.5 c mango	1 c skim milk 1 small banana

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole	Refined		Sea-	Meats, Poultr	Nuts, Seeds, Soy	

									Grai ns			foo d	y, Eggs	Produc ts	
Rigid dietary intake following plan (see meal plan below*) for 3 days followed by normal eating for 4 days	Daily	2,00 0	2.5					2	3	3	3	5.5			27 (5. 5 ser v)

Low FODMAP Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	2 fruits, 1 WG, 1 dairy	2/3 c non-fat vanilla soy yogurt ¼ c granola 1 c strawberries	¾ c. cheerios 1 c unsweetened vanilla soy milk 1 large banana	2/3 c non-fat vanilla soy yogurt ¼ c granola 1 c blackberries	½ c oatmeal (made with 0.5 c unsweetened vanilla soy milk) 0.5 unsweetened vanilla soy milk for drinking or topping 1 c. strawberries	¼ c granola 2/3 c non-fat vanilla soy yogurt 1 c blue berries	¾ c. cheerios 1 c unsweetened vanilla soy milk 1 large banana	½ c oatmeal (made with 0.5 c unsweetened vanilla soy milk) 0.5 unsweetened vanilla soy milk for drinking or topping 1 c. blackberries
Snack	1 grain	1 oz honey chex	1 oz baked Tostito corn chips	1 oz rice cakes	1 oz honey chex	1 oz rice cakes	1 oz honey chex	1 oz rice cakes
Lunch	1.5c veg, 2 WG, 1.5oz protein	2 tbsp peanut butter (plant pro.) 1.5 c. celery 2 oz gluten free pretzels	1.5 oz hard-boiled egg 1.5 c. spinach ¼ c. tomato ¼ c. cucumber 2 oz gluten free croutons	chicken soup (1.5 oz chicken, ¼ c. carrots, ¼ c. corn, ¼ c peas, 2 c broth, 0.5 c egg noddle) 1 oz crackers	4 oz 96% lean beef burger patty 2 oz gluten free bun 0.5 c romaine lettuce (topping)	2 tbsp peanut butter (plant pro.) 12 gluten free crackers 0.5 sliced bell pepper 0.5 baby carrots	sandwich with fried egg (1.5 whole egg), gluten free toast (2 oz), 0.5 c. tomato	chicken salad (1.5 oz chicken, ¾ c. ice burg lettuce¼ shredded carrots, ¼ tomatoes, ¼ c. corn, ¼ c.

			2 tbsp Italian dressing		0.5 c tomato (topping) 0.5 c. oven baked sweet potato fries 1 tsp vegetable oil		1 c oven baked home fries 1 tsp vegetable oil	red bell pepper) 2 tbsp low-fat ranch 2 oz baked tortilla chips
Snack	1 fruit, 1 dairy	2/3 c non-fat vanilla soy yogurt 0.5 c. pineapple	1 c fat free soy chocolate milk 0.5 c grapes	2/3 c non-fat vanilla soy yogurt 0.5 c. pineapple	1 c fat free soy chocolate milk 0.5 c grapes	2/3 c non-fat vanilla soy yogurt 0.5 c. mandarin oranges	1 c fat free soy chocolate milk 0.5 c grapes	2/3 c non-fat vanilla soy yogurt 0.5 c. pineapple
Dinner	1c veg, 2 grain, 4oz protein	4 oz Sirloin steak 1.25 c baked sweet potato 2 oz gluten free dinner roll	Stir fry (4 oz skinless chicken breast, ¼ c sugar snap peas, ¼ c. baby corns, ¼ red pepper, ¼ carrots) 2/3 c. brown rice 3 tbsp teriyaki sauce	4 oz salmon fillet 1.5 c. sautéed spinach (1 tsp vegetable oil) 2/3 c quinoa	2 c. turkey chili (includes 1 cup red orange, 4 oz turkey 2 oz gluten free corn bread	4 oz pork tenderloin 1 c oven baked red potatoes 1 tsp vegetable oil 2 oz gluten free dinner roll	4 oz Rotisserie chicken (no skin, white meat only) 1 c steamed green beans 2 oz gluten free corn bread	4 oz baked cod 0.5 c. butternut squash 0.5 tsp vegetable oil 1 c gluten free spaghetti ½ marinara sauce (topping)
Snack	1 fruit, 1 dairy	1 c unsweetened vanilla soy milk	2/3 c non-fat vanilla soy yogurt 0.5 c mango	1 c unsweetened vanilla soy milk	2/3 c non-fat vanilla soy yogurt 0.5 c black cherries	1 c unsweetened vanilla soy milk	2/3 c non-fat vanilla soy yogurt 0.5 c mango	1 c unsweetened vanilla soy milk

		1 small banana		1 small banana		½ c. strawberries		1 small banana

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	
Restriction of carbohydrate rich foods - highly fermentable oligosaccharides, disaccharides, monosaccharides and polysaccharides	Daily	2,000	2.5					2	3	3	3	5.5			27 (5.5 serv)
	Weekly	14,000	Restriction of high-FODMAP vegetables: beans, lentils, broccoli, asparagus, garlic, onion Inclusion of low-FODMAP vegetables: tomato, eggplant, cucumbers					Restriction of high-FODMAP fruits: peaches, apples, pears Inclusion of	Restriction of high-FODMAP grains: wheat-based products Inclusion of low-FODMAP grains: oats,		Restriction of high-FODMAP dairy: milk, yogurts, ice cream, milk-based	8	26	5	189

				low-FODMAP fruits: blueberries, oranges, limes, lemons, strawberries, pineapples	quinoa, rice, gluten free products	products Inclusion of low-FODMAP dairy: some cheeses, non-dairy based milk products that are calcium fortified				

Paleo Diet Menu

Meal	Meal Plan (as exchanges)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	2 fruits, 3oz protein, 1c veg	1 c blackberries, 3 fried eggs, ½ a large tomato sliced	1 large banana, 3 scrambled eggs with 1c diced bell peppers	1 c strawberries, 3 hard boiled eggs, 1c sautéed spinach	1 large apple, 3 scrambled eggs, 1c salsa	1 c blueberries, 3 fried eggs, ½ a large tomato sliced	1 large banana, 3 scrambled eggs with 1c diced mushrooms	1 large apple, 3 hard boiled eggs, 1c carrot sticks
Snack	-	-	-	-	-	-	-	-
Lunch	2c veg, 3 oz protein, 2 fruit	3 tbsp almond butter (plant pro.) 2 c. celery, 1 large apple	3 oz tuna 2 c. spinach ¼ c. tomato ¼ c. cucumber 2 tbsp Italian dressing 1c honey dew	chicken soup (3 oz chicken, 1/2 c. carrots, 1 c. celery, 1/2 c onion, 2 c broth) 2 small plums	Stir fry: 3oz cashews chopped 1c broccoli, 1/2 c carrots, 1/2 c. yellow peppers 1 tsp vegetable oil, 2 tbsp teriyaki sauce 1c pineapple	3 tbsp almond butter (plant pro.) 1 c celery (dipping) 1/2 c baby carrots (dipping) 1 large apple	3 oz salmon with 2 tbsp teriyaki sauce, 1 c. butternut squash 1 c zucchini 1 tsp vegetable oil 1c honey dew	chicken salad (3 oz chicken, 1 c. iceburg lettuce¼ c shredded carrots, ¼ c cherry tomatoes, ¼ c. chopped red onion, ¼ c. cucumber) 1 tbsp balsamic vinegar + 1 tbsp olive oil

								2 small plums
Snack	2 fruit	1 c. peaches	1 c grapes	1 c. pineapple	1 c grapes	1 c. mandarin oranges	1 c grapes	1 c. pineapple
Dinner	2.5c veg, 6oz protein	6 oz Sirloin steak 1.5 c sauteed mushrooms 1 c grilled zucchini	Stir fry (3 oz skinless chicken breast, 3 oz chopped cashews, 3/4 c green beans, 1/2 c. bok choy, 1 c red pepper, 1/2 c carrots) 3 tbsp teriyaki sauce	6 oz salmon fillet 2.5 c. blackened broccoli (1 tsp vegetable oil)	3 c. turkey chili without beans (includes 1.5 cup red orange) + 1 c additional tomato sauce	6 oz pork tenderloin 2.5 c sauteed collard greens 1 tsp vegetable oil	6 oz Rotisserie chicken (no skin, white meat only) 2.5 c roasted asparagus	6 oz baked cod 2.5c sauteed spinach 1 tsp vegetable oil
Snack	2 fruit	1 large banana	1 c mango	1 large pear	1 c black cherries	1 c. strawberries	1 c mango	1 large banana

Rules	Timeframe for Recs	Calorie Intake	Vegetables (cup equiv)					Fruits (cup equiv)	Grains (oz equiv)		Dairy (cup equiv)	Protein (oz equiv)			Oils (g)
			Dark Green	Red Orange	Legume	Starchy	Other		Whole Grains	Refined		Sea-food	Meats, Poultry, Eggs	Nuts, Seeds, Soy Products	
Restriction of grains, legumes, peanuts, peas, dairy products, refined sugar, artificial sweetener, salt, potatoes, trans fats, vegetable oil, and highly processed foods.	Daily	2,000	5.5					4 (2)	0	0	0	12 (5.5)			27 (5.5 serv)
	Weekly	14,000	14	11	0	0	13	28 (14)	0	0	0	19	43.5	14 (no peanuts or soy)	189

Appendix B: Systematic Review Search Strategy

Date	Database	Search Strategy	Number of Results (Primary Search) (Additional Article from Secondary Search)
4/7/2022 12/14/22	PubMed from inception	(students OR college OR ("universities"[Mesh])) AND ((diet [Mesh] OR Nutritional Requirements [Mesh]) AND index) AND (depression OR anxiety OR stress) (students OR college OR ("universities"[Mesh])) AND ((diet [Mesh] OR Nutritional Requirements [Mesh]) AND index) AND ((("academic performance" [Mesh] OR "educational measurement"[Mesh]))	481 (44) 13 (0)
4/7/2022 12/14/22	Cochrane Library, from inception	MeSH descriptor: [Diet, Healthy] AND MeSH descriptor: [Universities] AND (MeSH descriptor: [Stress, Psychological] OR MeSH descriptor: [Depression] explode all trees OR MeSH descriptor: [Anxiety] explode) MeSH descriptor: [Diet, Healthy] AND MeSH descriptor: [Universities] AND (MeSH descriptor: [Academic Performance]	0 (0) 0 (0)
4/7/2022 12/14/22	SPORTDiscus (EBSCOhost), from 1830	((DE "DIET") AND (DE "COLLEGE students")) AND ((DE "PSYCHOLOGICAL stress") OR (DE "anxiety") OR (DE "depression")) ((DE "DIET") AND ((DE "ACADEMIC achievement") AND (DE "COLLEGE students")	7 (0) 4 (0)
4/7/2022 12/14/22	Web of Science (Clarivate), from inception	(TS=(dietary quality) OR AB=(dietary quality)) AND (TS=(college) OR AB=(college)) AND ((TS=(stress) OR AB=(stress)) OR (TS=(anxiety) OR AB=(anxiety)) OR (TS=(depression) OR AB=(depression))) (TS=(dietary quality) OR AB=(dietary quality)) AND (TS=(college) OR AB=(college)) AND (TS=(academic performance) OR AB=(academic performance))	100 (15) 12 (1)
4/7/2022 12/14/22	Education Full Text (EBSCO Host)	((DE "DIET") AND (DE "COLLEGE students")) AND ((DE "PSYCHOLOGICAL stress") OR (DE "anxiety") OR (DE "depression")) (DE "DIET") AND ((DE "ACADEMIC achievement") AND (DE "COLLEGE students")	4 (2) 1 (0)

	from 1983		
4/7/2022 12/14/22	SCOPUS, from 1800s	(KEY (*diet** AND *quality*)) AND (KEY (*college* AND *student*)) AND ((KEY (*stress*)) OR (KEY (*anxiety)) OR* (KEY (*depression*))) ((KEY (diet* AND quality)) AND (KEY (college AND stude nt)) AND (KEY (academic AND performance)))	16 (2) 0 (1)
4/7/2022 12/14/22	APA PsycInfo (ProQuest), from 1800s	su(diet) AND su(college) AND (su(stress) OR su(anxiety) OR su(depression)) su(diet) AND su(college) AND su(academic performance)	52 (0) 1 (0)
4/7/2022 12/14/22	ProQuest Central, from inception	su(diet) AND su(college) AND (su(stress) OR su(anxiety) OR su(depression)) su(diet) AND su(college) AND su(academic performance)	253 (4) 3 (0)