Mediterranean Diet Adherence in the Southeast United States: Validation of a Field-Based Survey Instrument and the Impact of Nutrition Knowledge

by

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Abstract

The Mediterranean diet (MD) has been shown to reduce chronic disease risk, and nutrition knowledge has been shown to correlate with diet choices. However, Mediterranean diet adherence in the southeast United States is lacking. The present studies aimed to: 1) develop and validate a survey instrument to assess nutrition knowledge of the MD and 2) determine to what extent nutrition knowledge is associated with MD adherence. A MD Nutrition Knowledge (MDNK) questionnaire was developed using previously validated instruments to parallel the short validated MD Adherence Screener (MEDAS). The survey tool was validated in a student population then distributed to an adult population in east Alabama. A significant positive linear relationship was observed between MDNK and MEDAS scores ($p=0.001$). Together the MDNK and MEDAS questionnaires are effective tools for assessing baseline knowledge and adherence and can be used for targeted clinical interventions to increase knowledge adherence for disease prevention and management.

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Table of Contents

List of Tables

List of Figures

Introduction

The Mediterranean diet is a cultural lifestyle that has the potential to prevent and manage chronic disease states as well as increase longevity. The history behind the discovery of the diet and its various health benefits are important for understanding all that the diet encompasses and why it is so widely promoted today.

History of the Mediterranean Diet

Ancel Keys was a physician scientist from Minnesota who pioneered research on the Mediterranean diet. It was while he was in Naples, Italy in 1952 that Keys observed that the very low incidence of coronary heart disease in Naples was associated with the traditional eating pattern of the Naples population. Later Keys would come to call this eating pattern the "Mediterranean diet", the diet traditional to those residing in the Mediterranean region, which promotes health and longevity (VanItallie, 2005). Inspired by what he saw in Naples, Keys began the Seven Countries study which was the first to link the eating patterns of Greece, Italy and other Mediterranean countries to their low rates of heart disease. (Keys, 1995).

The Seven Countries study made seminal discoveries about diet and disease. The study included sixteen populations from seven countries: Greece, Finland, Japan, Yugoslavia, Italy, the Netherlands and the United States. It revealed that mortality rates due to coronary heart disease were lower in the Mediterranean region than in Northern European countries, the United States and Japan (Keys, 1997). Key's was the first scientist to establish the link between cholesterol and heart disease as well as the first to recognize that diet contributes to atherosclerosis (Oransky,

2004; VanItallie, 2005). He found saturated fat to be a major dietary villain and significant contributor to coronary heart disease (Keys, 1995). This link between diet and disease has sparked the interest of many scientists and has led to many studies on the Mediterranean diet and its components.

Diet Overview

The Mediterranean diet is a lifestyle that incorporates healthy foods, exercise, biodiversity and culture. It is a way of living that is second nature for those in the Mediterranean region and is now being adapted by others around the world (Willet et al, 1995). The Mediterranean region, also known as the Mediterranean basin, refers to the regions of land surrounding the Mediterranean Sea. As shown in Figure 1, the basin covers parts of three different continents: Africa, Asia and Europe and includes Spain, France, Italy, Croatia, Greece, Turkey, Egypt, Libya, Algeria and Morocco. The unifying element of the Mediterranean basin is the climate that is characterized by mild, damp winters and hot, dry summers which influences lifestyle and eating patterns (Batisse, 1990).

Figure 1. The Mediterranean basin: Countries bordering the Mediterranean Sea.
Anderson J.B., Sparling M.C. (2015). The Mediterranean way of eating: evidence for chronic disease prevention and weight management (1st Edition). CRC Press.

Populations of the Mediterranean region who have traditionally adhered to a Mediterranean diet have the highest adult life expectancy in the world and the lowest rates of coronary heart disease, certain cancers and other diet-related diseases (Willet, 1995). Diet patterns with comparable components to the Mediterranean diet have exhibited similar benefits. In 1994, a Mediterranean diet similar comparable to the USDA's food guide pyramid was created to encourage an attractive and practical dietary pattern for Americans and Northern Europeans wishing to improve their health (Willet, 1995).

The Spanish Mediterranean diet Foundation has adapted a newer version of the Mediterranean diet pyramid to illustrate the foods that should be eaten at each meal, each day and each week. As shown in Figure 2, physical activity, rest, relationships, eating seasonal foods, cooking and eco-friendly products are the base of the pyramid. A Mediterranean lifestyle cherishes food and meal times and uses them to nourish the body and mind by coming together with others. Water and herbal infusions are also important basics of the diet, as adequate hydration is vital for maintaining equilibrium and supporting physical activity, and herbs and spices are used to garnish meals while adding micronutrients (Foundacion Dieta Mediterranea, 2016).

Olive oil is a vital staple of the Mediterranean diet and should be the main source of added fat. Olive oil is used not only for cooking but for drizzling on top of salads and dipping bread, and there is no limitation for how much should be consumed on a daily basis (Foundacion Dieta Mediterranea, 2016). Keys demonstrated in his research that the type of fat in foods is important as it can affect blood cholesterol and contribute to cardiovascular disease (Oransky,

2004). Olive oil, especially extra virgin olive oil, is rich in phenolic compounds that have many anti-inflammatory and antioxidant properties (Santangelo et al, 2016) as well vitamin E, beta carotene and monounsaturated fats which all work to prevent cardiovascular disease (Foundacion Dieta Mediterranea, 2016).

Traditionally, plant foods make up the core of the Mediterranean diet (Willet, 1995). In 1995, Keys wrote that what greatly distinguishes the Mediterranean diet from American and Northern European countries is that the "heart" of the diet is mainly vegetarian including far less meat and dairy than other diets (Keys, 1995). One to two servings of fruits, vegetables and grains are recommended at each meal. Fruits and vegetables are an important source of vitamins, minerals and antioxidants for health and disease prevention. At least one serving of raw fruits and vegetables per day is encouraged, as they have a higher fiber content than their cooked counterparts and do not lose any nutrients through the cooking process. Grains include bread, pasta, rice, couscous and other cereals and are preferred in whole grain varieties which have greater nutrient and fiber content. Additionally, grains are an excellent source of carbohydrates which are needed for energy to perform the physical activities of daily life (Foundacion Dieta Mediterranea, 2016).

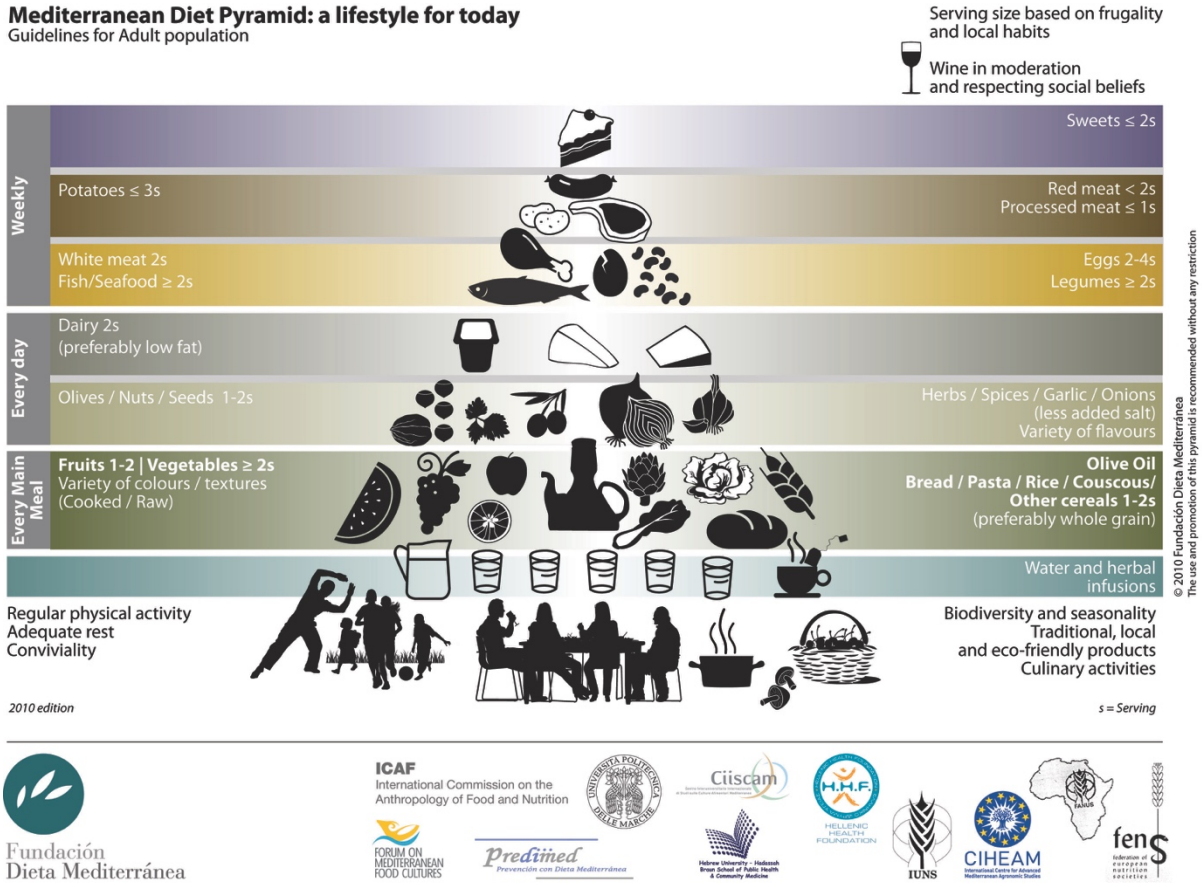

Figure 2. The Mediterranean diet pyramid, created by the Spanish Mediterranean diet Foundation. Foundacion Dieta Mediterranea (2016). Mediterranea Diet. Retrieved July 01, 2016, from http://dietamediterranea.com/en/

Nuts, seeds, olives, herbs, spices, garlic and onions should be consumed at least twice daily but are not necessary at every single meal. These foods and garnishes provide additional nutrients and antioxidants for overall health (Foundacion Dieta Mediterranea, 2016). Nuts are a good source of healthy fat along with olive oil and can help prevent cardiovascular disease and some cancers as well (Sabate, Ros & Salas-Salvadó, 2006). Dairy products are also recommended on a daily basis but should not be consumed in excess. Dairy provides protein, vitamins and minerals for bone health such as calcium and phosphorus. In addition, fermented dairy products like yogurt and cheese promote a healthy intestinal flora, allowing for optimal digestion and GI tract function (Foundacion Dieta Mediterranea, 2016).

Weekly recommendations suggest two servings of white meat, two or more servings of fresh seafood, two or less servings of red meat, one or less serving of processed meat, three or less potatoes, two to four eggs and two or more legumes. This encourages foods that are fresh and local and limits the intake of processed foods that have been stripped of their nutrient content and contain artificial ingredients. While meat is an important source of iron, large volumes of red meat and processed meats are not recommended as they contain high amounts of cholesterol, saturated fats and carcinogens like nitrates and nitrites. Seafood and lean white meats are the preferred sources of animal protein (Foundacion Dieta Mediterranea, 2016); fish is an excellent source of heart-healthy omega-3 fatty acids and should be consumed abundantly. Even small amounts of omega-3 fatty acids can be protective against cardiovascular disease (de Lorgeril & Salen, 2006). Eggs are a good source of protein as well and are regarded as an alternative to fish or lean meats (Foundacion Dieta Mediterranea, 2016).

Sweets should be consumed less than two times per week, preferably on a very limited basis. Keys noted that one of the greatest differences between the Mediterranean region and the United States and Northern Europe was that the Mediterranean regions frequently consumed fruits for dessert instead of cakes and other baked goods (Keys, 1995). In certain regions wine is also a staple of the Mediterranean diet and should be consumed in moderation and with respect to social and religious beliefs (Foundacion Dieta Mediterranea, 2016). All aspects of the Mediterranean diet pyramid are vital for optimal health as each part provides essential nutrients. While the diet comes naturally for those in the Mediterranean region, it can be plausible and practical in other parts of the world as well (Willet, 1995) and is currently a hot topic for disease prevention and overall health.

Health Benefits

Ansel Keys started what would become a world-wide interest in the Mediterranean diet and what its implementation could mean for the rest of the world. The Seven Countries study found all-cause coronary heart disease death rates to be lower in cohorts who consumed olive oil as the main dietary fat. A negatively related ratio was observed between the rate of monounsaturated to saturated fatty acid consumption (Keys et al, 1986). Besides the Seven Countries study, other observational studies have looked at the Mediterranean diet and its impact on disease and morality. Higher conformity to a Mediterranean diet has shown strong evidence for a decreased risk of death from all causes (hazard ratio 0.79; 95% CI: 0.76-0.83) including death from cancer (hazard ratio 0.78; 95% CI: 0.69-0.87) (Mitrou et al, 2007). In addition to decreased cancer mortality, Mediterranean diet adherence has shown a 12% reduction in cancer

incidence (hazard ratio 0.88; 95% CI: 0.80-0.95) (Benetou et al, 2008) and decreased lung cancer risk (Fortes et al, 2003). Adherence to a Mediterranean diet pattern has also shown an inverse relationship with obesity (odds ratio 0.49; 95% CI: 0.42-0.56) (Panagiotakos, Chrysohoou, Pitsavos & Stefanadis, 2006) and a decrease in BMI of 0.43 ($p = 0.030$) in men and 0.68 ($p = 0.007$) in women (Schroder, Marrugat, Villa, Covas & Elosua, 2004).

Observational studies have shown great promise for disease prevention and/or treatment with the Mediterranean diet. However, causal inference is difficult to demonstrate in observational studies. Therefore, recent completed experimental studies have investigated the extent of this relationship. The Spanish PREDIMED study was the first randomized controlled trial conducted to test the Mediterranean diet in the primary prevention of major chronic diseases. The study divided participants into three intervention groups: a Mediterranean diet supplemented with virgin olive oil, a Mediterranean diet supplemented with nuts and a low fat diet control group (Martinez-Gonzalez et al, 2012). The PREDIMED study found that a Mediterranean diet is a safe strategy to reduce major cardiovascular disease risk factors (Martinez-Gonzalez et al, 2012; Estruch et al, 2013). The Mediterranean diet favorably reduced LDL oxidation in the olive oil group by -10.6 (95% CI: -14.2 to -6.1) and in the nut group by -7.3 (95% CI: -11.2 to -3.3) (Fito et al, 2007). sVCAM-1 (soluble vascular cell adhesion molecule) and CRP (C-reactive protein), inflammatory markers related to atherosclerosis, decreased in the olive oil group ($p < 0.001$ and $p = 0.02$ respectively) (Mena et al, 2008). Mediterranean diet adherence was inversely associated with hypertension (odds ratio 0.82; 95% CI: 0.68-0.98), diabetes (odds ratio 0.85; 5% CI: 0.74-0.99) and obesity (odds ratio 0.84; 95%

CI: 0.73-0.97) (Sanchez-Tainta et al, 2008). Many studies have since been derived from the PREDIMED study and have found that Mediterranean diet adherence can lower diastolic blood pressure by -1.53 mmHg (95% CI: -2.01 to 1.04) in the olive oil group and -0.65 mmHg (95% CI: -1.15 to -0.15) in the nut group (Toledo et al, 2013), reduce total body weight in both the olive oil and nut groups ($p = 0.003$ and $p = 0.021$, respectively) (Lasa et al, 2014) and also reduce metabolic syndrome in both the olive oil and nut groups (odds ratio 1.3; 95% CI: 0.8-2.1 and odds ratio1.7; 95% CI: 1.1-2.6, respectively) (Salas-Salvado et al, 2008).

Measuring Diet Adherence

Various Mediterranean diet screeners have been used to assess adherence to the Mediterranean diet. In 1995, a 9-point Mediterranean diet adherence screener was created and validated for a Greek population (Trichopoulou et al, 1995). The screener included the food groups defined by the traditional Mediterranean diet: vegetables, legumes, fruits and nuts, dairy products, cereals, meats and meat products, ethanol, monounsaturated: saturated fat ratio, in order to assess the impact of diet on overall survival (Trichopoulou et al, 1995). The screener was later revised to include fish intake based on a finding that a high consumption of fish and omega-3 fatty acids was associated with a lower risk of coronary heart disease deaths (Hu et al, 2002) and used again to assess Mediterranean diet adherence and survival in a Greek population (Trichopoulou, Costacou, Bamia & Trichopoulos, 2003). Adherence results were broken down into thirds: low (score 0-3), medium (score 4-5) and high (score 6-9) diet adherence. It was found that higher adherence associated with a reduction in mortality; a two-point increment in

adherence score was associated with a 25% reduction in total mortality ($p < 0.001$) (Trichopoulou et al, 2003).

For the PREDIMED study, the 9-point Greek Mediterranean diet adherence screener was adapted to include five additional items. The new 14-point screener added questions about food intake habits and food consumption frequency, totaling twelve questions about food consumption and two questions about food intake habits which are considered characteristic of the Spanish Mediterranean diet. Each answer that aligned with the Mediterranean diet was given a score of "1" and each answer that did not align a "0", with a possible total score range of "0" to "14". The screener was then validated in a Spanish population (Schroder et al, 2011). The screener has since been used in populations outside of Spain. In a study conducted in Molise, a region between central and southern Italy, Mediterranean diet adherence and nutrition knowledge were assessed in relation to obesity. Adherence was divided into two groups: low (score 0-4) diet adherence and high (score >4) adherence. Results showed that the odds of having a higher adherence increased according to nutrition knowledge level (low, medium or high), with people in the highest nutrition knowledge group having 52% statistically significant higher probability to have high adherence than those in the low knowledge group. Odds ratio of being obese decreased according to increasing nutrition knowledge level as well (odds ratio 0.61; 95% CI: 0.40-0.95) (Bonaccio et al, 2013). Another study looking at a cohort of the PREDIMED trial to assess Mediterranean diet adherence and obesity divided the screener results into thirds: low (score ≤5) diet adherence, medium (6-9) diet adherence and high (≥10) diet adherence. The majority of both men and women fell into the medium diet adherence categories and

demonstrated an inverse association between Mediterranean diet adherence and obesity indexes (Martinez-Gonzalez et al, 2012).

A modified Mediterranean diet score was developed to assess Mediterranean diet adherence in a North American working population (Yang, Farioli, Korre & Kales, 2014). Similar components to the 14-point screener were analyzed with the addition of the frequency of fast food and fried food consumption. The screener consisted of 11 different food categories. For each question a score of "4" was given for an answer that aligned with the Mediterranean diet except for wine consumption which was given a "2" for adherence. A score of "0" was given for an answer that did not align, with a possible range of 0 (no conformity to the Mediterranean diet) to 42 (maximal conformity to the Mediterranean diet). Scores were divided into four quartiles: I (score ≤17.5), II (score 17.6-21.4), III (21.5-25.0) and IV (≥25.0). Mean adherence was a score of 21.3 which falls into quartile II, representing medium diet adherence. Results showed that higher adherence scores were inversely related to risk of weight gain over the past five years (odds ratio 0.57; 95% CI: 0.39-0.84) (Yang et al, 2014).

Nutrition Knowledge

There are many different nutrition education models and theories on how nutrition how nutrition education should be implemented in order to affectively increase nutrition knowledge. One theory behind nutrition knowledge has been that knowledge can influence behavior through attitudes. Therefore, greater nutrition knowledge could create a positive attitude towards healthy foods ultimately increasing their intake (Shepherd & Towler, 1992). The Social Cognitive Theory suggests that the next step in planning future actions or changing behaviors requires self-

regulatory capabilities to set goals and establish self-direction (Malone, 2002). According to this notion an individual must possess nutrition knowledge in order to set goals to make healthy food choices and perform the behavior of eating healthy foods (Bandura, 1986). Similarly, the Theory of Planned Behavior suggests that attitudes are determined by beliefs about the likelihood of outcomes and their importance which means that a positive attitude about healthy eating must be present for healthy food choices to be made. This suggests that increasing nutrition knowledge resulting in an understanding of why certain foods should be eaten could create a positive attitude towards healthy heating and ultimately increase healthy food choices (Kim, Reicks & Sjoberg, 2003). Nutrition knowledge has since been found to have a small significant negative correlation with attitude (Shepherd & Towler, 1992) which further suggests that nutrition knowledge is correlated with attitudes and beliefs.

Another common nutrition education theory is the Health Belief Model which was originally created to explain preventive health behavior. It defines health behavior as any activity believed to be healthy that is undertaken for the purpose of preventing or detecting disease (Rosenstock & Kirscht, 1974). The Health Belief Model has shown statistically significant improvement through nutrition education intervention in the areas of knowledge, attitude and nutrition behavior (Naghashpour, Shakerinejad, Lourizadeh, Hajinajaf & Jarvadni, 2014). Traditionally the model is applied in populations who are at a high risk for disease. When applied in a population that was not at a higher risk for disease, the Health Belief model was effective at changing behavior by increasing fruit and vegetable intake (Tavassoli et al, 2015). While the Health Belief Model focuses on prevention, the Life Course Model focuses on

intervention. It suggests that life span and life stage determine behavior which then determines health outcomes. In order for optimal health outcomes to occur, prevention must start early. The model proposes that health status is determined by environmental conditions which means that a person's environment is the most important factor in the subsequent possession of nutrition knowledge and healthy eating behaviors and should be the target of nutrition education (Haughton et al, 2012).

All of these theories suggest that in some way nutrition knowledge is related to attitudes about healthy behaviors and/or healthy behaviors themselves, highlighting the possible usefulness of measuring nutrition knowledge in varying populations. However, measuring nutrition knowledge can be challenging. Measurement tools of nutrition knowledge are frequently one-dimensional focusing on specific areas of knowledge, but nutrition knowledge is quite complex and can be hard to define. In addition, tools for assessing nutrition knowledge are often not validated or proved to be reliable (Hendrie, Coveney & Cox, 2008). In 1999, Parmenter and Wardle hoped to overcome these obstacles by creating and validating a general nutrition knowledge questionnaire that assessed a broad range of nutrition knowledge including dietary recommendations, nutrients, choosing daily foods and diet-disease relationships. Their general nutrition knowledge questionnaire is now commonly used to assess nutrition knowledge and has been adapted for various populations (Hendrie et al, 2008; Parmenter, Waller & Wardle., 1999). While other factors besides knowledge affect dietary choices such as demographics and socioeconomic status (Arruda et al, 2014; Beydoun & Wang, 2008; Wang & Chen, 2011),

measuring nutrition knowledge is still regarded as a useful tool to provide insight into the food choices of a given population (Arruda et al, 2014).

Chapter 1

Nutrition Knowledge and Mediterranean Diet Adherence: Validation of a Field-Based Survey Instrument

Abstract

Nutrition knowledge influences food choice and diet quality. Mediterranean diet adherence has been demonstrated to reduce chronic disease risk and is being promoted as a healthy diet worldwide. However, the relationship between nutrition knowledge and adherence to a Mediterranean diet in the United States and other countries outside of the Mediterranean region is lacking. The objectives of the present study were: 1) to develop and validate a survey instrument to assess nutrition knowledge of the Mediterranean diet and 2) to determine whether nutrition knowledge correlated with diet adherence. A Mediterranean diet Nutrition Knowledge (MDNK) questionnaire was developed using previously validated instruments. Fifteen questions were selected that paralleled the short validated Mediterranean diet Adherence Screener (MEDAS). The study population included 127 students enrolled in three university courses with varying exposure to formal nutrition education: Political Science (n = 29), Introductory Nutrition (n = 56), and Human Nutrient Metabolism (n = 42). Test-retest reliability was estimated in the Introductory Nutrition class. Cronbach's α for internal validity of MDNK was acceptable for a short questionnaire (0.653). Test-retest reliability was established (r = 0.853). Total MDNK and MEDAS scores significantly increased with nutrition education ($p < 0.001$). The distribution of MEDAS scores towards high Mediterranean diet adherence significantly increased with formal nutrition education ($p = 0.002$). There was a weak but significant association between MDNK and MEDAS scores ($r = 0.06$, $p = 0.004$). The MDNK survey is a valid and reliable instrument for assessing baseline knowledge. It was further demonstrated that nutrition knowledge

positively correlates with diet adherence. Together the MDNK/MEDAS questionnaire can be an effective tool for assessing baseline knowledge and Mediterranean diet adherence for targeted interventions.

Key Words: Mediterranean diet, Nutrition, Knowledge, Diet Adherence

1. Introduction

The traditional Mediterranean diet originated in the regions surrounding the Mediterranean Sea. Consumption primarily of fruits, vegetables, olive oil, whole grains, nuts and legumes with wine in moderation, some fish and very little meat, processed foods and sweets represents an eating pattern consistent with adherence to a Mediterranean diet pattern (Ferro-Luzi & Branca, 1995; Martinez-Gonzalez et al, 2012; Simopoulos, 2001). The foods that are a rich part of the Mediterranean diet are high in vitamins, minerals, antioxidants, omega 3-fatty acids, monounsaturated fatty acids and fiber (Henriquez Sanchez et al, 2012) all of which possess a wide range of health benefits. Accordingly, greater adherence to a Mediterranean diet pattern shows a significant inverse association with metabolic syndrome, LDL-cholesterol and higher HDL-cholesterol (Yang, Farioli, Korre & Kales, 2014). Greater adherence is also positively associated with a reduction in overall mortality, cardiovascular disease risk, and neoplastic disease (Sofi, Macchi, Abbate, Gensini & Casini, 2014). In addition, self-reported mental and physical quality of life has been directly associated with adherence to a Mediterranean style diet (Henriquez Sanchez et al, 2012).

According to the Social Cognitive Theory (Bandura, 1986) as it relates to healthy food choices, an individual must possess nutrition knowledge in order to perform the behavior of choosing to consume a healthy diet. Significant positive but weak associations between nutrition knowledge and diet quality, likely mediated by socioeconomic status and gender, have been reported (Beydoun & Wang, 2008; Bonaccio et al, 2013; Parmenter et al, 2000; Spronk, Kullen, Burdon & O'Connor, 2014; Worsley, Wang, Byrne & Yeatman, 2014). Although other

behavioral models support that other factors are involved in food choice (Ajzen, 1991; Brunso & Grunert, 1995), small or medium correlations ($r < 0.5$) between nutrition knowledge and diet quality may have a significant impact of public health when considered from a population perspective (Wardle, Parmenter & Waller, 2000).

If adherence to a Mediterranean style diet can reduce the risk of chronic disease and nutrition knowledge plays a role in diet quality, it is important to assess the relationship between nutrition knowledge and adherence to a Mediterranean style diet in both countries bordering the Mediterranean Sea and other areas of the world in which the Mediterranean style diet is being promoted as a healthy diet. Recently in Italy, nutrition knowledge was shown to be significantly associated with adherence to a Mediterranean diet pattern in adults (Bonaccio et al, 2013). However, the relationship between nutrition knowledge and adherence to a Mediterranean style diet in other areas of the world in which the Mediterranean style diet is being promoted as a healthy diet is lacking. In addition, a short questionnaire based on procedural and general nutrition knowledge that parallels the components of the Mediterranean diet does not exist. Therefore, the purpose of this study was to compile and validate a survey instrument for adults that include: 1) procedural and general nutrition knowledge questions that parallel the Mediterranean diet; 2) a Mediterranean diet screener; and 3) demographic questions.

2. Methods

2.1 Survey Instrument Development

Development of a Mediterranean Diet Nutrition Knowledge (MDNK) questionnaire began with a pool of questions from three previously validated questionnaires (Dickson-Spillman &

Siegrist, 2011; Dickson-Spillman, Siegrist & Keller, 2011; Yoo, Saliba MacDonald, Prenzler & Ryan, 2013) (Table 1). The questions were chosen based on their correlation with parameters of the Mediterranean diet, as outlined in a previously validated screener used to score adherence to the Mediterranean diet (Schroder et al, 2011). The initial pool contained twenty-two questions. A qualitative assessment of the pool of questions was conducted by administering the questionnaire to undergraduate nutrition majors enrolled in a Mediterranean diet seminar course (n = 12). Upon completing the questionnaire, each question was analyzed and discussed with the students. Questions that were repetitive or poorly understood were eliminated in an effort to develop a concise set of questions which paralleled the 14 questions in the Mediterranean diet questionnaire (Schroder et al, 2011). The final survey instrument consisted of a 14-Point Mediterranean Diet Adherence Screener (MEDAS), the 15-question MDNK questionnaire and five demographic questions (Appendix 1) derived from a general nutrition knowledge questionnaire (Parmenter & Wardle, 1999).

2.2 Validity and Reliability

To test the validity of the final survey instrument, the MDNK questionnaire was distributed to students in courses with three different levels of formal nutrition education exposure: none, a Political Science course (n = 30); intermediate, an Introductory Nutrition course (n = 56); and high, a Human Nutrient Metabolism course (upper division nutrition major course) (n = 43). Greater formal nutrition education exposure was hypothesized to be associated with greater MDNK scores. Thus, students enrolled in the Political Science course would be expected to score the lowest, with students in the Introductory Nutrition course scoring higher and Human

Nutrient Metabolism students scoring the highest. Incomplete surveys resulted in the exclusion of students from the Political Science (n = 1) and Human Nutrient Metabolism (n = 1) courses.

In order to assess the reliability of the MDNK questionnaire, the survey instrument was distributed to the Introductory Nutrition course twice: the second time two weeks after the initial distribution. This two-week period was chosen under the premise that it is long enough for the students to forget the exact questions on the survey but short enough to limit gains in new nutrition knowledge in the course during that time (Jones et al, 2015).

Table 1: Preliminary Mediterranean Diet Nutrition Knowledge (MDNK) questionnaire

Question	Scope†	Inclusion	MEDAS††
1. A salad dressing made with mayonnaise is as healthy as the same dressing made with olive oil.[17]	General	Yes	1
2. A scoop of chocolate ice cream is just as healthy as a scoop of lemon sorbet.[17]	General	No	11
3. Fat is always bad for your health; you should therefore avoid it as much as possible.[16]	Procedural	Yes	12
4. To eat healthily, you should eat less fat. Whether you also eat more fruit and vegetables does not matter.[16]	Procedural	Yes	2
5. The health benefit of fruits and vegetables lies alone in the supply of vitamins and minerals.[17]	General	Yes	3
6. If you have eaten high-fat foods, you can reverse the effects by eating apples.[16]	Procedural	Yes	4
7. Fruit can be fully replaced by vitamin and mineral supplements.[16]	Procedural	No	3
8. A healthy meal should consist of half meat, a quarter vegetables and a quarter side dishes.[16]	Procedural	Yes	5
9. Meat should be the basis of our daily diet.[16]	Procedural	No	5
10. Skim milk contains fewer vitamins and minerals than whole milk.[17]	General	Yes	6
11. For healthy nutrition, dairy products should be consumed in the same amounts as fruit and vegetables.[16]	Procedural	Yes	6
12. Brown sugar is much healthier than white sugar.[17]	General	No	7
13. Wine has better health properties than other alcoholic beverages.[18]	Food Quality and Preference	No	8
14. Wine can reduce the risk of certain diseases.[18]	Food Quality and Preference	Yes	8
15. Red wine has more health enhancing properties.[18]	Food Quality and Preference	No	8
16. Lentils contain only few useful nutrients, therefore their health benefit is not great.[17]	General	Yes	9
17. Oily fish (salmon, mackerel) contain healthier fats than red meat.[17]	General	Yes	10
18. The same amount of sugar and fat contains equally many calories.[17]	General	Yes	7
19. To eat healthily, you should eat less. It does not matter what foods you reduce.[16]	Procedural	Yes	11
20. A balanced diet implies eating all foods in the same amounts.[16]	Procedural	No	11
21. The same amount of beef steak and chicken breast contains an equal amount of calories.[17]	General	Yes	13
22. Pasta with tomato sauce is healthier than pasta with mushroom and cream sauce.	Procedural	Yes	14

† Scope of the nutrition knowledge
†† Corresponding question in the 14-point Mediterranean diet questionnaire (Schroder, et al., 2011) and Supplemental Table 1.

2.4 Statistical Analysis

The descriptive statistics used were absolute frequencies and percentages for categorical variables and mean and standard deviation (SD) for quantitative variables. All data analyses were conducted with SAS version 9.4 (SAS, Cary, NC). The GLM Procedure was used to perform analysis of variance (ANOVA) tests to assess MDNK and MEDAS scores and the demographic variables. A one-sided association test using the gamma statistic was used to assess individual MDNK and MEDAS questions. Pearson chi-squared test was used to examine the distribution of low, medium, and high MEDAS scores. The REG and CORR procedures were used to perform: 1) linear regression to assess the relationship between MDNK and MEDAS scores, and 2) Pearson correlation between MDNK and MEDAS scores and demographic variables, respectively. A significance level of 0.05 was set.

3. Results

The participant characteristics are found in Table 2. The Political Science course was predominantly male (62.1%) while the Introductory Nutrition and Human Nutrient Metabolism courses were predominantly female (75% and 88.1%, respectively). Participants in all three courses were predominantly in the 18–24 age group (89.5%) and of white ethnicity (86.8%).

Internal validity of the MDNK questionnaire was found to be adequate (Cronbach's α = 0.653) which is consistent with what has been reported for short surveys with narrow scale width (Spiliotopoulou, 2009). Test-retest reliability revealed a strong positive linear relationship between the two attempts (r value = 0.853). Taken together, these two characteristics indicated

that the MDNK questionnaire can be regarded as a valid, reliable tool for assessing knowledge of the Mediterranean diet.

As shown in Figure 3a, mean MDNK score was significantly different ($p < 0.001$) across the three courses: the highest MDNK score (10.98 ± 3.16) was observed in the Human Nutrient Metabolism course, followed by Introductory Nutrition (9.41 ± 3.70) and Political Science (6.96 ± 4.09). We next examined whether individual MDNK questions were different between the three courses. As shown in Table 3, significant differences between courses with a significant positive trend with increasing exposure to formal nutrition education were observed in knowledge of fruits and vegetables (MDNKQ2) and protein (MDNKQ5 and MDNKQ10). Significant positive trends with exposure to formal nutrition education in the knowledge of lipids (MDNKQ1), sweets (MDNKQ8), and protein (MDNKQ14) were also observed. In contrast, the knowledge of fruits and vegetables (MDNKQ3) and dairy (MDNKQ6) were significantly different between courses but did not exhibit a positive trend with exposure to formal nutrition education. These MDNK results suggest that nutrition education influences knowledge across a range of food categories.

Table 2: Participant demographic characteristics according to formal nutrition education exposure

	Formal Nutrition Education Exposure					
	None		Intermediate		High	
	Political Science (n= 29)		Introductory Nutrition (n= 56)		Human Nutrient Metabolism (n= 42)	
Demographic Characteristics	n	%	n	%	n	%
Gender						
Male	18	62.1	14	25.0	5	11.9
Female	11	37.9	42	75.0	37	88.1
Age						
less than 18	0	0.0	1	1.8	1	2.4
18-24	23	79.3	54	96.4	39	92.9
25-34	5	17.2	1	1.8	2	4.8
35-44	1	3.4	0	0.0	0	0.0
<45	0	0.00	0	0.0	0	0.0
Ethnicity						
White	22	75.9	50	89.3	40	95.2
Black Caribbean	0	0.0	1	1.8	0	0.0
Black African	4	13.8	3	5.4	0	0.0
Black other	1	3.4	0	0.0	0	0.0
Indian	0	0.0	0	0.0	0	0.0
Pakistani	1	3.4	0	0.0	0	0.0
Asian-other	0	0.0	2	3.6	0	0.0
Other ethnic group	0	0.0	0	0.0	1	2.4
Education						
High School Diploma	17	58.6	46	82.1	33	78.6
GED	0	0.0	1	1.8	0	0.0
Technical or trade certificate	0	0.0	0	0.0	2	4.8
Associate degree	4	13.8	7	12.5	3	7.1
Bachelor's degree	8	27.6	2	3.6	3	7.1
Master's or professional degree	0	0.0	0	0.0	0	0.0
Qualification						
Health or nutrition related qualifications	0	0.0	1	1.8	11	26.2
No health or nutrition related qualifications	29	100.0	55	98.2	30	71.4

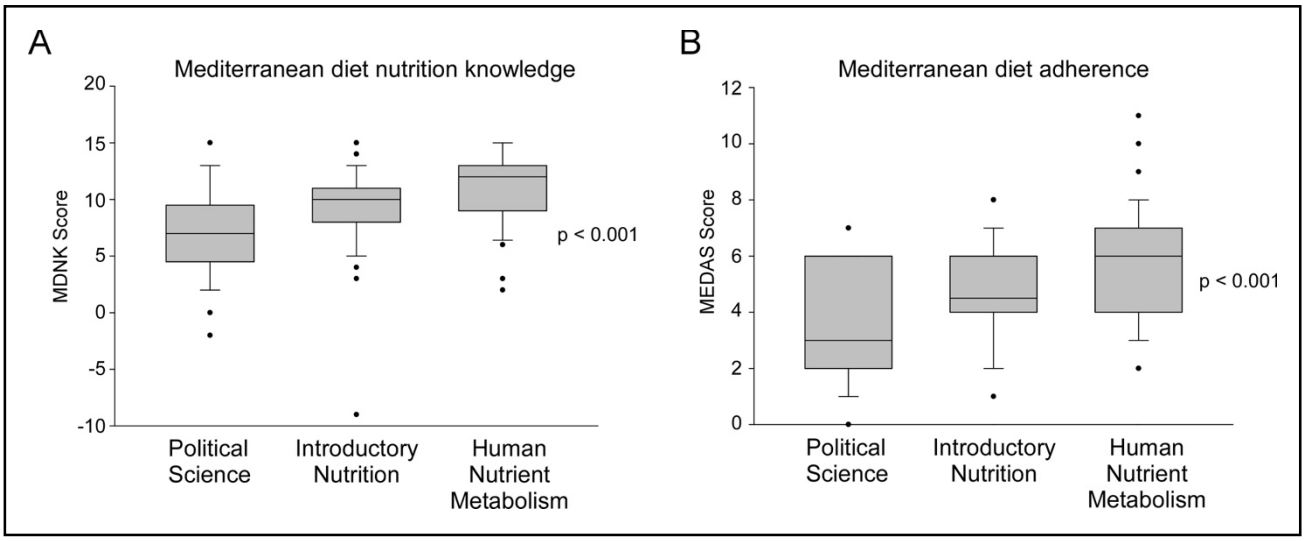

Figure 3. Total MDNK and MEDAS scores. Total MDNK (A) and MEDAS (B) scores for each course are shown as box plots. The top and bottom of the boxes define the 25th and 75th percentiles. The middle line is the median class score. The error bars define the 10th and 90th percentiles. The dots are outliers (scores that fell outside of the 10th and 90th percentiles). ANOVA was used to test for significant differences between the three courses.

Table 3: Mediterranean Diet Nutrition Knowledge (MDNK) scores according to formal nutrition education exposure

		Formal Nutrition Education Exposure								
		None		Intermediate		High				
		Political Science		Introductory Nutrition		Human Nutrient Metabolism				
Question	Category	Mean	SD	Mean	SD	Mean	SD	F value[†]	P value	Trend* P value
MDNKQ1[‡]	Lipids	0.76	0.51	0.86	0.44	0.90	0.43	0.89	0.412	0.029
MDNKQ2	Fruits and Vegetables	0.59	0.73	0.68	0.72	0.95	0.31	3.66	**0.029** [$]	**<0.001**
MDNKQ3	Fruits and Vegetables	0.41	0.82	-0.04	0.95	0.60	0.73	6.99	**0.001**	0.062
MDNKQ4	Lipids	0.76	0.51	0.79	0.6	0.76	0.53	0.04	0.964	0.476
MDNKQ5	Protein	-0.55	0.74	0.38	0.93	0.50	0.83	14.94	**<0.001**	**<0.001**
MDNKQ6	Dairy	0.07	0.80	0.55	0.78	0.26	0.94	3.48	**0.034**	0.180
MDNKQ7	Dairy	0.41	0.78	0.43	0.83	0.43	0.86	0.00	0.996	0.375
MDNKQ8	Sweets	0.59	0.57	0.59	0.65	0.79	0.56	1.49	0.230	**0.015**
MDNKQ9	Wine	0.59	0.68	0.84	0.5	0.83	0.49	2.39	0.096	**0.044**
MDNKQ10	Protein	0.28	0.70	0.46	0.66	0.79	0.47	6.44	**0.002**	**<0.001**
MDNKQ11	Lipids	0.59	0.63	0.82	0.54	0.93	0.34	3.96	**0.022**	**0.001**
MDNKQ12	Sweets	0.83	0.54	0.82	0.54	0.95	0.31	1.03	0.362	0.063
MDNKQ13	Lipids	0.86	0.20	0.89	0.41	0.95	0.31	0.47	0.628	0.157
MDNKQ14	Protein	0.52	0.69	0.73	0.59	0.81	0.55	2.11	0.126	**0.010**
MDNKQ15	Fruits and Vegetables	0.28	0.75	0.61	0.65	0.52	0.71	2.21	0.114	0.102

[‡] MDNK question (MDNKQ)

[†] ANOVA test statistic

* Trend was assessed with a one-sided association test using gamma statistics

[$] p values < 0.05 are indicated in bold font

To examine Mediterranean diet adherence in the three courses, MEDAS scores were divided into thirds: low (scores 1-4), medium (scores 5-7) and high (scores 8-14). The proportion of students with low, medium, and high adherence was significantly different with exposure to formal nutrition education ($p = 0.002$) (Table 4). Low adherence ranged from 67.9% in Political Science to 25.6% in human nutrient metabolism; conversely, high adherence was greatest in Human Nutrient Metabolism (16.2%) and lowest in Political Science (0%).

Total MEDAS score was found to be significantly different ($p < 0.001$) across the three courses: the highest mean MEDAS score (5.69 ± 2.00) was observed in human nutrient metabolism, followed by Introductory Nutrition (4.64 ± 1.67) and lastly Political Science (3.55 ± 2.13) (Fig. 3b). We next examined whether individual MEDAS questions were different between the three courses. As shown in Table 5, significant differences ($p < 0.05$) among the courses together with a significant positive trend ($p < 0.01$) with exposure to formal nutrition education was observed in the consumption of lipids/extra virgin olive oil (MEDASQ1), protein/meat (MEDASQ5), dairy (MEDASQ6), sweets (MEDASQ11), and protein (MEDASQ13).

We then examined whether MDNK and MEDAS scores were different in the demographic categories used in the study population. As shown in Table 6, mean MDNK and MEDAS scores for females (9.98 ± 3.66 and 5.00 ± 1.86, respectively) were significantly greater ($p < 0.01$) than those for males (7.89 ± 4.07 and 4.11 ± 2.33, respectively). Significant differences ($p < 0.05$) in mean MDNK scores were also observed in the ethnicity and education categories while mean MEDAS score was significantly different ($p < 0.05$) for health or nutrition-related qualifications.

A significant linear relationship ($r^2 = 0.06$, $p = 0.004$) between MDNK and MEDAS scores with a positive slope was observed when all participants were analyzed together but not separately (Fig. 4). This demonstrates that MDNK is indeed associated with adherence to the Mediterranean diet, although this relationship is weak. To examine the role of the demographic characteristics of the study population on the relationship between MDNK and MEDAS scores, a Pearson correlation analysis was performed. As shown in Table 7, a significant positive correlation was observed in the relationship between MDNK and MEDAS scores among females ($r = 0.26$, $p = 0.013$) but not among males ($r = 0.12$, $p = 0.475$). We also observed significant positive correlations between participants in the 18-24 age group ($r = 0.27$, $p = 0.003$), of white ethnicity ($r = 0.25$, $p = 0.008$), with a high school diploma ($r = 0.31$, $p = 0.002$), and possessing no health or nutrition related qualifications ($r = 0.29$, $p = 0.017$). Taken together, these results suggest that demographics exert an influence over the relationship between MDNK and MEDAS scores.

Table 4: Mediterranean diet adherence with formal nutrition education exposure

	Formal Nutrition Education Exposure			
	None	Intermediate	High	
MEDAS Score Category	Political Science	Introductory Nutrition	Human Nutrient Metabolism	Total
Low (1-4)*	67.9%	50%	25.6%	48.5%
Medium (5-7)	35.7%	44.6%	58.1%	45.6%
High (8-14)	0%	5.4%	16.2%	7.1%

* Significance across score categories by Pearson's chi-squared test ($x^2 = 15.05$, $p = 0.002$)

Table 5: Mediterranean diet adherence in the individual MEDAS questions according to formal nutrition education exposure

		Formal Nutrition Education Exposure								
		None		Intermediate		High				
		Political Science		Introductory Nutrition		Human Nutrient Metabolism				
Question	Category	Mean	SD	Mean	SD	Mean	SD	F value[†]	P value	Trend* P value
MEDASQ1[‡]	Lipids	0.34	0.48	0.68	0.47	0.76	0.43	7.57	**0.001**[$]	**<0.001**
MEDASQ2	Lipids	0.07	0.26	0.00	0.00	0.07	0.26	2.07	0.130	0.382
MEDASQ3	Fruits and Vegetables	0.24	0.44	0.16	0.37	0.29	0.46	1.13	0.326	0.269
MEDASQ4	Fruits and Vegetables	0.10	0.31	0.14	0.35	0.21	0.41	0.87	0.423	0.097
MEDASQ5	Protein	0.17	0.38	0.45	0.50	0.64	0.49	8.52	**<0.001**	**<0.001**
MEDASQ6	Dairy	0.38	0.49	0.55	0.50	0.71	0.46	4.12	**0.019**	**0.002**
MEDASQ7	Sweets	0.59	0.50	0.79	0.41	0.76	0.43	2.10	0.127	0.069
MEDASQ8	Wine	0.00	0.00	0.02	0.13	0.00	0.00	0.63	0.534	0.555
MEDASQ9	Protein	0.07	0.26	0.09	0.29	0.07	0.26	0.08	0.927	0.504
MEDASQ10	Protein	0.14	0.35	0.07	0.26	0.05	0.22	0.99	0.373	0.911
MEDASQ11	Sweets	0.45	0.51	0.63	0.49	0.76	0.43	3.75	**0.026**	**0.004**
MEDASQ12	Protein	0.14	0.35	0.16	0.37	0.21	0.41	0.40	0.673	0.192
MEDASQ13	Protein	0.59	0.50	0.63	0.49	0.86	0.35	4.22	**0.017**	**0.005**
MEDASQ14	Fruits and Vegetables	0.28	0.45	0.29	0.46	0.29	0.46	0.01	0.994	0.467

[‡] MEDAS question (MEDASQ)
[†] ANOVA test statistic
* Trend was assessed with a one-sided association test using gamma statistics
[$] p values < 0.05 are indicated in bold font

Table 6: Demographic variable analysis for MDNK and MEDAS scores for all participants

	MDNK Score		MEDAS Score		MDNK Score	MEDAS Score
Demographic Categories[†]	Mean	SD	Mean	SD	P value	P value
Gender					**0.006**[$]	**0.002**
Male	7.89	4.07	4.11	2.33		
Female	9.98	3.66	5.00	1.86		
Age					0.825	0.300
less than 18	10.50	0.70	4.00	2.83		
18-24	9.35	3.93	4.72	2.04		
25-34	9.38	4.27	5.50	2.00		
Ethnicity					**0.034**	0.096
White	9.63	3.85	4.84	2.03		
Black African	5.00	2.71	4.14	2.19		
Asian-other	6.00	4.24	3.00	1.41		
Education					**0.030**	0.576
High School Diploma	9.72	3.50	4.61	2.04		
Technical or Trade Certificate	12.00	2.83	4.50	2.12		
Associate Degree	9.21	3.19	5.00	2.11		
Bachelor's Degree	6.62	6.17	5.08	1.89		
Nutrition Qualification					0.778	**0.002**
Health or nutrition related qualifications	10.17	3.95	6.25	1.82		
No health or nutrition related qualifications	9.25	3.89	4.57	2.01		

[†]n=127
[$]p values < 0.05 are indicated in bold font

Observations	n	R-squared	F value	p value
All Classes	127	0.062	8.28	0.004
Political Science	29	0.088	2.61	0.118
Introductory Nutrition	56	0.003	0.14	0.710
Human Nutrient Metabolism	42	0.002	0.10	0.759

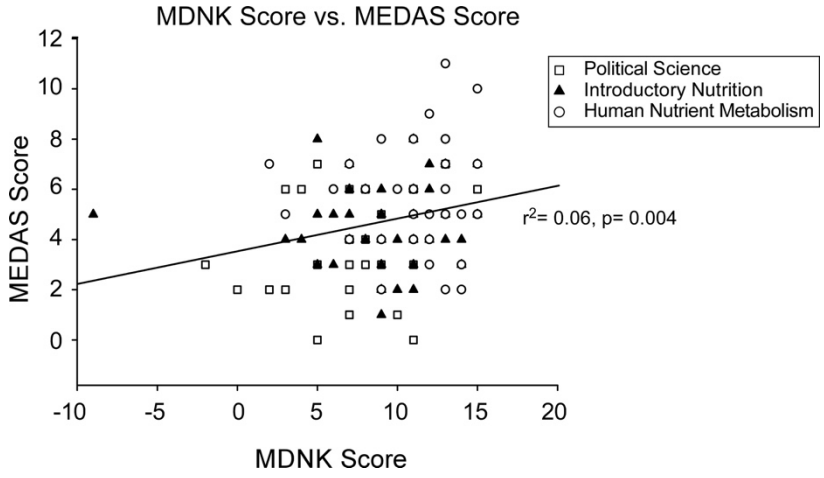

Figure 4. Association between MDNK and MEDAS scores. Linear regression was used to assess the relationship between MDNK and MEDAS scores for participants in each course and all participants. R-squared, F values, and p values are shown. The line represents the linear relationship between MDNK and MEDAS scores for all participants.

Table 7: Demographic correlation between MDNK and MEDAS scores

Demographic Characteristics[†]	R value[††]	P value*
Gender		
Male	0.12	0.475
Female	0.26	**0.013**
Age		
18-24	0.27	**0.003**
25-34	-0.08	0.860
Ethnicity		
White	0.25	**0.008**
Black African	0.28	0.542
Education		
High School Diploma	0.31	**0.002**
Associate degree	-0.02	0.938
Bachelor's degree	0.40	0.181
Qualification		
Health or nutrition related qualifications	0.22	0.488
No health or nutrition related qualifications	0.29	**0.017**

[†] n = 127
[††] Pearson correlation coefficient
[*] p values < 0.05 are indicated in bold font

4. Discussion

We validated a nutrition knowledge questionnaire constructed to evaluate knowledge of nutrition paralleling a short Mediterranean diet adherence screener. Knowledge scores correlated with exposure to formal nutrition education as evidenced by significantly higher mean scores and positive trend across increasing levels of exposure in political science, Introductory Nutrition and Human Nutrient Metabolism courses. Beyond validity and reliability of the knowledge component of the survey, adherence to the Mediterranean diet was assessed in each of the three courses using the previously validated MEDAS (Schroder et al, 2011). Based on MEDAS scores stratified into thirds, adherence in students enrolled in the Human Nutrient Metabolism course was found to be medium. This result compares well to the Mediterranean Dietary Quality Index (MDQI) scores of normal weight students attending universities in Italy and Spain (Baldini, Pasqui, Bordoni & Maranesi, 2009) and to students enrolled in a medical school in Sicily, Italy (Fiore et al, 2015). In contrast, Mediterranean diet adherence was low in the Political Science and Introductory Nutrition courses which is comparable to overweight Spanish university students (Baldini et al, 2009). The present study found that both overall MDNK and MEDAS questionnaire scores increased with exposure to formal nutrition education. There was a significant positive linear relationship between Mediterranean diet nutrition knowledge and adherence which is in agreement with results of a general population survey from the Mediterranean region (Bonaccio et al, 2013). Additionally, in a recent systematic review exploring the relationship between nutrition knowledge and food consumption patterns,

significant positive but weak ($r < 0.5$) associations between higher nutrition knowledge and dietary intake were found in a majority of the studies (Spronk et al, 2014).

Gaps in nutrition knowledge or the possession of greater nutrition knowledge has previously been reported to influence the consumption of selective dietary components (Beydoun & Wang, 2008; Dickson-Spillmann & Siegrist, 2011; Spronk et al, 2014). Responses to the MDNK survey, specifically to questions pertaining to fruits and vegetables, protein, and lipids, were significantly different across the three courses with a positive trend for exposure to formal nutrition education. Similarly, in the MEDAS survey, adherence as evidenced by reported consumption of lipids, protein, dairy, and sweets was found to be significantly different among the three courses with a positive trend for exposure to formal nutrition education. The only MEDAS question and corresponding MDNK question to be both significantly different among the three courses and with a positive trend for exposure to formal nutrition education was MEDASQ5 (How many servings of red meat, hamburger, or meat products (ham, sausage, etc.) do you consume per day?). This result suggests a strong relationship between nutrition knowledge and Mediterranean diet adherence specifically regarding consumption of red meat which is consistent with a previously reported negative correlation between red meat consumption and general nutrition knowledge in Swiss consumers (Dickson-Spillmann & Siegrist, 2011). Responses to MEDASQ1 (Do you use olive oil as main culinary fat?) and MEDASQ13 (Do you preferentially consume chicken, turkey, or rabbit meat instead of veal, pork, hamburger, or sausage?) were significantly different between the three courses with a positive p trend for exposure to formal nutrition education; the corresponding MDNK question

also exhibited a positive trend for exposure to formal nutrition education. These results suggest a linkage between Mediterranean diet adherence and nutrition knowledge concerning olive oil and meat consumption that is consistent with that found in middle-aged men from Northern France (Dallongeville, Marecaux, Cottel, Bingham & Amouyel, 2001) and a general population from a Mediterranean region (Bonaccio et al, 2013).

Relationships between the demographic characteristics of our population and knowledge and adherence were explored. General nutrition knowledge assessed across populations from both within and away from the Mediterranean region indicates that females have greater nutrition knowledge (Grunert et al, 2012; Hendrie, Cox & Coveney, 2008; Parmenter et al, 2000; Worsley, Wang, Byrne & Yeatman, 2014). In agreement with these findings, females scored significantly higher on the MDNK questionnaire in the present study. Importantly, our results indicate that females outside of the Mediterranean region can have greater nutrition knowledge related to the Mediterranean diet. Additionally, nutrition knowledge was significantly and positively associated with adherence to the Mediterranean diet in our female population. Independent of course enrollment and therefore formal exposure to nutrition education in a university setting, females scored significantly higher than males with regard to adherence in the present study. These findings are in agreement with a report from the Mediterranean region that female medical students were significantly more likely to exhibit good adherence to the Mediterranean diet than male medical students (Fiore et al, 2015) and that women were more likely to exhibit a high Mediterranean-style dietary pattern score in the Framingham Heart Study Offspring Cohort (Rumawas, Meigs, Dwyer, McKeown & Jacques, 2009).

In addition to gender, other demographic characteristics exerted influence over MDNK and MEDAS scores. Students of white ethnicity and those with a technical or trade certificate scored significantly higher with regard to knowledge while those with either health or nutrition related qualifications scored significantly higher with regard to adherence. Mediterranean diet related nutrition knowledge was significantly and positively associated with adherence to the Mediterranean diet for students ages 18-24 as compared to other age stratifications and those of white ethnicity, possessing a high school diploma and with no health or nutrition-related qualifications which constitute the majority of the participants in the study. These findings are in agreement with previous studies reporting that gender, age, level of education, and employment status are found to be associated with higher nutrition knowledge and dietary intake (Beydoun & Wang, 2008; Dickson-Spillmann & Siegrist, 2011; Grunert et al, 2012; Hendrie et al, 2008; Parmenter et al, 2000).

A limitation of the present study is that ethnic diversity, technical training, and health and nutrition related background in the study population prevented stratification across courses. Our relatively small study population is an additional limitation. In contrast, a strength of the present study is that nutrition knowledge was assessed across three courses of formal nutrition education. Since diet quality scores that evaluate adherence to dietary guidelines have been recommended as being valuable for assessing the relationship between nutrition knowledge and dietary intake (Spronk et al, 2014), our novel design to parallel the MDNK and MEDAS questionnaires allowed us to achieve a means of assessing knowledge and adherence related to the Mediterranean diet.

5. Conclusion

Overall, the MDNK survey is a valid and reliable instrument for assessing baseline nutrition knowledge of the Mediterranean diet. It was further demonstrated that general nutrition knowledge as it relates to the Mediterranean diet correlates with Mediterranean diet adherence assessed using the 14-question MEDAS questionnaire. Students with greater exposure to formal nutrition education displayed both greater knowledge of the Mediterranean diet and greater diet adherence. Together the MDNK and MEDAS questionnaires are effective tools for assessing baseline knowledge and adherence, laying the foundation for targeted clinical interventions.

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Chapter 2

Mediterranean Diet Adherence in the Southeast United States: Impact of Nutrition Knowledge

Abstract

The Mediterranean diet (MD) has been shown to reduce chronic disease risk and is a recommended diet for prevention and management of diabetes. Adherence to the Mediterranean in the southeast United States, where obesity and diabetes are most prevalent, is unknown. The objectives of the present study were to: 1) determine MD adherence patterns and 2) determine to what extent basic nutrition knowledge is associated with MD adherence. The study population included 230 adults shopping at either a supermarket or farmers market in eastern Alabama. Previously validated short Mediterranean Diet Adherence Screener (MEDAS) and Mediterranean Diet Nutrition Knowledge (MDNK) questionnaires were used to assess Mediterranean diet adherence and nutrition knowledge related to the Mediterranean diet, respectively. Participants shopping at farmers markets were used to validate the survey instrument in the field. Patrons of farmers markets scored highest on the MEDAS questionnaire (5.37, SD 1.86); most patrons fell into the medium MD adherence tertile (59.5%). Comparatively, supermarket shoppers had lower MEDAS scores (4.49, SD 2.16) ($p = 0.001$), with most falling into the low adherence tertile (51.3%). MDNK scores were higher for patrons of farmers markets (mean 9.50, SD 3.78) compared to supermarkets (mean 7.02, SD 4.67) ($p < 0.001$); a significant positive linear relationship was observed between MDNK and MEDAS ($p = 0.001$). Gaps in nutrition knowledge were seen in four main food categories (fruits and vegetables, protein, lipids and dairy) and females, those of white ethnicity and those with the greatest amount of formal education scored highest on the MDNK questionnaire. Together the

MDNK and MEDAS questionnaires are effective tools for assessing baseline knowledge and adherence and can be used to identify specific patterns of consumption, the impact of demographic factors in at risk populations, and target nutritional interventions to improve MD adherence for prevention and management of diabetes and other chronic disease.

Key Words: Mediterranean diet, Nutrition Knowledge, Diet Adherence

1. Introduction

According to the Centers for Disease Control, nearly 30 million people in the United States currently have diabetes (Centers for Disease Control and Prevention, 2014). The American Diabetes Association has recently recommended adhering to a Mediterranean-style diet as one way to prevent diabetes (American Diabetes Association, 2016; Benson, Pereira & Boucher, 2011; Evert et al, 2014). This recommendation is based on the observation that a reduction in the occurrence of new-onset diabetes was observed in the PREDIMED study, a randomized clinical trial on the Mediterranean diet (Salas-Salvado et al, 2014). If adherence to a Mediterranean-style diet can aid in the management and treatment of diabetes and lower cardiovascular events yet the diet is not widely known or practiced, it may be that general nutrition knowledge is acting as an impediment to adherence (Bonanni et al, 2013; Dickson-Spillmann & Siegrist, 2011).

Adhering to a Mediterranean-style diet by incorporating extra virgin olive oil, a main staple of the Mediterranean diet, has been shown to reduce diabetes risk in patients with high cardiovascular risk factors (Salas-Salvado et al., 2014) and reduce the occurrence of new-onset diabetes (Jensen & Sherman, 2014). Using extra virgin olive oil or nuts in a Mediterranean-style diet has been shown to reduce central fat mass and waist circumference improving total body weight and glucose metabolism (Lasa et al, 2014). Additionally, adherence to a Mediterranean-style diet has been shown to reduce hyperglycemia, inflammation and oxidative stress and improve GLP-1 (glucagon-like peptide 1) action which all help to effectively manage type 2 diabetes (Cariello et al, 2014). Further, Mediterranean diet adherence has been associated with a

lower incidence of gestational diabetes as well as improved glucose tolerance in pregnant women with and without gestational diabetes (Karamanos et al, 2014).

The Centers for Disease Control has identified the southeast United States as the "diabetes belt", where a greater percentage of residents (11.7%) have been diagnosed with type 2 diabetes compared to those residing outside of the diabetes belt (8.5%) (Centers for Disease Control and Prevention, 2014; Barker, Kirtland, Gregg, Geiss & Thompson, 2011). Alabama currently has the highest rates of diabetes (12.9%) within the "diabetes belt" and in the United States as a whole ("2014 National Diabetes Statistics", 2015), making Alabama a prime location for study. Studying markets where food is purchased may provide some insight into eating patterns as shopping at supermarkets has been shown result in higher caloric intake due to the consumption of more processed foods while decreasing the intake of healthier foods (Michimi & Winberly, 2010). It is not currently known how general nutrition knowledge may impact adherence to a Mediterranean-style diet pattern in the southeast United States where diabetes is so prevalent. For this study, a previously validated questionnaire (Validation Paper) that assesses nutrition knowledge specifically related to the Mediterranean diet and Mediterranean diet adherence was used to determine nutrition knowledge and adherence in a community within the "diabetes belt".

2. Methods

1.1 Study Population

Surveys were distributed to adults at farmers markets and one chain of supermarket in both Auburn and Opelika, Alabama. Auburn is the largest urban city in eastern Alabama with a population of 60,258 and is a college town, home to Auburn University. With a population of

29,171, neighboring Opelika has demographics more representative of the state (numbers taken from US Census Bureau, 2015).

2.2 Survey Instrument

A three-part survey was used to determine general nutrition knowledge as it relates to the Mediterranean diet, adherence to a Mediterranean-style diet pattern and demographic characteristics of the sample population. Adherence to the Mediterranean diet was determined using a previously validated 14-point Mediterranean Diet Screener (MEDAS) (Schroder et al, 2011) with the exception of one question which was revised to be more applicable to the North American population. A Mediterranean diet Nutrition Knowledge (MDNK) questionnaire was developed utilizing validated instruments (Dickson-Spillman & Siegrist, 2011; Dickson-Spillman et al, 2011; Yoo et al, 2013). Fifteen questions were selected that paralleled the short validated Mediterranean diet Adherence Screener (MEDAS). The questions covered each food group of the Mediterranean diet while never explicitly asking about the Mediterranean diet, allowing for an objective representation of the knowledge the general community possessed about these foods rather than their knowledge of a specific diet. The MDNK questionnaire was previously validated in a population of university students (n = 127) (Validation paper). The three-page survey concluded with five demographic questions taken from a validated instrument (Parmenter & Wardle, 1999). These questions were used to determine whether a survey should be excluded (i.e. participant being under the age of 18) as well as to compare participant demographics.

In the MDNK questionnaire correct responses were scored as one point, 'not sure' answers were scored as zero, and incorrect responses were penalized one point. The rationale for this scoring pattern was that awareness that one does not know is superior to simply having incorrect knowledge. The maximum and minimum score for the MDNK questionnaire was 15 points and negative 15 points, respectively. Each question in the 14-point MEDAS was scored zero or one point for adherence to the Mediterranean diet as previously described (Schroder et al, 2011). MEDAS scores were divided into three levels to categorize adherence as low (scores 1-4), medium (scores 5-7) and high (scores 8-14) diet adherence.

1.2 Data Collection

Convenience sampling was used to have shoppers at Winn Dixie supermarkets and farmers markets to fill out surveys for this study. The surveys were distributed at four different locations: one supermarkets and one farmers market in each city. A total of 287 surveys were collected. Surveys with one or more question left blank were considered incomplete and excluded from statistical analysis. Fifty-seven surveys were excluded due to incomplete questions and age (<18 years), leaving 230 surveys for data analysis.

2.4 Statistical Analysis

The descriptive statistics used were absolute frequencies and percentages for categorical variables and mean and standard deviation (SD) for quantitative variables. All data analyses were conducted with SAS version 9.4 (SAS, Cary, NC). The GLM Procedure was used to perform analysis of variance (ANOVA) tests to assess MDNK and MEDAS scores and the demographic variables. A one-sided association test using the gamma statistic was used to assess individual

MDNK and MEDAS questions. Pearson chi-squared test was used to examine the distribution of low, medium, and high MEDAS scores. The REG and CORR procedures were used to perform: 1) linear regression to assess the relationship between MDNK and MEDAS scores, and 2) Pearson correlation between MDNK and MEDAS scores and demographic variables, respectively. A significance level of 0.05 was set.

3. Results

Response rates at the supermarkets were lower overall than those at the farmers markets. The response rate at the supermarket in Auburn was 52.2% while the response rate at the supermarket in Opelika was 37.7%. The farmers market in Auburn had a response rate of 72% and the farmers market in Opelika had a response rate of 70.9%. Collectively, the average response rate was 45.2% at supermarkets compared to 71.5% at farmers markets.

Demographic characteristics of participants are found in Table 8. Shoppers at both supermarkets and farmers markets were predominantly female (58.8% and 64.9% respectively) and of white ethnicity (63.9% and 84.7% respectively). The majority of supermarket shoppers were between the ages of 20-24 while the majority of farmers market shoppers fell into the 25-74 age group. Farmers market shoppers also possessed higher levels of education.

To examine Mediterranean diet adherence in our general population, MEDAS scores were divided into thirds: low (scores 1-4), medium (scores 5-7) and high (scores 8-14). The proportion of shoppers with low, medium, and high adherence was significantly different between market types ($p < 0.001$). Low adherence was greatest in supermarket shoppers (51.3%) and lowest in farmers market shoppers (27.9%); conversely, high adherence was greatest in farmers market

Table 8: Participant demographic characteristics

	Farmers Market (n= 111)		Supermarket (n= 119)	
Demographic Characteristics[†]	n	%	n	%
Gender				
Male	39	35.1	49	41.2
Female	72	64.9	70	58.8
Age				
18-24	8	7.2	34	28.6
25-34	20	18.0	13	10.9
35-44	14	12.6	16	13.4
45-54	20	18.0	24	20.2
55-64	2	1.8	1	0.8
65-74	22	19.8	14	11.8
more than 75	2	1.8	5	4.2
Ethnicity				
White	94	84.7	76	63.9
Black Caribbean	0	0.0	2	1.7
Black African	6	5.4	6	5.0
Black other	4	3.6	4	3.4
Indian	2	1.8	2	1.7
Asian-other	3	2.7	3	2.5
Other ethnic group	2	1.8	2	1.7
Education				
High School Diploma	11	9.9	32	2..7
GED	2	1.8	7	5.9
Technical or trade certificate	4	3.6	10	8.4
Associate degree	14	12.6	15	12.6
Bachelor's degree	34	30.6	36	30.3
Master's or professional degree	45	40.5	19	16.0
Qualification				
Health or nutrition related qualifications	12	10.8	19	16.0
No health or nutrition related qualifications	99	89.2	100	84.0

[†]n=230

Table 9: Mediterranean diet adherence

MEDAS Score Category	Farmers Market	Supermarket	Total
Low (1-4)*	27.9%	51.3%	40.0%
Medium (5-7)	59.5%	38.7%	48.7%
High (8-14)	12.6%	10.1%	11.3%

* Significance across score categories by Pearson's chi-squared test ($x^2 = 13.25$, $p < 0.001$)

MEDAS Survey	F Value	P Value
Overall	5.66	**0.004**
Geographic Location	0.64	0.426
Market	10.55	**0.001**
Location*Market	2.34	0.128

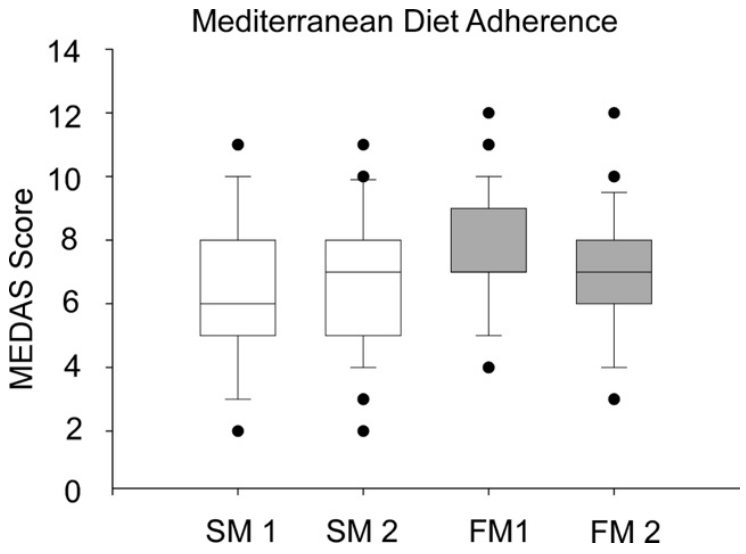

Figure 5. Total MEDAS scores for each market are shown as box plots. The top and bottom of the boxes define the 25th and 75th percentiles. The middle line is the median class score. The error bars define the 10th and 90th percentiles. The dots are outliers (scores that fell outside of the 10th and 90th percentiles). ANOVA was used to test for significant differences between the markets. Supermarkets (SM); Farmers markets (FM)

shoppers (12.6%) and lowest in supermarket shoppers (10.1%). As a whole, the overall sample population exhibited mostly low (40.0%) and medium (48.7%) diet adherence (Table 9).

As shown in Figure 5, total MEDAS score was found to be significantly different between supermarkets and farmers markets ($p = 0.001$) but not between geographic location (Auburn and Opelika) ($p = 0.426$). Mediterranean diet adherence was lower overall among supermarket shoppers (mean 4.49, SD 2.16) than among farmers market shoppers (mean 5.37, SD 1.86). We then examined whether the scores of individual MEDAS questions were different between market types to assess possible differences in the consumption of specific Mediterranean diet food components. As shown in Table 10, significant differences between markets were observed with supermarket shoppers exhibiting significantly lower adherence than farmers market shoppers in the consumption of lipids/extra virgin olive oil (MEDASQ1), fruits and vegetables (MEDASQ3), protein (MEDASQ5) and dairy (MEDASQ6).

After finding adherence in the general population to be relatively low when combining scores from both markets (mean 4.93), nutrition knowledge was explored. Farmers markets were used to validate the nutrition knowledge survey instrument since farmers market shoppers have previously been shown to possess greater than average nutrition knowledge through a survey tool assessing nutrition knowledge, consumption patterns and demographic variables (Webber, Stephenson, Mayes & Stephenson, 2013). As shown in Figure 6, mean MDNK score was significantly different across farmers markets and supermarkets ($p < 0.001$) with farmers market shoppers scoring higher (mean 9.50, SD 3.78) than supermarket shoppers (mean 7.02, SD 4.67).

Table 10: Mediterranean diet adherence in the individual MEDAS questions

		Farmers Market		Supermarket			
Question	Category	Mean	SD	Mean	SD	t-value[†]	P value
MEDASQ1[‡]	Lipids	0.74	0.44	0.59	0.49	2.43	**0.016**[$]
MEDASQ2	Lipids	0.05	0.21	0.04	0.20	0.10	0.911
MEDASQ3	Fruits and Vegetables	0.45	0.5	0.30	0.46	2.33	**0.021**
MEDASQ4	Fruits and Vegetables	0.20	0.4	0.21	0.41	0.22	0.824
MEDASQ5	Protein	0.52	0.5	0.34	0.47	2.90	**0.004**
MEDASQ6	Dairy	0.61	0.49	0.46	0.50	2.30	**0.022**
MEDASQ7	Sweets	0.70	0.46	0.59	0.49	1.67	0.097
MEDASQ8	Wine	0.00	0.00	0.03	0.18	1.96	0.052
MEDASQ9	Protein	0.18	0.39	0.13	0.34	0.95	0.342
MEDASQ10	Protein	0.07	0.26	0.08	0.28	0.33	0.737
MEDASQ11	Sweets	0.76	0.43	0.66	0.48	1.69	0.093
MEDASQ12	Protein	0.16	37	0.16	0.70	0.00	0.959
MEDASQ13	Protein	0.69	0.46	0.67	0.47	0.35	0.729
MEDASQ14	Fruits and Vegetables	0.24	0.43	0.23	0.42	0.28	0.771

[‡] MEDAS question (MEDASQ)
[†] ANOVA test statistic
* Trend was assessed with a one-sided association test using gamma statistics
[$] p values < 0.05 are indicated in bold font

MDNK Survey	F Value	P Value
Overall	10.6	**< 0.001**
Geographic Location	0.62	0.432
Market	19.33	**<0.001**
Location*Market	0.00	0.989

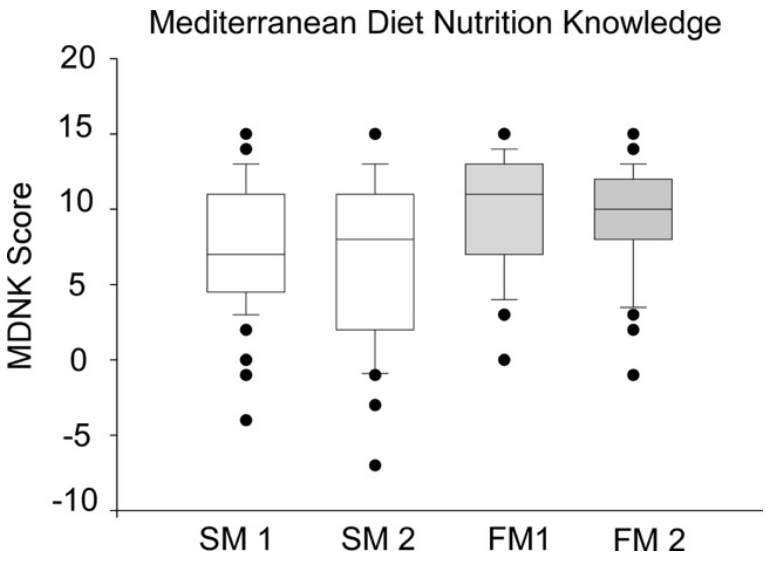

Figure 6. Total MDNK scores for each market are shown as box plots. The top and bottom of the boxes define the 25th and 75th percentiles. The middle line is the median class score. The error bars define the 10th and 90th percentiles. The dots are outliers (scores that fell outside of the 10th and 90th percentiles). ANOVA was used to test for significant differences between the markets. Supermarkets (SM); Farmers markets (FM)

Table 11: Mediterranean Diet Nutrition Knowledge (MDNK) scores

Question	Category	Farmers Market Mean	Farmers Market SD	Supermarket Mean	Supermarket SD	t-value[†]	P value
MDNKQ1[‡]	Lipids	0.93	0.29	0.76	0.53	2.85	0.005
MDNKQ2	Fruits and Vegetables	0.49	0.84	0.27	0.93	1.86	0.064
MDNKQ3	Fruits and Vegetables	0.41	0.84	0.19	0.92	1.90	0.059
MDNKQ4	Lipids	0.58	0.65	0.48	0.72	1.07	0.286
MDNKQ5	Protein	0.41	0.88	0.03	0.92	3.21	**0.002**[$]
MDNKQ6	Dairy	0.37	0.84	0.15	0.89	1.98	**0.048**
MDNKQ7	Dairy	0.67	0.69	0.50	0.72	1.83	0.069
MDNKQ8	Sweets	0.59	0.65	0.59	0.64	0.00	0.975
MDNKQ9	Wine	0.73	0.57	0.72	0.55	0.10	0.924
MDNKQ10	Protein	0.86	0.42	0.54	0.61	4.57	**<0.001**
MDNKQ11	Lipids	0.84	0.46	0.69	0.62	2.06	**0.041**
MDNKQ12	Sweets	0.61	0.76	0.58	0.76	0.33	0.746
MDNKQ13	Lipids	0.72	0.69	0.55	0.82	1.74	0.083
MDNKQ14	Protein	0.71	0.59	0.63	0.65	0.99	0.323
MDNKQ15	Fruits and Vegetables	0.59	0.68	0.34	0.81	2.53	**0.012**

[‡] MDNK question (MDNKQ)
[†] ANOVA test statistic
[$] p values < 0.05 are indicated in bold font

No significant difference was seen between geographic location (Auburn and Opelika) ($p = 0.432$). We next examined whether the scores for individual MDNK questions were different between market types to assess possible gaps in the nutrition knowledge of specific food categories. As shown in Table 11, significant differences between markets with supermarket shoppers scoring significantly lower were observed in the knowledge of protein (MDNKQ5 and MDNKQ10), dairy (MDNKQ6), lipids (MDNKQ11) and fruits and vegetables (MDNKQ15). These MDNK results suggest that supermarket shoppers possess lower nutrition knowledge than farmers market shoppers across the range of food categories which parallels with adherence, as supermarkets shoppers exhibited lower adherence in the same four food categories.

We then stratified by demographic categories to examine whether MDNK and MEDAS scores were different in the demographic categories used in the study population. As shown in Table 12, mean MDNK and MEDAS scores for females (8.56 ± 4.50 and 5.13 ± 2.05 respectively) were significantly greater ($p = 0.013$ and $p = 0.010$ respectively) than those for males (7.67 ± 4.30 and 4.58 ± 2.07 respectively). Significant differences were also seen in mean MDNK scores for ethnicity ($p < 0.001$) and education ($p = 0.012$), with those of white ethnicity and with a master's or professional degree scoring highest (9.43 ± 3.55 and 9.84 ± 3.40 respectively) and those of Black African ethnicity or with a GED scoring lowest (3.66 ± 4.37 and 4.56 ± 5.48 respectively). Ethnicity and education did not significantly impact MEDAS scores.

There was a significant linear relationship with a positive slope ($p = 0.001$) between MDNK and MEDAS scores when scores from all markets were combined (Figure 7). To assess how demographics may influence this relationship, odds ratios for demographic categories were

analyzed over a 95% confidence interval. As shown in Table 13, males were significantly more likely to score lower than females in both MDNK and MEDAS surveys (odds ratio 0.50; 95% CI: 026-0.96). Those of Black African ethnicity were significantly more likely to score lower than other ethnic groups (odds ratio 0.05; 95% CI: 0.00-0.92) and those of Chinese ethnicity (odds ratio 0.23; 95% CI: 0.08-0.63). Those who identified as “Black other” were significantly more likely to score lower than those of Chinese ethnicity (odds ratio 0.13; 95% CI: 0.02-0.76). This further suggests that demographics exert influence over the relationship between MDNK and MEDAS scores.

Table 12: Demographic variable analysis for MDNK and MEDAS scores for all participants

	MDNK Score		MEDAS Score		MDNK Score	MEDAS Score
Demographic Categories[†]	Mean	SD	Mean	SD	P value	P value
Gender					**0.013[$]**	**0.010**
Male	7.67	4.30	4.58	2.07		
Female	8.56	4.50	5.13	2.05		
Age					0.434	0.242
18-24	6.57	3.95	4.50	2.14		
25-34	7.27	5.11	4.58	2.25		
35-44	8.10	4.10	5.10	2.01		
45-54	8.34	4.52	4.50	2.16		
55-64	8.95	4.76	4.45	1.83		
65-74	9.83	3.60	5.36	1.91		
More than 75	7.86	4.71	5.71	1.60		
Ethnicity					**< 0.001**	0.073
White	9.43	3.55	4.92	1.89		
Black Caribbean	4.50	10.61	5.00	5.66		
Black African	3.66	4.37	4.17	2.36		
Black Other	6.70	5.58	5.20	2.30		
Indian	7.33	2.89	6.67	1.53		
Asian-other	3.80	3.96	7.40	2.88		
Other ethnic group	8.00	6.56	5.67	1.15		
Education					**0.012**	0.079
High School Diploma	6.11	4.28	4.40	2.22		
GED	4.56	5.48	4.11	2.52		
Technical or Trade Certificate	5.43	5.98	4.29	1.94		
Associate Degree	8.07	3.92	5.14	1.96		
Bachelor's Degree	9.07	4.21	4.83	1.95		
Master's or professional degree	9.84	3.40	5.52	2.01		
Nutrition Qualification					0.064	0.448
Health or nutrition related qualifications	7.58	5.29	5.32	2.10		
No health or nutrition related qualifications	8.32	4.29	4.85	2.06		

[†]n=230
[$]p values < 0.05 are indicated in bold font

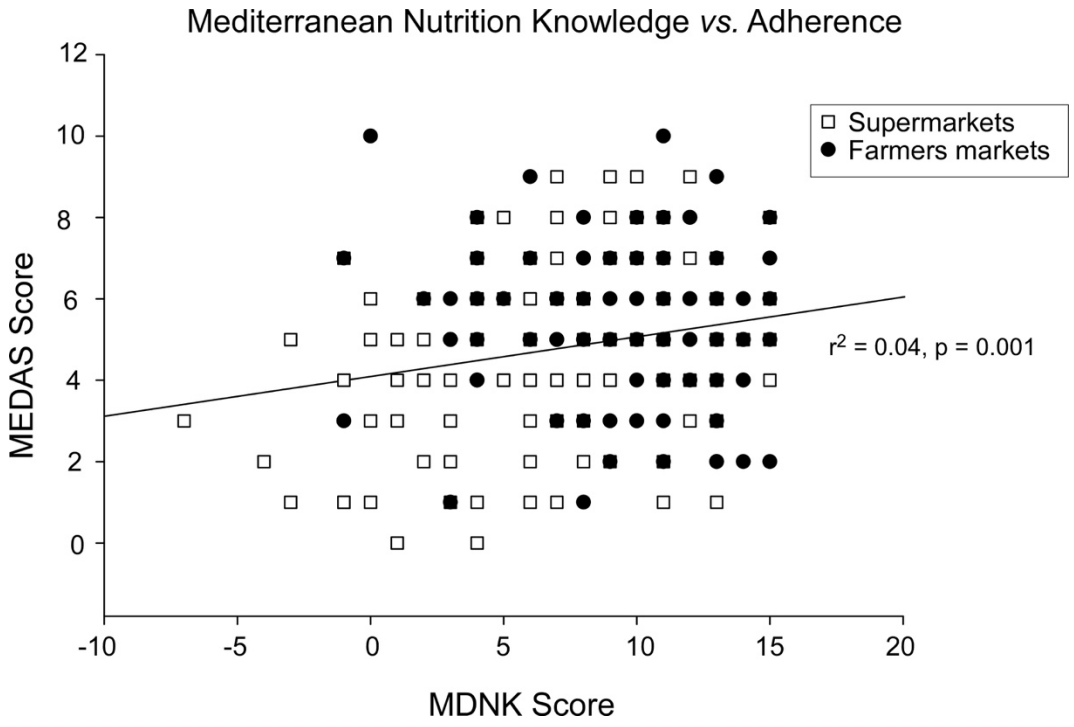

Figure 7. Association between MDNK and MEDAS scores. Linear regression was used to assess the relationship between MDNK and MEDAS scores for participants at both markets.

Table 13: Odds ratios across 95%CI according to demographic category

Demographic Characteristics[†]	Odds Ratio	95%CI
Gender (vs female)		
Male	0.501	**0.26-0.96**[$]
Age (vs more than 75)		
18-24	0.827	0.11-6.22
25-34	3.816	0.52-27.96
35-44	1.481	0.20-10.92
45-54	2.034	0.29-14.13
55-64	6.300	0.86-46.13
65-74	3.169	0.45-22.45
Ethnicity (vs other)		
White	0.248	0.02-4.21
Black African	0.047	**0.00-0.92**
Black Other	0.219	0.01-4.72
Indian	0.581	0.01-25.58
Asian-Other	0.432	0.01-13.58
Ethnicity (vs Chinese)		
Black African	0.225	**0.08-0.63**
Black Other	0.125	**0.02-0.76**
Indian	0.256	0.05-1.15
Pakistani	0.482	0.18-1.33
Bangladeshi	0.474	0.21-1.06
Qualifications		
Health or nutrition related qualifications vs no health or nutrition related qualifications	0.415	0.16-1.06

[†]n=230
[$]95%CI that represent differences in demographic categories are indicated in bold font

4. Discussion

People who possess general nutrition knowledge can be used as the control to determine baseline nutrition knowledge in a given population (Pinho, Moura, Silveira, Botelho & Caldiera, 2013). Farmers market shoppers in Kentucky, a member of the "diabetes belt", have been shown to possess greater than average nutrition knowledge (Webber et al, 2013). In order to further validate our nutrition knowledge field instrument, we compared MDNK scores at farmers markets with MDNK scores at supermarkets. As anticipated, farmers market shoppers did indeed have greater nutrition knowledge than supermarket shoppers which also correlated with greater adherence to the Mediterranean diet. This is consistent with findings from our previous research that greater nutrition knowledge correlates with greater Mediterranean diet adherence (Validation paper) and with findings that farmers market shoppers in the United States are more likely than non-farmers market shoppers to choose nutrition as the most important characteristic of food rather than cost, leading to healthier food choices (Zepeda, 2009; Wolf, Spittler & Ahern, 2005).

In rural areas of the southern United States, fruit and vegetable consumption is positively associated with farmers market use (Pitts et al, 2014) as farmers markets are built on the premise of fresh, local produce. Additionally, groceries purchased at supermarkets may increase shoppers' caloric intake from processed foods while decreasing the intake of healthier food items such as fruits and vegetables. This is particularly seen among low-income families (Michimi & Winberly, 2010). Consistent with these findings, the majority of our sample shopping at supermarkets exhibited low adherence to a Mediterranean-style diet. There were 21.8% more participants in the low adherence group at supermarkets than at the farmers markets. Adherence

in the southeast United States is currently not known, but Mediterranean diet adherence in a North American working population has been explored. The majority of the North American sample fell into the lower end of medium diet adherence (quartile II of IV) (Yang et al, 2014). This compares to our population sample as the majority of all participants were in the low (40.0%) and medium (48.7%) diet adherence categories. These adherence rates are lower than those of countries surrounding the Mediterranean. In a sample of a Greek population the majority of men (42.8%) and women (43.2%) exhibited medium diet adherence with very few in the low (27.6% and 33.4% respectively) diet adherence category (Trichopoulou et al, 2003). Similarly, the majority of an adult sample in Sicily, Italy demonstrated medium (67.3%) diet adherence (Grosso et al, 2013).

Upon discovering mean adherence in the general community to be relatively low, the possible correlation between diet adherence and nutrition knowledge was explored. It has been previously found that education level correlates with greater knowledge and adherence (Validation paper; Hu et al, 2013) and that Mediterranean diet adherence increases according to nutrition knowledge level (Bonaccio et al, 2013). To examine if gaps in nutrition knowledge were correlated with low diet adherence, individual MDNK and MEDAS questions were analyzed. Responses to the MDNK survey, specifically to questions pertaining to fruits and vegetables, protein, lipids and dairy were significantly different among the two market types with the supermarket shoppers scoring lower. Similarly, in the MEDAS survey, adherence as evidenced by reported consumption of fruits and vegetables, lipids, protein and dairy was found to be significantly different among the two market types; supermarket shoppers exhibited lower

adherence. Responses to MEDASQ1 (Do you use olive oil as main culinary fat?), MEDASQ3 (How many vegetable servings do you consume per day?), MEDASQ5 (How many servings of red meat, hamburger, or meat products do you consume per day?) and MEDASQ6 (How many servings of butter, margarine, or cream do you consume per day?) were significantly different between market types. This suggests that farmers market shoppers possess greater nutrition knowledge in these areas which then corresponds with greater adherence. MDNKQ6 (Skim milk contains fewer vitamins and minerals than whole milk) is the corresponding MDNK question that parallels MEDASQ6 which also exhibited significance. These results suggest that there is a link between nutrition knowledge and the consumption of fruits and vegetables, lipids, protein and dairy. This is supported by findings that there are gaps in the nutrition knowledge of fruits and vegetables and what constitutes a balanced diet that exerts influence on diet choices (Dickson-Spillmann & Siegrist, 2011).

After finding a correlation between knowledge and adherence, relationships between demographic characteristics of our population and knowledge and adherence were analyzed. Females exhibited both greater nutrition knowledge and greater adherence than males, which is consistent with previous findings that females possess greater general nutrition knowledge than males (Lynn, Wilberg-Neidhardt & Margraf-Stiksrud, 2005; Dickson-Spillmann & Siegrist, 2011) and are more likely to read food labels (McLean-Meyinsse, 2001). Females have also been reported to possess higher Mediterranean diet adherence scores and a higher intake of fruits and vegetables than males (Mattioli, Pennella, Pedrazzi & Farinetti, 2015). In addition to gender, ethnicity exerted influence over MDNK and MEDAS scores. In the present sample, those of

white ethnicity had significantly higher mean MDNK scores than those of Black African ethnicity (9.43 ± 3.55 and 3.66 ± 4.37 respectively), which is supported by the finding that those of white ethnicity are more nutritionally aware and possess more label reading behaviors than African Americans (Wright & Wang, 2006). It has also been reported that those of white ethnicity possess greater awareness of nutrition-related health risks than other ethnicities which then demonstrates a positive association with healthy eating (Wang & Chen, 2011).

Aside from gender and ethnicity, those who had completed higher levels of formal education holding an associate degree, bachelor's degree, or master's or professional degree had greater nutrition knowledge and adherence than those with a high school diploma, GED, or technical or trade certificate. This suggests that greater knowledge does correlate with greater adherence; a significant linear relationship was seen between MDNK and MEDAS scores. These findings are supported by our previous report that exposure to formal nutrition education correlates with Mediterranean diet adherence (Validation paper) and that Mediterranean diet adherence increases according to nutrition level (Bonaccio et al, 2013). This is also supported by findings that people with little education and of lower socioeconomic status are less likely to adhere to a Mediterranean-style diet (Hu et al, 2013; Panagiotakos et al, 2007; Wang & Chen, 2011), and that those with little education consume fewer fruits and vegetables overall (Shohaimi et al, 2004). These results suggest that demographic components may influence the possession of general nutrition knowledge and ultimately the ability to make healthy food choices that align with a Mediterranean-style diet.

A limitation of the present study is the small sample size (n = 230). In order to fully understand Mediterranean diet adherence in the southeast United States, studies need to be conducted throughout the southeast. In contrast, a strength of the present study this is the first sample collected to analyze Mediterranean diet adherence in a general adult population of the southeast United States. Another strength is the use of the innovative MDNK (Validation paper) and MEDAS survey tool which allows for the assessment of general nutrition knowledge specific to the Mediterranean diet in conjunction with Mediterranean diet adherence.

5. Conclusion

In the present general adult community there are gaps in nutrition knowledge that correlate with Mediterranean diet adherence. Gaps in nutrition knowledge are seen in four main food categories (fruits and vegetables, protein, lipids and dairy) and females, those of white ethnicity and those with the greatest amount of formal education scored highest on the MDNK questionnaire. Together the MDNK and MEDAS questionnaires are effective tools for assessing baseline knowledge and adherence. They can be used to assess which populations would benefit from targeted clinical interventions to increase nutrition knowledge in specific food categories in order to increase Mediterranean diet adherence for diabetes prevention and management.

Acknowledgements

We would like to thank the Auburn and Opelika Winn Dixie supermarkets, The Market at Ag Heritage Park and Opelika's Farmers Market for allowing us to distribute surveys to their customers.

Conclusion

Assessing adherence to the Mediterranean diet is useful as adherence to a Mediterranean-style diet can both prevent and manage a number of diseases. The Mediterranean diet has been shown to reduce major cardiovascular disease risk factors (Martinez-Gonzalez et al, 2012) and has been recommended to both prevent and manage cardiovascular disease (Estruch et al, 2013; Eliat-Adar, Sinai, Yosefy & Henkin, 2013). Current recommendations by the American Diabetes Association suggest that the Mediterranean diet could be one effective method for preventing and managing diabetes (American Diabetes Association, 2016; Benson et al, 2011; Evert et al, 2014), as Mediterranean diet adherence has been shown to reduce the occurrence of new-onset diabetes (Jensen & Sherman, 2014) and improve total body weight and glucose metabolism (Lasa et al, 2014). The Mediterranean diet is also useful for lowering cancer risk. Adherence to a Mediterranean diet is recommended to decrease the risk of developing both breast cancer (Mourouti et al, 2014) and lung cancer (Fortes et al, 2003). In addition, Mediterranean diet adherence has been shown to protect against cognitive decline and dementia (Poie, Ralston & Walker, 2013) and is considered protective against degenerative diseases, including Alzheimer's disease (Sofi, Macchi, Abbate, Gensini & Casini, 2010; Gu, Luchsinger, Stern & Scarmeas, 2010).

At this point in time, Mediterranean diet adherence rates are not known in the southeast United States. This study set out to explore adherence rates in a general population of east Alabama that belongs to both the "diabetes belt" (Centers for Disease Control and Prevention,

2014; Barker et al, 2011) and the "stroke belt" (Hajjar & Kotchen, 2003). Alabama currently has the highest rates of diabetes (12.9%) within the "diabetes belt" and in the United States as a whole ("2014 National Diabetes Statistics", 2015), making it location of interest for Mediterranean diet adherence study. In addition to adherence, nutrition knowledge of the food components associated with the Mediterranean diet was assessed. The rationale for the knowledge element of this study is based on findings that Mediterranean diet adherence increases according to nutrition level (Bonaccio et al, 2013) and that gaps in nutrition knowledge or the possession of greater nutrition knowledge can influence the consumption of selective dietary components (Beydoun & Wang, 2008; Dickson-Spillman & Siegrist, 2011; Spronk, 2014). As a first step, a Mediterranean diet Nutrition Knowledge (MDNK) questionnaire was created from previously validated instruments (Dickson-Spillman & Siegrist, 2011; Dickson-Spillman et al, 2011; Yoo et al, 2013) to include questions about each food group expressed in the Mediterranean diet. The questions covered each food group of the Mediterranean diet while never explicitly asking about the Mediterranean diet, allowing for an objective representation of the knowledge the general community possessed about these foods rather than their knowledge of a specific diet. The survey tool was then validated in a university student population that included three different courses (political science, introductory nutrition and human nutrient metabolism) across formal nutrition education before its distribution to the general adult population.

Mediterranean diet adherence was examined in university students and a general adult population. It was found that the majority of the student sample fell into the low diet adherence

category. While greater adherence correlated with greater exposure to nutrition education, the students as a whole were in the low diet adherence (48.5%) and medium diet adherence (45.6%) categories. This is comparable to a study looking at medical students in Sicily, Italy which found that only 22.6% of students displayed "good" Mediterranean diet adherence (score ≥8), leaving the majority of students in the medium and low diet adherence categories (Fiore et al, 2015). In the general adult population, about half of the participants surveyed at the supermarkets fell into the low diet adherence (51.3%) category and only a small percentage belonged to the high adherence (10.1%) category. This correlates with a previous finding in a North American working population where the majority of the participants fell into the lower end of the medium adherence quartiles (quartile II of IV) (Yang et al, 2014). When compared to general populations of countries surrounding the Mediterranean, adherence in our general community was low. In a sample consisting of regions all over Greece, the majority of both men (42.8%) and women (43.2%) were in the medium diet adherence categories (Trichopoulou, 2003). Similarly, the majority of an adult sample in Sicily, Italy demonstrated medium diet adherence (65.3%) (Grosso et al, 2013). However, farmers market shoppers in our general community were largely in the medium diet adherence (59.5%) category. This demonstrates a gap in diet adherence in the general population between those who shop at supermarkets and those who shop at farmers markets.

After finding Mediterranean diet adherence to be relatively low in the general population, the possible correlation between nutrition knowledge and diet adherence was explored. Farmers markets were used to validate the field instrument since it has previously been found that farmers

market shoppers possess greater than average nutrition knowledge (Webber et al, 2013). Within the general population the supermarket shoppers displayed significantly lower nutrition knowledge than the farmers market shoppers. Further, a positive linear relationship was demonstrated between nutrition knowledge and Mediterranean diet adherence in both the students and the general adult population. This suggests that there is a correlation between nutrition knowledge and Mediterranean diet adherence. In addition, exposure to formal nutrition education correlated with greater diet adherence.

Our results demonstrated that the MDNK survey can effectively assess general nutrition knowledge as it relates to the Mediterranean diet. In the future, the MDNK survey tool can be used for theory based interventions on the Mediterranean diet. The Social Cognitive Theory states than an individual must possess nutrition knowledge in order to set goals to make healthy food choices and perform the behavior of eating healthy foods (Bandura, 1986). Our studies suggest that the questions in the MDNK survey have the capacity to assess baseline knowledge as it relates to the Mediterranean diet so areas of knowledge lacking in a population could be targeted for nutrition education. Increasing knowledge in the lacking areas would then allow individuals to set health goals and ultimately make healthy food choices (Bandura, 1986; Malone, 2002). The Theory of Planned Behavior suggests that a positive attitude about healthy heating must be present for healthy food choices to be made (Kim et al, 2003). Using the MDNK survey tool to assess areas where knowledge may be lacking in the Mediterranean diet gives insight into what food groups could use positive reinforcement. After first increasing knowledge in the necessary food groups positive attitudes could then be instilled about those food groups to

hopefully increase their consumption (Kim et al, 2003; Shepherd & Towler, 2007). For preventive education, the MDNK survey could be used in conjunction with the Health Belief Model. After assessing baseline nutrition knowledge, lacking areas in the Mediterranean diet could be targeted for nutrition education. Educating patients on how those foods help prevent disease allows the patients to understand why they should consume those foods (Naghashpour et al, 2014). The MDNK survey would also be useful with the Life Course Model. As the Life Course Model focuses on intervention (Haughton et al, 2012), the nutrition education tool highlights areas where educational intervention may be necessary.

A limitation to the present studies was the small sample size (validation study n = 127; general population n = 230). Mediterranean diet adherence was determined in a general population in east Alabama, which makes up only a small part of the southeast United States. In order to fully understand Mediterranean diet adherence in the southeast United States, additional studies need to be conducted throughout the southeast. Since the MDNK survey tool was created with the intention of Mediterranean diet education in mind, another limitation is that the effectiveness of Mediterranean diet education has not been explicitly tested. While knowledge was found to correlate with adherence, it has not been demonstrated whether Mediterranean diet education increases diet adherence. However, a recent food-based nutrition education intervention showed improvements in nutrition knowledge by an average of 16.75 percentage points (Carraway-Stage, Hovland, Showers, Diaz & Duffrin, 2015). Increasing diet adherence could also be difficult in the United States as the intake of many food components associated with the Mediterranean diet is currently low ("Dietary Guidelines for Americans 2015-2020",

2015). According to the 2015-2020 Dietary Guidelines, three-fourths of Americans are not eating enough fruits and vegetables, fruit, dairy or oils while more than half of the population is meeting or exceeding total grain and protein recommendations and exceeding added sugar, saturated fat and sodium intake ("Dietary Guidelines for Americans 2015-2020", 2015).

In contrast, a strength of the present study is that nutrition knowledge was assessed across three courses of formal nutrition education to assess validity of the instrument. Our results demonstrated a dosage effect of formal nutrition education on Mediterranean diet adherence. This is supported by a previous finding that increased nutrition knowledge correlated with increased Mediterranean diet adherence (Bonaccio et al, 2013) which suggests that Mediterranean diet education could be useful as increasing knowledge of the diet may increase adherence. Another strength of this study is the innovative MDNK survey tool that was developed and used to assesses general nutrition knowledge of the food components of the Mediterranean diet. To our knowledge this is the first nutrition knowledge questionnaire to be paralleled with a Mediterranean diet adherence screener. This survey tool allows for the assessment of knowledge as it relates to the Mediterranean diet which is particularly useful for theory based interventions on the Mediterranean diet that aim to increase Mediterranean diet knowledge and ultimately diet adherence.

The Mediterranean diet has made a name for itself in disease prevention and management. The success of Mediterranean diet education has yet to be studied, however the MDNK survey tool created in this study could be useful for doing so in conjunction with a theory based interventions. Together the MDNK and MEDAS questionnaires are effective tools

for assessing baseline Mediterranean diet knowledge and diet adherence. They could help close gaps between knowledge and adherence in the southeast United states which has historically had the highest stroke mortality rate and hypertension rates (Hjjar & Kotchen, 2003) as well as a greater percentage of type 2 diabetes diagnoses (Centers for Disease Control and Prevention, 2014; Barker et al, 2011) than other regions of the United States (Hajjar & Kotchen, 2003). This high prevalence of chronic disease is believed to be related to dietary factors (Hajjar & Kotchen, 2003) as the southeast consumes foods that are typically higher in salt (Smith et al, 2006) and diets that are lower in many essential minerals (potassium, calcium, phosphorus, magnesium, copper, riboflavin, niacin and iron) and vitamins (A, C and B6) (Hajjar & Kotchen, 2003) when compared to other regions of the United States. In the future, the questionnaires can be used in a given population both within and outside of the southeast United States to assess populations which may benefit from targeted theory based clinical interventions to increase nutrition knowledge in specific food categories in order to increase Mediterranean diet adherence for disease prevention and management.

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Appendices

Appendix 1: Survey Tool

AUBURN UNIVERSITY

DEPARTMENT OF NUTRITION, DIETETICS, AND HOSPITALITY MANAGEMENT

Information Letter

This survey is for research purposes only. The intent of this survey is to study regional eating patterns and nutrition knowledge. Filling out this survey is completely voluntary and your participation is optional. Should you choose to participate, you will be asked to check the boxes that correspond to your eating patterns and understanding of nutrition. The survey will take about ten minutes to complete. All of your answers will be kept confidential and your name will be in no way tied to your survey. Should you have any questions about this research study, you can contact Michael Greene at mwg0006@auburn.edu. If you have any questions or concerns about your rights as a participant in this study, you can call the AU Office of Research Compliance/IRB at 334-844-5966.

The Auburn University Institutional Review Board has approved this document for use from 4/28/15 to 4/27/18 Protocol # 15-176 EX 1504

Michael W. Greene

4/28/2015

Date

We would like to ask you a few questions about your diet	**Check the box that applies**		
1. Do you use olive oil as main culinary fat?	Yes ☐	No ☐	
2. How many tablespoons of olive oil do you consume in a given day (including oil used for frying, salads, out-of-house meals, etc.)?	<1 ☐	1-4 ☐	>4 ☐
3. How many vegetable servings do you consume per day? (1 serving: ½ cup cooked, 1 cup raw [consider side dishes as half a serving])	<1 ☐	1-2 ☐	>2 ☐
4. How many fruit units (including natural fruit juices) do you consume per day? (1 serving: 1 cup)	<1 ☐	1-3 ☐	>3 ☐
5. How many servings of red meat, hamburger, or meat products (ham, sausage, etc.) do you consume per day? (1 serving: 2-3 ounces)	<1 ☐	1-3 ☐	>3 ☐
6. How many servings of butter, margarine, or cream do you consume per day? (1 serving: 1 tablespoon)	<1 ☐	1-3 ☐	>3 ☐
7. How many sweet or carbonated beverages do you drink per day?	<1 ☐	1-3 ☐	>3 ☐
8. How many glasses of wine do you drink per week? ☐Red ☐White ☐Both	<2 ☐	2-7 ☐	>7 ☐
9. How many servings of legumes (beans, black eyed peas) do you consume per week? (1 serving: 1 cup)	<1 ☐	1-3 ☐	>3 ☐
10. How many servings of fish or shellfish do you consume per week? (1 serving: 2-3 ounces of fish or 3 ounces of shellfish)	<1 ☐	1-3 ☐	>3 ☐
11. How many times per week do you consume commercial sweets or pastries (not homemade), such as cakes, cookies, biscuits, or custard?	<3 ☐	3-5 ☐	>5 ☐
12. How many servings of nuts (including peanuts) do you consume per week? (1 serving: ¼ cup)	<1 ☐	1-3 ☐	>3 ☐

	Yes	No	
13. Do you preferentially consume chicken, turkey, or rabbit meat instead of veal, pork, hamburger, or sausage?	☐	☐	
Are you a vegetarian or vegan? ☐Yes ☐No			
14. How many times per week do you consume boiled vegetables, pasta, rice, or other dishes with a sauce of tomato, garlic, onion, or leeks without meat sautéed in olive oil?	<1 ☐	1-2 ☐	>2 ☐

This next set of questions is about your understanding of nutrition	**Check the box that applies**		
	True	False	Not Sure
1. A salad dressing made with mayonnaise is as healthy as the same dressing made with olive oil.	☐	☐	☐
2. To eat healthily, you should eat less fat. Whether you also eat more fruit and vegetables does not matter.	☐	☐	☐
3. The health benefit of fruits and vegetables lies alone in the supply of vitamins and minerals.	☐	☐	☐
4. If you have eaten high-fat foods, you can reverse the effects by eating apples.	☐	☐	☐
5. A healthy meal should consist of half meat, a quarter vegetables and a quarter side dishes.	☐	☐	☐
6. Skim milk contains fewer vitamins and minerals than whole milk.	☐	☐	☐
7. For healthy nutrition, dairy products should be consumed in the same amounts as fruit and vegetables.	☐	☐	☐
8. The same amount of sugar and fat contains an equal amount of calories.	☐	☐	☐
9. Wine can reduce the risk of certain diseases.	☐	☐	☐
10. Lentils contain only few useful nutrients, therefore their health benefit is not great.	☐	☐	☐
11. Oily fish (salmon, mackerel) contain healthier fats than red meat.	☐	☐	☐
12. To eat healthily, you should eat less. It does not matter what foods you reduce.	☐	☐	☐
13. Fat is always bad for your health; you should therefore avoid it as much as possible.	☐	☐	☐
14. The same amount of beef steak and chicken breast contains an equal amount of calories.	☐	☐	☐
15. Pasta with tomato sauce is healthier than pasta with mushroom and cream sauce.	☐	☐	☐

Finally, we would like to ask you a few questions about yourself

1. Are you male or female?
   a) Male ☐
   b) Female ☐

2. How old are you?
   a) less than 18 ☐
   b) 18-24 ☐
   c) 25-34 ☐
   d) 35-44 ☐
   e) 45-54 ☐
   f) 55-64 ☐
   g) 65-74 ☐
   h) more than 75 ☐

3. What is your ethnic origin?
   a) White ☐
   b) Black Caribbean ☐
   c) Black African ☐
   d) Black other ☐
   e) Indian ☐
   f) Pakistani ☐
   g) Bangladeshi ☐
   h) Chinese ☐
   i) Asian- other ☐
   Please specify:

   ……
   j) Any other ethnic group ☐
   Please specify:

   ……

4. What is the highest level of education you have completed?
   a) Elementary school ☐
   b) Middle school ☐
   c) High school diploma ☐
   d) GED ☐
   e) Technical or trade certificate ☐
   f) Associate degree ☐
   g) Bachelor's degree ☐
   h) Master's or professional degree ☐

5. Do you have any health or nutrition related qualifications?

a) Yes ☐
Please specify:

……

b) No ☐