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Consuming an Anti-Inflammatory Diet to Alleviate Chronic Pain

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Abstract: The purpose of this study was to determine if there was a relationship between consuming an anti-inflammatory diet and alleviating chronic pain in specific daily activities. A sample of 12 men and women 21 years of age or over volunteered to participate. Subjects were recruited from social media sources and were pre-screened by telephone to meet inclusion criteria. The five week study included a 1-week control diet consuming a typical Western diet (diet WD) diet followed by a 4-week Pain Free/anti-inflammatory diet (diet PF). Chronic pain was self-reported using a standard 0-10 Numeric Pain Scale. Daily food records to assess compliance and electronic questionnaires were used to collect data. The questionnaire data were evaluated to describe the sample and to compare the means and percentages of the pain levels post diet WD to post diet PF. A paired *t*-test indicated a significant reduction ($p < .001$) in self-reported pain with the treatment diet. A non-parametric Friedman's test compared diet WD to diet PF and self-reported pain was significantly reduced ($p < .03$) in all 6 daily activities (walking, climbing stairs, carrying objects, dressing, grooming, and sleeping). This study found that 100% of participants used this diet intervention to reduce their chronic pain in specific daily activities. Uncontrolled weight loss was a limitation of the study and was experienced by all participants and may have contributed to a reduction in chronic pain. Further research with larger samples is needed to determine whether following an anti-inflammatory diet may be a viable choice to alleviate chronic pain.

Keywords: inflammation, anti-inflammatory, diet, pain, chronic pain

Introduction

Chronic pain is recurring pain that can last for months or years and can drastically reduce the quality of a person's life. Chronic pain is often resistant to conventional medical treatments and the use of drugs for pharmacologic pain management can have long term side effects. The search for alternatives to alleviate chronic pain has lead to diet. Dramatic changes in dietary consumption in the past century have turned the intake of food into a daily danger and a cause of continuous systemic stress in the body (Bosma-den Boer, van Wetten, & Pruimboom, 2012).

A number of epidemiological studies worldwide have documented a link between various dietary patterns and markers of inflammation (Ahluwalia, Andreeva, Kesse-Guyot, & Hercberg, 2013). Systemic low-grade inflammation is a common denominator in many chronic illnesses, like chronic pain. Most chronic inflammatory diseases have been linked to diet and modifying it could prevent, delay or even heal these diseases (Ruiz-Núñez, Pruimboom, Dijck-Brouwer, & Muskiet, 2013).

It is the position of the Academy of Nutrition and Dietetics (AND) that dietary intervention positively impacts health outcomes across the life span and that prevention is the most effective method to address chronic disease. Although the positive impacts of dietary changes have been clearly demonstrated, less than 1% of US adults have a diet considered ideal (Slawson, Fitzgerald, & Morgan, 2013).

Evidence suggests that some types of dietary interventions may have significant effects on chronic pain. The available research has suggested a link between food and pain. Some researchers have proposed that dietary interventions can activate and support the body's natural defense against pain (Bell, 2007).

An anti-inflammatory diet involves consuming a predominately plant based diet. Research findings have shown that a plant based diet has demonstrated a reduction in pain and disease activity and an improvement in physical function and vitality (McIlwain & Bruce, 2006).

Statement of Purpose

The goal of this quasi-experimental study was to identify whether there is a relationship between consuming an anti-inflammatory diet to decrease chronic inflammation and alleviate chronic pain, and the impact of the anti-inflammatory diet on specific daily activities like walking, climbing stairs, carrying or handling objects, dressing, personal grooming, and sleep.

Theoretical Framework

The Health Belief Model (HBM) was developed to explain and predict behaviors in the

1950's by social psychologists who worked with the U.S. Public Health Service. They developed the model to explain why medical screening programs were unsuccessful (Becker, 1974). The model has since evolved and has expanded.

HBM is based on the premise that health behavior is determined by perceptions or personal beliefs about a disease and the strategies that can be used to decrease the occurrence of that disease. Basically people are more likely to take a health related action if they feel they can avoid a negative health condition. The original model had four main constructs that formed the foundation of the model. These constructs or perceptions can be used to explain health behavior and a person's willingness to take action regarding the disease. The four original perceptions of the model were: perceived susceptibility, perceived severity, perceived benefits and perceived barriers. Added later were two more perceptions: cues to action and self-efficacy (Champion & Skinner, 2008).

Perceived susceptibility refers to beliefs about an individual's risk of developing an illness or disease. Perceived severity is the belief about the severity of an illness and the consequences of leaving it untreated. Perceived benefits are the positive results an individual feels they may receive if an action is followed. Perceived barriers are the factors which may discourage an individual from taking action. Cues to action may be factors or influences which move an individual to take action. Self-efficacy refers to an individual's belief that a behavior can be successfully performed. Refer to Figure 1 for a visual depiction of the HBM (Champion & Skinner, 2008).

This quasi-experimental study looked at an individual's level of chronic pain, if the consumption of an anti-inflammatory diet alleviated chronic pain, and the impact of the anti-inflammatory diet on daily activities like walking, climbing stairs, carry or handle objects, dressing, personal grooming, and sleep. Key concepts for this study evaluated if the perceived severity of the chronic pain would cause an individual to take action by changing behavior and recognize the perceived benefits of consuming an anti-inflammatory diet.

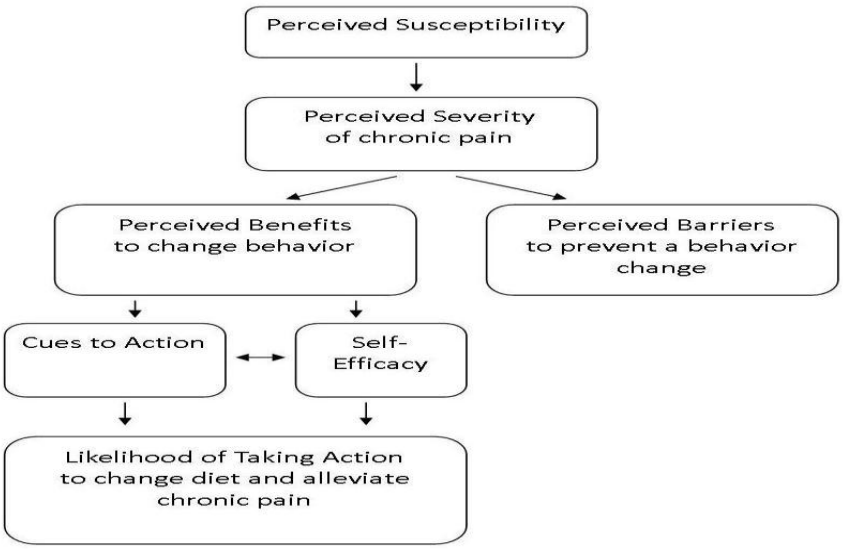

Figure 1. Health Belief Model relationships of perceptions.

Adapted from the Health Belief Model (Champion & Skinner, 2008).

Significance and Justification

The number of people suffering from chronic diseases, like chronic pain, has increased dramatically over the last three decades. The increased rate of chronic system illnesses suggests that inflammation, which is caused by excessive and inappropriate innate immune system activity, is chronically activated in the body (Bosma-den Boer et al., 2012). Chronic pain which can go on for months or years is considered the most costly health problem in the U.S. due to increased medical expenses, lost income, lost productivity, and compensation payments (Bell, 2007). Chronic use of anti-inflammatory medications impedes the body from making a full recovery since even a low-grade inflammation will continue to trigger the body's stress system (Bosma-den Boer et al., 2012).

According to the Academy of Nutrition and Dietetics (AND), dietary intervention positively impacts health outcomes across the life span and that prevention is the most effective method to prevent chronic disease. Although the positive impacts of dietary changes have been clearly demonstrated, less than 1% of US adults have a diet considered ideal (Slawson et al., 2013).

Examination of diet as a whole through analysis of dietary patterns has become a strong field of research to address the complex diet-disease paradigm (Ahluwalia et al., 2013). Scientific literature indicates that a number of dietary interventions have been shown to have anti-inflammatory effects (Bell, 2007).

Changes in dietary consumption in the past century have turned the intake of food into a daily danger and a cause of continuous systemic stress. Some dietary changes include an increase in the omega-6 to omega 3-fatty acid ratio, a high intake of saturated fatty acids and refined carbohydrates, introduction of industrially produced trans fatty acids, lower intake of vitamins D and K, imbalanced intake of antioxidants, high intake of anti-nutrients, an altered intake of dietary fiber and an abundant intake of high glycemic foods (Bosma-den Boer et al., 2012).

A health care focus involving nutrition is a very important factor in understanding the development of chronic inflammation (Bosma-den Boer et al., 2012). In understanding the foods that trigger chronic inflammation, dietary changes can be made to alleviate the chronic inflammation and therefore chronic diseases. The goals for Healthy People 2020 include a primary focus to promote quality of life and to attain high-quality, longer lives free of preventable disease, disability, injury and premature death (Slawson et al., 2013). A report from the National Prevention Strategy reflects the efforts of federal agencies to shift the focus of health care from problem-based medicine to one of prevention and wellness. Strategies include empowering people through education and motivating them towards healthy choices across a life span (Slawson et al., 2013).

An anti-inflammatory diet involves consuming a predominately plant based diet. Research findings have shown that a plant based diet has demonstrated a reduction in chronic inflammation. These dietary changes favor the production of anti-inflammatory chemicals in the body which target and eliminate the pro-inflammatory markers. For example, phytochemicals found in colorful fruits and vegetables and whole grains are loaded with anti-inflammatory compounds. The vitamin C found in fruits and vegetables is a natural antioxidant which helps control inflammation in the body and is involved in rebuilding and regenerating damaged joint tissue (McIlwain & Bruce, 2006).

Review of the Literature

The goal of this quasi-experimental study was to identify whether there is a relationship between consuming an anti-inflammatory diet to decrease chronic inflammation and alleviation of chronic pain, and does the anti-inflammatory diet alleviate chronic pain on specific daily activities like walking, climbing stairs, carrying or handling objects, dressing, personal grooming, and sleep. This literature review explored many topics related inflammation, diet, pain, and chronic disease. The major topics discussed involve describing inflammation, explaining what chronic low grade inflammation does to the body, identifying biomarkers for inflammation, evaluating the effect of chronic pain on daily activities, defining the Western diet, discussing anti-inflammatory diets, explaining the importance of the omega-6 to omega-3 ratio, oxidative stress, and the role of antioxidants. The tools section identified a research method used for this study that may be most productive to determine the individual link between anti-inflammatory diets, chronic inflammation, and chronic pain. The literature review concludes with two studies that were evaluated to show the link between consuming an anti-inflammatory diet and relieving the symptoms of chronic pain disorders.

The Inflammatory Process

Inflammation is a key function in the process in which the body responds to an injury or infection. It limits the survival of invading pathogens, promotes tissue survival, repair and recovery. Inflammation is generally beneficial to the body as a natural process. The acute phase of inflammation normally results in recovery from the offending agent, progresses to healing, and then returns to normal values in a short period of time. When this normal response is not properly controlled, the inflammatory response can continue and lead to state of chronic low-grade inflammation for weeks, months or years (Wärnberg, Gomez-Martinez, Romeo, Diaz & Marco, 2009).

There are two types of inflammation, classical and silent. Classical inflammation is the damage caused by a chronic disease that generates constant pain signals. Silent inflammation or chronic low-grade inflammation is below the level

of pain sensation. It is mostly ignored for years until enough accumulated organ damage builds up and manifests itself as the pain of classical inflammation. Both types of inflammation are mediated by eicosanoids. These are primary hormones derived from long-chain essential fatty acids which are the key inflammatory mediators for the innate immune system. Every cell in the body is capable of producing eicosanoids. Eicosanoids modulate the immune system by turning on the inflammatory response (the "bad") or turning off the inflammatory response (the "good"). Each individual needs a balance of "good" and "bad" eicosanoids in order to maintain a state of wellness or balance in the body (Sears & Ricordi, 2010).

Chronic Low-Grade Inflammation, Pain, and the Effect on the Body

Chronic low-grade inflammation or silent inflammation is associated with several metabolic abnormalities and chronic diseases namely, metabolic syndrome, atherosclerosis, type 1 and type 2 diabetes, autoimmune diseases, and cancer (Ahluwalia et al., 2013; Wärnberg et al., 2009). The immune system is not designed to cope with long term, chronic stimulation. The modern diet disrupts the natural process of inflammation resolution and therefore increases the rates of chronic systemic illnesses. When the innate immune system is constantly reacting because of inflammation, then it is unable to respond to other danger signals. This leads to unresolved and chronic inflammation in the body (Bosma-den Boer et al., 2012).

Long-term inflammation causes adaptive changes to occur in the nervous system. These changes can cause the sensation of pain to become exaggerated or inappropriate. Inflammation is widely associated with various clinical pain conditions in the body. Examples of these clinical pain conditions include arthritis, rheumatoid arthritis, and osteoarthritis. Pain, including joint stiffness, is the prevailing symptom of arthritis for which people seek treatment. A failure to resolve acute inflammation may lead to a transition from acute pain to chronic pain. Unresolved inflammation leads to chronic inflammation and this has been largely ignored in the pain research field due to its low intensity, localized nature, and lack of detection in blood tests (Ji, Xu, Strichartz & Serhan, 2011).

Chronic pain can last for months or years and can drastically reduce the quality of a person's life. It can be difficult to exactly determine the factors that cause chronic pain to persist over time. Chronic pain is often resistant to conventional medical treatments and the use of drugs for pharmacologic pain management can have well-known and long term side effects (Ji et al., 2011). Much research has been done to determine the toxicity of consuming non-steroidal anti-inflammatory drugs (NSAIDs). However dietary interventions are attractive choices for inflammatory pain management due to availability, low cost, and low toxicity. Dietary components have the potential to influence physiological systems in the same manner as drugs (Bell, 2007).

Biomarkers of Inflammation

Unhealthy diets promote a pro-inflammatory environment marked by higher levels of biomarkers. (Ahluwalia et al., 2013). Biomarkers are molecules that can be measured which reflect the severity or presence of a disease state in biological systems. Diet can alter these inflammatory markers due to the quantity of food consumed, the macronutrient and antioxidant content, the glycemic load and the fatty acid ratio (Neustadt, 2011).

C-Reactive Protein (CRP) is an important biomarker which rises in response to inflammation (Boamponsem & Boamponsem, 2011). CRP is an acute phase protein reactant and a very sensitive marker of inflammation. The concentrations are very easily and accurately measured in blood and have become a powerful predictor of certain disease risk (Wärnberg et al., 2009). However, even though it is sensitive, it is not a selective marker because it can react to simple infections. A newer and more selective marker of chronic inflammation involves measuring the ratio of two key fatty acids in the blood, the omega-6 fatty acid arachidonic acid (AA) and the omega-3 fatty acid eicosapentaenoic acid (EPA). A higher AA/EPA ratio indicates a greater the level of silent inflammation that is likely to be found in the body (Sears & Ricordi, 2010).

The Effect of Chronic Pain on Daily Activities

Chronic pain is a debilitating condition that can cause additional symptoms that may affect quality of life. Several studies have evaluated the relationship between chronic pain and patterns of physical activities. People suffering from chronic pain have limitations in their daily life compared to individuals not suffering from this condition. Symptoms have been reported to considerably affect physical health and work related activities. Individuals with chronic pain tend to be less physically active, have ill health, and have increased number of visits to health-care

professionals (Björnsdóttir, Jónsson & Valdimarsdóttir, 2013). Chronic pain is associated with reduced health-related quality of life and poor sleep quality. Women are found to suffer more from chronic pain symptoms than men. Light daily activities such as walking, washing dishes, yard work, and sitting for long periods have been found to be reduced in people suffering with chronic pain (Dansie, Turk, Martin, Van Domelen & Patel, 2014).

The Western Diet or Standard American Diet

Many epidemiological studies worldwide have documented a link between various dietary patterns and markers of inflammation. These studies for the most part have shown that Western dietary patterns are positively associated with higher concentrations of CRP and that healthy dietary patterns have been associated with lower inflammatory markers (Ahluwalia et al., 2013).

The Western diet or standard American diet (SAD) (Neustadt, 2011) is significantly different from our ancestors' diet. Prior to the agricultural revolution over 10,000 years ago, people consumed a Paleolithic diet or Hunter-Gatherer diet which consisted of a variety of wild plants and animal foods. In contrast, the Western diet consists of a high intake of saturated fatty acids, industrially produced trans fatty acids, processed foods, low or poor intakes of mono- and poly-unsaturated fatty acids, and micronutrients (Neustadt, 2011). The monounsaturated fats that are consumed in the Western diet mainly come from beef, dairy fats, and partially hydrogenated vegetable oils versus the non-animal sources of monounsaturated fat in a plant-based diet from olive oil, canola oil, nuts, and avocados (Hu, 2003). The consumption of the ratio of omega-6 to omega-3 fatty acids is off balance as well as the ratio of potassium to sodium (Neustadt, 2011). Other factors affecting the Western diet include the consumption of carbohydrates with a high glycemic index and a high glycemic load; a low intake of fruits, vegetables, and dietary fiber; low levels of vitamin D, vitamin K, and magnesium; and an imbalance between the many micronutrients that make up our antioxidant/pro-oxidant network which perpetuate pro-inflammatory conditions (Ruiz-Nunez et al., 2013). Foods commonly consumed in the Western diet are grass-fed beef, processed meat, refined-grain products, eggs, french fries, high-fat dairy products, sweets and other desserts (Neustadt, 2011). The consumption of fish, fruit, and vegetables is considered too low in most Western countries (Ruiz-Nunez et al., 2013).

Since the 1970s, there has been an increase in overall calorie consumption of over 500 kcal/day. The Western diet consists of an abundance of foods and beverages with added sugars and fats that displace nutrient-dense foods. Overconsumption of energy dense foods creates an imbalance in energy intake that has lead to an increase in obesity, heart disease, diabetes mellitus, certain cancers, and metabolic dysfunctions. Obesity plays a role in arthritis and other inflammatory conditions. The rise in calorie consumption can be attributed to Americans snacking more frequently, eating more meals away from home, consuming much larger portions of high-calorie foods when dining out, and eating food from larger plates in restaurants and at home. This current dietary pattern combined with inactivity may be the main force behind many health challenges faced in the United States today as Americans continue to be overfed and undernourished (Grotto & Zied, 2010). As calorie consumption increases and fat is stored in adipose tissue, a concern over abdominal adiposity increases. People with abdominal adiposity are particularly prone to the pro-inflammatory effects of unhealthy diets. Visceral obesity, the fat surrounding the body's internal organs, may be favored by Western dietary patterns and is a key promoter of low-grade systemic inflammation (Esposito & Giugliano, 2006).

Industrialized societies consuming the Western diet today are characterized by several differences in comparison to ancestral diets:

1) an increase in energy intake and decrease in energy expenditure; (2) and increase in saturated fat, omega-6 fatty acids and trans fatty acids, and a decrease in omega-3 fatty acid intake; (3) a decrease in complex carbohydrates and fiber; 4) an increase in cereal grains and a decrease in fruits and vegetables; and (5) a decrease in protein, antioxidants and calcium intake (Neustadt, 2011, p. 50).

Anti-Inflammatory Diets

An anti-inflammatory diet involves consuming foods which favor the production of anti-inflammatory chemicals in addition to reducing consumption of dietary components or foods that directly activate the inflammatory response of the innate immune system. The goal of the anti-inflammatory diet is to reduce silent inflammation. An anti-inflammatory diet is based on balance and moderation of dietary components like carbohydrates, protein, and fat at each meal. Supplementing the diet with sources rich in the

omega-3 fatty acid EPA and polyphenols inhibits the inflammatory response. Ingesting dietary nutrients like AA, saturated fats, and high glycemic carbohydrates that raise insulin levels will induce an inflammatory response (Sears & Ricordi, 2010).

The Mediterranean diet relies on whole grains, legumes, nuts, fruit, vegetables, and fiber with moderate consumption of fish and yogurt, low intakes of poultry and red meat, and moderate consumption of wine. Foods that are rich in monounsaturated and polyunsaturated fats have a lower ratio of omega-6 to omega-3 fatty acids (Ahluwalia et al., 2013; Esposito et al., 2004).

A healthy, plant-based diet maximizes consumption of nutrient dense plant foods like vegetables, fruits, beans, peas, lentils, soybeans, seeds, nuts, and whole grains while minimizing processed foods, oils, and animal foods. Sometimes the phrase plant-based is used interchangeably with the terms vegetarian or vegan. There are varying degrees of what foods are included in a plant-based diet and they are typically identified by what they include versus what they exclude. For example, a lacto-vegetarian's diet includes milk but excludes eggs, meat, seafood, and poultry (Tuso et al., 2013). Healthy dietary patterns share a common emphasis on plant-based foods because they are rich in fiber, antioxidants, and polyphenols (Ahluwalia et al., 2013). Polyphenols are phytochemicals that are abundant in foods and drinks derived from plants and appear to protect against disease due to their anti-inflammatory properties. Sources include grapes, wine, green tea, chocolate, spices like curcumin and turmeric, olives, apples, onions, and leafy green vegetables. Polyphenols work to inhibit the mediators of inflammation and enhance those mediators with antioxidative and anti-inflammatory effects (Shapiro, Singer, Halpern & Bruck, 2007).

Data from observational studies have shown that populations following plant-based diets have lower rates of heart disease, lower blood pressure, lower body weight, lower body mass index, lower C-reactive protein levels, lower blood concentrations of inflammatory markers, improved insulin sensitivity, and better glycemic control (Ferdowsian & Barnard, 2009). A report from the Dietary Guidelines Advisory Committee released in 2015 made several recommendations for bold action to create a culture of health and encourage all Americans to focus on a healthy overall dietary pattern. This report uses rigorous scientific standards and provides consistent, concise, and reliable information on healthful eating. Fruits and vegetables were included in every dietary pattern with beneficial health outcomes. Other healthy dietary patterns include whole grains, low-fat or nonfat dairy, seafood, legumes, and nuts; and limits sodium, saturated fat, refined grains, sugar-sweetened foods and beverages, and red and processed meats (Anderson & Campbell, 2015). While many chronic diseases cannot be cured, plant-based diets may be a practical solution for control and prevention (Tuso et al., 2013).

Omega-3 fatty acids and omega-6 fatty acids. Polyunsaturated fatty acids (PUFA) include omega-6 fatty acids and omega-3 fatty acids. These are essential fatty acids because they need to be supplied for the body through diet (Bosma-den Boer et al., 2012). Omega-3 fatty acids help reduce inflammation while some omega-6 fatty acids tend to promote inflammation. The imbalances now seen between the intake of omega-6 fatty acids and omega-3 fatty acids is very different from the ratio seen in the original diet of our ancestors (Candela, López, & Kohen, 2011).

The Western diet has significant caloric content in the form of fats, namely a diet high in saturated fats, rich in omega-6 fatty acids, and low intake of omega-3 fatty acids. The intake of omega-3 fatty acids has decreased while the intake of omega-6 fatty acids has increased (Candela et al., 2011). The American Heart Association expresses that it is beneficial to consume omega-6 fatty acids from vegetable oils, nuts, and seeds versus from saturated and trans-fats (Harris et al., 2009).

Many epidemiological studies and clinical trials have shown the relationship between beneficial effects in different diseases and the intake of omega-3 fatty acids. The omega-3 fatty acids which consist of linolenic acid from plant origin, and eicosapentaenoic acid (EPA) and docohexaenoic acid (DHA) from fish origin, are essential for growth and development and play a key role in the prevention and management of many disease and inflammatory conditions (Candela et al., 2011). Studies have shown that liquid vegetable oils, such as canola and soybean oil found in a plant based diet, contain high amounts of alpha-linolenic acid, an essential omega-3 fatty acid important in the prevention of cardiovascular disease (Hu, 2003).

Most interesting is how food production changes in the 1940s - 1950s have influenced the animals we consume. A change in the nutritional composition of the animal feed decreased the omega-3 fatty acid content. The confinement of the animals and the excessive energy content of the diet fed to the livestock has increased the saturated

fat content of the meat. Since animals are not grazing on green leaves and insects, a natural source of omega-3, this contributes to a decrease in the omega-3 fatty acid content of their meat. In addition to livestock, the fish we consume that are raised in fish farms contains less omega-3 fatty acids because the fish feed provided to them contains less omega-3 fatty acids (Candela et al., 2011).Therefore in consuming these animals, we are ingesting more saturated fat and less omega-3 fatty acids than our ancestors.

Norris and Dennis (2012) published a groundbreaking study that showed how omega-3 fatty acids from fish oil functioned inside a cell to produce anti-inflammatory effects. Scientists noticed that the small molecules released in response to inflammation have a dual purpose to first send out a signal to stop runaway inflammation; and second to trigger the active resolution phase of inflammation. These pro-resolution molecules called lipoxins, resolvins, and protectins work together to actively resolve acute inflammation. Chronic inflammation results when there are reduced levels of pro-resolution molecules to deactivate the inflammation reaction. This study and other studies showed that when restoring levels of pro-resolution molecules to normal levels, the inflammatory process can be rapidly resolved and the healing can begin. These pro-resolution molecules like resolvins and protectins are directly formed from the omega-3 fatty acids EPA and DHA. The researchers said that having enough omega-3 fatty acids provides the body with the tools necessary to fight and resolve acute inflammation. The researchers also noted that deficiencies in pro-resolution molecules have been identified in most of the chronic inflammation related diseases of aging like metabolic syndrome, cardiovascular disease, lung diseases like asthma and COPD, neurodegenerative diseases like Alzheimer's and Parkinson's, and cancer (Bronwell, 2012; Norris & Dennis, 2012). Foods that are good sources of omega-3 fats include ground flax seeds, flax oil, walnuts, and canola oil (Tuso et al., 2013).

The role of antioxidants. Oxygen is a life-driving molecule which is necessary for our survival, while at the same time, can be toxic by causing cellular deterioration. The immune system requires reactive oxygen species (ROS) to kill pathogens, however an excess of these free radicals has a negative role in inflammation. Free radicals are molecular fragments which are dangerous byproducts of the oxidative process and are believed to induce inflammation in many chronic diseases (Chiurchiù & Maccarrone, 2011; Neustadt, 2011). Oxidative stress results from an imbalance of free radicals, the pro-oxidant compounds, and antioxidants. Oxidative stress from increased amounts of ROS can cause extensive damage to cell structures, like the polyunsaturated fatty acids in the cell membrane, DNA, RNA, and proteins. Antioxidants work by competing with oxidizable substrates and eliminating free radicals (Porter, 2012; Whitney & Rolfes, 2011).

Regular consumption of fruits and vegetables minimizes the harmful effects of oxidative stress because they contain many antioxidant properties. The major antioxidants present in fruits and vegetables are vitamin C, vitamin E, carotenoids, and polyphenols, which all provide protection against free radicals (Porter, 2012). The vitamin C found in fruits and vegetables is a natural antioxidant which helps control inflammation in the body and is involved in rebuilding and regenerating damaged joint tissue. Preventing cartilage destruction can mean less pain and greater mobility and less chronic pain in the joints (McIlwain & Bruce, 2006). Vitamin C works with vitamin E to create an antioxidant network. Vitamin E is a highly effective antioxidant in the membrane bilayer which delays or inhibits cellular damage by scavenging free radicals (Chiurchiù & Maccarrone, 2011). An advantage of liquid vegetable oils found in a plant based diet is that they contain higher amounts of vitamin E versus animal fats which contain few antioxidants (Hu, 2003). Carotenoids are photosynthetic pigments synthesized by plants which are able to trap single, free floating oxygen (Chiurchiù & Maccarrone, 2011). Polyphenols are a large group of phytochemicals which are the most abundant antioxidant in the diet (Chiurchiù & Maccarrone, 2011). Phytochemicals found in colorful fruits and vegetables and whole grains are rich in anti-inflammatory compounds (McIlwain & Bruce, 2006). Flavanoids are the largest and most prominent group of polyphenols and are ideal scavengers by inhibiting oxidation (Porter, 2012). Good sources of flavanoids include apricots, cherries, grapes, broccoli, tomatoes, and tea (McIlwain & Bruce, 2006).

Study Design

A quasi-experimental design was chosen for this study to measure the degree of change in pain level that occurred in each participant as a result of the anti-inflammatory diet intervention. Use of a pre-test questionnaire allows for documentation and assessment of conditions before an intervention is introduced (Augustine, Slack, &

Warholak, 2015). Use of a post-test questionnaire allows for a comparison in evaluation of the results of the intervention (Mansour, Skull, & Parker, 2015). This study used a quasi-experimental design to compare the efficacy of the use of the anti-inflammatory diet on individuals with chronic pain.

In a related pre-test post-test study, women with chronic neck pain were given an intervention involving either a new complementary treatment or a commonly used treatment. Each participant's pain was assessed by using a verbal analogue pain scale of 0-10. Before the treatment in a pre-test assessment, each participant self-reported for pain. After the treatment, each participant was assessed using a post-test with the same verbal analogue pain scale of 0-10. The verbal pain scale measurements were used to calculate the change in pain. Statistical analysis was completed to determine the efficacy of the complementary treatment versus the commonly used treatment. The researchers concluded that the outcomes for participants receiving the new complementary treatment were better than expected (

Population and Sample

Participants included people with a history of chronic pain who were interested in ways to alleviate their pain through alternative methods. Potential subjects were those individuals who responded to the social media posting. To be included in the study, participants had to report: (a) having chronic pain; (b) consuming a typical Western diet, also known as the standard American diet, with meat or fish or eggs or dairy; (c) having access to a computer with the internet; and (d) being 21 years or over.

Data Collection Methods

Participants for this study responded by email to a social media posting. After they responded, the researcher conducted a phone interview to explain the purpose of the study and the procedures to consume foods from diet WD for one week and then foods from diet PF for four weeks. The researcher used a pre-screening phone survey questionnaire asking if the following statements applied to them to ensure that the individual had chronic pain, consumed a typical Western diet, also known as the standard American diet, with meat or fish or eggs or dairy, had access to a computer with the internet, and was 21 years or over. Respondents who answered no to the group of questions were excluded. Respondents who answered yes to the group of questions met the inclusion criteria for the study and were advised of the next steps. Participants were advised that if they experienced increased pain while participating in the study that they should discontinue the diet and consult their private physician. The researcher asked them to review and sign an informed consent form and return it to the researcher via email, mail, or fax. Participants were provided with an electronic questionnaire at baseline to complete.

Participants were asked to record food consumed daily and provided with a form. The participants were asked to forward the food record form to the researcher on a weekly basis by email, mail or fax. Instructions regarding how to fill out the food record for food and beverages consumed were provided. The researcher reviewed the food record forms to assess compliance of foods and drinks consumed compared to approved or suggested foods and drinks in each diet. Participants started out daily with a score of 100 points. One point was deducted for foods not approved on the list from diet WD. Compliance for diet PF was based on the foods and approved foods listed in the 28-day PF diet. One point was deducted for each food consumed that was not approved for intake on the 28-day diet. The researcher hoped for daily compliance of 75 points or greater, and expected compliance of 50 points or greater for achieving effectiveness of the study. Compliance of 49 points or less did not exclude participants from the study.

Following completion of diet WD, the participants followed diet PF for four weeks. Participants were supplied online with an electronic book titled Diet for a Pain Free Life which contained a structured 28-day meal plan to follow as well as a list of acceptable foods, snack choices, and recipes. Permission was received from the author to use the 28-day diet plan as listed in the book, as well as supplemental diet and recipe information provided by the McIlwain Medical Group. Again food records were recorded on a weekly basis by each participant at the participant's home and submitted to the researcher by email, mail, or fax. After 14 days, 21 days and at the conclusion of the 28-day consumption of diet PF, an electronic questionnaire was filled including the 0-10 Numeric Rating Scale.

Protection of Human Subjects

Prior to conducting the study, the researcher obtained approval from the Institutional Review Board (IRB). Participation in the study was voluntary. Only the researcher had contact with the participants. Participants were informed that their personal information would be kept confidential

and any data collected would be stored on a password protected computer. An informed consent form notified the subjects of the purpose of the research, the procedures and time duration, any potential discomforts, potential benefits, a confidentiality statement, participation and withdrawal information, and their rights as research subjects.

Tools

Multiple tools were used throughout this quasi-experimental study to gather information from the participants. A pre-screening survey questionnaire was used to determine inclusion and exclusion eligibility for the interested participants. The researcher developed this survey and included questions pertinent to the study. The researcher asked each selected participant to record their food and beverage intake each day. A food record form with seven day slots was provided. Instructions regarding how to fill out the food record for food and beverages consumed were provided. Both the food record log and instruction form were developed by the researcher. To assess compliance of foods and drinks consumed during both diet sessions, the research reviewed the food records submitted. Participants started out daily with a score of 100 points. One point was deducted for foods not approved on the list from diet WD. Compliance for diet PF was based on the foods and approved foods listed in the 28-day PF diet. One point was deducted for each food consumed that was not approved for intake on the 28-day diet. A total compliance score was calculated at the end of diet WD and at the end of diet PF. Electronic questionnaires administered through SurveyMonkey were used to gather information from participants regarding demographics and pain. The researcher developed three questionnaires which were administered at baseline after the one-week session of diet WD and after 14 days, 21 days and at the conclusion of the 28-day consumption of diet PF Each questionnaire included a 0-10 Numeric Rating Scale (McCaffery & Beebe, 1993) as a pain intensity instrument to determine the participant's perceived level of pain. The 0-10 Numeric Rating Scale is valid, reliable, and appropriate for use in clinical practice. Researchers seeking a sensitive pain scale would choose this scale. It has good sensitivity and generates data that can be analyzed for statistical use (Williamson & Hoggart, 2005). Use of this type of scale provided ratio level data which allowed for the greatest number of options for statistical analysis (Mowery, 2011).

Pilot Study

The three questionnaires developed by the researcher were pilot tested on three individuals with chronic pain who were not study participants. The intent of this pilot test was to ensure accuracy and ease of use of the questionnaires. The researcher asked them to review and sign an informed consent form and return it to the researcher via email or mail. The researcher asked the participants to provide feedback and evaluate the questionnaires. Neither the results from the pilot study nor the participants were used to answer the research questions.

Treatment of Data

Returned questionnaires were evaluated to ensure all questions were answered. Participants were allowed one inadvertently unanswered question per questionnaire with the exception of question number 5 on the baseline evaluation questionnaire. Each participant had to answer yes to having chronic pain. Participants answering no were excluded from the study and the surveys were destroyed.

Description of sample. Descriptive statistics were used to examine participant demographic characteristics and self reported data from the baseline evaluation questionnaire regarding age, gender, ethnicity, and education level using frequencies and percentages. Question number 5 asking to confirm or deny chronic pain was used as an exclusion criterion. Responses to question number 6 about the length of time having chronic pain, question number 7 asking about the level of pain today, and question number 9 about use of medication were also used to describe the sample using frequencies and percentages.

All three questionnaires asked participants to record height and weight. Data were used to calculate body mass index (BMI) which the researcher used to track changes through the study by evaluating data from the questionnaires at 14 days, 21 days and at the conclusion of 28-days.

Research question one. Does consumption of an anti-inflammatory diet alleviate chronic pain? The data gathered from the post WD and post PF questionnaires after 14 days, 21 days and at the conclusion of the 28-days were used to answer the first research question. Question number 1 on the post WD questionnaire regarding level of pain today was compared to question number 1 regarding level of pain today on the post PF questionnaire from 28-days. The number indicated on the 0-10 Numeric Rating Scale for pain was used to calculate a mean pain score. A paired *t*-test was used to compare pain levels post

WD diet to post PF diet. A statistical significance level of ($p<0.05$) was used.

Research question two. Does the anti-inflammatory diet alleviate chronic pain on specific daily activities like: walking, climbing stairs, carrying or handling objects, dressing, personal grooming, and sleep? The data gathered from the post WD and post PF questionnaires after 14 days, 21 days and at the conclusion of the 28-day were used to answer the second research question about pain on specific daily activities. Question number 2 regarding level of pain per activity on the post WD questionnaire was compared to question number 2 regarding level of pain per activity on the post PF questionnaire after 14 days, 21 days and 28-days. The numbers indicated on the 0-10 Numeric Rating Scale for pain were used to calculate mean pain scores. Non-parametric Friedman's test was used to analyze the pain level for each daily activity such as walking, climbing stairs, carrying or handling objects, dressing, personal grooming, and sleep. A statistical significance level of ($p<0.05$) was used.

Compliance evaluation. The seven day food records were reviewed and analyzed to determine compliance to both the WD and PF diets. The researcher evaluated the compliance in each diet, summarized the points and assessment and calculated percentages. Data were categorized into compliance categories of 75% of greater, 50-74%, 25-49%, and less than 25% and were reposted as frequencies and percentages in each category. The researcher hoped for compliance daily of 75% or greater and expected compliance of 50% or greater for achieving effectiveness of the study. Compliance of 49% or less did not exclude participants from the study. Assessing compliance of foods consumed allowed the researcher to better interpret results of the study.

Conclusion

This quasi-experimental study investigated a relationship between consuming an anti-inflammatory diet and alleviating chronic pain, and whether the anti-inflammatory diet alleviates chronic pain on specific daily activities like walking, climbing stairs, carrying or handling objects, dressing, personal grooming, and sleep. The participants who met the inclusion criteria were volunteers who were asked to complete two sessions of consuming foods. Each participant was asked to sign a letter of informed consent prior to beginning the experiment. Lists of acceptable foods were provided to consume for one week from diet WD and an eBook was provided to each participant with a diet plan to follow for four weeks for diet PF. The participants kept food records daily and completed three electronic questionnaires before, during and after the study. The researcher obtained approval from the Institutional Review Board (IRB) before the study was conducted.

The data from the food records and questionnaire including the pain scale were evaluated using a paired *t*-test, non-parametric Friedman's test, frequencies and percentages. The data collected from the electronic questionnaires were compared between diet WD and diet PF after 14 days, 21 days and at the conclusion of the 28-day to answer the research questions regarding level of chronic pain.

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