Traditional Ethnic Diets, Genetic Pre-Susceptibility and Gene-Diet Interaction Associations with Type 2 Diabetes and Risk Factors

Carla Isabel Mercado

A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2012

Annette L. Fitzpatrick, PhD, Chair
Shirley A. Beresford, PhD
Robyn McClelland, PhD
Mario Kratz, PhD
Chris Carlson, PhD

Program Authorized to Offer Degree:

Epidemiology

University of Washington

Abstract

The prevalence of obesity and type 2 diabetes in the US is reaching epidemic levels particularly among ethnic minorities. It is believed that this discrepancy is due to a shift from traditionally ethnic to westernized lifestyles. This shift may affect distinct ethnicities differently due to some unknown genetic factor. A recent study found that genetic differences in the proglucagon gene exist among various ethnic backgrounds. This gene is responsible for the production of the gut derived peptide hormone GLP-1 that delays gastric emptying, triggers satiety signals in the brains, and acts as an incretin. The need to replicate these findings as well as consider diet in the association between the proglucagon gene and type 2 diabetes are addressed here. This dissertation identified traditional ethnic dietary patterns and investigated whether diet acculturation is associated with presence, development and risk factors of type 2 diabetes. The genetic association between the proglucagon gene and diabetes prevalence and incidence, fasting glucose, fasting insulin, A1c, and body mass index were examined. The testing of the proglucagon gene-diet acculturation interaction in the risk factors as well as prevalence and incidence of type 2 diabetes were then evaluated. The MESA Study was ideal for examining these relationships as it is a prospective multi-site study of adults from various ethnic backgrounds who were periodically evaluated for dietary, anthropometric and phlebotomy measures over 10 years of follow-up. Statistical approaches included confirmatory factor analysis (CFA) to calculate dietary adherence, Cox proportional hazards regression to test diet and genetic associations with incidence of type 2 diabetes, and multiple linear regressions of the data to test diet and genetic associations with risk factors for type 2 diabetes. We found that adherence to a Western diet was positively associated with BMI in Mexican Americans (β = 0.84, 95% CI = 0.15-1.53), African Americans (β = 0.89, 95% CI = 0.18-1.60), and European Americans (β = 0.67, 95% CI = 0.13-1.21). No significant associations were found between the proglucagon SNPs and A1c, fasting glucose, and risk or incidence of type 2 diabetes. There was gene-diet interaction associated with incident type 2 diabetes (interaction p-values ranged from 0.03 – 0.08) among Chinese, Mexican, and African Americans. These findings provide new knowledge that can be used to develop effective intervention strategies for obesity as well as prevention of type 2 diabetes.

Traditional Ethnic Diets, Genetic Pre-Susceptibility and Gene-Diet Interaction Associations with Type 2 Diabetes and Risk Factors

Carla Isabel Mercado

Chair of the Supervisory Committee:

Research Associate Professor Annette L. Fitzpatrick, PhD

Epidemiology

ACKNOWLEDGEMENTS

The author wishes to express sincere appreciation to the members of this Dissertation Committee for their contribution and guidance. The Department of Epidemiology and Graduate Opportunities & Minority Achievement Program at the University of Washington have provided great support and resources which were important in the completion of this project. This study was funded and supported by the Presidential Fellowship and McMahon Award from Graduate Opportunities & Minority Achievement Program. This thesis would never have been completed without the encouragement and devotion of the author's family and friends.

The Multi-Ethnic Study of Atherosclerosis (MESA) research was supported by contracts N01-HC-95159 through N01-HC-95169 from the National Heart, Lung, and Blood Institute and RR-024156. The author thanks the other investigators, the staff, and the participants of the MESA study for their valuable contributions. A full list of participating MESA investigators and institutions can be found at http://www.mesa-nhlbi.org.

DEDICATION

To my wonderful husband, Hector, for making this journey possible. I appreciate your endless loyalty, devotion, and unlimited support.

TABLE OF CONTENTS

LIST OF FIGURES

Page Number

LIST OF TABLES

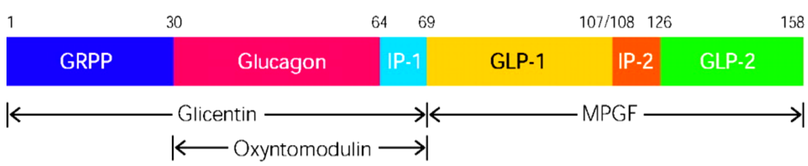
Page Number

Chapter 1: Overview of the Conceptual Model on Genetic Susceptibility and Traditional Ethnic Diet Adherence with the Risk of Type 2 Diabetes

Type 2 diabetes, a devastating disease with an estimated total cost of $174 billion in the US during 2007, affects ethnicities differently [1]. The age standardized prevalence of diagnosed diabetes was greater among Native Americans (16.5%), African Americans (11.8%), Hispanics (10.4%), and Asian-Americans (7.5%) than European Americans (6.6%). A similar trend was observed for obesity among adults of different ethnicities; African Americans (35.7%), Hispanics (28.7%), and European Americans (23.7%) [2]. Although obesity was identified as a prominent risk factor for type 2 diabetes, the discrepancy in prevalence of type 2 diabetes among different ethnicities was still present after taking into account body mass [3].

The health disparities in type 2 diabetes and obesity among ethnicities may be due to genetic factors. One possible explanation can be found in the proglucagon gene which encodes for the following peptides related to glucose metabolism: glucagon, glucagon-like peptide 1 (GLP-1), glucagon-like peptide 2 (GLP-2), glicentin, and oxyntomodulin (OXM) [4-6].

Figure 1.1 Proglucagon Gene [6]

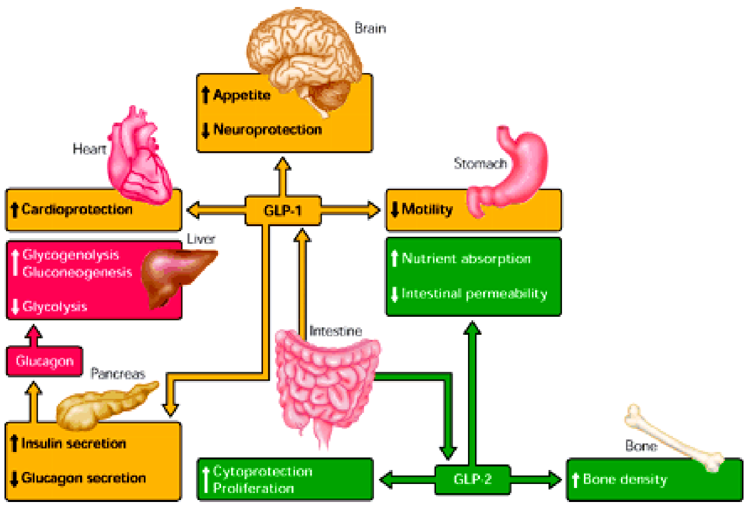


GRPP: Glicentin-related pancreatic peptide
IP-1: Intervening peptide 1
IP-2: Intervening peptide 2
MPGF: Major proglucagon-derived fragment
GLP-1: Glucagon-like peptide 1
GLP-2: Glucagon-like peptide 2

Glucagon is produced in the pancreas in response to low blood glucose levels and stimulates glucose production. The gut derived peptide hormones, glicentin and glucagon-like peptide 1 (GLP-1), are released in response to ingestion of food, primarily carbohydrate-rich nutrients, and delay gastric emptying as well as trigger satiety signals in the brain [4,7-10]. Additionally, these hormones act as an incretin, stimulating the release of insulin and inhibiting glucagon action [8]. GLP-1 has been found to lower body weight, in particularly body fat, by increasing energy expenditure and fat oxidation [11-14].

OXM and GLP-2 are also secreted in the intestinal tract [6,10]. Although OXM and GLP-2 inhibit gastric emptying and gastric acid secretion, OXM also stimulates intestinal glucose uptake and decreases pancreatic glucose secretion [5]. Similar to GLP-1, OXM treatment resulted in reduced body weight and loss of adipose tissue, despite of identical calorie intake, and is believed to increase energy expenditure [15-17].

Figure 1.2 Proglucagon Peptides Functions [6]



Preliminary Data

Carlson et al. have observed an association between the SNP rs6732914 in the proglucagon gene with fasting glucose and body mass index (Carlson et al., personal communication 2009). Specifically, the minor G allele, associated with what Carlson et al. hypothesized may be lower production of GLP-1, is more common (allele frequency ≈ 0.2 – 0.3) among Native Americans, Mexican-Americans, and African-Americans and quite rare in European Americans (allele frequency ≈ 0.02). Since the glucagon gene encodes for several key hormones affecting energy and glucose homeostasis, it is a strong candidate gene for diabetes related traits. With European populations having lower risk for type 2 diabetes and showing selective pressure near the glucagon gene, Carlson et al resequenced glucagon in a multi-ethnic panel. Evidence of recent positive selection sweep for one haplotype in European Americans and balancing selection for a divergent haplotype in Mexican Americans, tagged by SNP rs6732914G, was found. Also, Rs6732914G was associated with elevated fasting glucose in non-diabetic individuals (p=0.02 in Mexican-Americans and p=0.00007 in African-Americans), fasting insulin (p=0.02 in African Americans), and BMI (p=0.04 in African Americans). Functional analysis showed that rs6732914 alters the poly-A cleavage site of glucagon mRNA, with in-vitro tests demonstrating significantly reduced expression from the G allele.

Thrifty Gene and Thrifty Phenotype Theories

A theory was proposed about 60 years ago, suggesting that the great disparities in the prevalence of obesity and type 2 diabetes among particular populations can be explained historically by adaptations in the ability to store fat during periods of food surplus [18]. This adaptation, known as the "thrifty genotype," would provide a survival advantage during times of famine resulting in fertility selection [19].

There has been accelerated evolution within the proglucagon gene of mammals more likely due to adaptation to a new physiological function [20], resulting in differential genetic susceptibility to obesity and type 2 diabetes across populations. Whereas at some point there may have been perfect balance between energy intake and energy expenditure in reference to genetic susceptibility **(Figure 3)**, selection pressure of thrifty genes due to food shortages, psychosocial stress [21], and brain (cognitive) involvement in food intake which was not always present [22] shifted the base of the scale **(Figure 4A)**.

Figure 1.3 Historical balance between Energy Intake, Energy Expenditure, and Genetic Susceptibility

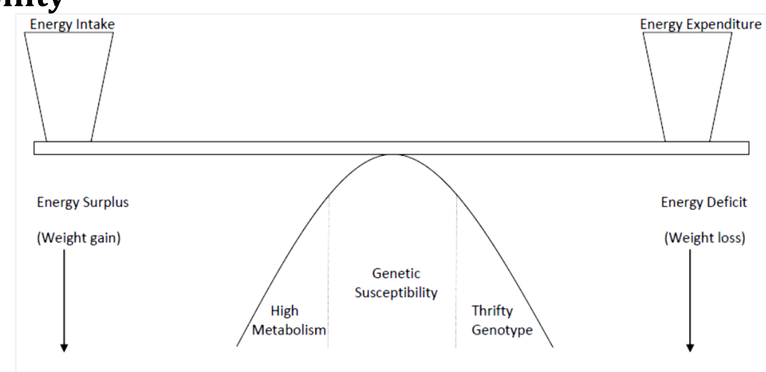
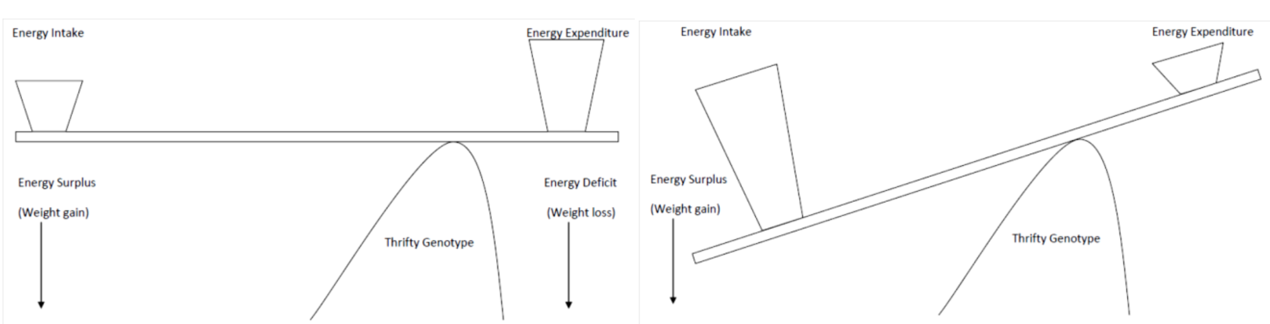


Figure 1.4 Balance of Thrifty Genotype in Environment with reduce Energy Intake (A) and Westernized Lifestyle (B)

A. **B.**



This type of shift would be more pronounced in populations where the historical selective pressures were the greatest and less so in populations where food was available year round, such as in European countries. The thrifty genotype supports the differences observed in obesity and type 2 diabetes between ethnicities, and also explains why the adoption of a westernized lifestyle **(Figure 4B)** accelerates the risk of type 2 diabetes across these populations [23,24].

Since few candidate genes or cluster of genes have been found to be strongly associated with obesity or type 2 diabetes across ethnicities [25], it has been proposed that in developing countries early metabolic adaptations have enhanced survival in undernourished fetuses as long as a nutritionally restricted lifestyle followed [26,27]. However, once the diet changed to one with a high caloric, high fat, and refined carbohydrate intakes, the elevated susceptibility to obesity and type 2 diabetes became manifested. This is known as the "thrifty phenotype," which is the underlying hypothesis supporting changes in health observed during acculturation toward a "westernized lifestyle." Many believe that the increase in obesity and type 2 diabetes are a result of socioecological adaptations in which lifestyles have shifted from more muscle dependent to brain dependent [28], but this hypothesis does not address why there are differences across ethnic populations in the United States.

The approach in this study was to consider the combined effects of both concepts on health, that is, the "thrifty geno-phenotype." The proglucagon gene, possibly a thrifty gene, has been observed to express GLP-1 at lower levels in African-Americans than in European Americans [29]. It has also been shown that diets high in fiber increases production of GLP-1 [30,31]. Ethnically traditional diets, consisting of fruits and vegetables, are high in fiber and acculturation has been found to be associated with changes away from traditional diets [32]. Similarly, acculturation was observed to be associated with negative health outcomes including greater prevalence of type 2 diabetes and obesity [33]. Since vegetarian diets have been observed to be protective against type 2 diabetes [34], it is possible that the increased fruit and vegetable consumption of the diet is what is important with the thrifty genotype concept. Data, however, are inconsistent and probably due to the many differences between a vegetarian and non-vegetarian diet. Although a combination diet comprising of high protein and high fiber resulted in the greatest GLP-1 secretion in an experiment [35], among south Asian Indians who are predominantly vegetarian, protein was found to be associated with an increased risk of type 2 diabetes [36]. Also among Europeans, a Mediterranean diet increased GLP-1 secretion compared to a carbohydrate rich diet [37]. Therefore, there may be other components of a traditional diet within each ethnicity which interact to prevent the phenotypic expression of the thrifty genotype.

Recent studies have focused on adaptation to a westernized lifestyle as the main culprit for the increase in obesity prevalence over the past few decades. Obesity was found to be significantly associated with duration of residency in the United States, especially for immigrants arriving at a young age or for second or later generation immigrants [38-40]. Body mass index is 30% greater in those born in the United States than those born in the countries of their ethnic origin among the same gender [41]. Similarly, diet has been observed to differ based on acculturation defined by language spoken and number of generations residing in the United States [42-45]. The more acculturation towards the westernized lifestyle, the unhealthier the diet consisting of a greater percent of energy coming from fat and less from fruit and vegetable consumption [42,46-48]. These dietary differences based on acculturation were also observed among adolescents [49,50]. Furthermore, acculturation identified by language spoken and number of years residing in the United States has been found to be associated with type 2 diabetes [46,51]. However, adherence to a "healthy" non-ethnically traditional diet among African Americans and Hispanics did not seem to decrease the risk of type 2 diabetes, even though the risk was decreased among European Americans [52]. Although it was recognized that ethnic differences in dietary habits among South East Asians was the most influential factor in the difference of fasting serum insulin, deviation from a traditional diet among ethnic minority populations in association with type 2 diabetes has not been thoroughly investigated [48,53].

The Multi-Ethnic Study of Atherosclerosis (MESA), a large ethnically diverse longitudinal study in which multiple laboratory measurements as well as diet were ascertained, was used to assess these factors over time as they relate separately and conjointly to obesity and type 2 diabetes.

MESA (Multi-Ethnic Study of Atherosclerosis)

Study setting and Participants

The Multi-Ethnic Study of Atherosclerosis (MESA) is a multi-site study of risk factors that predict progression to clinical cardiovascular disease. MESA began recruiting participants in 2000 at six field centers are: Wake Forest University, Columbia University, Johns Hopkins University, University of Minnesota, Northwestern University, and the University of California Los Angeles. MESA consists of one of the most diverse cohort studies with a total of 6814 participants: 2622 European Americans, 803 Chinese-American, 1893 African-American, and 1496 Hispanic. Since Hispanics consists of ethnicities from different countries in the Caribbean, Latin America, and South America, we only included Mexican-Americans who comprised the majority of this Hispanic group. Eligibility into the MESA study was limited to persons living in the geographic boundaries of each field center, ranging in age from 45 to 84 years, who were free of cardiovascular disease at baseline, and who were European American, Chinese-American, African-American, or Hispanic. Participants were excluded if undergoing active treatment for cancer, were pregnant, weighed over 300 pounds, were cognitive impaired, planned on leaving the community within five years, or spoke a language other than English, Spanish, Cantonese or Mandarin.

At baseline, the MESA participants each received an extensive exam which included measures of socio-demographic factors, lifestyle factors, psychosocial factors, and collection of blood samples. Since the baseline visit, there have been four follow-up visits with the fourth (10yr) visit collected in 2010. Anthropometric and laboratory measurements have been ascertained longitudinally.

Measures of Laboratory, Anthropometric, and other relevant variables

Although fasting glucose was measured at every visit, fasting insulin was only obtained at visit 1 and A1c only at visit 2. Blood samples were processed using the Cardiovascular Health Study standardized protocol [54] and all participants were asked to fast for 12 hours. Body mass index (kg/m^2) was calculated using measures of height (nearest 0.1 cm) and weight (nearest 0.5 kg) obtained at every visit. Standard questionnaires, both self-administered and interview-based, were used to obtain information on demographics, education, medication use, medical history, physical activity, smoking status, and immigration status.

Dietary Assessment

Diet was assessed by a self-administered 120 -item food frequency questionnaire (FFQ) measuring usual dietary intake, alcohol consumption, and supplement use in the past year. The FFQ was developed from the Insulin Resistance Atherosclerosis Study (IRAS) FFQ which was validated in a diverse cohort (European American, African American, and Hispanics) [55]. In order to adapt to MESA participant population, the IRAS FFQ was modified to include specific Chinese foods as well as use of dietary supplements [56].

The FFQ measured frequency of consumption and serving size for every food item. There were nine categories of frequency including rare or never, 1 per month, 2-3 per month, 1 per week, 2 per week, 3-4 per week, 5-6 per week, 1 per day, and 2+ per day; for food items and the following for beverages: rare or never, 1-3 per month, 1 per week, 2-4 per week, 5-6 per week, 1 per day, 2-3 per day, 4-5 per day, and 6+ per day. Serving size was recorded as small, medium, or large.

Project description

In this project, we identified traditional ethnic and Western diets and examined the association between these diets with risk of and risk factors for type 2 diabetes. We then investigated the relationship between the proglucagon SNP (rs6732914) with glycemic traits and type 2 diabetes, considering the interaction between diet and the proglucagon SNP with these outcomes.

In Chapter 2, we present a qualitative study that identified indicator foods comprised of a traditional Mexican, Chinese, and African-American diets. Focus groups, consisting of each ethnic group (Mexican, Chinese, and African Americans), were conducted in Washington State to determine which items on the MESA FFQ were indicators of each respective traditional ethnic diet and a Western diet. This chapter also presents insight on socioeconomic factors which may have influenced diets in the past.

Chapter 3 describes a study that investigated adherence to traditional Mexican, Chinese, and African-American diets in association with incident and prevalent type 2 diabetes and its risk factors among participants of MESA. Adherence to a traditional diet was determined by frequency of consumption of indicator foods, identified for each ethnic diet in Chapter 2, and tested in the association with each of the following outcomes: body mass index, A1c, fasting glucose, fasting insulin, and presence and incidence of type 2 diabetes. Consumption of a Western diet, using Western indicator foods identified in Chapter 2, was also investigated with these outcomes.

In the last two chapters, Chapter 4 and 5, we explored the risk of type 2 diabetes and glycemic traits with the Proglucagon gene. The study of the Proglucagon SNP rs6732914 association with incident and prevalent type 2 diabetes and its risk factors among MESA participants is illustrated in Chapter 4. We tested the association by ethnicity with each of the following: body mass index, A1c, fasting glucose, fasting insulin, and presence and incidence of type 2 diabetes. In Chapter 5, an overall conclusion of the studies in this dissertation is presented. Results of the interaction between Proglucagon SNP rs6732914 and adherence to traditional ethnic diet with risk and risk factors for type 2 diabetes among MESA are discussed.

Chapter 2: Indicator Foods Related to Traditional Ethnic and Western Dietary Patterns in Mexican, Chinese, and African Americans: A Qualitative Study of Focus Groups

ABSTRACT

Introduction: The most prevalent chronic diseases disproportionately affect United States (US) minority ethnic populations with rates higher in the US compared to those in their home countries. Dietary recommendations for prevention and management of chronic diseases are usually different than traditional ethnic diets. With global dietary patterns becoming more Westernized, studies are needed to investigate the effects of traditional ethnic diets on health outcomes. The objective of this study was to identify key foods which define traditional Mexican, Chinese, and African American diets.

Methods: We conducted a total of seven focus groups among Mexican, Chinese, and African Americans in Washington State from June to August 2011 in adults age 20 – 85.

Results: Traditional Chinese, Mexican, and African America diets were fairly healthy by recent dietary guidelines and tended to exclude highly processed ingredients. The principal indicator foods of a traditional Chinese diet were congee, rice, soup, noodles, vegetables, fruit, tea, stir-fry, stew, and soy milk. Important indicator foods of traditional Mexican diet were tortillas, rice, beans, soup, stew, chicken, vegetables, fruit, salsa, and coffee. The major key foods of a traditional African American diet included greens, soup, fruit, vegetables, chicken, stew, rice, potato/sweet potato, cornbread/biscuits, and coffee. Different from traditional diets, a Western dietary pattern was perceived to include consumption of pizza, soda, hamburger, burritos, cheese, chips, beef, and bread.

Conclusion: There were many similarities between these traditional diets across ethnicities. Socioeconomic factors often influenced dietary habits over the years. Future dietary health studies or health promotion programs in these populations should consider these indicator foods and factors in the development of their dietary components.

INTRODUCTION

Many chronic diseases, such as diabetes, hypertension, and cardiovascular disease; disproportionately affect minority ethnic populations compared to European Americans [1,57-59]. Acculturation toward a Westernized lifestyle, including diet, has been a main focus for explaining these health disparities [60-62]. As individuals become more acculturated toward the Westernized lifestyle, the less healthy their diet becomes, usually characterized as a greater percent of energy coming from fat and less from fruit and vegetable consumption [42,46-48]. However, there are numerous aspects of a Western diet that may contribute to increased risk of chronic diseases.

Although traditional ethnic diets have not been widely researched, the Mediterranean diet has been reported to be associated with a decrease in cardiovascular risk as well as its risk factors [63,64]. In dietary association studies, dietary patterns and their effects are difficult to reproduce in different ethnic populations and therefore may not be generalizable [65,66]. Interventions in minority ethnic populations have primarily consisted of "healthy" dietary recommendations in US or Western terms, which often require great changes from traditional diets. As a result, it may be difficult for minorities to attain long term adherence to these diets. This may be one reason that ethnicity appears as a strong effect modifier when comparing associations between a "healthy" dietary pattern with type 2 diabetes [67].

Investigation of associations between diet and chronic disease are not new. However, there are very few examining the effects of traditional ethnic diets or the impact of modifying food intake from traditional diets on chronic diseases in high-risk ethnic minority populations. Identification of ethnically traditional diets is first needed before examining their effects on health outcomes. In this study, we conducted seven focus groups to identify traditional Mexican, Chinese, and African American diets as well as food items comprising a Western diet. The objectives of this study were to identify the key foods which comprise a traditional ethnic diet in three US ethnic minority groups, as well as the indicator foods of a Western diet.

METHODS

Participants and location

We conducted a total of seven focus groups among Mexican, Chinese, and African Americans in Washington State from June to August 2011. All participants classified themselves as Mexican, Chinese, or African American ethnicity and were either born and raised in Mexico or China, or could remember traditional diets eaten in their households prior to the prominence of fast foods and the emergence of a western diet. Each focus group was recorded on a digital audio recorder, transcribed, and translated into English if needed.

Participants for the two focus groups identifying a traditional Mexican diet were recruited from Comunidad a Comunidad (Community to Community Development), Cocinas Sanas (Healthy Kitchens) Program which focuses on good nutrition among Latino farm worker families. Cocina Sanas staff recruited participants in their program. Focus groups took place at the Bellingham Food Co-op and were led by a bilingual focus group facilitator. Both groups were conducted in Spanish.

Three focus groups were conducted to ascertain a traditional Chinese diet. Participants from the first group were from the Seattle Formosan Christian Church. This focus group consisted of young adults who were available in the evening on a weekday from the College Fellowship. These participants were primarily from Taiwan, representing Chinese immigrants in Seattle who arrived to the US at a young age, and the discussion was facilitated in English. Two focus groups, one in Mandarin and the other in Cantonese, were carried out at the Seattle Parks and Recreation, International District/Chinatown Community Centers by members of the Senior Games program. These participants were senior citizens who arrived to the US as adults and had very limited English fluency. A volunteer and member of the Senior Games program recruited participants from various regions in China (North, South, rural, and urban). These focus groups were led simultaneously in different rooms by facilitators fluent in their respective native language.

For the traditional African American diet focus groups, members were recruited from the Central Area Senior Center Diabetes Awareness Education Workshop in Seattle. The Central Area Senior Center provides resources in physical, emotional, educational, and spiritual areas in a multicultural environment. Participants of the focus groups consisted of all the members attending the Diabetes Awareness Education Workshop on the day the focus group was scheduled.

Focus group sessions

Each discussion lasted between 1 ½ to 2 hours and a $20 incentive as well as beverages and healthy snacks were provided to each participant. Participants were asked to talk about foods in their traditional diet with a focus on their food intake while growing up or before coming to the United States. These foods include a typical breakfast, snack, lunch, dinner, beverages, and desserts. We also asked about food preparation and types of fats traditionally used. We put emphasis on foods that were eaten regularly, such as two to three times a week or at least weekly. The diets captured in these focus groups reflected what was eaten regularly on a day-to-day basis and was not to include foods consumed only for special occasions like celebration or parties. We also asked them to name foods that were not part of their traditional diet and those that they associated with the term 'Western diet'. In the second part of the focus group, we reviewed a list of food items from the MESA food frequency questionnaire (FFQ). Then we asked the participants to identify the ones that were an important part of their traditional diet, eaten at least 1 to 3 times per week.

Indicator foods

One person (C.I.M.) reviewed all transcripts and classified all foods mentioned into one of the following categories: breakfast, lunch, dinner, vegetables, meats, snacks, beverages, other, and fats and oils. Within each category, food items were categorized as being either traditional or Western (changes in diet away from traditional), depending on content of the discussion. Since frequency of consumption of food items mentioned was captured, a special note was made for those items consumed 2 – 3 times per week or more. An overview of the entire traditional diet was reviewed and indicator foods, based on frequency of consumption, were identified to define each traditional ethnic diet and a Western dietary pattern.

RESULTS

A total of 48 participants took part in the seven focus groups including 23 Chinese, 10 Mexican, and 15 African American participants (Table 2.1). All but one participant in the first Chinese diet focus group were born and raised in Taiwan. Ages ranged from 21 to 58 years old with a median time in the US of 14 years. The two Chinese diet groups from the Senior Games program (groups 2 and 3) had an age range of 60 to 83 years old. Fourteen of these participants were born in various regions of mainland China and two were from Taiwan, with 11 median years in the US. From the Mexican diet focus groups, seven of the ten participants were born and raised in Mexico. Ages ranged from 20 to 80 years old and among those born in Mexico the median years in the US was 11 years. The African American diet focus groups consisted of seven participants from the South, six from the Northwest, and two from other regions of the US. Thirteen of the fifteen African American participants were members of the Central Area Senior Center and ranged in age from 57 to 85 years old. Two had a younger generation relative present who helped provide information on dietary changes from one generation to the next contributing definition of a Western diet.

Table 2.1 Number of Mexican, Chinese, and African American participants, age range, and language for each focus group in Washington State (Summer 2011).

	Mexican (n=10)			**Chinese (n=23)**			**African American (n=15)**		
	N	**Age range**	**Language**	**N**	**Age range**	**Language**	**N**	**Age range**	**Language**
Group 1	6	20-80	Spanish	7	21-58	English	9	57-84	English
Group 2	4	39-43	Spanish	8	60-72	Mandarin	6	31-85	English
Group 3				8	64-83	Cantonese			

Traditional Mexican Diet

Traditionally, a Mexican diet consists of two light meals and one heavy meal. The big meal of the day is at lunch time. However, it was clear that there was not a set schedule for the meals; people only ate when they were hungry. For one participant who was raised in a very poor town, only two meals were consumed in a day, in the morning and in the afternoon. Although flour tortillas have been around for about five hundred years, they were considered a recent food compared to corn tortillas which have been around since 10,000 BC [68]. Traditionally, corn tortillas are consumed throughout all of Mexico whereas flour tortillas are more commonly found in northern Mexico and southwestern US regions. In the focus groups, the participants referred to the corn tortilla as the staple traditionally eaten in their homes back in Mexico. In general, they did not begin consuming flour tortillas until relocating to the US.

The overall traditional Mexican diet began with breakfast usually consisting of beans with tortillas or a piece of plain bread (sliced, bolillo (oval shaped crusty roll), or Mexican sweet bread) and coffee. Some participants remembered their mothers occasionally making homemade bread. Bolillos were very affordable and would be eaten about two to three times per week.

> *Bolillos were eaten naturally…you do not use butter or margarine…Not like here, people put mayonnaise, jam, cream cheese, none of that was used.*

Although sometimes there were eggs, beans and tortillas were eaten more often. Cold and cooked cereals were also consumed regularly. The main cold cereal mentioned was Corn Flakes. The hot cereals, especially oatmeal, were traditionally prepared more watered down than what is found in the US and served as a thick drink. Meat was usually not consumed for breakfast. Homemade yogurts were also eaten; many participants remember a jar kept in the kitchen where yogurt was made from milk or water. This was eaten about once or twice a week, usually for breakfast. Another traditional dish mentioned was chilaquiles, which was made about once a week using the leftover tortillas. Breakfast was meant to be light so the portions were usually small.

Lunch was the main meal of the day and there were two main types. Sometimes it consisted of a fideo soup (tomato based thin noodle soup) as an appetizer followed by rice, beans, corn tortillas, and a meat dish. The most common meat dish was usually some type of stew with vegetables. Stews were eaten about three times per week. With this type of lunch, fideo soups were almost always made.

> *[Fideo soups] were eaten before the meal (lunch). That way if the kids did not eat their food, they would eat these soups which have vegetables, garlic, onions, and tomatoes. Then you know that they have gotten their nutrients.*

Another very typical lunch included Mexican style soups (meat and many vegetables in a broth) served with corn tortillas, rice, and raw vegetables for toppings. Mexican style soups were eaten two to three times per week. Cream soups were not part of traditional Mexican diets. In conjunction with the foods eaten for lunch and sometimes breakfast, homemade salsa and/or chilies were eaten practically daily. Traditionally, salsa was homemade and had the best taste when made in a molcajete (traditional Mexican stone mortar and pestle tool).

The dinner or evening meal was very light. This meal consisted of a hot drink like coffee, Mexican hot chocolate, atole (corn flour based hot drink), or tea (mainly cinnamon and mint); with some type of food item including: bread (Mexican sweet bread or bolillo), a corn on the cob, or a quesadilla. Mexican sweet bread was eaten about twice a week for breakfast or dinner.

The consensus from both Mexican diet focus groups was that "snacks" did not exist. Normally, everyone waited for the meal; bilingual participants could not find the Mexican Spanish word for "snacks". Although not considered a snack by the participants, fruit was mentioned as a food that could be eaten at any time of the day.

> *Sometimes a fruit after eating…Fruits could be found like vegetables, they were plenty and cheap… Every day you ate fruit, sometimes watermelon or apples or oranges or whichever fruit that was there…It was very easy to eat fruit in Mexico because here you are always running around that you want foods that are fast and it is difficult to eat fruit…It is also very expensive to eat fruit here (meaning US)…the bad thing about here*

> *All fruits were eaten fresh, never canned.*
> *We ate nuts but it was because those trees were next to where we lived. We ate nuts practically daily.*

Although vegetables were used in almost all main dishes, vegetables as a side dish were not very common in Mexico. Vegetables were used in the main dishes to help stretch the foods and many participants mentioned eating the vegetables from their gardens. However, beans were frequently eaten by themselves and not in a mixed dish. Beans were eaten at least three times per week as a soup, accompanied with rice, or refried. However, refried beans were not consumed as frequently as boiled beans.

> *We would make boiled beans and then after a few days of eating the beans we would refry what was left with lard.*

Although potatoes and sweet potatoes were both consumed, potatoes were consumed more than sweet potatoes because they were used in many traditional dishes. In the traditional Mexican diet, all vegetables were usually eaten naturally without any additional toppings.

> *Potatoes were mainly used for soups but not with butter or oil…We also ate a lot more sweet potato than we eat here (US).*

> *We do not put anything on top of potatoes and vegetables, these are eaten naturally.*

Chicken was the most common source of animal protein. Although organ meats were eaten, including tripe and stomach, they were eaten about once a month. Frequency of fish consumption depended on whether the family fished. On average, fish was eaten weekly or twice a month.

> *We did not eat much meat [beef] (the term meat in Spanish can be considered beef)…to buy meat was too expensive so we ate a lot of chicken…[If there was meat] we would eat tomato and a lot of vegetables with the meat, like stews because that way we could make enough food for eight people.*

> *In my house, there is not much meat. We ate chicken.*

> *Rice every day, beans, potatoes but meat is not like it is here (US). More chicken.*
> *Meat was mainly used in stews or in soups*

However, in villages that were very poor with no refrigeration, the structure of the meals was different. Participant described that a pot of Mexican style soup, beans or stew was made in the morning along with rice which became the food for the day. There were two main meals in which this dish was eaten. There were not many dairy products or eggs used due to lack of refrigeration. Nonetheless, the same foods were still eaten at high frequency; rice, beans, soups, and stews. Furthermore, the same types of hot drinks were also consumed.

Common beverages consumed on a daily basis included: aguas frescas (homemade drinks made usually from fresh fruit and sweetened according to the ripeness of the fruits; however these drinks can be made from rice as well as Jamaica flower), homemade lemonade, tea (mainly cinnamon and mint), whole milk (three to four times per week, not daily), Mexican hot chocolate, and coffee (daily). Desserts were not a regular food item. They were made every now and then in the home and most common desserts made in the home were capirotada (Mexican style bread pudding) and arroz con leche (Mexican rice pudding). Most participants remembered having desserts on rare occasions.

Traditionally, Mexican foods were commonly prepared using vegetable oil, corn oil, vegetable shortening, and pig lard.

> *Lard was used but not every day, only when there was any left over from cooking bacon or other meats.*

Derived from the overall traditional diet described, the top ten key foods (based on frequency of consumption) of a traditional Mexican diet were tortilla, rice, beans, soup, stew, chicken, vegetables, fruit, salsa, and coffee (Table 2.2).

Traditional Chinese Diet

Although there is a great variety of dietary difference throughout China, we attempted to identify an overall Chinese diet while highlighting these differences. Major differences found were diets based on Northern and Southern regions as well as in urban and rural settings. The biggest difference between the Northern and Southern Chinese diets were the consumption of rice versus noodles.

> *When it comes to traditional food, Northern Chinese people tend to like to eat noodles, and not the Southern Chinese people. So, in China, traditional food to the Northerners is more wheat based, and traditional food for the Southerners is more rice based.*

> *The main staples in Northern China are steamed buns, congee, and noodles…Rice is scarce*

> *Unlike the North, in the South, we do not make our noodles. They grow the wheat themselves. If we want noodles, we have to go out and buy it. It feels cheaper that way. When we were celebrating our birthdays, we would eat noodles. When we celebrated New Years, we would eat dumplings. Otherwise, normally speaking, we would always eat rice.*

Northerners like to drink green tea. Southerners like to drink black tea... Northerners eat noodles [for dinner]... [and we only] eat rice a couple of times a month.

In Shanghai, we eat these noodle based foods one to two times every week at most…we eat rice more.

Canton (Southern region of China) eats rice and boils soup every day… Cantonese people are most adept at making soup. It is very diverse

It is also worth noting that rice mentioned in these discussions was always in reference to steamed white rice.

We go to the restaurant for [fried rice] because we don't know how to make it…We rarely fry rice on our own.

Urban regions were identified as places where there was greater variety of food and dimsum (wide variety of individual portion food items served with tea; also referred to as *yum cha* meaning tea tasting) was eaten more regularly. Participants stated that dimsum could be eaten almost daily for breakfast or lunch, depending on its availability and one's financial situation.

For the elderly, if their finances allow, they may eat dimsum and drink tea. [For lunch], it could be two dimsum dishes and one pot of tea.

Working people don't have the option to dimsum

Similar to the other traditional diets described, economical influence was a recurring theme.

Places like Shanghai and Taiwan are considered the rather well off regions. Many of the villagers in China were very poor, and even for us things have become very different from 30 – 40 years ago…After the reformation and opening of China, things became easier to get a hold of…[Before the reformation] we had the fortune of eating rice. Other people seldom ate it. It was only during New Year's celebration that these places would get to eat meat.

There was nothing to eat in the 60s and 70s…We rarely ate meat. We made soup out of it but we didn't eat it (because it was used for the soup base).We occasionally steamed it.

Some eat yam as their main staple or eat yam instead of eating noodles. If you are in the village area especially, these are their main staple.

Regardless of regional differences, congee (a type of rice porridge) was identified as a traditional dish for breakfast or lunch. Although participants from Southern China (Canton) region ate congee daily for breakfast, people from the city expressed less frequency of consumption. Congee is usually cooked with something inside and served with pickled vegetables on the side. Other traditional breakfast items mentioned included: Chinese pancakes (made with eggs and vegetables), yogurt (after reformation and usually homemade consumed plain/unsweetened), deep-fried Chinese donuts with soymilk and egg, noodles (meaning noodle soup), soup (such as Chinese coriander soup). It was also noted that some people might eat leftovers for breakfast.

> *Yogurt is a modern thing. It is after the China's reformation and opening to outside world that it was introduced [to China]. When I was a kid it was milk and milk powder, but there was no yogurt.*

A typical lunch commonly eaten would consist of: noodles in plain soup; cold noodles dressed in a sauce with vegetables, egg, and shredded meat; stir fry vegetables with meat and rice or noodles; congee with meat and vegetables; or wonton soup. Rice and noodles were not eaten together; it was either one or the other.

> *Wonton with soup [by itself] already has things like meat and vegetables. So you don't need to add other things.*

> *Generally speaking, the people who work will probably stir-fry only one dish for lunch…at most they stir fry one vegetable dish [and] the meat dish is usually a leftover dish. Vegetables should be eaten.*

> *[For people who work], we do not go home. We have continuous shifts…What we eat for lunch are cold dishes…buy from a food court…or eat out.*

Dinner was identified as being very similar to lunch, but with a greater quantity of food prepared. It was considered the largest meal of the day.

> *[Compared to lunch] dinner is a bigger thing because during the day everyone is at work but for dinner everyone comes back home. You have the whole family. Usually one big meat dish and two/three vegetable dishes and rice or maybe noodles.*

> *Dinner and lunch are not much different. Ingredients are about the same…more dishes for dinner…the only difference is that the family is together during dinner.*

> *[For rice as main staple, dinner] consists of one to three vegetable dishes (depending on family size), one meat dish, and soup broth accompanied by rice.*

> *[For steamed buns as main staple, dinner] includes congee, a meat dish and two vegetables (these are usually stir-fried)…vegetables and meat can be cooked together or separately and steamed buns.*

Stews were also eaten often and a large quantity was prepared and saved for consecutive meals. Soups were also an essential part of the diet and were consumed almost daily.

> *It is usually you have stew this week or you don't because it kind of last. So it is high quantities and you use it throughout the week.*

Soup I have every single day back home…usually the broth comes from pork or chicken and they usually make their own stock from the bones, no can or bottled stuff. Then there usually some type of vegetables, anything from carrots to melons to radish to a whole range of vegetables but the core of the soup is the broth.

We drink the broth and that is what is important because the broth is thought to have all the important nutrients of the vegetables and meat that we sometimes don't even eat the vegetables or meat. It is thought that they do not have any more nutrients in them.

The meats commonly used were chicken, duck, goose, pork, fish, and wide variety of seafood. Organ meats and sausages (not like US breakfast sausage but more like bratwurst) were also eaten. In certain regions, seafood was eaten at high frequency due to affordability.

We eat a lot of fish, even fried fish, but never breaded. We do not bread our seafood.

In China, fish is the cheapest…You can buy one fish for 50 cents and the fish will weigh at least half a kilogram.

In China, we mainly eat pork and fish…because pork and fish are produced a lot in China…and beef is expensive.

We eat gizzards and hearts. We eat a lot of these. Pig liver. We mainly use the organs from a pig…We do not eat organs from a cow…We eat stomach.

In the past we ate intestines. We ate pig stomach the most. Pig lungs as well…Pig heart, pig kidney…liver.

Due to the availability and affordability of traditional Chinese food vendors, a wide array of common snacks were mentioned including melon seeds, nuts (peanuts), pickled plums, jerky (squid, beef, or pork), dried bean curd, tofu flower (jellied bean curd), cotton candy, popcorn/kernel flakes (different from US type and sometimes used rice), corn, steamed bun, roasted sweet potato, and carrot pancake.

For snacks, some like corn, steamed bun, melon seeds, fruit, roasted sweet potatoes, roasted Chinese yam, carrot pancake, lotus, and hanzuo which is made of sticky rice and vegetables.

[In the city,] it is kind of interesting and a snack is kind of hard to define. The street car vending is very popular in Taiwanese food culture and these street car vendors sometimes they sell snacks. These so called snacks are like a meal but in a very small quantity. So it can go from dumplings to buns to meat on a stick or fried pork or chips or fried chicken even popcorn chicken. It sort of encompasses this food culture or sometimes what is called a night market.

In China, snacks were sold everywhere, and very convenient.

Snacks are pretty natural…made of melons/squash and have been kept in their original form without going through too much processing.

In the traditional Chinese diet, vegetables were a must and a wide variety of vegetables were eaten regularly. This traditional diet used many more types of vegetables than can be found in the US as well as beans and bean products. In large cities, like Taiwan, gardening was not possible because the population density was so high that most people lived in apartments or condos. However, the traditional markets had very fresh and affordable produce so that it was not difficult to obtain a wide variety of vegetables. Interestingly, in Chinese culture vegetables were almost always cooked and green salads were not part of the traditional diet.

> *Usually dishes have a huge variety of vegetables a lot more than you can find here [US]. A lot of times it would be rare that you would use only a few types all the time.*
>
> *Also the vegetables have to be eaten hot…In my country we think about pesticides and bacteria. It is not good to eat vegetables raw, they must be cooked. It is more healthy.*
>
> *You can eat [uncooked] cucumbers, tomatoes, carrots, turnip (daiko), Chinese parsley, and spinach…But normally, we do not eat the leafy kinds of vegetables.*
>
> *Not a lot of potato, just sweet potato…we put it sometimes in the congee…sometimes on the rice…or eat a whole one for a snack.*
>
> *Most people eat red bean, mung bean, black beans, and white peas. These four beans are eaten by people in general. We eat them often too. Besides these four, we also eat peanuts.*
>
> *We use a lot of bean products…like tofu and bean curd.*
>
> *Tofu is a traditional food…[eaten] at least two to three times a week*

Beverages were not consumed during the meals. It was more common to drink soup or tea after the meal and water or tea between meals if thirsty. Many participants cited drinking plain boiled water as the main form of drinking water. This was very different for them in the US when they found most beverages were cold. The teas mentioned as commonly consumed were: green, black, wintermelon, grass jelly tea, chrysanthemum tea, and herbal tea. Teas were traditionally consumed naturally, without sugar or milk.

> *We care more about the taste/quality of the tea leaves…You drink [tea] in place of water.*
>
> *We also drink a lot of water*
>
> *Well, now it is starting to change, but traditionally it is only tea and no coffee.*
>
> *Soymilk is usually drunk in the morning…as part of breakfast*

We didn't drink much milk as well. Our milk was normally made from milk powder. Kids and older folks drank it.

We seldom drink juice

Although fruit was not mentioned during the discussion of snacks, lunch, or dinner; it was cited as what is usually eaten to accompany the meals, sort of the dessert.

[For dinner] we usually eat rice then the dishes then drink the soup then eat some fruit in this order.

Well it is usually lunch then fruit and dinner then fruit.

We eat fruit every day and soup too.

It was stated that on a regular basis desserts were not eaten. However, one common dessert was Lotus with Osthanmus sweetened congee and was popular in Shanghai and among the young and elders. Chinese food preparation traditionally used pork lard. However, people now tend to use vegetable oils for stir frying vegetables and the fats from meats when stir frying meats. Nonetheless the most common oils used were: soybean oil, peanut oil, sesame oil, or other vegetable oils.

[For food preparation] we use soy sauce, rice wine, vinegar, sugar, sesame oil, and that is about it.

The top indicator foods for a traditional Chinese diet founded on the overview of the diet presented were: congee, rice, soup, noodles, vegetables, fruit, tea, stir fry, stew, and soy milk (Table 2.2).

Traditional African American Diet

A typical African American breakfast consisted of hot/cold cereals or eggs, toast, and some type of meat. Hot cereals (oatmeal, cream of wheat, corn meal, and grits) were mainly eaten during the winter months. The most common cold cereals were Corn Flakes and Wheaties. Hot and cold cereals were eaten about two to four times per week, otherwise it was an egg based breakfast. Two participants did specify that they would mainly eat leftovers from the previous dinner for breakfast. Also, if milk was consumed, it was always whole milk or powdered milk.

I could remember having corn meal mush and Corn Flakes…also there was bacon, eggs, sausage.

The hot cereals, I would have either oatmeal or cream of wheat. One or the other every day, if I wasn't eating Wheaties.

Eggs were a stable part of the diet. You wouldn't have breakfast without an egg…Everyday [an egg] and sausage or bacon.

When discussing foods usually eaten for lunch, one focus group listed items related to the financial situation of the times.

It depended on the economy. During the depression, we ate what we could eat. We ate frog legs.

Fatback, pork, lots of chicken, turkey, duck, goose, whatever, black birds. We hunted a lot for squirrel and rabbit.

When I was young, lunch was not a scheduled thing. It was what you get.

The other focus group described a typical lunch that they would take to school while growing up which seemed to be similar among this generation. A typical lunch consisted of a sandwich (peanut butter or tuna), carrots, milk, a fruit, maybe some goobers (peanuts). The limited funds were a recurring topic expressed as lunch was whatever was available and sometimes it would be a sugar sandwich. Also, items such as bread, corn bread, and biscuits were made from scratch and purchasing these was unusual due to the greater expense.

As we entered the topic of dinner, economical and urban/rural differences appeared, especially in reference to gardening.

For me living in the South, it was all about the garden. And most of the time the garden had butter beans, peas, snap peas, string beans, and stuff like that. And everyone was canning, everybody. Everybody had a cupboard or one of those rooms off the kitchen where they had the entire beginning of the winter was spent canning. At least a week was spent canning. You know tomatoes, beans, whatever else you could get in there. So soup was one of the main things you would have in the winter months. You would eat other things, but the main staple would be soup.

We also had a garden so we ate a lot of vegetables from the garden.

There were a lot of fresh vegetables. My favorite was greens, collard greens and mustard greens, more mustard greens than any other.

In contrast, the urban point of view focused on the regularity

Oh okay, well I grew up in New Orleans. So we did not have access to vegetable gardens and all of this…Growing up was a regular menu: red beans on Monday, stew or something like that on Tuesday, Cabbage Wednesday, Spaghetti dish Thursday, Fish Friday, Saturday was whatever was left maybe put together some sandwiches or something, and Sunday was chicken…I am not sure if it was traditional to have certain foods on certain days because you could go outside the household and everyone would be having the same thing. So there was not I will have dinner at so and so house because they were having the same thing.

Overall, many agreed that dinner included some type of meat, usually chicken, with rice and beans or potatoes. Sweet potatoes were also eaten regularly. There were a lot of vegetables with some type of greens every day, like mustard greens, cabbage, or spinach. Similar to the Mexican diet focus groups, most participants agreed that the vegetables and beans would stretch the meal. Spaghetti was also eaten at least once a week because of affordability.

> *Rice was a staple…we did not have it every day, but we would have a lot.*
>
> *…when you got tired of rice, my mom would get out the flour and whip up some chicken dumplings, especially if you had chicken for days.*
>
> *Potatoes were used a lot at least once a week*
>
> *[Potatoes] were one of those things that there were plenty of it and mother would always find a way to use it. She could go get a lot of potatoes for a little bit of money and she would use it. The same with rice [and the] same thing with beans.*
>
> *We ate a lot of beans, that's for sure.*
>
> *During the depression era, they had a program in welfare where they gave stuff called commodities. This was milk, beans, lots of beans, lima beans, red beans, and all these.*
>
> *Yes, we would eat vegetable soup and chicken soup…black beans, peas…[We would have soup] at least once a week if not more.*
>
> *When we used to have stews back then that was from the leftovers, that is why we had them often.*
>
> *Dinner basically consisted of lots of cabbage or different greens and corn bread.*

The meats most commonly consumed reflected their cost. Beef, especially steak, was rarely eaten. In addition to chicken, organ meats and certain pork cuts were also used because these would practically be given away at the butcher shops. Also, fishing was common and fish was consumed about once a week.

> *We did not eat a lot of steak but a lot of chicken…and organ meats like liver and kidneys…chittlings, gizzards…we ate brains…hog balls we would fry…chicken feet*
>
> *Part of the things when I was growing up, I used to check the meats and we would get whatever was left.*
>
> *Same thing with hog. Same thing with chicken feet, they would throw it away.*

The most common snacks were fruits and nuts. If any food items were eaten between meals, it would be fruits.

> *Well, there was so much fruit around. We would eat that and nuts. We had our own walnut trees, melons, watermelons, peanuts, goobers.*

Pretty much the same because if we did not have, we would raid other people's trees, apples, cherries, and pears.

Also, a lot of fruit. This was how we supplemented our diet when we were young and growing up as teenagers, we would raid our neighbors' fruit trees…All we had to worry about were the dogs, but those were the good old days.

Regular beverages were water, homemade lemonade, sun tea, whole milk, powder milk, with coffee stated as a staple. When oil or grease were needed, traditional foods were mainly prepared using Crisco, lard, and the can with the drippings from previously made foods.

Based on the overall traditional African American diet defined, the top ten indicator foods were: greens, soup, fruit, vegetables, chicken, stew, rice, potato/sweet potato, cornbread/biscuits, and coffee (Table 2.2). Because of frequency of consumption, greens were considered separately from all other vegetables. Since beans were not consumed as frequently as greens, they were included under vegetables.

Western Diet

All focus groups, regardless of ethnicity, identified similar themes defining a Western diet. The first major theme that appeared concerned fast foods and restaurant eating including pizza, hamburgers, and burritos (even among Mexican focus group).

Growing up, I never knew what a burrito was. There were no burritos in Mexico.(From Mexican diet focus group)

Although [hamburgers] were there when we were growing up, it was not eaten because you had to go to a café to get a hamburger. And if you went to a café, it was just a little bit too much. People weren't really going out like that…but now anyone could get a hamburger. (From African American diet focus group)

The second theme that emerged was the quantity of soda commonly consumed. Although soda was mentioned in the African American and the Mexican American diet focus groups as a drink during their childhood, it was not something that was consumed daily or when consumed it was one cup during one meal.

You couldn't buy a twelve pack of soda…Soda is consumed like water…they drink soda all day. (Combined quotes from African American and Mexican diet focus groups)

Another common concept was the quantity of cheese, bread, and meat (primarily beef) consumed regularly in the Western lifestyle. Although all focus groups mentioned traditional foods, which include these items, they did not remember eating as much as is consumed today. It was noted that many current dishes include lots of bread and cheese.

> *Cheese was used but not a lot like here (referring to US). It was used to sprinkle on top of foods or in quesadillas, so it was used three or four times per week but not in large quantities. (From Mexican diet focus group)*

> *We do not use butter or cheese. There is not much dairy products…There are no traditional dishes that use cheese. (From Chinese diet focus group)*

The last idea that materialized was the consumption of processed foods and junk food. Potato chips were mentioned in all the focus groups as well as the quantity and frequency of consumption. With all these themes in mind, we defined the Western diet pattern by the following key foods: pizza, soda, hamburger, burritos, cheese, chips, meat (beef), and bread (Table 2.2).

Table 2.2 Indicator foods (based on frequency of consumption) for traditional Mexican, Chinese, African American, and Western diet patterns from focus groups in Washington State (Summer 2011).

Mexican	Chinese	African American	Western
Tortilla	Congee	Greens	Pizza
Beans	Noodles	Potato/Sweet potato	Hamburger
Salsa	Soy milk	Cornbread/biscuit	Burritos
Chicken	Stir fry	Chicken	Meats
Rice	Rice	Rice	Bread
Soup	Soup	Soup	Chips
Stew	Stew	Stew	Cheese
Vegetables	Vegetables	Vegetables	Soda
Fruit	Fruit	Fruit	
Coffee	Tea	Coffee	

DISCUSSION

Overall, the traditional Chinese, Mexican, and African America diets were fairly healthy by recent US dietary guidelines and comprised of available natural ingredients. Meals were consumed at home, and cooked from scratch. The top ten key indicator foods of a traditional Chinese diet were congee, rice, soup, noodles, vegetables, fruit, tea, stir fry, stew, and soy milk. For a traditional Mexican diet, the top ten indicator foods were tortilla, rice, beans, soup, stew, chicken, vegetables, fruit, salsa, and coffee. In a traditional African American diet, the top ten key foods included: greens, soup, fruit, vegetables, chicken, stew, rice, potato/sweet potato, cornbread/biscuits, and coffee. After synthesizing the data from all focus groups to define a Western dietary pattern, the top key foods mentioned were pizza, soda, hamburger, burritos, cheese, chips, meat (beef), and bread.

Although these traditional diets were derived from different regions of the world, there were many similarities among them. All three traditional diets identified frequent consumption of fruits and vegetables. Even though they were prepared very differently, other common foods included rice, beans, and soups. One theme that appeared across all focus groups was the need to feed the entire family on limited financial resources. Most participants, regardless of ethnicity, came from large families and any method that would stretch the meal to feed everyone was used. Due to their availability and affordability, vegetables were the main items used in meals to achieve this goal.

While these traditional diets were comprised of many of the same natural ingredients, they became very distinct after preparation. The main difference that arose from the focus groups involved eating behaviors. In the traditional Mexican diet, lunch was identified as the largest meal of the day. Whereas, in a traditional African American and Chinese diets, lunch was what was available and dinner was the main meal. Another difference that emerged was the consistency of using fresh ingredients over time in the Mexican and Chinese diets. In contrast, the African American diet was highly influenced by government food resources provided during the Depression. Many of these participants recalled eating a lot of government cheese, especially in sandwiches, because it was free and it stretched the meals. Otherwise, cheese was not traditionally used because of the expense.

Cultural perceptions of the perceived effect of food on health influenced the traditional diets and appeared in the Chinese diet focus group. Traditional foods were discussed as having certain properties, such as: "cold" or "hot" along with their health benefits. It was believed that a balance is needed among these properties or certain foods should be consumed to address certain health conditions. The "cold" and "hot" properties are not in reference to temperature but more so the effect those foods have on the body. For example, on hot days, foods or herbs with "cooling" properties would be used in soups or teas. For this reason, the cooking methods changed according to the season. Although the other focus groups did not mention these food properties, this historical classification of foods has been observed in many countries [69].

There was also discussion in the Chinese diet focus groups about consuming certain foods for their medicinal properties. This may be due to the impact of traditional Chinese medicine and how it has been incorporated into their lifestyles. Some examples given by the participants were "stimulation of blood circulation by the lotus", "white tree fungus is good for the eyes", "woodear fungus reduces cholesterol levels and clears the blood vessels", and "pumpkin soup reduces sugar levels". These items would be used in soups or teas to address health conditions. As a result, among this ethnic group, diets changed due to health recommendations made here in the US. A few major changes mentioned included eating oatmeal as the main breakfast, eating fewer eggs, switching away from white rice and using more red rice, brown Jasmine rice, and red sticky rice, and using olive oil as the main oil. Traditional preparations of foods seemed to have also changed with increased steaming or blanching due to acknowledgements made about olive oil not being suitable for high temperature cooking. Based on the Chinese food culture, this population may be more likely to successfully adhere to dietary interventions.

Traditional Mexican and African American diets are usually perceived to be very unhealthy in the US. These misconceptions are most likely due to the commercialization of so called "Mexican" and "Southern" foods. However, we learned through these focus groups that traditional diets were not all deep-fried and loaded with cheese. For example, many foods that are commonly considered to be Mexican, such as nachos and burritos, are not traditional to Mexico. Traditional diets were well-balanced meals where the high caloric items were not eaten frequently or were consumed in moderation.

Traditional diets were greatly influenced by affordability and availability. Therefore, it is not surprising that the greatest changes away from a traditional diet in these populations are influenced by cost of indicator foods in a Western diet. However, the Western diet has also provided other conveniences including the conservation of time and quantity of food available. In all the traditional dietary patterns, foods were made from natural ingredients that require time to prepare and amounts were based on resources. As society has changed, the Western diet has subsequently met the challenges of affordability, availability, sufficient and minimal preparation time, and thus ethnic diets have also changed.

One limitation of this study is that all participants were recruited in Washington State and people of these ethnicities residing in other states may have a different definition of these traditional diets. Nonetheless, we attempted to limit this bias by focusing on diets from childhood or prior to migrating into the US. We recruited people who were born and raised in various regions of their home country to obtain a wide perspective. Another limitation may be recall bias and important indicator foods could have been missed. However, the group discussions seemed to have transferred participants back in time and place evoking strong memories. Many stories were shared about childhood experiences or how life was "back then" and this may have helped to reduce recall bias. It is also important to consider that commercialization of non-traditional foods or changes away from traditional food preparation may have begun to occur during or prior to the time during the participants' childhood. This was evident when discussions focused on traditional fats used for cooking. Although all focus groups stated that traditional methods used lard, they all mentioned vegetable oils which were not industrialized until the early 1900s. Another food item mentioned by the African American and Mexican American diets focus groups, which may not be historically traditional, was "Corn Flakes". Additionally, the participants in the African American diet focus groups had childhoods during or post-World War II; as a result their diets were influenced by government commodities. Ideally, we would want to interview people who were present 200 or 300 years ago, which is not possible. Nonetheless, even if certain non-traditional products or ingredients were already introduced to these diets, focus group participants recalled meals being prepared and consumed in the home. The one exception was with the traditional Chinese diet where food vendors in China have been part of the culture for centuries and purchasing prepared food outside the home was not considered unusual. However, the foods sold by these food vendors were prepared with natural ingredients without overly processed food items.

To our knowledge, this was the first study to identify indicator foods of traditional Mexican, Chinese, and African American diets for the purpose of dietary health studies. The results of this study provide insights on many similarities between these traditional ethnic diets as well as factors that influence dietary habits. Our findings suggest that societal structure, especially the economy, highly impacts the diets of these populations. Future intervention studies or health promotion programs in these populations may want to consider these indicator foods in the development of their dietary components to increase adherence to nutritional recommendations. The next step in our research is to apply these indicator foods to characterize the degree to which individuals follow a traditional diet versus a Western dietary pattern and evaluate their associations with risk of type 2 diabetes (Chapter 3).

Chapter 3: Traditional Ethnic Diet Association with Prevalence and Incidence of Type 2 Diabetes and Risk Factors: the Multi-Ethnic Study of Atherosclerosis

ABSTRACT

Background: Risk of type 2 diabetes differs based on ethnicity. Epidemiologic evidence suggests some of the responsibility may be due to dietary changes towards a Western diet.

Objectives: We hypothesize that adherence towards a traditional ethnic diet, measured by confirmatory factor analysis (CFA), in Chinese, Mexican, and African Americans would be associated with lower risk of type 2 diabetes and related glycemic traits. We also tested associations between the adherence towards a pre-specified Western dietary pattern and these outcomes focusing on risk differences between Chinese, Mexican, African, and European Americans.

Design: Using longitudinal data from 2,382 European Americans, 762 Chinese Americans, 1,433 African Americans, and 761 Mexican Americans in the Multi-Ethnic Study of Atherosclerosis (MESA), CFA was performed to calculate dietary adherence scores on 10 indicator foods of each traditional ethnic diet and 8 indicator foods of a Western diet. These factor scores were investigated for associations with body mass index (BMI), A1c, fasting glucose, fasting insulin, and relative risk and incidence of type 2 diabetes.

Results: We found that adherence to a Western diet was associated with greater BMI in Mexican Americans (β = 0.84, 95% CI = 0.15-1.53), African Americans (β = 0.89, 95% CI = 0.18-1.60), and European Americans (β = 0.67, 95% CI = 0.13-1.21). Western diet adherence was also associated with greater values of fasting insulin in African Americans (β = 0.89, 95% CI = 0.17-1.62) and a similar relationship was observed in European Americans (β = 0.84, 95% CI = -0.004-1.69). Traditional diet adherence was inversely associated with BMI (β = -0.40, 95% CI = -0.58 - -0.21) and fasting insulin (β = -0.32, 95% CI = -0.51 - -0.14) in African Americans.

Conclusion: In a multi-ethnic cohort study, diet acculturation was estimated and the associations with

BMI and glycemic traits were examined. Western diet adherence, consisting of common fast food items, was associated with greater BMI values. A traditional ethnic diet, comprised of greater consumption of fruit and vegetables as well as less processed foods, was associated with lower BMI and fasting insulin measures in African Americans. As many other associations were found to be null, confirmation of these results is needed.

INTRODUCTION

Rates of obesity and type 2 diabetes have escalated dramatically in the last few decades, especially among ethnic minority populations [3]. Recent studies have focused on acculturation towards a Westernized lifestyle as the main culprit for increased prevalence of obesity and of type 2 diabetes. Obesity was found to be significantly associated with duration of residency in the US, especially for immigrants arriving at a young age or persons born to immigrant parents [38-40]. Among the same gender, body mass index (BMI) has been reported to be 30% greater in those born in the US than those born in their countries of origin [41].

Similarly, acculturation defined by primary language spoken and number of years residing in the US has been associated with type 2 diabetes [46,51]. Dietary habit changes have also been documented in immigrants as they have become acculturated to a Westernized lifestyle [42-45]. A study reported that adherence to the DASH (Dietary Approach to Stop Hypertension) diet, a "healthy" but non-ethnically traditional diet, did not have the same benefit on the risk of type 2 diabetes among African Americans and Hispanics as was observed among non-Hispanic whites [52]. Although it was recognized that ethnic differences in dietary habits among East Asians was the most influential factor associated with differences in fasting serum insulin, deviation from a traditional diet among minorities in association with type 2 diabetes has not been thoroughly investigated [48,53]. Since the degree of acculturation towards a Westernized lifestyle often results in a more unhealthy diet, consisting of a greater percent of energy coming from fat and less from fruit and vegetable consumption [46-48], it is unclear if changes in traditional diet adherence are responsible for these health disparities. The Multi-Ethnic Study of

Atherosclerosis (MESA) provides a unique opportunity to investigate the associations between diet acculturation and obesity as well as type 2 diabetes in minority US populations.

The objective of this study was to evaluate associations between diet acculturation and risk of type 2 diabetes and related glycemic traits in three ethnicities of participants in MESA. Using indicator foods of traditional Chinese, Mexican and African Americans diets identified in Chapter 2, we developed adherence scores for traditional and Western diets in each ethnicity. We investigated the associations between adherence to these diets and fasting glucose, fasting insulin, A1c, and BMI in participants of the same ethnicity. We also considered change in fasting glucose and BMI as well as incidence of type 2 diabetes and ever diagnosed with type 2 diabetes.

METHODS

Study Setting and Participants

The Multi-Ethnic Study of Atherosclerosis (MESA) was described in greater detail in Chapter 1. Briefly, MESA is a multi-site cohort study designed to investigate risk factors that predict progression to clinical cardiovascular disease. A total of 6,814 participants were recruited in 2000 to 2001 with ages ranging from 45 to 84 years and who were Caucasian, Chinese-American, African-American, or Hispanic [56].

The MESA participants each received an extensive baseline exam which included measures of socio-demographic factors, lifestyle factors, psychosocial factors, and collection of blood samples. As a result, dietary (Food Frequency Questionnaire (FFQ)), anthropometric (body mass index), and laboratory (A1c, fasting insulin and fasting glucose) measurements were ascertained. Although blood samples were collected and physical exams were performed at every visit, the FFQ and fasting insulin were only measured at baseline and A1c was obtained only at visit 2.

The longitudinal study described here consisted of 5,338 participants enrolled in MESA after excluding individuals without a completed dietary assessment (n=577) and non-Mexican Americans in the Hispanic group (n=695). Participants using medications affecting fasting glucose, fasting insulin, or

A1c were excluded from the analyses with those outcomes (n=544). Residuals and leverage analysis were performed in the linear regression analysis for fasting glucose, fasting insulin and A1c to determine if transformation of these variables was necessary. Any observations with Cook's standard deviation greater than 5 and leverage greater than or equal to 0.2 were not included in those analyses which resulted in removing 0 to3 observations per regression analysis with a total of ten participants who were excluded.

Pre-defined Traditional Ethnic and Western Dietary Patterns

A complete description on defining traditional Mexican, Chinese, and African American dietary patterns as well as Western diet was presented in Chapter 2. Briefly, we conducted seven focus groups among Mexican, Chinese, and African Americans in Washington State. Food items from the FFQ which represented the indicator foods of a traditional Chinese diet are shown in Table 3.1. Important indicator foods and food items from FFQ used to characterize these indicator foods of traditional Mexican and African American diets are presented on Tables 3.2 and 3.3, respectively. The greatest differences from traditional diets to recent diet (Western dietary pattern) were consumption of pizza, soda, hamburger, burritos, cheese, chips, meat (beef), and bread; and food items in the FFQ denoting the Western diet are presented in Table 3.4.

Table 3.1 Traditional Chinese Diet indicator foods and food items from MESA Food Frequency Questionnaire used to capture Chinese dietary pattern

Indicator foods	Food items on FFQ
Congee	15. Other hot cereal (grits, cream of wheat, mush, congee)
Noodles	55. Oriental noodles with meat (saimen, ramen, wonton mein) 57. Chow mein
Soymilk	109. Soy milk
Stir fry	58. Stir-fried beef, pork or chicken with vegetables, including beef broccoli 59. Stir-fried shrimp or fish with vegetables 60. Stir-fried tofu or tempeh with vegetables 61. Stir-fried vegetables (no meat)
Rice	47. White, Mexican or sticky rice
Soup	33. Pea, lentil, black bean, potajes soups 34. Miso soup or sauce with soybean paste 35. Other soups including vegetable beef, tomato, egg drop, chicken noodle
Stew	79. Meat, chicken or turkey stew, pot pie or empanada 80. Fish stew or seafood gumbo, paella
Vegetables	37. Tossed salad with spinach, romaine or dark greens, cooked spinach, turnip greens, collards 38. Tomatoes (cooked or raw), tomato juice 39. Avocado, guacamole 40. Carrots 41. Broccoli, cabbage, cauliflower, brussel sprouts, sauerkraut, kimchee 42. Green beans, peas, snow peas 43. Corn, hominy 44. Winter squash, acorn squash 45. Pinto, black, baked, butter or red beans, pork and beans, black-eyed peas 46. Any other vegetables including summer squash, zucchini, asparagus, mixed vegetables 51. Boiled, baked, mashed or other potatoes, turnips 52. Sweet potatoes, yams
Fruit	1. Peaches, apricots, nectarines, plums 2. Cantaloupe, mango, papaya 3. Strawberries, blueberries, other berries 4. Apples, applesauce, pears 5. Banana, plantains 6. Oranges, grapefruit, tangerines, kiwi 7. Dried fruit including raisins, prunes, figs, apricots 8. Any other fruit (pineapple, persimmon, grapes, other melon, canned peaches, fruit cocktail, etc.
Tea	119. Herbal tea 120. Black or green tea

Table 3.2 Traditional Mexican Diet indicator foods and food items from MESA Food Frequency Questionnaire used to capture Mexican dietary pattern

Indicator foods	Food items on FFQ
Tortilla	73. Flour or corn tortilla on the side
Beans	45. Pinto, black, baked, butter or red beans, pork and beans, black-eyed peas
Salsa	72. Salsa
Chicken	87. Roasted, broiled, baked, or ground chicken or turkey 88. Fried chicken
Rice	47. White, Mexican or sticky rice
Soup	33. Pea, lentil, black bean, potajes soups 35. Other soups including vegetable beef, tomato, egg drop, chicken noodle
Stew	79. Meat, chicken or turkey stew, pot pie or empanada 80. Fish stew or seafood gumbo, paella
Vegetables	36. Tossed salad with iceberg or light green lettuce 37. Tossed salad with spinach, romaine or dark greens, cooked spinach, turnip greens, collards 38. Tomatoes (cooked or raw), tomato juice 39. Avocado, guacamole 40. Carrots 41. Broccoli, cabbage, cauliflower, brussel sprouts, sauerkraut, kimchee 42. Green beans, peas, snow peas 43. Corn, hominy 44. Winter squash, acorn squash 46. Any other vegetables including summer squash, zucchini, asparagus, mixed vegetables 51. Boiled, baked, mashed or other potatoes, turnips 52. Sweet potatoes, yams
Fruit	1. Peaches, apricots, nectarines, plums 2. Cantaloupe, mango, papaya 3. Strawberries, blueberries, other berries 4. Apples, applesauce, pears 5. Banana, plantains 6. Oranges, grapefruit, tangerines, kiwi 7. Dried fruit including raisins, prunes, figs, apricots 8. Any other fruit (pineapple, persimmon, grapes, other melon, canned peaches, fruit cocktail, etc.
Coffee	118. Coffee (regular or decaffeinated) not including latte, café au lait

Table 3.3 Traditional African American Diet indicator foods and food items from MESA Food Frequency Questionnaire used to capture African American dietary pattern

Indicator foods	Food items on FFQ
Greens	37. Tossed salad with spinach, romaine or dark greens, cooked spinach, turnip greens, collards
Potato/Sweet potato	51. Boiled, baked, mashed or other potatoes, turnips 52. Sweet potatoes, yams
Cornbread/biscuit	20. Biscuits, other muffins, croissants, corn bread, hush puppies
Chicken	87. Roasted, broiled, baked, or ground chicken or turkey 88. Fried chicken
Rice	47. White, Mexican or sticky rice
Soup	33. Pea, lentil, black bean, potajes soups 35. Other soups including vegetable beef, tomato, egg drop, chicken noodle
Stew	79. Meat, chicken or turkey stew, pot pie or empanada 80. Fish stew or seafood gumbo, paella
Vegetables	36. Tossed salad with iceberg or light green lettuce 38. Tomatoes (cooked or raw), tomato juice 39. Avocado, guacamole 40. Carrots 41. Broccoli, cabbage, cauliflower, brussel sprouts, sauerkraut, kimchee 42. Green beans, peas, snow peas 43. Corn, hominy 44. Winter squash, acorn squash 45. Pinto, black, baked, butter or red beans, pork and beans, black-eyed peas 46. Any other vegetables including summer squash, zucchini, asparagus, mixed vegetables
Fruit	1. Peaches, apricots, nectarines, plums 2. Cantaloupe, mango, papaya 3. Strawberries, blueberries, other berries 4. Apples, applesauce, pears 5. Banana, plantains 6. Oranges, grapefruit, tangerines, kiwi 7. Dried fruit including raisins, prunes, figs, apricots 8. Any other fruit (pineapple, persimmon, grapes, other melon, canned peaches, fruit cocktail, etc.
Coffee	118. Coffee (regular or decaffeinated) not including latte, café au lait

Table 3.4 Western Diet indicator foods and food items from MESA Food Frequency Questionnaire used to capture the Western dietary pattern

Indicator foods	Food items on FFQ
Pizza	78. Pizza
Hamburger	83. Hamburger, cheeseburger, meat loaf, hash
Burritos	62. Burritos or quesadillas with no meat 63. Burritos, quesadillas or fajitas with meat, poultry or seafood
Meat	84. Beef, pork or lamb steaks, roasts, barbeque or ribs
Bread	17. White bread or rolls (hamburger buns, bagels, pita, English muffins, etc.)
Chips	23. Potato, corn or tortilla chips
Cheese	29. Cheddar, American, Chihuahua, Swiss, cream cheese, cheese spreads, other cheese
Soda	110. Coke, Pepsi, 7-up or other carbonated beverages (not diet) 112. Diet Coke, diet Pepsi, diet 7-up or other diet carbonated beverages

Since the degree of adherence toward traditional ethnic and Western diets was the focus of this study, the sum of frequency of consumption (per month) of the items measuring each indicator food was used in the confirmatory analysis. The values given to the frequency categories for food items were 0 (rare or never), 1 (1 per month), 2.5 (2-3 per month), 4 (1 per week), 8 (2 per week), 14 (3-4 per week), 22 (5-6 per week), 30 (1 per day), and 60 (2+ per day). Values given for beverages were 0 (rare or never), 2 (1-3 per month), 4 (1 per week), 12 (2-4 per week), 22 (5-6 per week), 30 (1 per day), 75 (2-3 per day), 135 (4-5 per day), and 180 (6+ per day). A large serving size score was calculated by summing the amount of times large serving size was marked for the food items included in the traditional diet as a measure of a Western behavior.

Confirmatory Factor Analysis (CFA)

CFA is a form of structural equation modeling, a statistical estimation method, and different than the statistical methods usually used for dietary pattern analysis, such as, Factor Analysis and Cluster Analysis. CFA allows calculation of latent variables, like our dietary adherence scores, from observed variables or, in this case, from the indicator foods. The dietary adherence scores were derived from simultaneous performing regression analysis of each indicator food associated with the dietary pattern. Each regression coefficient is equivalent to the factor loading of that indicator food which can then be used to estimate the factor score, adherence to that specific dietary pattern.

For each ethnicity except European Americans, we pre-defined 2 latent variables, traditional ethnic and Western dietary patterns. In European Americans, we only calculated a Western diet score. Covariance structures of the two groups of indicator foods chosen within each ethnicity were examined for convergence and discriminant validity. To estimate pre-defined factor structures, CFA was performed separately for each ethnicity using the SEM (structural equation modeling) command in STATA 12.1 (StataCorp, College Station, Tex). Two-factor measurement models were used allowing correlation between the traditional ethnic diet and Western diet while only permitting the assigned indicator foods to load to its assigned dietary pattern. In calculating factor loadings for each indicator food and factor scores, quasi-maximum likelihood option was used to relax normality assumption when estimating standard errors. All factor loadings were standardized by using model fitted variances as $(\sigma_{xy}/\sigma_x\sigma_y)$. Using the factor loadings, the traditional ethnic diet factors and Western diet factor were estimated and resulted in a continuous measure representing adherence to dietary pattern with normal distribution (mean = 0, SD = 1) or distributions skewed to the right.

Each dietary pattern was compared with non-dietary acculturation variables to validate this measure. For the Chinese and Mexican Americans, dietary scores were investigated with proportion of years residing in the US. Since most African American participants were born in the US, we used their age as form of acculturation with the assumption that the younger participants would have greater acculturation and more likely to follow a Westernized lifestyle. Associations between dietary scores and acculturation variables were tested using linear regression as well as assessing the associations graphically.

Association Analyses

The association between adherence towards traditional ethnic or Western diets and body mass index, A1c, fasting glucose, fasting insulin, prevalent and incident type 2 diabetes were investigated within each ethnicity separately. Multivariable linear regression models were used to investigate the cross sectional associations between the dietary factor scores and each baseline risk factor for type 2 diabetes (fasting glucose, fasting insulin, A1c (exam 2), and BMI). Participants using medications affecting fasting glucose, fasting insulin, and A1c levels were excluded from the analysis with those outcomes. Regression analysis right-censored on the use of diabetes medication were performed for fasting glucose, fasting insulin, and A1c outcomes as a sensitivity analysis. A general estimating equation (GEE) model with Gaussian error, identity link, and exchangeable correlation matrix was used to investigate the association between the two dietary patterns and longitudinal values (repeated measures) of fasting glucose and BMI. We used relative risk regression for the presence (prevalent and incident) and Cox proportional hazards regression for the incidence of type 2 diabetes. Calculations of rates for diabetes incidence used person-time as days between date of baseline clinic visit and the date of the clinic visit with the first occurrence of one of the following: reported use of any medication for diabetes (including either insulin or oral hypoglycemic agents [sulfonylureas, biguanides, alpha-glucosidase inhibitors, thiazolidinediones, and k-channel blockers to enhance insulin secretion]), reported diabetes diagnosis, had fasting glucose level ≥126 mg/dl , or last follow-up visit. Due to the relationship between fasting glucose and fasting insulin, all models with fasting insulin as the dependent variable considered diabetes status as a categorical variable classified as: normal (fasting glucose (FG) <100mg/dl), elevated fasting glucose (FG = 100 – 125 mg/dl), and type 2 diabetes (FG >125 mg/dl). Adjustments for the other covariates were performed in a five step hierarchical manner for all analyses. Models 1 were the unadjusted analysis and only included the factor score in the model. Models 2 included the factor and large serving size scores. The third model consisted of all dietary variables: factor score, large serving size score, and total caloric intake (kcal). Models 4 were adjusted for all dietary and demographic [age (years), gender, education (<high school/GED, completed high school/GED, some college, bachelor's degree, graduate or professional school), and immigration status (born in US or immigrated to US)] variables. Models 5 included all variables mentioned plus behavioral factors (total moderate and vigorous physical activity (MET-min/wk), alcohol use (never, former,

current), and smoking status (never, former, current)). Robust standard errors were used in all models. Significant results were denoted by p-values less than 0.05. All analysis was performed using STATA version 12.1 (StataCorp, College Station, Tex).

RESULTS

Across ethnic groups, the mean age (62 yrs old) and gender distribution were the same. However, there were some differences in baseline demographic and behavioral characteristics between ethnicities among MESA participants. A greater percent of European Americans had higher levels of education compared to Chinese, African, and Mexican Americans (Table 3.5). Among Mexican American, only about 30% were educated beyond High School. Ethnic differences were apparent for cigarette smoking status and alcohol use with Chinese Americans having the greatest percent of “Never” use of 75% and 55% respectively. European Americans had the greatest percent of “Current” alcohol use (71%).

Although diabetes status was similar between Chinese, African, and Mexican Americans; only 6% of European Americans had diabetes compared to the 13 – 20% among the other ethnicities. Similarly, European Americans had the lowest values of fasting glucose, fasting insulin, A1c, and blood pressure. BMI and total daily caloric intake were lowest among Chinese Americans who also reported the lowest levels of total moderate and vigorous physical activity.

Table 3.5a Baseline demographic and behavioral characteristics by ethnicity: MESA Classic

	European American		Chinese American		African American		Mexican American	
	2382		762		1433		761	
	N	%	N	%	N	%	N	%
Gender								
Female	1245	52.3	389	51.0	783	54.6	375	49.3
Male	1137	47.7	373	49.0	650	45.4	386	50.7
Education								
Less than High School/GED	113	4.7	190	24.9	162	11.3	366	48.1
Completed High School/GED	403	16.9	126	16.5	266	18.6	149	19.6
Some College	672	28.2	151	19.8	508	35.5	194	25.5
Bachelor's Degree	533	22.4	173	22.7	252	17.6	31	4.1
Graduate or Professional School	659	27.7	122	16.0	239	16.7	21	2.8
Cigarette smoking status								
Never	1072	45.0	573	75.2	650	45.4	395	51.9
Former	1048	44.0	147	19.3	521	36.4	275	36.1
Current	261	11.0	42	5.5	256	17.9	91	12.0
Alcohol use								
Never	218	9.2	415	54.5	250	17.4	191	25.1
Former	445	18.7	114	15.0	456	31.8	209	27.5
Current	1701	71.4	230	30.2	715	49.9	361	47.4
Diabetes status								
Normal	1968	82.6	527	69.2	976	68.1	482	63.3
IFG	264	11.1	129	16.9	211	14.7	122	16.0
Untreated Diabetes	43	1.8	23	3.0	44	3.1	29	3.8
Treated Diabetes	101	4.2	81	10.6	197	13.7	127	16.7
Diabetes meds								
No	2267	95.2	680	89.2	1228	85.7	619	81.3
Yes	115	4.8	82	10.8	205	14.3	142	18.7
Immigration status								
Born US	2224	93.4	26	3.4	1301	90.8	374	49.1
Immigrated to US	117	4.9	688	90.3	97	6.8	335	44.0

Table 3.5b Baseline demographic and behavioral characteristics by ethnicity: MESA Classic

	European American		Chinese American		African American		Mexican American	
	2382		762		1433		761	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age (years)	62.7	10.3	62.4	10.4	62.5	10.1	61.6	10.3
Years in US for immigrants	39.0	15.1	18.9	11.6	27.9	11.2	27.5	16.4
Proportion of years in US for immigrants	1.0	0.1	0.3	0.2	1.0	0.1	0.7	0.3
Fasting glucose calibrated (mg/dl)	91.3	21.9	99.2	28.7	99.5	31.3	106.0	40.8
Fasting insulin	9.1	5.6	9.6	12.6	11.5	29.0	12.3	13.1
Hemoglobin A1c	5.5	0.6	5.8	0.9	5.9	1.1	6.0	1.4
Systolic blood pressure (mmHg)	123.4	20.3	124.5	21.7	131.7	21.7	127.7	23.1
Diastolic blood pressure (mmHg)	70.1	9.8	71.9	10.4	74.5	10.3	71.0	10.4
Height (cm)	169.0	9.7	161.6	8.6	168.4	9.7	161.8	9.4
Weight (pounds)	175.2	37.0	138.5	24.5	187.2	37.5	172.7	33.6
Body mass index (kg/m^2)	27.8	5.1	24.0	3.3	30.0	5.8	29.9	5.2
Total daily Calories	1564.9	729.5	1167.5	572.2	1586.2	887.7	1704.9	881.0
Moderate/vigorous physical activity (MET-min/wk)	5736.0	5409.9	3731.9	3908.6	6522.2	6964.5	6395.5	6663.0
Total intentional exercise (MET-min/wk)	1710.3	2328.2	1124.1	1493.9	1750.0	2781.8	1326.9	2231.0
Western diet score	0.0004	0.5	-0.0004	0.4	0.004	0.6	0.01	0.7
Traditional Diet Score			0.001	1.6	-0.01	1.9	-0.02	9.7
Large serving size score			0.5	1.6	1.8	3.2	1.4	2.8

Table 3.6 Characteristics of untransformed values for indicator foods for Chinese, Mexican, African, and European Americans: MESA

Chinese Americans (N = 762)

	Frequency/month		
Food items	**Mean**	**SD**	**Maximum**
Chinese diet			
Congee	4.5	7.5	30
Noodles	8.4	8.4	61
Soymilk	7.2	15.6	180
Stir-fry	46.8	26.8	180
Rice	36.0	20.3	60
Soup	13.5	12.5	90
Stew	3.7	7.1	68
Vegetables	58.6	34.0	480
Fruit	56.4	38.3	287.5
Tea	31.4	43.6	315
Western diet			
Pizza	0.7	1.4	14
Hamburgers	0.7	1.8	30
Burritos	0.3	1.8	30
Meat	2.0	3.5	30
Bread	9.9	10.8	60
Chips	1.5	2.8	30
Cheese	1.0	3.4	30
Soda	11.2	29.5	270

Mexican Americans (N = 761)

	Frequency/month		
Food items	**Mean**	**SD**	**Maximum**
Mexican diet			
Tortilla	22.4	20.1	60
Beans	13.2	13.0	60
Salsa	9.4	13.4	60
Chicken	7.5	7.0	68
Rice	7.5	7.5	60
Soup	6.8	8.2	82
Stew	1.9	4.1	38
Vegetables	52.0	35.3	238
Fruit	57.7	43.7	330
Coffee	36.0	40.1	180
Western diet			
Pizza	1.4	2.1	30
Hamburgers	0.7	1.8	14
Burritos	4.8	6.2	44
Meat	3.0	4.6	60
Bread	10.5	13.3	60
Chips	3.4	6.1	60
Cheese	6.7	8.8	60
Soda	30.7	46.7	360

African Americans (N = 1433)

	Frequency/month		
Food items	**Mean**	**SD**	**Maximum**
Traditional diet			
Greens	4.7	6.8	60
Potato/Sweet potato	6.3	6.1	44
Cornbread/biscuit	4.2	6.3	60
Chicken	10.4	8.6	74
Rice	4.8	6.6	30
Soup	5.0	6.6	82
Stew	3.8	6.7	60
Vegetables	49.8	30.9	239
Fruit	62.2	48.5	420
Coffee	24.9	35.8	180
Western diet			
Pizza	1.4	2.3	30
Hamburgers	0.9	2.0	14
Burritos	0.6	2.3	36
Meat	3.6	4.9	60
Bread	11.1	15.2	60
Chips	3.7	6.0	60
Cheese	4.6	6.6	60
Soda	26.9	37.7	270

European American (N = 2382): MESA

	Frequency/month		
Food items	**Mean**	**SD**	**Maximum**
Western diet			
Pizza	1.9	2.1	22
Hamburgers	0.7	1.8	14
Burritos	1.0	2.0	30
Meat	4.1	4.5	30
Bread	14.7	15.9	60
Chips	3.6	6.1	60
Cheese	6.5	7.8	60
Soda	26.2	38.5	360

Among Chinese Americans, the most frequently consumed indicator foods were stir-fry dishes eaten a mean of 46.8 times per month (SD=26.8), rice (mean=36.0 times per month, SD=20.3), vegetables (mean=58.6 times per month, SD=34.0), fruits (mean=56.4 times per month, SD=38.3), and tea (mean=31.4 times per month, SD=43.6) (Table 3.6). Although defined differently, the traditional diet indicator foods most frequently consumed in Mexican and African American participants were vegetables (mean range =49.8 – 52.0 times per month), fruit (mean range =57.7 – 62.2 times per month), and coffee (mean range =36.0 – 24.9 times per month). For all four ethnicities, the most frequently consumed Western diet indicator food was soda (regular and diet). However, the frequency of soda drinking in a month was more than double among Mexican, African, and European Americans (mean range =26.2 – 30.7 times per month) compared to Chinese Americans (mean=11.2 times per month). Overall, Chinese American participants did not frequently consume most of the Western diet indicator foods.

Correlation matrixes of all foods for each ethnicity are shown in Table 3.7. Among Chinese Americans, the indicator foods with the greatest correlation were vegetables with fruits, soup, and stir-fry (r^2 = 0.29 – 0.34). In Mexican Americans, frequency of consumption of tortillas, beans, and salsa had good correlation (r^2 = 0.28 – 0.49). Similar to the Chinese American participants, there was good correlation between vegetables and fruit frequency of consumption among Mexican (r^2 = 0.38) and African Americans (r^2 = 0.35). Also, frequency of consumption of vegetables was correlated with consumption of soups in African American participants (r^2 = 0.29). There were no strong correlations in frequency of consumption between the Western indicator foods in Chinese Americans or European Americans participants. The Western indicator foods frequency of consumption with the greatest correlation was pizza and meats (r^2 = 0.26) in Mexican American and pizza and hamburgers (r^2 = 0.21) in African Americans.

Results from the CFA are presented in Table 3.8. Overall, most of the indicator foods had standardized factor loading significantly different from zero (p-value<0.001). Traditional and Western diet factors had correlations of 0.19 (Chinese), 0.15 (Mexican), and 0.32 (African American). There was acceptable fit with coefficient of determination (COD) ranging from 0.80 – 0.87 for Chinese, Mexican and African American diet factor analysis. The COD was lower for the European American diet factor analysis (COD = 0.53). All factor analysis had standardized RMSR less than the 0.1 threshold for acceptable fit. Across all ethnicities, Western diet scores had means close to zero (SD = 0.4 – 0.7) (Table 3.5). For the traditional diet scores, the means were also close to zero and Mexican Americans had the greatest variation in this diet score (SD = 9.7 versus 1.6 and 1.9 in the other groups).

There were significant associations between the traditional diet scores and non-dietary acculturation variables (Figure 3.1). The traditional diet scores were negatively associated with proportion of years in the US among Chinese Americans (Regression coefficient (β) = -1.13, 95% Confidence Interval (CI)= -1.63 – -0.64) and Mexican Americans (β = -14.17, 95% CI = -16.09 – -12.26). In African Americans, younger participants were less likely to adhere to a traditional diet than older ones (β = 0.02, 95% CI = 0.009 – 0.029).

Table 3.7 Correlation matrix of food items (frequency per month) used in confirmatory factor analysis for Chinese, Mexican, European, and African Americans: MESA

Chinese Americans (N = 761)	Chinese food items										Western food items							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Chinese diet																		
1.Congee	1																	
2.Noodles	0.10	1																
3.Soymilk	0.00	0.02	1															
4.Stir-fry	0.09	0.21	0.04	1														
5.Rice	0.09	-0.05	-0.03	0.14	1													
6.Soup	0.18	0.05	0.00	0.27	0.13	1												
7.Stew	0.05	0.04	-0.02	0.08	-0.04	0.14	1											
8.Vegetables	0.20	0.15	0.07	0.29	-0.01	0.30	0.09	1										
9.Fruit	0.03	0.08	0.12	0.08	-0.08	0.05	0.04	0.34	1									
10.Tea	-0.03	0.01	-0.04	0.02	-0.01	0.06	0.06	-0.01	-0.06	1								
Western diet																		
11.Pizza	-0.01	0.16	-0.01	-0.03	-0.16	-0.03	0.07	0.04	0.04	0.06	1							
12.Hamburgers	0.01	0.14	0.00	-0.02	0.01	-0.03	0.10	-0.01	0.10	0.01	0.10	1						
13.Burritos	-0.03	0.04	-0.04	0.01	-0.03	-0.03	0.22	0.04	0.07	-0.05	0.06	0.07	1					
14.Meat	-0.05	-0.02	-0.05	-0.02	-0.04	0.03	0.11	-0.06	-0.01	0.01	0.14	0.04	0.10	1				
15.Bread	0.02	0.02	-0.01	0.00	0.06	0.09	0.01	0.10	0.11	0.02	0.02	0.04	0.00	0.05	1			
16.Chips	0.00	0.10	0.02	-0.01	-0.07	0.04	0.11	0.08	0.03	0.04	0.15	0.09	0.05	0.09	0.17	1		
17.Cheese	-0.01	0.09	0.00	-0.01	-0.09	0.07	0.02	0.06	0.02	-0.01	0.17	0.11	0.02	0.07	0.10	0.10	1	
18.Soda	-0.07	-0.01	-0.01	0.02	-0.01	0.02	0.10	0.01	-0.01	-0.04	0.04	0.10	0.08	0.04	-0.03	0.08	0.00	1

Mexican Americans (N = 753)	Mexican food items										Western food items							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Mexican diet																		
1.Tortilla	1																	
2.Beans	0.49	1																
3.Salsa	0.31	0.28	1															
4.Chicken	0.13	0.10	0.13	1														
5.Rice	0.18	0.25	0.12	0.11	1													
6.Soup	0.12	0.25	0.09	0.11	0.27	1												
7.Stew	-0.09	-0.04	-0.01	0.06	0.04	0.06	1											
8.Vegetables	0.13	0.28	0.12	0.18	0.27	0.19	0.09	1										
9.Fruit	0.07	0.13	0.00	0.09	0.16	0.16	0.04	0.38	1									
10.Tea	-0.08	-0.04	0.03	0.00	-0.03	-0.01	0.03	-0.01	-0.04	1								
Western diet																		
11.Pizza	-0.04	-0.13	0.01	0.03	0.00	-0.06	0.09	0.00	0.01	0.14	1							
12.Hamburgers	-0.03	-0.06	0.04	0.08	0.08	0.02	0.11	0.01	-0.04	0.04	0.15	1						
13.Burritos	0.16	0.12	0.18	0.16	0.16	0.13	0.10	0.11	0.07	0.02	0.14	0.11	1					
14.Meat	0.03	0.01	0.09	0.09	0.06	-0.04	0.23	0.04	0.03	0.17	0.26	0.17	0.13	1				
15.Bread	0.04	-0.03	0.06	-0.04	0.07	0.00	0.08	0.05	-0.01	0.05	0.18	0.15	0.07	0.23	1			
16.Chips	0.06	0.02	0.18	-0.04	0.10	-0.02	0.07	0.01	-0.01	0.11	0.17	0.11	0.14	0.20	0.14	1		
17.Cheese	0.25	0.32	0.08	0.07	0.15	0.10	-0.01	0.20	0.09	0.01	0.09	0.03	0.11	0.07	0.04	0.07	1	
18.Soda	0.10	-0.01	-0.01	-0.06	0.08	0.01	0.05	-0.09	-0.01	0.08	0.14	0.07	0.03	0.08	0.19	0.16	0.05	1

Table 3.7 (continues)

African Americans	Traditional food items										Western food items							
(N = 1375)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Traditional diet																		
1.Greens	1																	
2.Potato/ Sweet potato	0.07	1																
3.Cornbread/ biscuit	0.02	0.13	1															
4.Chicken	0.12	0.20	0.02	1														
5.Rice	-0.02	0.05	0.10	0.09	1													
6.Soup	0.12	0.20	0.17	0.08	0.10	1												
7.Stew	0.04	0.15	0.08	0.17	0.14	0.19	1											
8.Vegetables	0.33	0.20	0.07	0.19	0.16	0.29	0.05	1										
9.Fruit	0.09	0.12	0.03	0.00	0.01	0.15	0.01	0.35	1									
10.Tea	0.01	-0.05	0.05	0.06	0.04	0.00	0.02	0.02	-0.06	1								
Western diet																		
11.Pizza	0.05	0.11	0.04	0.14	0.00	0.13	0.10	0.06	-0.02	0.01	1							
12.Hamburgers	-0.01	0.07	0.08	0.06	-0.01	0.05	0.12	-0.07	-0.09	0.00	0.21	1						
13.Burritos	0.05	0.01	0.03	0.08	0.08	0.07	0.17	0.08	-0.04	0.01	0.12	0.06	1					
14.Meat	0.08	0.15	0.09	0.21	0.12	0.10	0.12	0.08	-0.05	0.09	0.10	0.15	0.05	1				
15.Bread	-0.03	0.09	0.25	0.08	0.13	0.04	0.02	-0.06	-0.09	0.08	0.05	0.16	-0.01	0.18	1			
16.Chips	0.08	0.06	0.11	0.09	0.06	0.09	0.06	0.05	-0.05	0.04	0.15	0.10	0.04	0.15	0.18	1		
17.Cheese	0.11	0.02	0.08	0.11	0.10	0.07	0.00	0.11	-0.01	0.08	0.12	0.07	0.03	0.20	0.19	0.18	1	
18.Soda	-0.01	0.03	0.07	0.11	0.06	0.01	0.05	0.00	-0.05	0.10	0.09	0.11	-0.01	0.13	0.15	0.15	0.12	1

European Americans	Western food items							
(N = 2344)	11	12	13	14	15	16	17	18
Western diet								
11.Pizza	1							
12.Hamburgers	0.13	1						
13.Burritos	0.16	0.14	1					
14.Meat	0.04	0.13	0.01	1				
15.Bread	0.11	0.13	0.02	0.08	1			
16.Chips	0.14	0.12	0.12	0.19	0.17	1		
17.Cheese	0.10	0.15	0.11	0.18	0.12	0.19	1	
18.Soda	0.17	0.12	0.07	0.06	0.13	0.14	0.06	1

Table 3.8 Standardized factor loading for confirmatory factor analysis for Chinese, Mexican, European, and African Americans: MESA

Chinese Americans (N = 761)

Food item	Chinese food factor	Western food factor
Chinese diet		
Congee	0.270	0
Noodles	0.249	0
Soymilk	0.098	0
Stir-fry	0.427	0
Rice	0.045	0
Soup	0.428	0
Stew	0.164	0
Vegetables	0.731	0
Fruit	0.368	0
Tea	0.007	0
Western diet		
Pizza	0	0.396
Hamburgers	0	0.259
Burritos	0	0.170
Meat	0	0.248
Bread	0	0.227
Chips	0	0.395
Cheese	0	0.337
Soda	0	0.134

Significantly different from zero P-value < 0.001
Correlation between factors was 0.19(P-value = 0.064)
Coefficient of determination = 0.802
Standardized root mean square residual = 0.049

Mexican Americans (N = 753)

Food item	Mexican food factor	Western food factor
Mexican diet		
Tortilla	0.579	
Beans	0.701	
Salsa	0.387	
Chicken	0.235	
Rice	0.416	
Soup	0.358	
Stew	0.004	
Vegetables	0.427	
Fruit	0.265	
Coffee	-0.051	
Western diet		
Pizza		0.459
Hamburgers		0.318
Burritos		0.295
Meat		0.505
Bread		0.407
Chips		0.400
Cheese		0.199
Soda		0.276

Significantly different from zero P-value < 0.001
Correlation between factors was 0.15(P-value = .112)
Coefficient of determination = 0.871
Standardized root mean square residual = 0.070

African Americans (N = 1375)

Food item	Traditional food factor	Western food factor
Traditional diet		
Greens	0.359	
Potato/Sweet potato	0.368	
Cornbread/biscuit	0.206	
Chicken	0.316	
Rice	0.216	
Soup	0.461	
Stew	0.229	
Vegetables	0.655	
Fruit	0.340	
Coffee	0.033	
Western diet		
Pizza		0.327
Hamburgers		0.317
Burritos		0.123
Meat		0.436
Bread		0.387
Chips		0.409
Cheese		0.427
Soda		0.305

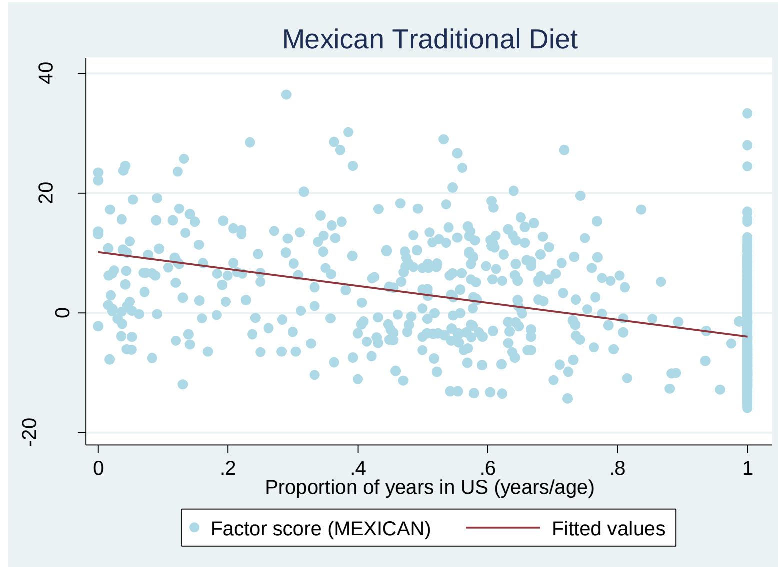
Significantly different from zero P-value < 0.001
Correlation between factors was 0.32(P-value = .017)
Coefficient of determination = .825
Standardized root mean square residual = .057

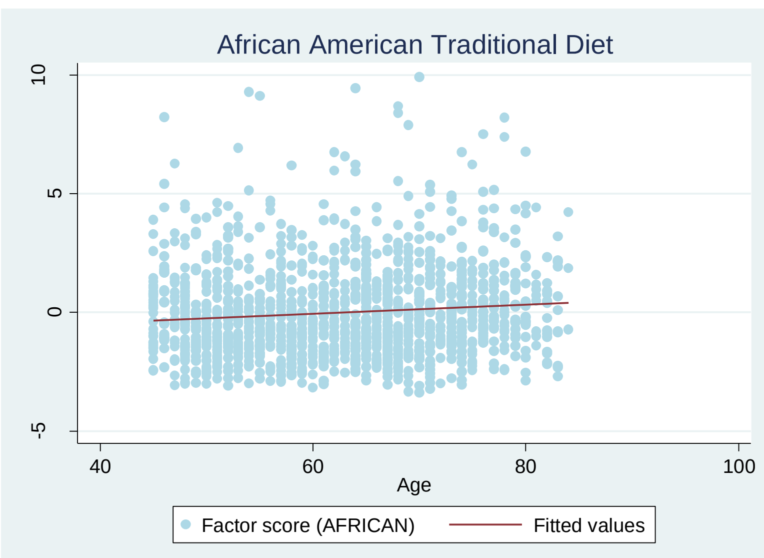
European American (N = 2344)

Food item	Western food factor
Western diet	
Pizza	0.339
Hamburgers	0.369
Burritos	0.264
Meat	0.302
Bread	0.319
Chips	0.464
Cheese	0.388
Soda	0.298

Significantly different from zero P-value < 0.001
Coefficient of determination = 0.529
Standardized root mean square residual = 0.030

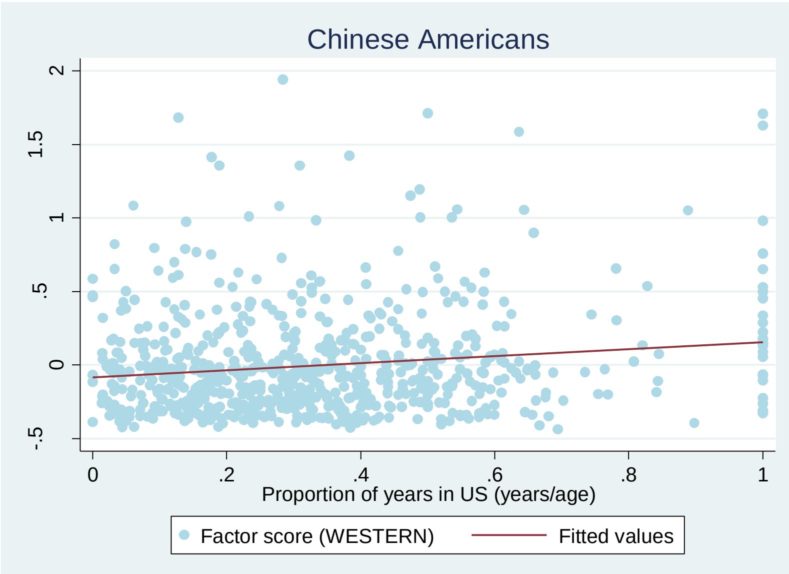
Figure 3.1 Scatter graphs with fitted line for traditional diet scores and acculturation (proportion of years in US or age) by ethnicity: MESA

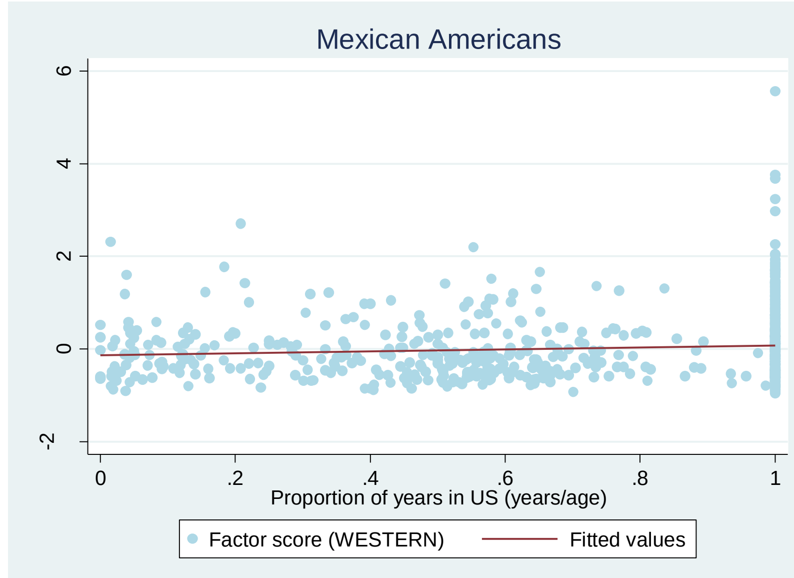


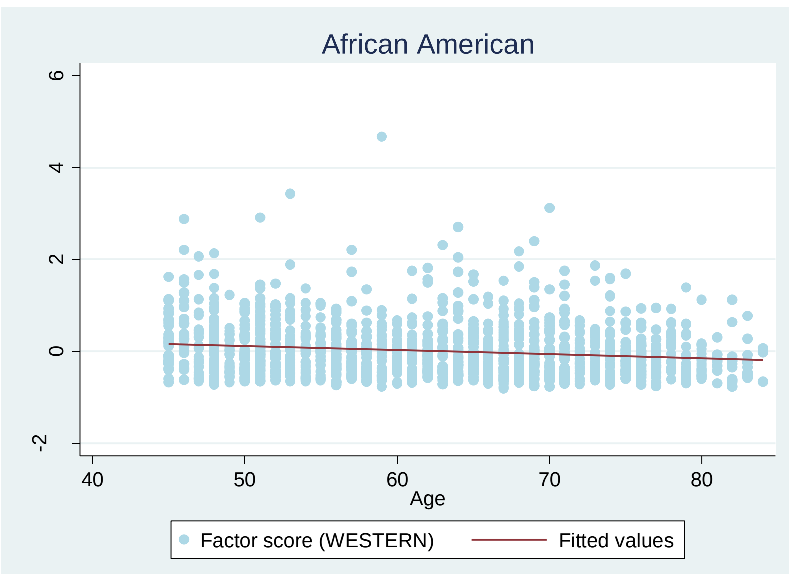


Traditional Diets	N	β	95% CI		P-value
Chinese Diet Score					
Proportion of years in US	713	-1.13	-1.63	-0.64	8.42E-06
Mexican Diet Score					
Proportion of years in US	709	-14.17	-16.09	-12.26	6.16E-42
African American Diet Score					
Age (years)	1433	0.02	0.009	0.029	1.91E-04

Figure 3.2 Scatter graphs with fitted line for Western diet scores and acculturation (proportion of years in US or age) by ethnicity: MESA







Western diet scores	N	β	95% CI		P-value
Chinese Americans					
Proportion of years in US	714	0.24	0.12	0.35	6.29E-05
Mexican Americans					
Proportion of years in US	709	0.21	0.05	0.38	0.012
African American					
Age (years)	1433	-0.01	-0.012	-0.006	2.32E-09

Association results

Among Chinese American participants, there was no significant association between traditional or Western diet adherence with baseline measures of BMI, hemoglobin A1c, fasting glucose, and fasting insulin (Table 3.9a). After adjusting for diet, demographic and behavioral confounders; BMI was significantly associated with Western diet adherence in Mexican Americans (β = 0.84, 95% CI = 0.15-1.53), African Americans (β = 0.89, 95% CI = 0.18-1.60), and European Americans (β = 0.67, 95% CI = 0.13-1.21). Western diet adherence was also associated with greater values of fasting insulin in African Americans (β = 0.89, 95% CI = 0.17-1.62) and similarly in European Americans (β = 0.84, 95% CI = -0.004-1.69). Traditional diet adherence was inversely associated with BMI (β = -0.40, 95% CI = -0.58 - -0.21) and fasting insulin (β = -0.32, 95% CI = -0.51 - -0.14) in African Americans. Although not statistically significant, fasting glucose coefficient estimates were positively associated with Western diet and negatively associated with a traditional diet in both Mexican and African Americans.

In the regression analysis right-censored on diabetes medication use, associations with A1c and fasting glucose were found in Mexican and African Americans (Table 3.9b). For African Americans, the associations of A1c and fasting glucose with the Western diet (β = 0.20, 95% CI = 0.04 – 0.36; β = 5.91, 95% CI = 1.16 – 10.66, respectively) were much greater than with the traditional diet (β = 0.052, 95% CI = 0.01 – 0.09; β = 1.29, 95% CI = 0.07 – 2.51, respectively). Although risk estimates were similar for A1c and fasting glucose in both Mexican and African Americans, these estimates were not significant in the full adjusted models for Mexican Americans.

In the longitudinal analysis between diet adherence, BMI and fasting glucose, there was a significant association between baseline traditional diet adherence and change in fasting glucose in Chinese Americans (full model, β for change = -0.20, 95% CI = -0.39 – -0.01, p-value for change = 0.037) (Table 3.10). No significant change in BMI or fasting glucose with diet adherence scores was observed among Mexican, African, and European Americans.

In the full models investigating relative risk and incidence of type 2 diabetes with traditional and Western adherence scores, type 2 diabetes incidence was significantly associated with Western diet score (Hazard Ratio (HR) = 0.14, 95% CI = 0.03 – 0.75) in Chinese Americans. In African Americans, the relative risk of type 2 diabetes was significantly associated with traditional diet adherence (Relative Risk (RR) = 1.06, 95% CI = 1.01 – 1.12) and Western adherence score (RR = 1.34, 95% CI = 1.07 – 1.69).

Table 3.9a Unadjusted and adjusted regression analysis results by ethnicity for Diet Adherence (Traditional and Western) and baseline BMI, A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

Chinese American	Body Mass Index					Hemoglobin A1c†					Fasting Glucose†					Fasting Insulin†‡				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Traditional Chinese diet	762	-0.10	-0.233	0.041	0.168	610	0.01	-0.027	0.050	0.552	678	0.47	-0.398	1.330	0.290	676	-0.03	-0.268	0.199	0.773
Western diet	762	0.05	-0.639	0.747	0.879	610	-0.003	-0.143	0.137	0.965	678	-0.05	-4.908	4.806	0.984	676	0.64	-0.753	2.024	0.369
Model 2*																				
Traditional Chinese diet	762	-0.12	-0.256	0.016	0.084	610	0.01	-0.029	0.048	0.625	678	0.28	-0.525	1.086	0.494	676	-0.05	-0.277	0.185	0.697
Western diet	762	-0.01	-0.694	0.682	0.986	610	-0.01	-0.152	0.128	0.867	678	-0.70	-5.510	4.112	0.776	676	0.60	-0.799	1.993	0.401
Model 3**																				
Traditional Chinese diet	762	-0.14	-0.288	0.012	0.072	610	0.01	-0.028	0.055	0.515	678	0.64	-0.204	1.487	0.137	676	-0.08	-0.318	0.164	0.531
Western diet	762	0.01	-0.803	0.829	0.975	610	-0.003	-0.178	0.173	0.977	678	0.81	-4.394	6.013	0.760	676	0.68	-1.083	2.441	0.449
Model 4***																				
Traditional Chinese diet	714	-0.06	-0.225	0.114	0.523	570	0.01	-0.036	0.050	0.758	635	0.70	-0.209	1.616	0.131	634	0.04	-0.227	0.305	0.771
Western diet	714	-0.07	-0.924	0.780	0.868	570	0.02	-0.162	0.201	0.834	635	0.38	-4.693	5.452	0.883	634	0.72	-1.088	2.527	0.435
Model 5§																				
Traditional Chinese diet	711	-0.04	-0.205	0.128	0.651	567	0.01	-0.034	0.056	0.635	632	0.78	-0.152	1.714	0.101	631	0.04	-0.225	0.308	0.760
Western diet	711	-0.08	-0.937	0.769	0.847	567	0.02	-0.164	0.195	0.864	632	0.57	-4.583	5.730	0.827	631	0.75	-1.077	2.568	0.422
Mexican American	**Body Mass Index**					**Hemoglobin A1c†**					**Fasting Glucose†**					**Fasting Insulin†‡**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Traditional Mexican diet	761	-0.01	-0.052	0.030	0.598	553	0.01	-0.004	0.029	0.135	618	0.25	-0.016	0.512	0.066	617	0.03	-0.031	0.085	0.360
Western diet	761	1.07	0.533	1.616	0.0001	553	0.06	-0.023	0.149	0.152	618	3.25	-0.305	6.806	0.073	617	0.56	-0.268	1.381	0.185
Model 2*																				
Traditional Mexican diet	760	-0.03	-0.065	0.012	0.178	553	0.01	-0.005	0.029	0.153	618	0.23	-0.046	0.516	0.101	617	0.02	-0.038	0.081	0.481
Western diet	760	0.94	0.403	1.481	0.001	553	0.06	-0.023	0.142	0.156	618	3.11	-0.554	6.772	0.096	617	0.51	-0.339	1.354	0.240
Model 3**																				
Traditional Mexican diet	760	-0.04	-0.081	0.003	0.067	553	0.01	-0.007	0.025	0.260	618	0.08	-0.202	0.361	0.581	617	0.01	-0.056	0.072	0.801
Western diet	760	1.42	0.743	2.103	0.00004	553	-0.06	-0.229	0.104	0.460	618	-0.81	-5.381	3.757	0.727	617	0.35	-0.779	1.483	0.541
Model 4***																				
Traditional Mexican diet	712	-0.01	-0.060	0.040	0.694	522	-0.01	-0.013	0.003	0.182	576	0.001	-0.306	0.307	0.997	575	-0.01	-0.072	0.062	0.875
Western diet	712	0.95	0.262	1.646	0.007	522	0.03	-0.103	0.157	0.679	576	1.79	-3.318	6.891	0.492	575	0.22	-0.895	1.337	0.698
Model 5§																				
Traditional Mexican diet	712	-0.01	-0.059	0.041	0.725	522	-0.01	-0.014	0.002	0.156	576	-0.003	-0.340	0.334	0.987	575	-0.01	-0.081	0.053	0.684
Western diet	712	0.84	0.151	1.526	0.017	522	0.03	-0.093	0.159	0.605	576	1.94	-3.342	7.229	0.471	575	0.36	-0.755	1.475	0.527
African American	**Body Mass Index**					**Hemoglobin A1c†**					**Fasting Glucose†**					**Fasting Insulin†‡**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Traditional African American diet	1433	-0.20	-0.357	-0.045	0.012	1086	0.002	-0.019	0.022	0.882	1223	-0.24	-0.907	0.428	0.481	1220	-0.15	-0.297	-0.009	0.037
Western diet	1433	0.68	0.169	1.194	0.009	1086	0.001	-0.063	0.065	0.981	1223	0.48	-1.331	2.287	0.604	1220	0.77	0.213	1.334	0.007
Model 2*																				
Traditional African American diet	1433	-0.22	-0.379	-0.069	0.005	1086	0.001	-0.020	0.022	0.912	1223	-0.26	-0.927	0.409	0.448	1220	-0.15	-0.295	-0.007	0.040
Western diet	1433	0.58	0.070	1.083	0.026	1086	-0.001	-0.065	0.062	0.964	1223	0.39	-1.463	2.247	0.679	1220	0.80	0.242	1.357	0.005
Model 3**																				
Traditional African American diet	1433	-0.28	-0.455	-0.096	0.003	1086	0.004	-0.019	0.028	0.720	1223	-0.33	-0.988	0.320	0.317	1220	-0.27	-0.432	-0.099	0.002
Western diet	1433	1.22	0.482	1.948	0.001	1086	0.02	-0.086	0.119	0.750	1223	0.77	-2.506	4.052	0.644	1220	1.04	0.327	1.757	0.004
Model 4***																				
Traditional African American diet	1398	-0.37	-0.554	-0.184	0.0001	1061	0.001	-0.023	0.026	0.919	1193	-0.24	-0.992	0.522	0.543	1190	-0.32	-0.508	-0.134	0.001
Western diet	1398	0.84	0.132	1.556	0.020	1061	0.03	-0.068	0.135	0.521	1193	1.62	-1.761	5.010	0.347	1190	0.87	0.146	1.589	0.018
Model 5§																				
Traditional African American diet	1392	-0.40	-0.582	-0.214	0.00002	1055	0.000	-0.024	0.025	0.976	1188	-0.31	-1.079	0.452	0.422	1185	-0.32	-0.512	-0.135	0.001
Western diet	1392	0.89	0.181	1.598	0.014	1055	0.03	-0.076	0.130	0.610	1188	1.89	-1.477	5.254	0.271	1185	0.89	0.170	1.615	0.015
European Americans	**Body Mass Index**					**Hemoglobin A1c†**					**Fasting Glucose†**					**Fasting Insulin†‡**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Western diet	2382	1.44	1.035	1.845	3.98E-12	2122	-0.01	-0.058	0.039	0.695	2261	1.19	-0.265	2.648	0.109	2259	1.35	0.705	2.001	0.00004
Model 3ł**																				
Western diet	2382	0.99	0.463	1.512	0.0002	2122	-0.07	-0.120	-0.010	0.020	2261	-1.61	-3.494	0.281	0.095	2259	1.05	0.255	1.852	0.010
Model 4*ł**																				
Western diet	2343	0.63	0.069	1.189	0.028	2088	-0.02	-0.073	0.036	0.514	2224	-0.11	-1.890	1.675	0.906	2222	0.82	-0.048	1.687	0.064
Model 5§ł																				
Western diet	2328	0.67	0.130	1.207	0.015	2076	-0.01	-0.070	0.041	0.609	2211	0.01	-1.711	1.735	0.989	2209	0.84	-0.004	1.686	0.051

†Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models, ‡Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)
*Model 2 adjusted for large serving size score, **Model 3 adjusted for large serving size score and total caloric intake, ***Model 4 adjusted for all diet (large serving size score and total caloric intake) and demographic characteristics (age, gender, education, and immigration status), §Model 5 adjusted for all diet, demographic characteristics, and behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), łModels did not include a large serving size score

Table 3.9b Censored regression analysis (censored by use of diabetes medication) by ethnicity for Diet Adherence (Traditional and Western) and baseline BMI, A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

Chinese American	Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted															
Traditional Chinese diet	682	0.008	-0.039	0.056	0.727	759	-0.485	-1.716	0.745	0.439	756	-0.081	-0.312	0.150	0.491
Western diet	682	-0.135	-0.309	0.038	0.126	759	-4.625	-10.522	1.272	0.124	756	0.627	-0.708	1.962	0.357
Model 2*															
Traditional Chinese diet	682	0.008	-0.039	0.056	0.734	759	-0.596	-1.780	0.589	0.324	756	-0.095	-0.323	0.133	0.415
Western diet	682	-0.138	-0.311	0.035	0.119	759	-5.097	-10.913	0.718	0.086	756	0.571	-0.768	1.910	0.403
Model 3**															
Traditional Chinese diet	682	0.032	-0.020	0.083	0.229	759	0.371	-0.861	1.603	0.555	756	-0.116	-0.356	0.124	0.342
Western diet	682	-0.057	-0.269	0.155	0.598	759	-0.520	-6.763	5.724	0.870	756	0.766	-0.948	2.479	0.381
Model 4***															
Traditional Chinese diet	639	0.016	-0.039	0.070	0.576	711	0.500	-0.798	1.798	0.450	709	-0.004	-0.268	0.260	0.976
Western diet	639	-0.016	-0.234	0.202	0.885	711	-1.175	-7.339	4.989	0.708	709	0.850	-0.881	2.582	0.335
Model 5§															
Traditional Chinese diet	636	0.019	-0.037	0.075	0.506	708	0.569	-0.746	1.883	0.396	706	-0.003	-0.267	0.261	0.984
Western diet	636	-0.019	-0.237	0.198	0.861	708	-0.733	-6.868	5.401	0.814	706	0.866	-0.862	2.595	0.325
Mexican American	**Hemoglobin A1c**					**Fasting Glucose**					**Fasting Insulin**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted															
Traditional Mexican diet	676	0.027	0.009	0.045	0.003	760	0.454	0.072	0.836	0.020	757	-0.040	-0.095	0.015	0.158
Western diet	676	0.037	-0.115	0.190	0.631	760	0.506	-4.242	5.254	0.834	757	0.429	-0.515	1.373	0.372
Model 2*															
Traditional Mexican diet	675	0.026	0.008	0.044	0.006	759	0.405	0.016	0.794	0.042	756	-0.044	-0.101	0.012	0.126
Western diet	675	0.019	-0.133	0.170	0.810	759	-0.141	-4.841	4.560	0.953	756	0.401	-0.556	1.358	0.411
Model 3**															
Traditional Mexican diet	675	0.030	0.011	0.049	0.003	759	0.469	0.042	0.897	0.031	756	-0.045	-0.108	0.019	0.166
Western diet	675	-0.011	-0.242	0.220	0.924	759	-0.814	-7.036	5.407	0.797	756	1.003	-0.244	2.250	0.115
Model 4***															
Traditional Mexican diet	639	0.022	0.002	0.042	0.029	711	0.380	-0.146	0.905	0.156	708	-0.016	-0.090	0.058	0.675
Western diet	639	0.130	-0.116	0.377	0.299	711	3.168	-3.855	10.191	0.376	708	0.470	-0.803	1.742	0.469
Model 5§															
Traditional Mexican diet	639	0.018	-0.001	0.038	0.068	711	0.288	-0.253	0.830	0.296	708	-0.026	-0.100	0.049	0.500
Western diet	639	0.127	-0.118	0.372	0.309	711	3.957	-3.174	11.088	0.276	708	0.566	-0.690	1.823	0.376
African American	**Hemoglobin A1c**					**Fasting Glucose**					**Fasting Insulin**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted															
Traditional African American diet	1261	0.018	-0.017	0.053	0.321	1428	0.398	-0.607	1.404	0.437	1422	-0.169	-0.343	0.005	0.057
Western diet	1261	0.020	-0.092	0.133	0.722	1428	0.408	-2.329	3.145	0.770	1422	0.873	0.259	1.488	0.005
Model 2*															
Traditional African American diet	1261	0.017	-0.018	0.052	0.335	1428	0.381	-0.629	1.392	0.459	1422	-0.162	-0.339	0.014	0.071
Western diet	1261	0.017	-0.094	0.128	0.764	1428	0.316	-2.463	3.094	0.824	1422	0.923	0.303	1.544	0.004
Model 3**															
Traditional African American diet	1261	0.044	0.005	0.083	0.028	1428	0.978	-0.132	2.088	0.084	1422	-0.274	-0.482	-0.067	0.010
Western diet	1261	0.184	0.023	0.345	0.025	1428	4.330	-0.411	9.070	0.073	1422	1.323	0.442	2.205	0.003
Model 4***															
Traditional African American diet	1233	0.051	0.010	0.093	0.015	1393	1.353	0.152	2.553	0.027	1387	-0.315	-0.539	-0.091	0.006
Western diet	1233	0.211	0.051	0.372	0.010	1393	5.793	1.053	10.533	0.017	1387	1.054	0.159	1.948	0.021
Model 5§															
Traditional African American diet	1227	0.052	0.010	0.094	0.015	1388	1.293	0.072	2.513	0.038	1382	-0.312	-0.538	-0.085	0.007
Western diet	1227	0.198	0.037	0.360	0.016	1388	5.910	1.160	10.660	0.015	1382	1.046	0.164	1.928	0.020
European Americans	**Hemoglobin A1c**					**Fasting Glucose**					**Fasting Insulin**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted															
Western diet	2221	0.002	-0.052	0.057	0.929	2376	1.940	-0.146	4.026	0.068	2374	1.322	0.670	1.974	0.0001
Model 3ᵻ**															
Western diet	2221	-0.039	-0.106	0.028	0.251	2376	-0.431	-3.437	2.576	0.779	2374	0.936	0.103	1.770	0.028
Model 4*ᵻ**															
Western diet	2186	0.006	-0.061	0.073	0.854	2337	1.196	-1.380	3.771	0.363	2335	0.665	-0.237	1.567	0.149
Model 5§ᵻ															
Western diet	2174	0.005	-0.064	0.073	0.894	2322	1.249	-1.249	3.747	0.327	2320	0.689	-0.185	1.563	0.122

ᵻModels did not include a large serving size score, *Model 2 adjusted for large serving size score, **Model 3 adjusted for large serving size score and total caloric intake

***Model 4 adjusted for all diet (large serving size score and total caloric intake) and demographic characteristics (age, gender, education, and immigration status).

§Model 5 adjusted for all diet, demographic characteristics, and behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status).

Table 3.10 Longitudinal analysis results by ethnicity for the association between Diet Adherence (Traditional and Western) and yearly change in BMI and Fasting Glucose: MESA

	Body Mass Index					Fasting Glucose!				
	N	β for Change	95% CI		P-value	N	β for Change	95% CI		P-value
Chinese American										
Model 1: unadjusted										
Traditional Chinese diet	762	0.003	-0.009	0.016	0.632	682	-0.171	-0.306	-0.035	0.013
Western diet	762	0.031	-0.032	0.093	0.339	682	-0.529	-1.156	0.099	0.099
Model 2*										
Traditional Chinese diet	762	0.003	-0.009	0.016	0.630	682	-0.165	-0.298	-0.032	0.015
Western diet	762	0.031	-0.032	0.093	0.340	682	-0.522	-1.143	0.099	0.099
Model 3**										
Traditional Chinese diet	762	0.003	-0.009	0.016	0.630	682	-0.166	-0.299	-0.033	0.014
Western diet	762	0.031	-0.032	0.093	0.340	682	-0.522	-1.141	0.098	0.099
Model 4***										
Traditional Chinese diet	714	0.005	-0.008	0.017	0.476	639	-0.136	-0.272	-0.001	0.049
Western diet	714	0.032	-0.034	0.098	0.338	639	-0.335	-0.941	0.270	0.278
Model 5§										
Traditional Chinese diet	711	0.007	-0.008	0.023	0.337	636	-0.202	-0.391	-0.012	0.037
Western diet	711	0.026	-0.053	0.106	0.517	636	-0.283	-1.230	0.664	0.558
Mexican American										
	Body Mass Index					**Fasting Glucose!**				
	N	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Model 1: unadjusted										
Traditional Mexican diet	761	-0.003	-0.007	0.002	0.235	627	-0.028	-0.068	0.011	0.155
Western diet	761	-0.055	-0.124	0.014	0.121	627	0.091	-0.636	0.818	0.807
Model 2*										
Traditional Mexican diet	760	-0.003	-0.007	0.001	0.192	627	-0.030	-0.068	0.009	0.132
Western diet	760	-0.057	-0.126	0.012	0.107	627	0.080	-0.639	0.800	0.827
Model 3**										
Traditional Mexican diet	760	-0.003	-0.007	0.001	0.191	627	-0.030	-0.068	0.008	0.124
Western diet	760	-0.057	-0.126	0.012	0.108	627	0.077	-0.640	0.794	0.833
Model 4***										
Traditional Mexican diet	712	-0.003	-0.008	0.002	0.214	585	-0.031	-0.072	0.009	0.123
Western diet	712	-0.055	-0.130	0.021	0.158	585	-0.063	-0.837	0.712	0.874
Model 5§										
Traditional Mexican diet	712	-0.001	-0.006	0.005	0.844	585	-0.040	-0.111	0.031	0.266
Western diet	712	0.020	-0.036	0.076	0.482	585	-0.036	-1.359	1.288	0.958
African American										
	Body Mass Index					**Fasting Glucose!**				
	N	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Model 1: unadjusted										
Traditional African American diet	1433	0.004	-0.009	0.017	0.522	1233	-0.026	-0.130	0.077	0.618
Western diet	1433	0.017	-0.024	0.058	0.412	1233	-0.131	-0.486	0.223	0.468
Model 2*										
Traditional African American diet	1433	0.004	-0.009	0.017	0.517	1233	-0.026	-0.129	0.078	0.624
Western diet	1433	0.017	-0.024	0.058	0.408	1233	-0.131	-0.485	0.224	0.471
Model 3**										
Traditional African American diet	1433	0.004	-0.009	0.017	0.515	1233	-0.026	-0.129	0.077	0.625
Western diet	1433	0.017	-0.024	0.058	0.417	1233	-0.132	-0.488	0.224	0.467
Model 4***										
Traditional African American diet	1398	0.004	-0.009	0.017	0.527	1203	-0.036	-0.141	0.069	0.500
Western diet	1398	0.013	-0.029	0.054	0.548	1203	-0.167	-0.527	0.193	0.362
Model 5§										
Traditional African American diet	1392	0.010	-0.007	0.027	0.246	1197	-0.003	-0.153	0.146	0.965
Western diet	1392	0.030	-0.026	0.085	0.296	1197	-0.231	-0.686	0.224	0.319
European American										
	Body Mass Index					**Fasting Glucose!**				
	N	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Model 1: unadjusted										
Western Diet	2382	0.025	-0.008	0.057	0.142	2279	-0.072	-0.303	0.158	0.540
Model 3ł**										
Western Diet	2382	0.025	-0.008	0.057	0.142	2279	-0.070	-0.300	0.160	0.549
Model 4*ł**										
Western Diet	2343	0.026	-0.007	0.060	0.119	2242	-0.111	-0.340	0.118	0.341
Model 5§ł										
Western Diet	2328	0.004	-0.039	0.047	0.862	2229	0.202	-0.120	0.524	0.218

łModels did not include a large serving size score, *Model 2 adjusted for large serving size score, **Model 3 adjusted for large serving size score and total caloric intake

***Model 4 adjusted for all diet (large serving size score and total caloric intake) and demographic characteristics (age, gender, education, and immigration status).

§Model 5 adjusted for all diet, demographic characteristics, and behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status).

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from Fasting glucose model

Table 3.11 Relative Risk regression and Cox Proportional Hazards results by ethnicity for Diet Adherence (Traditional and Western) with Ever (Prevalent and Incident) and Incident type 2 diabetes: MESA

Chinese American

	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Traditional Chinese diet	762	149	0.976	0.800	1.190	0.810	612	45	0.816	0.618	1.079	0.153
Western diet	762	149	0.767	0.443	1.327	0.343	612	45	0.498	0.203	1.221	0.128
Model 2*												
Traditional Chinese diet	762	149	0.980	0.767	1.253	0.873	612	45	0.810	0.617	1.065	0.131
Western diet	762	149	0.771	0.437	1.360	0.369	612	45	0.481	0.199	1.165	0.105
Model 3**												
Traditional Chinese diet	762	149	1.074	0.870	1.326	0.507	612	45	0.792	0.611	1.026	0.078
Western diet	762	149	1.003	0.625	1.608	0.992	612	45	0.376	0.130	1.086	0.071
Model 4***												
Traditional Chinese diet	714	140	1.085	0.947	1.242	0.238	573	43	0.746	0.565	0.985	0.039
Western diet	714	140	0.970	0.534	1.762	0.921	573	43	0.316	0.096	1.044	0.059
Model 5§												
Traditional Chinese diet	711	140	1.084	0.950	1.235	0.230	568	29	0.808	0.600	1.089	0.162
Western diet	711	140	0.970	0.499	1.885	0.9282	568	29	0.141	0.027	0.745	0.021

Mexican American

	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Traditional Mexican diet	761	218	1.015	1.003	1.026	0.011	565	62	1.015	0.989	1.041	0.258
Western diet	761	218	1.137	0.976	1.324	0.100	565	62	1.404	1.016	1.939	0.040
Model 2*												
Traditional Mexican diet	760	217	1.012	1.000	1.025	0.053	565	62	1.010	0.984	1.036	0.464
Western diet	760	217	1.106	0.926	1.321	0.266	565	62	1.347	0.967	1.877	0.078
Model 3**												
Traditional Mexican diet	760	217	1.014	1.001	1.028	0.036	565	62	1.005	0.977	1.034	0.711
Western diet	760	217	1.169	0.949	1.439	0.141	565	62	1.455	0.940	2.250	0.092
Model 4***												
Traditional Mexican diet	712	205	1.010	0.993	1.028	0.245	533	59	0.998	0.963	1.033	0.892
Western diet	712	205	1.185	0.971	1.445	0.094	533	59	1.400	0.888	2.207	0.147
Model 5§												
Traditional Mexican diet	712	205	1.010	0.992	1.028	0.282	525	40	0.984	0.940	1.029	0.478
Western diet	712	205	1.152	0.941	1.410	0.170	525	40	1.417	0.778	2.579	0.254

African American

	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Traditional African American diet	1432	342	1.003	0.960	1.049	0.878	1119	101	1.002	0.916	1.096	0.973
Western diet	1432	342	1.001	0.876	1.144	0.984	1119	101	1.088	0.809	1.464	0.577
Model 2*												
Traditional African American diet	1432	342	1.005	0.960	1.052	0.837	1119	101	1.003	0.916	1.098	0.953
Western diet	1432	342	1.006	0.877	1.153	0.934	1119	101	1.095	0.810	1.480	0.555
Model 3**												
Traditional African American diet	1432	342	1.035	0.986	1.087	0.164	1119	101	1.007	0.906	1.119	0.901
Western diet	1432	342	1.306	1.058	1.613	0.013	1119	101	1.216	0.790	1.871	0.375
Model 4***												
Traditional African American diet	1397	334	1.052	0.998	1.108	0.057	1092	99	1.019	0.910	1.140	0.745
Western diet	1397	334	1.330	1.066	1.660	0.012	1092	99	1.246	0.807	1.926	0.321
Model 5§												
Traditional African American diet	1391	334	1.060	1.005	1.119	0.032	1061	61	0.957	0.834	1.099	0.535
Western diet	1391	334	1.344	1.067	1.694	0.012	1061	61	1.181	0.652	2.141	0.583

European American

	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Western diet	2382	274	1.199	1.014	1.418	0.034	2166	130	1.211	0.903	1.624	0.201
Model 3ł**												
Western diet	2382	274	1.120	0.875	1.432	0.368	2166	130	1.015	0.704	1.464	0.935
Model 4*ł**												
Western diet	2343	268	1.220	0.914	1.628	0.178	2132	127	1.015	0.679	1.517	0.942
Model 5§ł												
Western diet	2328	263	1.132	0.860	1.491	0.377	2090	86	1.171	0.784	1.750	0.441

*Model 2 adjusted for large serving size score
**Model 3 adjusted for large serving size score and total caloric intake
***Model 4 adjusted for all diet (large serving size score and total caloric intake) and demographic characteristics (age, gender, education, and immigration status).
§Model 5 adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), and behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status).
łModels did not include a large serving size score

DISCUSSION

We found that adherence to a Western diet was positively associated with BMI in Mexican, African, and European American participants in both cross-sectional and longitudinal analysis. Among African Americans, Western dietary pattern was also associated with increased fasting insulin as well as with A1c and fasting glucose in the censored regression analysis. Traditional ethnic diet had a protective association with BMI and fasting insulin in African American participants. The African American group also showed greater relative risk of type 2 diabetes for Western diet adherence compared to following a more traditional ethnic diet. However, many other models resulted in associations that were not significant or had beta coefficients in the opposite direction of those hypothesized.

In general, the findings in this study are consistent with dietary pattern association studies addressing obesity. Western dietary patterns, usually defined as high consumption of meat, have repeatedly been found to be associated with BMI or weight gain in many ethnic populations [70-74]. Similarly, "healthy" dietary patterns, including consumption of fruits and vegetables, have been shown to be inversely associated with BMI in different populations [71,72,74,75]. The Western and traditional dietary patterns used in this study were defined with indicator foods that included some of the foods from empirically derived Western and "healthy" dietary patterns studies. However, not all food items in the traditional diets of this study would be categorized in previous studies as "healthy," such as fried chicken, stir-fried dishes, and white rice. Nonetheless, these are items incorporated in the traditional ethnic diets represented in this study. Overall, the traditional ethnic diets consisted of foods that were home-cooked and without use of overly processed food items.

The only traditional diet which has previously been extensively investigated with health outcomes is the Mediterranean diet. The Mediterranean diet has been shown to be negatively associated with BMI [76-78]. Similar to a Mediterranean diet, predefined traditional ethnic diets in this study included relatively large amounts of fruits and vegetables, as well as legumes. Of all the indicator foods for the traditional diets, the average frequency of monthly consumption was greatest for fruit and vegetables among Chinese, Mexican, and African Americans. Thus, it was not a surprise that these items had significant factor loadings. Aside from a few subtle differences, these ethnic diets were very similar in that five to seven of the ten indicator foods were the same. In fact, these traditional diets do not differ greatly from a Mediterranean diet with the exception of olive oil use in food preparation (all ethnic diets) and dairy consumption (Chinese diet). The traditional Chinese, Mexican, and African American diets used lard for food preparations as opposed to oils, although many ethnic households now use oil as the favored source of fat in the diet. Similar to the Mediterranean diet, these traditional diets emphasized low consumption of red meats, moderate consumption of poultry, high consumption of vegetables, and fruit as the main snack or daily dessert. Since the traditional diets in this study have some similarity to the Mediterranean diet, the hypothesized negative association between traditional African American diet and BMI observed was consistent with the literature.

Results from dietary association studies reported elsewhere with fasting insulin have been inconsistent and inconclusive. Empirically derived dietary patterns studies have observed no associations with fasting insulin [79-81] and a "healthy" pattern association with lower fasting insulin [82]. The few studies that have examined the Mediterranean diet with fasting insulin did not find any significant associations [83-85]. However, in this study we were able to detect significant associations between the traditional diet with lower fasting insulin measures, and between the Western diet and greater fasting insulin values in African Americans after accounting for all covariates.

Although the same predefined Western dietary pattern was used in the confirmatory factor analysis for all ethnic groups, frequency of consumption of these foods varied between these groups. Overall, Chinese American participants did not frequently consume Western diet indicator foods and there was greater variability in the frequency of foods consumed in the traditional Chinese dietary pattern. Additionally, few Chinese American participants were found to be overweight or obese (35.3%) compared to other ethnic groups (68.1 – 86.2%). This might be one reason why we were unable to observe associations between these diet scores and BMI. With the Western diet defined exactly the same for all groups, we are able to compare association with BMI across ethnicity. The positive relationship between Western diet and BMI varied by ethnicity (overall interaction p-value = 0.03). Compared to European Americans, the association between Western diet and BMI significantly differed for Chinese Americans (interaction p-value = 0.010) and African Americans (interaction p-value = 0.039).

This study was one of the first to use a method introduced by Pierce et al [43] which allows calculation of a score measuring adherence to a pre-specified dietary pattern. Usually, dietary studies use factor analysis or cluster analysis to empirically derive dietary patterns, an approach which might be considered data driven that does not allow for testing of a priori dietary patterns. Furthermore, to capture dietary acculturation as a measured behavior, we focused on frequency of consumption of indicator foods. This approach was also used to attempt to disentangle larger portion sizes as a Western behavior when evaluating traditional diet indicator foods. Adjusting for the large portion score and total caloric intake in the analysis allowed us to control for the amount of food consumed when addressing what was eaten (as defined by the dietary pattern). It is of particular interest that the Western dietary pattern was associated with BMI even after adjusting for total caloric intake. Additionally, this study was one of the first to investigate adherence to predefined traditional ethnic and Western diets with health outcomes in a multi-ethnic cohort.

The majority of dietary research have focused on specific nutrients or macronutrient composition of diets when investigating associations with health outcomes. In many recent dietary pattern association studies, the empirically derived "healthy" and "Western/unhealthy" dietary patterns are ones defined as low-fat versus high-fat diets. As a result, much emphasis has been placed on the amount of fat in the diet and less so on other aspects of the diet. As a sensitivity analysis, we assessed the effect that adjusting for total fat would have on the significant results found in Western diet and BMI as well as with traditional African American diet with BMI and fasting insulin. While in all ethnic groups the significant association between the Western diet score and BMI disappeared once accounting for total fat; the negative association for traditional diet with BMI (full model β = -0.38, 95% CI = -0.56 – -0.19) and fasting insulin (full model β = -0.29, 95% CI = -0.48 – -0.10) in the African American group remained significant. A reason we observed the effect adjusting for total fat had on the results from the Western dietary pattern is that this diet comprised of processed foods (typical fast food items) which are high in fat. Therefore it is difficult to disentangle the effect of the Western dietary pattern from total fat. However, in the traditional diet, regardless of adjustment for total fat in the diet, there remained a protective relationship with both BMI and fasting insulin in African Americans. Although the macronutrient approach has produced valuable information, it may not be the most practical method with chronic disease research where the goal is to develop effective recommendations consisting of dietary patterns which at risk individuals would more likely follow.

Dietary measurements in this study had limitations. First of all, dietary intake was obtained by self-report and differential measurement error most likely occurred based on BMI status and reporting indicator foods of a Western diet. This type of measurement error would bias the results towards the null, which may have affected results in the Chinese American group. Nonetheless, we were able to observe a significant association between the Western diet and BMI in the other ethnic groups. The FFQ used to assess the average diet in the past year was not developed specifically to capture the indicator foods of the traditional ethnic and Western diets specified in this study. Since many foods listed in one item in the FFQ were used to represent indicator foods, we might have not only captured the food of interest but other items as well. For example, items 79 and 80 were used to define the indicator food "stews" in the traditional diets (Tables 3.1 - 3.3). However, other foods were also measured in those food items, such as pot pie, empanadas, gumbo, and paella. Also, frequency of consumption was recorded categorically with categories representing ranges, like 2 – 3 times per month or 3 – 4 times per week. Therefore, measurement error could exist in the calculation of frequency of monthly consumption of indicator foods. This type of error would have caused noise in the analysis and made it more difficult to observe true associations.

Additional limitations of this study include small sample sizes in the ethnic stratified analysis, specifically in the Chinese and Mexican American participants. As a result it is possible that estimates which did not reach statistical significance were due to small sample sizes. In the longitudinal analysis, we were unable to examine whether these diets were associated with change in hemoglobin A1c or fasting insulin as they were only measured once. Furthermore, in the longitudinal analysis with BMI and fasting glucose as well as investigated incidence of type 2 diabetes, we did not have longitudinal measures of diet so we assumed diet remained constant in these analyses. Another concern is that the risk estimates may have been confounded by unmeasured demographic or behavior characteristics not included in the analysis. However, all analyses were adjusted for demographic and behavior characteristics believed to influence the associations between our dietary patterns and risk factors for type 2 diabetes.

In conclusion, we calculated scores of adherence to pre-specified traditional ethnic and Western dietary patterns using CFA in a multi-ethnic cohort study. Using these scores, we were able to examine the relationship of adherence toward a traditional diet with risk of type 2 diabetes and related glycemic traits in three ethnicities. We found that greater adherence to a traditional diet was inversely associated with BMI and fasting insulin among African Americans. We also assessed the connection between predefined Western diet (common fast food items) adherence and the same outcomes in four ethnic groups and found an association with greater BMI values in Mexican, African, and European Americans. Adherence to a Western diet was also associated with greater levels of fasting insulin in African Americans. Due to the multiple comparisons made in this study, and the lack of significance in many models developed, these findings need to be replicated and further investigated in a larger cohort of Chinese and Mexican Americans. However, the results of this study suggest a possible new direction and focus in dietary recommendation among ethnic minority populations at high risk for obesity and type 2 diabetes. Dietary patterns consisting of non-processed foods, as opposed to low fat diets, may be more effective in preventing these chronic diseases. Additionally, we observed that the Western diet may affect ethnic minority populations to a greater extent than European Americans. Greater educational efforts should target these populations regarding the negative health effects of a Western diet.

Chapter 4: Proglucagon Gene Loci and Type 2 Diabetes Risk, Prevalence and Incidence in the Multi-Ethnic Study of Atherosclerosis

ABSTRACT

Objective: The proglucagon gene encodes for key proteins involved in glucose and energy homeostasis. We investigated the association between rs6732914, a single nucleotide polymorphism in the proglucagon gene, and obesity as well as glycemic traits among participants of the Multi-Ethnic Study of Atherosclerosis (MESA).

Methods: In this study, 5516 unrelated MESA participants were genotyped and completed laboratory and anthropometric measurements. Four proglucagon single nucleotide polymorphisms [rs6732914 (imputed only in European and African Americans), rs5647, rs11897425, and rs13010545] were tested for association with body mass index, hemoglobin A1c, fasting glucose, fasting insulin, and risk and incidence of type 2 diabetes.

Results: We observed an additive association between proglucagon tag rs13010545 and fasting insulin in African Americans ($\beta = 0.56$, 95% CI = 0.03-1.10) taking into account age, gender and European ancestry. In the unadjusted model, the proglucagon tag rs11897425 was additively associated with BMI in Mexican Americans ($\beta = 0.60$, 95% CI = 0.061-1.149). No significant associations were found between the proglucagon SNPs and A1c, fasting glucose, and risk or incidence of type 2 diabetes.

Conclusion: Although we were unable to replicate previous associations with the proglucagon gene observed with BMI and fasting glucose in this multi-ethnic cohort, a larger study and other possible genes that may interact with the proglucagon gene are needed to properly evaluate these associations within ethnic groups.

INTRODUCTION

The proglucagon gene encodes key proteins involved in glucose and energy homeostasis: glucagon, glucagon-like peptide 1 (GLP-1), glucagon-like peptide 2 (GLP-2), glicentin, and oxyntomodulin (OXM) [4-6]. Glucagon is produced in the pancreas in response to low blood glucose levels and stimulates glucose production in the liver. The gut derived peptide hormone, GLP-1, is released in response to ingestion of food, primarily carbohydrate-rich meals and possibly the presence of protein, and delays gastric emptying as well as triggering satiety signals in the brain [4,7-10,86-89]. Additionally, this hormone acts as an incretin, stimulating the release of insulin and inhibiting glucagon action in the pancreas [8]. GLP-1 has been found to lower body weight, in particular body fat, by increasing energy expenditure and fat oxidation [12-14]. OXM and GLP-2 are also secreted in the intestinal tract [6,10]. While OXM and GLP-2 inhibit gastric emptying and gastric acid secretion, OXM also stimulates intestinal glucose uptake and decreases glucose secretion [5]. Similar to GLP-1, OXM treatment has been found to reduce body weight and adipose tissue, regardless of calorie intake, by increasing energy expenditure [15-17].

Carlson et al. have observed an association between the SNP rs6732914 in the proglucagon gene and both fasting glucose and body mass index (Carlson et al, personal communication 2009). The minor G allele has been reported to be common among Native Americans, Mexican-Americans, and African-Americans, but very rare in European Americans. In the Mexican-American Hypertension and Insulin Resistant study (MA HTN-IR, N = 899), the minor G allele was associated with elevated fasting glucose in Mexican-American non-diabetic individuals (quantitative transmission disequilibrium test (QTDT): p-value =0.016). In African-Americans from the Coronary Artery Disease Risk Development in Young Adults study (CARDIA, N =1622), an increase of 1.03 mg/dl in fasting glucose was observed per G allele at 15 years follow-up (p-value = 0.00007) adjusting for genetic ancestry. An association with BMI was also observed at year 15; African-American females had an increase of 0.91 BMI units per G allele (p-value = 0.019). Functional analysis showed that rs6732914 alters the poly-A cleavage site of proglucagon mRNA, with in vitro tests demonstrating significantly reduced peptide production from the G allele. The Multi-Ethnic Study of Atherosclerosis (MESA) provides a unique opportunity to validate associations between this SNP and BMI, as well as risk of type 2 diabetes in minority US populations.

The goal of this study was to replicate associations between a specific variation within the proglucagon gene and risk of type 2 diabetes and related glycemic traits in four ethnicities of participants in MESA. We tested if the imputed value of proglucagon SNP (rs6732914) and three tags are associated with risk and incidence of type 2 diabetes, body mass index (BMI), hemoglobin A1c, fasting glucose, and fasting insulin within each ethnicity (European American, Chinese American, Mexican American, and African American).

METHODS

Participants

Since the Multi-Ethnic Study of Atherosclerosis (MESA) has been described in greater detail in Chapter 1, a brief description is provided. MESA recruited 6814 participants who were European-American, Chinese-American, African-American, or Hispanic in 2000 to 2001 from six field centers: Wake Forest University, Columbia University, Johns Hopkins University, University of Minnesota, Northwestern University, and the University of California in Los Angeles [56]. A cohort study designed to investigate risk factors that predict progression to clinical cardiovascular disease, MESA participants each received at baseline an extensive physical exam which included measures of socio-demographic factors, lifestyle factors, psychosocial factors, and collection of blood samples. As a result, anthropometric (BMI) and laboratory (DNA extraction, A1c, fasting insulin and fasting glucose) measurements were ascertained. Although blood samples were collected and physical exams were performed at every visit, fasting insulin was only measured at visit 1 and hemoglobin A1c was obtained only at visit 2.

DNA extraction and genotyping

The commercial DNA isolation kit (Puregene; Gentra Systems, Minneapolis, MN) was used to extract DNA from peripheral leukocytes. A genome wide SNP genotyping of about one million SNPs was performed using Affymetrix Genome-Wide Human SNP Array 6.0 (Affy 6.0). The proglucagon SNP rs6732914 was not genotyped through Affy 6.0. However, three tags for proglucagon SNP rs6732914 have been genotyped; rs5647, rs11897425, and rs13010545. These tags as well as the imputed value for proglucagon SNP rs6732914 were used in the analysis.

Statistical Analysis

The association between SNPs and body mass index (BMI), hemoglobin A1c, fasting glucose, fasting insulin, prevalent and incident type 2 diabetes were investigated within each ethnicity separately. Multivariable linear regression models were used to investigate additive association of SNPs and each baseline risk factor for type 2 diabetes (including: fasting glucose, fasting insulin, A1c (exam 2), and BMI). Participants taking medications affecting levels of fasting glucose, fasting insulin, and A1c were excluded from analysis investigating those outcomes. These associations were also be investigated using linear regression censoring on this medication use as a sensitivity analysis. A general estimating equation (GEE) model with Gaussian error, identity link, and exchangeable correlation matrix was used to investigate the association between the SNPs and longitudinal values (repeated measures) of fasting glucose and BMI. We used relative risk regression for the presence (prevalent and incident) of type 2 diabetes and Cox proportional hazards regression for the incidence of type 2 diabetes. Calculations of rates for diabetes incidence used person-time as days between date of baseline clinic visit and the date of the clinic visit with the first occurrence of: (1) reported use of any medication for diabetes (including either insulin or hypoglycemic), (2) reported diabetes diagnosis, fasting glucose level ≥126 mg/dl , or (3) last follow-up visit. Due to the relationship between fasting glucose and fasting insulin, all models with fasting insulin as the dependent variable considered diabetes status as a categorical variable classified as normal (fasting glucose (FG) <100mg/dl), impaired glucose tolerance (FG = 100 – 125 mg/dl), and type 2 diabetes (FG >125 mg/dl). The adjusted models controlled for ancestry (proportion of European American descent), age at baseline, and gender. Analyses were stratified by race/ethnicity and robust standard errors were used in all models. Results were considered significant if a p-value less than 0.05 was found. All analyses were performed using STATA version 12.1 (StataCorp, College Station, Tex).

RESULTS

There were differences in baseline demographic and behavioral characteristics between ethnicities among MESA participants. Ethnic differences were apparent for cigarette smoking status and alcohol use with Chinese Americans having the greatest percent of “Never” use of 75% and 54% respectively (Table 4.1). European Americans had the greatest percent of “Current” alcohol use (71%) and African Americans had the greatest percent of “Current” smokers (18%). Although diabetes status was similar between Chinese, African, and Mexican Americans, only about 6% of European Americans had diabetes compared to the 13 – 20% among the other ethnicities. The presence of hypertension was similar between ethnic groups (~38%), except for African Americans where the presence of hypertension was about 60%. European Americans had the lowest values of fasting glucose, fasting insulin, hemoglobin A1c, and blood pressure. BMI was lowest among Chinese Americans with a mean of 24.0 kg/m^2 compared to 27.7 – 30.1 kg/m^2 in the other groups. Within each ethnicity group, the distributions of genotype frequencies for the three tags (rs5647, rs11897425, and rs13010545) were similar, except for African Americans where rs5647 had a very different distribution than the other two tags.

When looking at glycemic traits by genotypes of the Proglucagon gene tags, there was a greater prevalence of diabetes (treated and untreated) among participants with a G allele than the AA genotype in all three tags (Table 4.2). Similarly, fasting glucose and A1c levels were more elevated among G carriers than non-carriers. There appeared to be directionality in the means of fasting insulin and BMI with increasing means for every G allele. For fasting insulin, the means among participants with the GG genotype based on the three tags were greater (rs5647 = 16.8, rs11897425 = 13.7, and rs13010545 = 14.0) than the mean fasting insulin of any of the ethnicities (European American = 9.1, Chinese Americans = 9.6, African Americans = 11.5, and Mexican American = 12.3).

Table 4.1 Demographic characteristics at baseline by ethnicity: MESA

	European American		Chinese American		African American		Mexican American	
	2526		775		1611		806	
	N	%	N	%	N	%	N	%
Gender								
Female	1320	52.3	394	50.8	868	53.9	398	49.4
Male	1206	47.7	381	49.2	743	46.1	408	50.6
Cigarette smoking status								
Never	1119	44.3	581	75.0	720	44.7	416	51.6
Former	1113	44.1	149	19.2	583	36.2	289	35.9
Current	287	11.4	44	5.7	295	18.3	101	12.5
Alcohol use								
Never	235	9.3	420	54.2	274	17.0	198	24.6
Former	470	18.6	115	14.8	522	32.4	228	28.3
Current	1797	71.1	236	30.5	795	49.3	380	47.1
Diabetes status								
Normal	2090	82.7	536	69.2	1081	67.1	513	63.6
IFG	279	11.0	133	17.2	245	15.2	128	15.9
Untreated Diabetes	45	1.8	23	3.0	54	3.4	30	3.7
Treated Diabetes	106	4.2	81	10.5	225	14.0	134	16.6
Hypertension								
No	1551	61.4	483	62.3	652	40.5	494	61.3
Yes	975	38.6	292	37.7	959	59.5	312	38.7
Rs5647								
0 minor alleles	2416	95.6	486	62.7	1288	80.0	386	47.9
1 minor allele	107	4.2	259	33.4	296	18.4	327	40.6
2 minor alleles	3	0.1	30	3.9	25	1.6	93	11.5
Rs11897425								
0 minor alleles	2408	95.3	482	62.2	776	48.2	376	46.7
1 minor allele	116	4.6	261	33.7	670	41.6	331	41.1
2 minor alleles	2	0.1	32	4.1	163	10.1	99	12.3
Rs13010545								
0 minor alleles	2327	92.1	478	61.7	817	50.7	367	45.5
1 minor allele	181	7.2	264	34.1	652	40.5	330	40.9
2 minor alleles	7	0.3	30	3.9	140	8.7	106	13.2
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Rs6732914 (imputed)	0.0	0.21	.	.	0.4	0.51	.	.
Fasting glucose calibrated (mg/dl)	91.3	21.57	99.1	28.55	100.3	32.64	105.9	40.48
Fasting insulin	9.1	5.59	9.6	12.48	11.5	27.49	12.3	12.81
Hemoglobin A1c	5.4	0.63	5.8	0.91	5.9	1.13	6.0	1.35
Systolic blood pressure (mmHg)	123.5	20.45	124.5	21.67	131.7	21.81	127.3	22.98
Diastolic blood pressure (mmHg)	70.1	9.93	71.9	10.33	74.5	10.32	70.9	10.43
Body mass index (kg/m^2)	27.7	5.06	24.0	3.29	30.1	5.89	29.9	5.23

Table 4.2 Baseline characteristics by genotype of tags (rs5647, rs11897425, and rs13010545): MESA

Rs5647						
	AA		**AG**		**GG**	
	4576		**989**		**151**	
	N	**%**	**N**	**%**	**N**	**%**
Diabetes status						
Normal	3451	75.4	660	66.7	108	71.5
IFG	608	13.3	161	16.3	16	10.6
Untreated Diabetes	107	2.3	37	3.7	7	4.6
Treated Diabetes	397	8.7	130	13.1	19	12.6
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Rs6732914 (imputed)	0.1	0.36	0.5	0.49	0.4	0.63
Fasting glucose calibrated (mg/dl)	95.7	28.23	101.8	33.90	101.8	35.62
Fasting insulin	10.0	12.66	10.9	9.94	16.8	69.16
Hemoglobin A1c	5.6	0.91	5.9	1.16	5.9	1.20
Body mass index (kg/m^2)	28.2	5.44	28.4	5.78	28.9	5.90
Rs11897425						
	AA		**AG**		**GG**	
	4042		**1378**		**296**	
	N	**%**	**N**	**%**	**N**	**%**
Diabetes status						
Normal	3098	76.6	907	65.8	214	72.3
IFG	534	13.2	215	15.6	35	11.8
Untreated Diabetes	87	2.2	56	4.1	9	3.0
Treated Diabetes	313	7.7	196	14.2	37	12.5
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Rs6732914 (imputed)	0.0	0.05	0.6	0.42	1.2	0.62
Fasting glucose calibrated (mg/dl)	95.0	27.27	102.0	34.61	100.4	31.94
Fasting insulin	9.9	13.43	10.7	8.35	13.7	49.47
Hemoglobin A1c	5.6	0.89	5.9	1.14	5.8	1.11
Body mass index (kg/m^2)	27.9	5.37	28.8	5.77	29.6	5.81
Rs13010545						
	AA		**AG**		**GG**	
	3989		**1427**		**283**	
	N	**%**	**N**	**%**	**N**	**%**
Diabetes status						
Normal	3042	76.3	959	67.2	202	71.4
IFG	524	13.1	225	15.8	34	12.0
Untreated Diabetes	87	2.2	53	3.7	12	4.2
Treated Diabetes	326	8.2	186	13.0	34	12.0
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Rs6732914 (imputed)	0.0	0.14	0.6	0.48	1.1	0.67
Fasting glucose calibrated (mg/dl)	95.5	28.27	100.4	32.11	101.1	33.59
Fasting insulin	9.8	13.12	10.9	9.81	14.0	50.66
Hemoglobin A1c	5.6	0.89	5.9	1.12	5.9	1.18
Body mass index (kg/m^2)	28.0	5.40	28.7	5.69	29.5	5.88

Association Results

Within each ethnic group, there were no significant association between Proglucagon tags and baseline measures of BMI, A1c, fasting glucose, and fasting insulin (Table 4.3a). We observed an additive association between rs13010545 and fasting insulin in African Americans (adjusted model: Regression coefficient (β) = 0.56, 95% Confidence Interval (CI) = 0.034-1.095). In the unadjusted model, rs11897425 was additively associated with BMI in Mexican Americans (β = 0.60, 95% CI = 0.061-1.149). In the censored regression analysis, all three tags were significantly associated with fasting insulin in Chinese Americans (rs5647 β = -0.80, 95% CI = -1.497 - -0.106; rs11897425 β = -0.94, 95% CI = -1.618 - -0.272; rs13010545 β = -0.81, 95% CI = -1.500 - -0.111). Additionally, the association between rs13010545 and fasting insulin in African Americans was reproduced (β = 0.71, 95% CI = 0.125-1.288).

In the longitudinal analysis between proglucagon tags with BMI and fasting glucose, there was no significant change in BMI or fasting glucose based on the G allele (Table 4.4). However, the associations between BMI and rs11897425 in Mexican Americans observed during the baseline analysis were replicated in the unadjusted longitudinal analysis (β = 0.64, 95% CI = 0.09-1.19).

The relative risk and incidence of type 2 diabetes investigations with proglucagon tags yielded no significant difference for both risk and incidence of type 2 diabetes based on the G allele (Table 4.5).

The baseline, longitudinal, and risk and incidence of type 2 diabetes analysis with the imputed value of rs6732914 produced no significant associations with the outcomes.

Table 4.3a Regression analysis results by ethnicity for Proglucagon SNPs and baseline BMI, Hemoglobin A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

European American

	Body Mass Index					Hemoglobin A1c*					Fasting Glucose*					Fasting Insulin*				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Rs6732914 (imputed)	2526	-0.65	-1.442	0.141	0.107	2249	-0.02	-0.105	0.056	0.555	2399	0.13	-2.163	2.418	0.913	2399	-0.57	-1.358	0.210	0.151
Rs5647	2526	-0.68	-1.432	0.074	0.077	2249	-0.01	-0.089	0.059	0.697	2399	-0.03	-2.222	2.153	0.975	2399	-0.62	-1.370	0.126	0.103
Rs11897425	2526	-0.56	-1.339	0.209	0.153	2249	-0.02	-0.098	0.065	0.697	2399	0.56	-1.834	2.956	0.646	2399	-0.58	-1.327	0.163	0.126
Rs13010545	2515	-0.38	-1.030	0.261	0.243	2238	0.00	-0.069	0.072	0.968	2388	-0.82	-2.590	0.951	0.364	2388	-0.39	-1.035	0.246	0.227
Model 2: adjusted for age, gender, European ancestry																				
Rs6732914 (imputed)	2526	-0.69	-1.480	0.105	0.089	2249	-0.02	-0.102	0.054	0.542	2399	-0.19	-2.452	2.070	0.868	2399	-0.65	-1.452	0.151	0.112
Rs5647	2526	-0.71	-1.464	0.049	0.067	2249	-0.01	-0.083	0.058	0.734	2399	-0.29	-2.461	1.873	0.790	2399	-0.68	-1.455	0.089	0.083
Rs11897425	2526	-0.60	-1.374	0.179	0.132	2249	-0.02	-0.095	0.064	0.709	2399	0.29	-2.060	2.643	0.808	2399	-0.65	-1.411	0.116	0.096
Rs13010545	2515	-0.38	-1.026	0.262	0.245	2238	0.01	-0.062	0.076	0.842	2388	-0.52	-2.251	1.218	0.559	2388	-0.36	-1.020	0.296	0.281

African American

	Body Mass Index					Hemoglobin A1c*					Fasting Glucose*					Fasting Insulin*				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Rs6732914 (imputed)	1611	0.12	-0.441	0.688	0.669	1213	-0.05	-0.135	0.027	0.191	1373	-0.41	-2.472	1.653	0.697	1369	0.53	-0.222	1.282	0.167
Rs5647	1609	0.49	-0.187	1.164	0.157	1211	0.06	-0.044	0.166	0.255	1371	1.58	-1.176	4.334	0.261	1367	0.33	-0.486	1.149	0.426
Rs11897425	1609	0.11	-0.318	0.538	0.614	1211	-0.01	-0.070	0.049	0.736	1371	0.91	-0.691	2.503	0.266	1367	0.36	-0.144	0.866	0.161
Rs13010545	1609	0.09	-0.361	0.534	0.704	1211	0.03	-0.035	0.104	0.334	1371	1.21	-0.533	2.944	0.174	1367	0.52	0.000	1.031	0.050
Model 2: adjusted for age, gender, European ancestry																				
Rs6732914 (imputed)	1611	0.03	-0.519	0.583	0.909	1213	-0.05	-0.130	0.033	0.241	1373	-0.25	-2.309	1.806	0.811	1369	0.53	-0.240	1.294	0.178
Rs5647	1609	0.52	-0.127	1.168	0.115	1211	0.05	-0.051	0.158	0.316	1371	1.37	-1.396	4.127	0.332	1367	0.39	-0.418	1.205	0.342
Rs11897425	1609	0.10	-0.310	0.520	0.620	1211	-0.01	-0.070	0.050	0.741	1371	0.89	-0.676	2.463	0.264	1367	0.40	-0.115	0.906	0.129
Rs13010545	1609	0.08	-0.355	0.517	0.716	1211	0.03	-0.038	0.100	0.383	1371	1.14	-0.590	2.871	0.196	1367	0.56	0.034	1.095	0.037

Chinese American

	Body Mass Index					Hemoglobin A1c*					Fasting Glucose*					Fasting Insulin*				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Rs5647	775	0.03	-0.386	0.437	0.904	623	0.04	-0.043	0.121	0.348	691	0.98	-1.426	3.386	0.424	692	0.00	-0.590	0.592	0.998
Rs11897425	775	-0.05	-0.451	0.345	0.794	623	0.03	-0.050	0.115	0.438	691	1.06	-1.317	3.446	0.380	692	-0.07	-0.641	0.501	0.810
Rs13010545	772	0.05	-0.356	0.464	0.797	620	0.04	-0.042	0.122	0.344	688	1.00	-1.407	3.408	0.415	689	0.01	-0.583	0.596	0.982
Model 2: adjusted for age, gender, European ancestry																				
Rs5647	775	0.04	-0.368	0.452	0.841	623	0.04	-0.044	0.117	0.371	691	1.15	-1.247	3.552	0.346	692	0.02	-0.565	0.609	0.941
Rs11897425	775	-0.03	-0.426	0.365	0.880	623	0.03	-0.052	0.110	0.480	691	1.17	-1.219	3.555	0.337	692	-0.03	-0.591	0.536	0.924
Rs13010545	772	0.07	-0.336	0.480	0.728	620	0.04	-0.045	0.117	0.382	688	1.09	-1.314	3.492	0.374	689	0.05	-0.537	0.629	0.876

Mexican American

	Body Mass Index					Hemoglobin A1c*					Fasting Glucose*					Fasting Insulin*				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Model 1: unadjusted																				
Rs5647	806	0.38	-0.159	0.928	0.165	588	0.00	-0.090	0.090	0.996	655	-0.14	-2.649	2.375	0.915	655	0.08	-0.691	0.856	0.835
Rs11897425	806	0.60	0.061	1.149	0.029	588	0.01	-0.083	0.094	0.909	655	0.49	-1.876	2.860	0.683	655	0.44	-0.312	1.201	0.249
Rs13010545	803	0.45	-0.082	0.986	0.097	585	-0.01	-0.095	0.082	0.884	652	-0.29	-2.748	2.167	0.816	652	0.39	-0.371	1.147	0.316
Model 2: adjusted for age, gender, European ancestry																				
Rs5647	806	0.24	-0.307	0.783	0.392	588	-0.01	-0.097	0.086	0.902	655	-0.51	-3.148	2.132	0.706	655	-0.09	-0.873	0.701	0.831
Rs11897425	806	0.48	-0.071	1.028	0.088	588	0.00	-0.091	0.089	0.985	655	0.17	-2.133	2.469	0.886	655	0.30	-0.460	1.061	0.438
Rs13010545	803	0.31	-0.230	0.841	0.264	585	-0.01	-0.102	0.078	0.796	652	-0.61	-3.178	1.968	0.644	652	0.25	-0.515	1.015	0.521

*Models excluded participants taking medications affecting hemoglobin A1c, fasting glucose, and fasting insulin levels.

Table 4.3b Censored regression (censored on diabetes meds) results by ethnicity for Proglucagon SNPs and baseline Hemoglobin A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

	Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
European American															
	N	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**
Model 1: unadjusted															
Rs6732914 (imputed)	2354	-0.04	-0.143	0.055	0.386	2520	-0.50	-3.609	2.603	0.751	2520	-0.52	-1.509	0.461	0.297
Rs5647	2354	-0.03	-0.127	0.058	0.462	2520	-0.65	-3.609	2.318	0.669	2520	-0.58	-1.517	0.365	0.230
Rs11897425	2354	-0.03	-0.127	0.072	0.586	2520	0.17	-2.943	3.288	0.913	2520	-0.53	-1.450	0.398	0.264
Rs13010545	2343	0.00	-0.085	0.081	0.962	2509	-1.08	-3.463	1.309	0.376	2509	-0.07	-0.965	0.821	0.874
Model 2: adjusted for age, gender, European ancestry															
Rs6732914 (imputed)	2354	-0.04	-0.141	0.053	0.374	2520	-0.82	-3.884	2.240	0.599	2520	-0.59	-1.602	0.416	0.249
Rs5647	2354	-0.04	-0.129	0.051	0.396	2520	-0.92	-3.850	2.020	0.541	2520	-0.64	-1.607	0.336	0.200
Rs11897425	2354	-0.03	-0.128	0.066	0.528	2520	-0.12	-3.174	2.937	0.939	2520	-0.59	-1.539	0.358	0.223
Rs13010545	2343	0.00	-0.085	0.078	0.929	2509	-0.80	-3.140	1.535	0.501	2509	-0.04	-0.948	0.859	0.923
African American															
	Hemoglobin A1c					**Fasting Glucose**					**Fasting Insulin**				
	N	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**
Model 1: unadjusted															
Rs6732914 (imputed)	1408	-0.04	-0.176	0.094	0.548	1605	0.16	-3.348	3.666	0.929	1598	0.67	-0.295	1.629	0.174
Rs5647	1406	0.11	-0.051	0.277	0.178	1603	3.19	-1.495	7.875	0.182	1596	1.01	-0.083	2.096	0.070
Rs11897425	1406	0.00	-0.099	0.102	0.977	1603	1.78	-0.949	4.514	0.201	1596	0.26	-0.372	0.895	0.419
Rs13010545	1406	0.04	-0.070	0.144	0.492	1603	0.72	-2.220	3.665	0.630	1596	0.67	0.101	1.237	0.021
Model 2: adjusted for age, gender, European ancestry															
Rs6732914 (imputed)	1408	-0.04	-0.171	0.099	0.601	1605	0.49	-3.026	3.999	0.786	1598	0.69	-0.292	1.666	0.169
Rs5647	1406	0.10	-0.062	0.265	0.223	1603	2.97	-1.696	7.644	0.212	1596	1.03	-0.053	2.121	0.062
Rs11897425	1406	0.00	-0.102	0.099	0.978	1603	1.82	-0.882	4.531	0.186	1596	0.29	-0.353	0.939	0.374
Rs13010545	1406	0.03	-0.076	0.137	0.580	1603	0.69	-2.247	3.626	0.645	1596	0.71	0.125	1.288	0.017
Chinese American															
	Hemoglobin A1c					**Fasting Glucose**					**Fasting Insulin**				
	N	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**
Model 1: unadjusted															
Rs5647	696	-0.02	-0.135	0.099	0.763	773	-0.51	-3.968	2.953	0.774	774	-0.75	-1.442	-0.053	0.035
Rs11897425	696	-0.05	-0.163	0.066	0.404	773	-1.11	-4.475	2.253	0.517	774	-0.88	-1.548	-0.203	0.011
Rs13010545	693	-0.02	-0.133	0.101	0.794	770	-0.43	-3.899	3.040	0.808	771	-0.74	-1.439	-0.051	0.036
Model 2: adjusted for age, gender, European ancestry															
Rs5647	696	-0.03	-0.145	0.086	0.620	773	-0.36	-3.775	3.064	0.838	774	-0.80	-1.497	-0.106	0.024
Rs11897425	696	-0.06	-0.177	0.050	0.271	773	-1.11	-4.451	2.237	0.516	774	-0.94	-1.618	-0.272	0.006
Rs13010545	693	-0.03	-0.145	0.087	0.621	770	-0.39	-3.821	3.049	0.826	771	-0.81	-1.500	-0.111	0.023
Mexican American															
	Hemoglobin A1c					**Fasting Glucose**					**Fasting Insulin**				
	N	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**	**N**	**β**	**95% CI**		**P-value**
Model 1: unadjusted															
Rs5647	719	0.00	-0.173	0.170	0.989	805	-0.99	-5.634	3.660	0.677	805	-0.10	-0.943	0.746	0.819
Rs11897425	719	0.01	-0.157	0.179	0.896	805	-0.18	-4.709	4.344	0.937	805	0.23	-0.599	1.065	0.583
Rs13010545	716	-0.04	-0.208	0.122	0.609	802	-1.99	-6.471	2.499	0.385	802	-0.02	-0.847	0.811	0.966
Model 2: adjusted for age, gender, European ancestry															
Rs5647	719	-0.03	-0.206	0.140	0.705	805	-1.91	-6.622	2.793	0.425	805	-0.21	-1.082	0.670	0.645
Rs11897425	719	-0.02	-0.191	0.148	0.802	805	-1.10	-5.627	3.426	0.633	805	0.15	-0.714	1.014	0.734
Rs13010545	716	-0.08	-0.241	0.090	0.372	802	-2.86	-7.369	1.650	0.214	802	-0.11	-0.967	0.748	0.802

Table 4.4 Unadjusted and adjusted longitudinal (GEE) analysis results by ethnicity for Proglucagon SNPs with change in BMI and Fasting Glucose: MESA

	Body Mass Index					Fasting Glucose				
European American										
	N	**β for change**	**95% CI**		**P-value**	**N**	**β for change**	**95% CI**		**P-value**
Model 1: unadjusted										
Rs6732914 (imputed)	2526	0.034	-0.028	0.096	0.285	2418	-0.335	-0.785	0.115	0.145
Rs5647	2526	0.029	-0.029	0.088	0.329	2418	-0.300	-0.744	0.143	0.185
Rs11897425	2526	0.034	-0.026	0.093	0.270	2418	-0.328	-0.762	0.105	0.138
Rs13010545	2515	0.031	-0.026	0.088	0.286	2407	0.259	-0.378	0.897	0.425
Model 2: adjusted for age, gender, European ancestry										
Rs6732914 (imputed)	2526	0.034	-0.029	0.096	0.289	2418	-0.346	-0.792	0.099	0.128
Rs5647	2526	0.029	-0.030	0.088	0.332	2418	-0.314	-0.754	0.127	0.163
Rs11897425	2526	0.033	-0.026	0.093	0.274	2418	-0.337	-0.768	0.093	0.124
Rs13010545	2515	0.031	-0.026	0.088	0.288	2407	0.255	-0.383	0.893	0.433
African American										
	Body Mass Index					**Fasting Glucose**				
	N	**β for change**	**95% CI**		**P-value**	**N**	**β for change**	**95% CI**		**P-value**
Model 1: unadjusted										
Rs6732914 (imputed)	1611	0.035	-0.011	0.081	0.136	1382	-0.123	-0.478	0.231	0.495
Rs5647	1609	0.033	-0.022	0.088	0.233	1380	-0.026	-0.441	0.388	0.901
Rs11897425	1609	0.022	-0.016	0.059	0.258	1380	-0.129	-0.381	0.123	0.316
Rs13010545	1609	0.024	-0.014	0.062	0.212	1380	-0.081	-0.350	0.187	0.554
Model 2: adjusted for age, gender, European ancestry										
Rs6732914 (imputed)	1611	0.035	-0.011	0.080	0.138	1382	-0.124	-0.479	0.232	0.496
Rs5647	1609	0.033	-0.022	0.088	0.244	1380	-0.018	-0.435	0.399	0.933
Rs11897425	1609	0.021	-0.017	0.059	0.273	1380	-0.121	-0.374	0.132	0.350
Rs13010545	1609	0.024	-0.014	0.061	0.223	1380	-0.076	-0.346	0.193	0.579
Chinese American										
	Body Mass Index					**Fasting Glucose**				
	N	**β for change**	**95% CI**		**P-value**	**N**	**β for change**	**95% CI**		**P-value**
Model 1: unadjusted										
Rs5647	775	0.002	-0.036	0.040	0.917	695	-0.054	-0.397	0.288	0.756
Rs11897425	775	0.004	-0.033	0.041	0.828	695	-0.048	-0.386	0.290	0.781
Rs13010545	772	0.002	-0.035	0.040	0.911	692	-0.067	-0.410	0.276	0.701
Model 2: adjusted for age, gender, European ancestry										
Rs5647	775	0.002	-0.036	0.040	0.915	695	-0.051	-0.394	0.292	0.769
Rs11897425	775	0.004	-0.033	0.041	0.828	695	-0.044	-0.383	0.294	0.798
Rs13010545	772	0.002	-0.035	0.040	0.908	692	-0.062	-0.405	0.282	0.725
Mexican American										
	Body Mass Index					**Fasting Glucose**				
	N	**β for change**	**95% CI**		**P-value**	**N**	**β for change**	**95% CI**		**P-value**
Model 1: unadjusted										
Rs5647	806	-0.029	-0.077	0.019	0.235	664	0.065	-0.338	0.468	0.752
Rs11897425	806	-0.027	-0.073	0.020	0.260	664	0.074	-0.397	0.544	0.758
Rs13010545	803	-0.027	-0.073	0.019	0.255	661	0.142	-0.326	0.610	0.553
Model 2: adjusted for age, gender, European ancestry										
Rs5647	806	-0.029	-0.076	0.019	0.241	664	0.050	-0.354	0.455	0.808
Rs11897425	806	-0.026	-0.073	0.020	0.266	664	0.063	-0.409	0.534	0.795
Rs13010545	803	-0.027	-0.073	0.020	0.261	661	0.127	-0.342	0.597	0.594

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

Table 4.5 Relative Risk regression and Cox Proportional Hazards results by ethnicity for Proglucagon SNPs with Ever (Prevalent and Incident) and Incident type 2 diabetes: MESA

European American											
	Ever Type 2 Diabetes					Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted											
Rs6732914 (imputed)	2526	287	0.69	0.36	1.33	0.269	2297	136	0.71	0.26	1.94	0.508
Rs5647	2526	287	0.71	0.39	1.30	0.266	2297	136	0.72	0.27	1.88	0.498
Rs11897425	2526	287	0.81	0.47	1.40	0.449	2297	136	0.68	0.26	1.82	0.445
Rs13010545	2515	286	0.91	0.62	1.33	0.617	2286	135	0.79	0.40	1.54	0.486
Model 2: adjusted for age, gender, European ancestry												
Rs6732914 (imputed)	2526	287	0.70	0.37	1.34	0.287	2297	136	0.69	0.25	1.87	0.464
Rs5647	2526	287	0.72	0.39	1.33	0.297	2297	136	0.70	0.27	1.84	0.473
Rs11897425	2526	287	0.82	0.48	1.43	0.493	2297	136	0.67	0.25	1.77	0.422
Rs13010545	2515	286	0.94	0.64	1.38	0.764	2286	135	0.80	0.41	1.57	0.518

African American												
	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Rs6732914 (imputed)	1609	400	0.98	0.82	1.17	0.835	1243	121	0.83	0.55	1.23	0.352
Rs5647	1607	399	1.09	0.90	1.32	0.360	1242	121	1.04	0.68	1.57	0.869
Rs11897425	1607	400	1.01	0.90	1.14	0.836	1241	121	0.83	0.62	1.11	0.203
Rs13010545	1607	400	1.02	0.90	1.16	0.769	1241	121	0.92	0.70	1.20	0.537
Model 2: adjusted for age, gender, European ancestry												
Rs6732914 (imputed)	1609	400	0.99	0.83	1.18	0.876	1243	121	0.82	0.55	1.23	0.338
Rs5647	1607	399	1.07	0.88	1.30	0.506	1242	121	1.03	0.68	1.56	0.880
Rs11897425	1607	400	1.01	0.89	1.13	0.906	1241	121	0.82	0.61	1.10	0.187
Rs13010545	1607	400	1.01	0.89	1.15	0.905	1241	121	0.91	0.69	1.20	0.506

Chinese American												
	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Rs5647	775	150	0.97	0.78	1.20	0.767	625	46	1.13	0.71	1.80	0.595
Rs11897425	775	150	0.97	0.78	1.20	0.752	625	46	1.20	0.74	1.92	0.462
Rs13010545	772	149	0.99	0.80	1.22	0.927	622	45	1.22	0.78	1.93	0.379
Model 2: adjusted for age, gender, European ancestry												
Rs5647	775	150	0.94	0.76	1.18	0.611	625	46	1.11	0.69	1.79	0.666
Rs11897425	775	150	0.93	0.74	1.16	0.528	625	46	1.17	0.72	1.90	0.529
Rs13010545	772	149	0.97	0.78	1.20	0.749	622	45	1.20	0.76	1.90	0.435

Mexican American												
	Ever Type 2 Diabetes						Incident Type 2 Diabetes					
	Total	Ever T2D	RR	95% CI		P-value	Total	Incident T2D	HR	95% CI		P-value
Model 1: unadjusted												
Rs5647	806	233	1.01	0.87	1.16	0.935	602	69	0.91	0.66	1.26	0.582
Rs11897425	806	233	1.04	0.91	1.20	0.553	602	69	0.99	0.72	1.35	0.936
Rs13010545	803	233	0.98	0.85	1.13	0.795	599	69	0.93	0.68	1.27	0.646
Model 2: adjusted for age, gender, European ancestry												
Rs5647	806	233	1.00	0.86	1.16	0.969	602	69	0.89	0.64	1.23	0.480
Rs11897425	806	233	1.04	0.90	1.20	0.590	602	69	0.96	0.70	1.32	0.816
Rs13010545	803	233	0.97	0.84	1.13	0.730	599	69	0.91	0.66	1.25	0.546

DISCUSSION

Although previous work with the proglucagon gene found associations with BMI and fasting glucose, we were unable to replicate these findings in this multi-ethnic cohort. Findings from Carlson et al came from data in African and Mexican Americans collected at one site where the age distribution was younger (median 24 and 36, inter-quartile range 21 – 28 and 27 – 51, respectively). This study consisted of an older diverse ethnic population ranging in age from 45 – 84 years in six field centers around the US. Although we did not observe any differences in the association by field centers, these demographic differences and others were not identified may have led to discrepancies with the previous study.

Nonetheless, it is clear that there are associations between ethnicity and outcomes examined in these analyses as well as in pooled proglucagon SNPs genotype and those outcomes. Since differences in minor allele frequencies clearly exist within ethnic groups, the proglucagon variant rs6732914 might only be a marker for ethnicity. On the other hand, directionality and larger average values of glycemic traits were apparent in the baseline characteristics by tags genotypes (Table 4.2). Mean values for fasting insulin were greater in the GG genotype than any of the means within each ethnic group, suggesting some genetic association. Another possibility for our null findings is that, although we adjusted for age, we did not have enough power to detect an association with the wide age range among MESA participants, especially among Chinese and Mexican Americans.

Regardless, the results of this study may make sense if we consider the ethnic health disparities in obesity and type 2 diabetes as a phenomenon which has occurred in the last few decades. If the proglucagon SNP rs6732914G was associated with risk and risk factors of type 2 diabetes regardless of dietary influences, the ethnic health disparities we observe in today's world would have been present throughout time. Historically, these differences have not been present, even if this gene affects susceptibility to obesity and type 2 diabetes.

The proglucagon gene encodes for key proteins involved in glucose and energy homeostasis. In the gastrointestinal tract, the transcription and translation of these proteins are triggered by consumption of foods, primarily carbohydrate-rich foods. Assuming an association between the proglucagon gene and susceptibility to obesity and type 2 diabetes exists, we may need to consider diet in these models or the possibility of a gene-diet interaction. With dietary measurements collected for MESA participants, we will investigate the effect diet measures have on the associations between the proglucagon SNPs with obesity and glycemic traits in Chapter 5.

This study is not without limitations. First, the proglucagon SNP of interest (rs6732914) has not been genotyped and imputed values were only available for European and African Americans. Although three highly correlated tags (R^2 = ~80%) were substituted in the analysis, the association between rs6732914 with obesity and glycemic traits was not tested and true associations might not have been captured in the analysis with the tags. Another limitation may have been a lack of power to detect an association in this multi-ethnic population due to small sample size after stratification by ethnicity.

In conclusion, we were unable to replicate Carlson et al. findings of proglucagon SNP (rs6732914) association with BMI and fasting glucose in our analyses using imputed genotype values and three tags. Further investigation considering diet or examining proglucagon gene association with obesity and type 2 diabetes in a larger multi-ethnic study may be worthwhile.

Chapter 5: Gene-diet Interaction, Conclusion and Implications for Future Research

In this dissertation, we investigated whether dietary acculturation or genetic susceptibility may contribute to the health disparities found within ethnic groups for obesity and type 2 diabetes. In Chapter 2, we first identified indicator foods of traditional Mexican, Chinese, and African American diets which can be used in dietary pattern association studies among these ethnic populations. We found that traditional ethnic diets were fairly similar and consisted of fresh and mostly unprocessed foods such as fruits, vegetables, and rice. A Western diet was described as primarily processed foods and snacks developed by the fast-food industry in the modern US.

In Chapter 3, we then measured how participants from MESA adhere to their traditional ethnic and Western diets as well as whether their adherence was associated with body mass index, A1c, fasting glucose, fasting insulin, and risk and incidence of type 2 diabetes. Although many associations were null, we did observe that greater adherence toward a Western diet was positively associated with BMI among most ethnic groups. In African Americans, the Western diet was also associated with greater fasting insulin values and the traditional African American diet was inversely associated with both BMI and fasting insulin.

In Chapter 4, we attempted to replicate associations previously observed in Mexican Americans and African Americans between the proglucagon gene SNP rs6732914 with BMI, fasting insulin and fasting glucose. Although the actual SNP rs6732914 has not been genotyped in MESA, we tested these association using three tags and imputed values for European and African Americans. We did not find the same results that Carlson et al observed. To properly investigate whether the proglucagon SNP rs6732914G is associated with increased susceptibility to obesity and type 2 diabetes, we will consider a gene-diet interaction in this Chapter using the traditional ethnic and Western dietary patterns.

GENE-DIET INTERACTION

The statistical methods used in examining the gene-diet relationship in this study are very similar to what has been described in Chapters 3 and 4. A brief description follows.

Statistical Methods

The proglucagon SNPs interaction with adherence to a traditional ethnic diet and Western diet associations with baseline risk factor for type 2 diabetes (including: fasting glucose, fasting insulin, A1c [exam 2], and BMI) within each ethnicity. The proglucagon SNPs were examined additively and in a genetic dominant model when testing for interactions. Interactions were determined using a Wald test based on use of robust standard errors in the multivariable linear regression models. If interactions with p-values<0.1 were observed with the baseline outcomes, G-allele stratified analysis were performed for the diet associations with baseline and longitudinal outcomes. Gene-diet interaction was investigated in relative risk regression for the presence of type 2 diabetes (prevalent and incident) and Cox proportional hazards regression for the incidence of type 2 diabetes. When interactions with p-values<0.1 were observed in the relative risk and Cox regressions, genotype stratified analysis were performed using a genetic dominant model (presence of G-allele). Fasting insulin models were adjusted for diabetes status as a categorical variable classified as normal (fasting glucose (FG) <100mg/dl), impaired glucose tolerance (FG = 100 – 125 mg/dl), and type 2 diabetes (FG >125 mg/dl). Additionally all gene-diet interaction models and stratified models were controlled for ancestry (proportion of European American descent), diet covariates [large serving size score and total caloric intake (kcal)], demographic variables [age (years), gender, education (<high school/GED, completed high school/GED, some college, bachelor’s degree, graduate or professional school), and immigration status (born in US or immigrant)], and behavioral factors [total moderate and vigorous physical activity (MET-min/wk), alcohol use (never, former, current), and smoking status (never, former, current)]. In the Cox proportional hazard regression, there were limited number of incident cases in the European American group and as a result only adjustment for total caloric intake was possible. Analyses were stratified by race/ethnicity and robust standard errors were used in all models. Interaction p-values <0.1 were further investigated and significant association results were denoted by p-values less than 0.05. All analysis was performed using STATA version 12.1 (StataCorp, College Station, Tex).

Results

Using an additive genetic model, the Wald p-values for the proglucagon gene-diet interactions for cross-sectional analysis of baseline measures are presented in Table 5.1. Among African Americans, significant gene-diet interactions were present for fasting glucose in the Western diet and A1c for both diets. There was also a significant gene-diet interaction for BMI with the Western diet as well as an interaction between rs11897425 and traditional diet for fasting glucose in Mexican Americans. There were no significant gene-diet interactions in European and Chinese Americans.

When considering a genetic dominant model in testing for gene-diet interactions (Table 5.2), the results were fairly similar to the additive model (Table 5.1). The additive model appears to be a better fit in African Americans compared to Mexican Americans where the interactions were more enhanced in the dominant model. As a result, all analysis considering BMI and glycemic traits were stratified by the presence of the G allele (genetic dominant model). For both African and Mexican Americans, results are also presented by SNP genotypes.

Table 5.1 Wald p-values for Proglucagon gene (ADDITIVE MODEL) and Diet Adherence (Traditional and Western) interaction from regression analysis by ethnicity for with baseline BMI, A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

	Body Mass Index		Hemoglobin A1c		Fasting Glucose		Fasting Insulin	
European American								
	N	**P-value**	**N**	**P-value**	**N**	**P-value**	**N**	**P-value**
Western diet								
Rs5647	2327	0.954	2075	0.683	2210	0.267	2208	0.231
Rs11897425	2327	0.771	2075	0.931	2210	0.216	2208	0.406
Rs13010545	2318	0.727	2066	0.196	2201	0.145	2199	0.260
Chinese American								
	Body Mass Index		**Hemoglobin A1c**		**Fasting Glucose**		**Fasting Insulin**	
	N	**P-value**	**N**	**P-value**	**N**	**P-value**	**N**	**P-value**
Traditional diet								
Rs5647	711	0.692	567	0.307	632	0.166	631	0.818
Rs11897425	711	0.715	567	0.235	632	0.208	631	0.573
Rs13010545	708	0.715	564	0.345	629	0.149	628	0.936
Western diet								
Rs5647	711	0.950	567	0.312	632	0.272	631	0.599
Rs11897425	711	0.795	567	0.191	632	0.354	631	0.730
Rs13010545	708	0.974	564	0.310	629	0.251	628	0.596
African American								
	Body Mass Index		**Hemoglobin A1c**		**Fasting Glucose**		**Fasting Insulin**	
	N	**P-value**	**N**	**P-value**	**N**	**P-value**	**N**	**P-value**
Traditional diet								
Rs5647	1333	0.245	1008	0.047	1135	0.722	1132	0.337
Rs11897425	1334	0.969	1009	0.029	1136	0.809	1133	0.937
Rs13010545	1333	0.475	1008	0.070	1135	0.617	1132	0.481
Western diet								
Rs5647	1333	0.803	1008	0.056	1135	0.065	1132	0.471
Rs11897425	1334	0.217	1009	0.057	1136	0.027	1133	0.506
Rs13010545	1333	0.801	1008	0.247	1135	0.060	1132	0.983
Mexican American								
	Body Mass Index		**Hemoglobin A1c**		**Fasting Glucose**		**Fasting Insulin**	
	N	**P-value**	**N**	**P-value**	**N**	**P-value**	**N**	**P-value**
Traditional diet								
Rs5647	711	0.664	521	0.874	575	0.107	574	0.502
Rs11897425	711	0.598	521	0.670	575	0.029	574	0.504
Rs13010545	708	0.592	518	0.786	572	0.124	571	0.464
Western diet								
Rs5647	711	0.062	521	0.757	575	0.768	574	0.477
Rs11897425	711	0.149	521	0.646	575	0.221	574	0.362
Rs13010545	708	0.083	518	0.662	572	0.691	571	0.288

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

*Participants taking medications affecting the outcomes: hemoglobin A1c, fasting Glucose, or fasting Insulin; were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

Table 5.2 Wald p-values for Proglucagon gene (DOMINANT GENETIC MODEL) and Diet Adherence (Traditional and Western) interaction from regression analysis by ethnicity for with baseline BMI, A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

European American								
	Body Mass Index		Hemoglobin A1c		Fasting Glucose		Fasting Insulin	
	N	P-value	N	P-value	N	P-value	N	P-value
Western diet								
Rs5647	2327	0.966	2075	0.682	2210	0.260	2208	0.264
Rs11897425	2327	0.757	2075	0.911	2210	0.179	2208	0.411
Rs13010545	2318	0.798	2066	0.196	2201	0.126	2199	0.285
Chinese American								
	Body Mass Index		Hemoglobin A1c		Fasting Glucose		Fasting Insulin	
	N	P-value	N	P-value	N	P-value	N	P-value
Traditional diet								
Rs5647	711	0.540	567	0.347	632	0.238	631	0.876
Rs11897425	711	0.379	567	0.257	632	0.267	631	0.906
Rs13010545	708	0.578	564	0.397	629	0.209	628	0.850
Western diet								
Rs5647	711	0.875	567	0.304	632	0.213	631	0.839
Rs11897425	711	0.821	567	0.143	632	0.271	631	0.878
Rs13010545	708	0.952	564	0.302	629	0.190	628	0.835
African American								
	Body Mass Index		Hemoglobin A1c		Fasting Glucose		Fasting Insulin	
	N	P-value	N	P-value	N	P-value	N	P-value
Traditional diet								
Rs5647	1333	0.137	1008	0.082	1135	0.654	1132	0.321
Rs11897425	1334	0.802	1009	0.098	1136	0.672	1133	0.798
Rs13010545	1333	0.587	1008	0.102	1135	0.441	1132	0.263
Western diet								
Rs5647	1333	0.662	1008	0.073	1135	0.124	1132	0.444
Rs11897425	1334	0.675	1009	0.161	1136	0.144	1133	0.571
Rs13010545	1333	0.683	1008	0.489	1135	0.088	1132	0.902
Mexican American								
	Body Mass Index		Hemoglobin A1c		Fasting Glucose		Fasting Insulin	
	N	P-value	N	P-value	N	P-value	N	P-value
Traditional diet								
Rs5647	711	0.605	521	0.894	575	0.151	574	0.374
Rs11897425	711	0.540	521	0.893	575	0.025	574	0.406
Rs13010545	708	0.515	518	0.890	572	0.187	571	0.435
Western diet								
Rs5647	711	0.046	521	0.835	575	0.730	574	0.883
Rs11897425	711	0.058	521	0.856	575	0.147	574	0.743
Rs13010545	708	0.043	518	0.789	572	0.694	571	0.740

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

The presence of the G allele had an effect on the Western diet association with baseline BMI, hemoglobin A1c, fasting glucose, and fasting insulin in European Americans (Table 5.3). Although significant associations and estimates observed in Chapter 3 with the Western diet and BMI in this ethnic group appeared to be the same in this analysis among non-G allele carriers, the sample size among carriers of the G allele is much smaller and produced non-significant and inconsistent estimates. Interestingly, most of the coefficients estimated in European Americans appear to show a reduced risk among G allele carriers for the association with the Western diet and all the baseline outcomes.

Although the associations between the Western diet and the baseline outcomes were not statistically significant in Chinese Americans, the estimated association coefficients were always greater for G allele carriers than the AA genotype. There also appears to be genetic differences in the associations between diet with BMI and fasting glucose in this group. Particularly, the traditional diet association with BMI was consistently protective for G allele carriers compared to those with the AA genotype. In fasting glucose relationship with either diet pattern, the coefficients were always much greater among G allele carriers than non-carriers.

Although traditional diet still remains negatively and Western diet positively associated with most baseline outcomes in African Americans, the coefficients did not greatly differ based on the genetic dominant model (AA versus AG/GG) for BMI and fasting glucose (Table 5.3). For hemoglobin A1c and fasting insulin, the association with Western diet was greater for the G allele carriers compared to those with the AA genotype. When not considering a dominant model and reviewing these associations based on genotype (Table 5.4), the relationships between traditional and Western diets with BMI, hemoglobin A1c, and fasting glucose were affected more so for the GG genotype compared to AA and AG suggesting a recessive model for these outcomes. However, fasting insulin did appear to follow more of a dominant model. Since rs5647 was not a good tag for this ethnic group, with a very limited number of GG genotypes, this SNP will not be used in the rest of the analysis for this group.

In Mexican Americans, all baseline outcomes associations with Western dietary pattern were much greater among G allele carriers compared to the AA genotype (Table 5.3). Traditional diet did not appear to be associated with the baseline outcomes, with most coefficients near zero regardless of genotype. When looking at the relationships by the tags' three genotypes (Table 5.4), the AG genotype produced similar results to the dominant model and the results for the GG genotype were inconsistent, most likely due to the small number of Mexican American participant with that genotype.

Table 5.3 Adjusted regression analysis results for Proglucagon SNPs (Dominant model) and baseline BMI, Hemoglobin A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA**

European American																				
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Western diet	2226	0.67	0.114	1.233	0.018	1986	-0.01	-0.070	0.044	0.652	2113	0.03	-1.752	1.811	0.974	2111	0.85	-0.030	1.721	0.058
AG/GG																				
Western diet	101	0.46	-1.887	2.811	0.697	89	-0.09	-0.320	0.148	0.465	97	-1.39	-7.659	4.882	0.661	97	0.36	-1.565	2.280	0.713
Rs11897425																				
AA																				
Western diet	2217	0.68	0.124	1.243	0.017	1979	-0.01	-0.069	0.045	0.685	2105	0.06	-1.726	1.842	0.949	2103	0.84	-0.037	1.719	0.060
AG/GG																				
Western diet	110	-0.49	-2.865	1.888	0.685	96	-0.13	-0.343	0.081	0.223	105	-3.53	-9.779	2.710	0.264	105	0.04	-1.973	2.047	0.971
Rs13010545																				
AA																				
Western diet	2144	0.67	0.095	1.243	0.022	1914	-0.01	-0.068	0.050	0.755	2036	-0.01	-1.857	1.828	0.988	2035	0.86	-0.044	1.761	0.062
AG/GG																				
Western diet	174	0.97	-0.827	2.765	0.288	152	-0.13	-0.304	0.040	0.131	165	-1.78	-6.825	3.262	0.487	164	0.31	-1.177	1.793	0.683

Chinese American																				
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Traditional diet	448	0.03	-0.197	0.267	0.769	352	0.01	-0.039	0.052	0.786	395	0.90	-0.073	1.882	0.070	395	0.01	-0.403	0.426	0.956
Western diet	448	-0.13	-1.188	0.929	0.810	352	-0.02	-0.345	0.305	0.902	395	-1.62	-9.838	6.598	0.699	395	0.69	-1.058	2.431	0.439
AG/GG																				
Traditional diet	263	-0.15	-0.383	0.076	0.190	215	0.03	-0.046	0.114	0.408	237	1.65	-0.450	3.753	0.123	236	-0.02	-0.361	0.326	0.920
Western diet	263	0.08	-1.379	1.546	0.911	215	0.06	-0.123	0.243	0.520	237	2.17	-3.308	7.639	0.436	236	0.80	-2.870	4.478	0.667
Rs11897425																				
AA																				
Traditional diet	444	0.04	-0.188	0.277	0.708	351	0.01	-0.038	0.053	0.751	390	1.09	0.040	2.131	0.042	390	0.00	-0.415	0.406	0.983
Western diet	444	-0.11	-1.176	0.953	0.838	351	-0.04	-0.357	0.286	0.827	390	-1.40	-9.645	6.843	0.738	390	0.61	-1.151	2.375	0.495
AG/GG																				
Traditional diet	267	-0.15	-0.385	0.084	0.209	216	0.04	-0.043	0.113	0.378	242	1.46	-0.451	3.380	0.133	241	0.01	-0.321	0.344	0.945
Western diet	267	-0.02	-1.415	1.379	0.979	216	0.10	-0.085	0.284	0.288	242	2.20	-3.397	7.791	0.440	241	0.80	-2.804	4.409	0.662
Rs13010545																				
AA																				
Traditional diet	440	0.03	-0.206	0.264	0.810	347	0.01	-0.039	0.055	0.728	388	0.87	-0.124	1.871	0.086	388	0.06	-0.360	0.477	0.784
Western diet	440	-0.10	-1.169	0.964	0.851	347	-0.03	-0.355	0.303	0.877	388	-1.64	-9.877	6.598	0.696	388	0.64	-1.110	2.384	0.474
AG/GG																				
Traditional diet	268	-0.15	-0.383	0.077	0.190	217	0.03	-0.048	0.112	0.428	241	1.71	-0.381	3.804	0.108	240	-0.04	-0.377	0.305	0.835
Western diet	268	-0.02	-1.472	1.429	0.977	217	0.06	-0.119	0.237	0.516	241	1.98	-3.298	7.260	0.460	240	0.88	-2.745	4.504	0.633

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

P-values <0.05

P-values <0.1

Table 5.3 (continues)

African American																				
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Traditional diet	1073	-0.32	-0.533	-0.110	0.003	809	-0.02	-0.043	0.011	0.239	912	-0.34	-1.089	0.409	0.373	911	-0.32	-0.537	-0.095	0.005
Western diet	1073	0.88	0.098	1.657	0.027	809	0.02	-0.092	0.124	0.771	912	2.29	-1.311	5.900	0.212	911	0.90	0.019	1.775	0.045
AG/GG																				
Traditional diet	260	-0.63	-1.078	-0.183	0.006	199	0.05	-0.015	0.110	0.132	223	-0.24	-2.695	2.211	0.846	221	-0.61	-1.088	-0.142	0.011
Western diet	260	1.25	-0.571	3.064	0.178	199	0.12	-0.209	0.459	0.461	223	-0.32	-10.963	10.323	0.953	221	0.95	-0.717	2.621	0.262
Rs11897425																				
AA																				
Traditional diet	654	-0.45	-0.729	-0.171	0.002	492	-0.01	-0.044	0.022	0.513	561	-0.24	-0.928	0.444	0.489	560	-0.35	-0.609	-0.086	0.009
Western diet	654	0.81	-0.192	1.807	0.113	492	0.04	-0.062	0.136	0.463	561	2.99	0.600	5.374	0.014	560	0.66	-0.396	1.720	0.220
AG/GG																				
Traditional diet	680	-0.34	-0.598	-0.076	0.011	517	0.01	-0.032	0.049	0.669	575	-0.44	-1.983	1.111	0.580	573	-0.30	-0.601	-0.005	0.047
Western diet	680	1.03	-0.011	2.066	0.053	517	0.07	-0.126	0.258	0.500	575	2.28	-4.478	9.032	0.508	573	1.39	0.298	2.479	0.013
Rs13010545																				
AA																				
Traditional diet	686	-0.37	-0.651	-0.098	0.008	516	-0.02	-0.050	0.018	0.357	582	-0.28	-1.021	0.471	0.469	581	-0.25	-0.500	0.003	0.052
Western diet	686	0.95	-0.014	1.918	0.053	516	0.07	-0.022	0.163	0.135	582	2.24	-0.072	4.549	0.058	581	0.44	-0.496	1.380	0.355
AG/GG																				
Traditional diet	647	-0.42	-0.679	-0.152	0.002	492	0.01	-0.029	0.054	0.563	553	-0.45	-1.965	1.059	0.556	551	-0.42	-0.733	-0.100	0.010
Western diet	647	0.73	-0.326	1.794	0.174	492	0.02	-0.189	0.234	0.835	553	2.38	-4.861	9.627	0.518	551	1.66	0.418	2.911	0.009

Mexican American																				
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Traditional diet	337	-0.04	-0.107	0.028	0.248	253	-0.01	-0.023	0.002	0.094	277	-0.32	-0.758	0.116	0.149	277	-0.02	-0.123	0.076	0.643
Western diet	337	-0.04	-0.949	0.873	0.935	253	-0.09	-0.279	0.095	0.333	277	2.04	-8.969	13.048	0.716	277	0.31	-1.074	1.702	0.657
AG/GG																				
Traditional diet	374	0.00	-0.070	0.075	0.946	268	0.00	-0.012	0.010	0.891	298	0.26	-0.240	0.756	0.309	297	0.00	-0.091	0.094	0.974
Western diet	374	1.27	0.366	2.175	0.006	268	0.15	-0.013	0.319	0.072	298	2.46	-0.569	5.496	0.111	297	0.61	-1.246	2.469	0.517
Rs11897425																				
AA																				
Traditional diet	329	-0.04	-0.112	0.022	0.186	248	-0.01	-0.023	0.002	0.100	272	-0.37	-0.781	0.042	0.078	272	-0.01	-0.107	0.086	0.829
Western diet	329	-0.06	-1.036	0.924	0.911	248	-0.10	-0.295	0.091	0.299	272	-3.81	-7.897	0.275	0.067	272	0.46	-0.813	1.725	0.480
AG/GG																				
Traditional diet	382	0.01	-0.064	0.080	0.827	273	0.00	-0.012	0.010	0.879	303	0.29	-0.219	0.796	0.264	302	0.00	-0.088	0.096	0.935
Western diet	382	1.14	0.272	2.005	0.010	273	0.16	-0.007	0.325	0.061	303	6.81	-1.556	15.168	0.110	302	0.50	-1.389	2.394	0.602
Rs13010545																				
AA																				
Traditional diet	320	-0.04	-0.111	0.026	0.225	237	-0.01	-0.024	0.002	0.098	261	-0.31	-0.757	0.144	0.181	261	-0.01	-0.109	0.094	0.881
Western diet	320	-0.08	-1.032	0.869	0.866	237	-0.11	-0.299	0.087	0.281	261	1.89	-9.459	13.241	0.743	261	0.25	-1.136	1.641	0.721
AG/GG																				
Traditional diet	388	0.01	-0.064	0.080	0.829	281	0.00	-0.011	0.011	0.966	311	0.23	-0.270	0.723	0.370	310	-0.01	-0.103	0.080	0.807
Western diet	388	1.24	0.380	2.109	0.005	281	0.16	-0.001	0.320	0.051	311	2.37	-0.595	5.328	0.117	310	0.51	-1.323	2.344	0.584

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

P-values <0.05

P-values <0.1

Table 5.4 Adjusted regression analysis results for Proglucagon SNPs (by Genotype) and baseline BMI, Hemoglobin A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA**

African Americans																				
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Traditional diet	1073	-0.32	-0.533	-0.110	0.003	809	-0.02	-0.043	0.011	0.239	912	-0.34	-1.089	0.409	0.373	911	-0.32	-0.537	-0.095	0.005
Western diet	1073	0.88	0.098	1.657	0.027	809	0.02	-0.092	0.124	0.771	912	2.29	-1.311	5.900	0.212	911	0.90	0.019	1.775	0.045
AG																				
Traditional diet	241	-0.72	-1.198	-0.236	0.004	184	0.04	-0.026	0.111	0.222	208	-0.06	-2.788	2.663	0.964	207	-0.64	-1.137	-0.144	0.012
Western diet	241	1.10	-0.828	3.037	0.261	184	0.10	-0.253	0.446	0.587	208	-2.06	-13.174	9.058	0.716	207	0.90	-0.794	2.596	0.296
GG																				
Traditional diet	19	1.11	-2.801	5.025	0.559	15	0.48	0.484	0.484	.	15	21.26	21.258	21.258	.	14	-7.94	-7.942	-7.942	.
Western diet	19	3.27	-9.229	15.760	0.591	15	2.54	2.544	2.544	.	15	111.67	111.671	111.671	.	14	26.38	26.379	26.379	.
Rs11897425																				
AA																				
Traditional diet	654	-0.45	-0.729	-0.171	0.002	492	-0.01	-0.044	0.022	0.513	561	-0.24	-0.928	0.444	0.489	560	-0.35	-0.609	-0.086	0.009
Western diet	654	0.81	-0.192	1.807	0.113	492	0.04	-0.062	0.136	0.463	561	2.99	0.600	5.374	0.014	560	0.66	-0.396	1.720	0.220
AG																				
Traditional diet	550	-0.29	-0.578	0.006	0.055	420	-0.01	-0.051	0.041	0.823	462	-0.17	-2.076	1.735	0.861	460	-0.23	-0.570	0.101	0.170
Western diet	550	0.49	-0.632	1.618	0.390	420	0.02	-0.183	0.215	0.873	462	1.23	-6.605	9.066	0.758	460	1.51	0.304	2.708	0.014
GG																				
Traditional diet	130	-0.56	-1.175	0.046	0.070	97	0.06	-0.009	0.133	0.084	113	-1.36	-2.976	0.264	0.100	113	-0.69	-1.550	0.168	0.114
Western diet	130	3.53	0.763	6.294	0.013	97	0.56	0.092	1.020	0.019	113	8.35	-0.559	17.256	0.066	113	0.81	-2.430	4.045	0.622
Rs13010545																				
AA																				
Traditional diet	686	-0.37	-0.651	-0.098	0.008	516	-0.02	-0.050	0.018	0.357	582	-0.28	-1.021	0.471	0.469	581	-0.25	-0.500	0.003	0.052
Western diet	686	0.95	-0.014	1.918	0.053	516	0.07	-0.022	0.163	0.135	582	2.24	-0.072	4.549	0.058	581	0.44	-0.496	1.380	0.355
AG																				
Traditional diet	538	-0.37	-0.659	-0.078	0.013	409	0.01	-0.042	0.053	0.814	460	-0.21	-2.028	1.605	0.819	459	-0.45	-0.796	-0.112	0.009
Western diet	538	0.66	-0.489	1.815	0.259	409	-0.03	-0.254	0.197	0.807	460	1.24	-6.914	9.404	0.764	459	1.96	0.589	3.332	0.005
GG																				
Traditional diet	109	-0.68	-1.373	0.015	0.055	83	0.05	-0.029	0.124	0.219	93	-0.83	-2.484	0.815	0.317	92	-0.45	-1.201	0.306	0.241
Western diet	109	1.66	-1.445	4.768	0.291	83	0.48	-0.058	1.019	0.079	93	13.96	4.560	23.357	0.004	92	-2.16	-6.216	1.897	0.293

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

P-values <0.05

P-values <0.1

Table 5.4 continues

	Mexican American																			
	Body Mass Index					Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647																				
AA																				
Traditional diet	337	-0.04	-0.107	0.028	0.248	253	-0.01	-0.023	0.002	0.094	277	-0.32	-0.758	0.116	0.149	277	-0.02	-0.123	0.076	0.643
Western diet	337	-0.04	-0.949	0.873	0.935	253	-0.09	-0.279	0.095	0.333	277	2.04	-8.969	13.048	0.716	277	0.31	-1.074	1.702	0.657
AG																				
Traditional diet	292	-0.01	-0.092	0.070	0.795	209	0.00	-0.013	0.011	0.891	231	0.21	-0.362	0.789	0.466	230	0.02	-0.084	0.121	0.717
Western diet	292	1.64	0.689	2.583	0.001	209	0.21	0.028	0.390	0.024	231	2.38	-0.950	5.712	0.160	230	1.41	-0.414	3.224	0.129
GG																				
Traditional diet	82	0.14	0.0005	0.278	0.049	59	0.01	-0.038	0.048	0.816	67	0.10	-0.916	1.116	0.845	67	-0.05	-0.312	0.220	0.731
Western diet	82	-0.11	-2.662	2.441	0.932	59	-0.11	-0.561	0.334	0.614	67	-0.18	-10.465	10.101	0.972	67	-4.27	-9.188	0.639	0.087
Rs11897425																				
AA																				
Traditional diet	329	-0.04	-0.112	0.022	0.186	248	-0.01	-0.023	0.002	0.100	272	-0.37	-0.781	0.042	0.078	272	-0.01	-0.107	0.086	0.829
Western diet	329	-0.06	-1.036	0.924	0.911	248	-0.10	-0.295	0.091	0.299	272	-3.81	-7.897	0.275	0.067	272	0.46	-0.813	1.725	0.480
AG																				
Traditional diet	295	-0.01	-0.088	0.071	0.826	209	-0.002	-0.014	0.010	0.758	231	0.29	-0.297	0.871	0.334	230	0.02	-0.077	0.124	0.647
Western diet	295	1.46	0.564	2.365	0.002	209	0.20	0.030	0.379	0.022	231	7.58	-2.447	17.599	0.138	230	1.31	-0.542	3.163	0.165
GG																				
Traditional diet	87	0.14	-0.010	0.295	0.067	64	0.01	-0.035	0.050	0.726	72	0.15	-0.902	1.202	0.777	72	-0.08	-0.330	0.172	0.532
Western diet	87	0.00	-2.498	2.488	0.997	64	-0.11	-0.528	0.303	0.590	72	-1.73	-11.426	7.969	0.723	72	-4.48	-9.383	0.417	0.072
Rs13010545																				
AA																				
Traditional diet	320	-0.04	-0.111	0.026	0.225	237	-0.01	-0.024	0.002	0.098	261	-0.31	-0.757	0.144	0.181	261	-0.01	-0.109	0.094	0.881
Western diet	320	-0.08	-1.032	0.869	0.866	237	-0.11	-0.299	0.087	0.281	261	1.89	-9.459	13.241	0.743	261	0.25	-1.136	1.641	0.721
AG																				
Traditional diet	294	-0.01	-0.087	0.076	0.898	211	-0.001	-0.013	0.011	0.816	232	0.15	-0.433	0.735	0.611	231	-0.01	-0.111	0.095	0.879
Western diet	294	1.62	0.712	2.529	0.001	211	0.23	0.065	0.401	0.007	232	2.47	-0.773	5.711	0.135	231	1.44	-0.328	3.205	0.110
GG																				
Traditional diet	94	0.14	0.013	0.261	0.031	70	0.005	-0.039	0.049	0.823	79	0.21	-0.750	1.171	0.663	79	-0.002	-0.238	0.234	0.987
Western diet	94	-0.26	-2.531	2.010	0.821	70	-0.10	-0.455	0.255	0.577	79	-1.56	-10.259	7.138	0.722	79	-4.25	-8.509	0.016	0.051

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

P-values <0.05

P-values <0.1

Table 5.5 Censored regression analysis (right censored based on diabetes medication use) for Proglucagon SNPs and baseline Hemoglobin A1c (visit 2), Fasting Glucose, and Fasting Insulin: MESA

Chinese American	Hemoglobin A1c					Fasting Glucose					Fasting Insulin				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647															
AA															
Traditional diet	401	0.025	-0.048	0.097	0.502	447	0.637	-1.110	2.385	0.474	446	-0.001	-0.405	0.404	0.997
Western diet	401	0.024	-0.329	0.377	0.893	447	-0.602	-9.797	8.594	0.898	446	1.016	-0.656	2.687	0.233
AG															
Traditional diet	209	0.023	-0.077	0.123	0.649	233	1.217	-1.278	3.713	0.337	232	-0.134	-0.499	0.230	0.469
Western diet	209	-0.211	-0.545	0.122	0.213	233	-4.616	-14.386	5.154	0.353	232	0.774	-3.272	4.820	0.706
GG															
Traditional diet	26	0.074	0.010	0.137	0.024	28	3.456	2.614	4.298	3.84E-09	28	1.430	-0.085	2.945	0.063
Western diet	26	0.038	-0.491	0.566	0.885	28	1.439	-7.651	10.529	0.748	28	1.342	-2.502	5.187	0.480
Rs11897425															
AA															
Traditional diet	400	0.031	-0.042	0.104	0.403	442	0.843	-0.951	2.638	0.356	441	-0.017	-0.419	0.385	0.934
Western diet	400	0.012	-0.343	0.367	0.948	442	-0.122	-9.448	9.205	0.980	441	0.917	-0.773	2.607	0.287
AG															
Traditional diet	209	0.022	-0.080	0.123	0.674	236	1.309	-1.125	3.742	0.290	235	-0.130	-0.489	0.229	0.478
Western diet	209	-0.169	-0.494	0.157	0.308	236	-4.511	-13.996	4.974	0.350	235	0.758	-3.208	4.725	0.707
GG															
Traditional diet	27	0.061	-0.035	0.156	0.206	30	2.735	0.757	4.712	0.008	30	1.441	0.564	2.318	0.002
Western diet	27	-0.00004	-0.400	0.400	0.9998	30	0.306	-13.417	14.028	0.964	30	1.737	-1.316	4.790	0.254
Rs13010545															
AA															
Traditional diet	395	0.027	-0.046	0.101	0.464	439	0.580	-1.199	2.360	0.522	438	0.044	-0.364	0.453	0.832
Western diet	395	0.018	-0.339	0.375	0.920	439	-0.606	-9.896	8.684	0.898	438	0.977	-0.698	2.652	0.252
AG															
Traditional diet	212	0.020	-0.078	0.119	0.683	238	1.405	-1.072	3.882	0.265	237	-0.160	-0.520	0.201	0.384
Western diet	212	-0.181	-0.504	0.143	0.272	238	-3.995	-13.543	5.554	0.411	237	0.861	-3.127	4.848	0.671
GG															
Traditional diet	26	0.074	0.010	0.137	0.024	28	3.456	2.614	4.298	3.84E-09	28	1.430	-0.085	2.945	0.063
Western diet	26	0.038	-0.491	0.566	0.885	28	1.439	-7.651	10.529	0.748	28	1.342	-2.502	5.187	0.480
African American	**Hemoglobin A1c**					**Fasting Glucose**					**Fasting Insulin**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs11897425															
AA															
Traditional diet	572	0.060	-0.006	0.125	0.074	654	2.426	0.631	4.221	0.008	651	-0.484	-0.787	-0.180	0.002
Western diet	572	0.206	-0.021	0.432	0.075	654	7.101	1.299	12.902	0.017	651	0.338	-0.796	1.472	0.559
AG															
Traditional diet	495	0.031	-0.039	0.101	0.387	546	0.555	-1.650	2.760	0.621	544	-0.093	-0.455	0.269	0.614
Western diet	495	0.096	-0.136	0.329	0.417	546	3.616	-4.605	11.838	0.388	544	1.582	0.185	2.979	0.027
GG															
Traditional diet	110	0.095	-0.004	0.195	0.059	130	-0.022	-2.947	2.902	0.988	129	-0.806	-1.605	-0.008	0.048
Western diet	110	1.541	0.576	2.507	0.002	130	16.581	-10.400	43.563	0.226	129	2.965	-1.232	7.162	0.165
Rs13010545															
AA															
Traditional diet	604	0.034	-0.028	0.095	0.284	685	2.170	0.368	3.973	0.018	682	-0.218	-0.471	0.035	0.091
Western diet	604	0.262	0.045	0.479	0.018	685	7.147	1.443	12.851	0.014	682	0.729	-0.222	1.680	0.133
AG															
Traditional diet	475	0.068	-0.003	0.139	0.062	535	1.052	-1.018	3.123	0.318	534	-0.460	-0.920	0.001	0.050
Western diet	475	0.040	-0.210	0.290	0.755	535	3.491	-4.814	11.796	0.409	534	1.550	-0.343	3.443	0.108
GG															
Traditional diet	97	0.034	-0.095	0.162	0.607	109	-2.019	-5.856	1.818	0.299	107	-0.462	-1.208	0.284	0.222
Western diet	97	1.199	0.408	1.989	0.003	109	18.055	-9.408	45.517	0.195	107	1.086	-4.266	6.438	0.688
Mexican American	**Hemoglobin A1c**					**Fasting Glucose**					**Fasting Insulin**				
	N	β	95% CI		P-value	N	β	95% CI		P-value	N	β	95% CI		P-value
Rs5647															
AA															
Traditional diet	306	0.016	-0.011	0.043	0.253	337	0.193	-0.538	0.924	0.603	336	-0.007	-0.102	0.087	0.876
Western diet	306	0.048	-0.317	0.413	0.796	337	5.420	-6.402	17.242	0.368	336	0.290	-1.128	1.709	0.687
AG															
Traditional diet	261	0.027	-0.006	0.060	0.107	292	0.573	-0.333	1.479	0.214	290	-0.099	-0.245	0.048	0.187
Western diet	261	0.177	-0.198	0.551	0.353	292	-0.442	-10.872	9.987	0.934	290	1.159	-1.094	3.412	0.312
GG															
Traditional diet	71	0.011	-0.049	0.072	0.710	81	-0.790	-2.282	0.703	0.296	81	0.051	-0.131	0.233	0.579
Western diet	71	0.108	-0.635	0.851	0.773	81	13.931	-9.660	37.522	0.243	81	-4.151	-8.184	-0.118	0.044
Rs11897425															
AA															
Traditional diet	299	0.015	-0.013	0.042	0.297	329	0.070	-0.638	0.778	0.846	328	0.001	-0.090	0.092	0.983
Western diet	299	0.068	-0.312	0.447	0.725	329	1.217	-7.839	10.273	0.792	328	0.604	-0.572	1.780	0.313
AG															
Traditional diet	262	0.029	-0.005	0.062	0.091	295	0.675	-0.245	1.596	0.150	293	-0.094	-0.236	0.049	0.197
Western diet	262	0.173	-0.192	0.537	0.351	295	3.701	-8.040	15.441	0.536	293	0.469	-2.145	3.084	0.724
GG															
Traditional diet	77	0.015	-0.040	0.070	0.588	86	-0.435	-1.903	1.032	0.557	86	0.001	-0.182	0.184	0.993
Western diet	77	0.123	-0.578	0.824	0.728	86	11.615	-13.243	36.472	0.356	86	-4.429	-8.487	-0.370	0.033
Rs13010545															
AA															
Traditional diet	290	0.017	-0.012	0.045	0.245	320	0.233	-0.528	0.994	0.547	319	0.006	-0.090	0.102	0.900
Western diet	290	0.044	-0.334	0.423	0.817	320	5.212	-7.058	17.483	0.404	319	0.230	-1.194	1.653	0.751
AG															
Traditional diet	263	0.025	-0.008	0.059	0.135	294	0.484	-0.428	1.397	0.297	292	-0.124	-0.275	0.026	0.104
Western diet	263	0.189	-0.176	0.555	0.309	294	-0.494	-10.649	9.661	0.924	292	1.249	-0.968	3.467	0.268
GG															
Traditional diet	82	0.021	-0.028	0.069	0.399	93	-0.357	-1.617	0.903	0.575	93	0.086	-0.085	0.258	0.321
Western diet	82	0.208	-0.458	0.874	0.537	93	15.099	-7.814	38.012	0.194	93	-4.134	-7.839	-0.429	0.029

**Models adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), and behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status).
#Fasting Insulin model adjusted for diabetes status (normal, impaired fasting glucose, and diabetes)

In the longitudinal analysis, there were no significant changes in BMI or fasting glucose associated with diet (Chapter 3), proglucagon tags (Chapter 4), or with diet stratified by G allele (dominant genetic model) in European, African, and Mexican Americans (Table 5.5). However the associations between traditional and Western diets with baseline outcomes by G allele (Table 5.3) were replicated in the GEE models testing for change (Table 5.5). On the other hand, significant or close to significant changes in BMI and fasting glucose associated with traditional diet were observed in Chinese Americans. Specifically, adherence to a traditional diet and the presence of the G allele was inversely associated with BMI. When considering fasting glucose, the negative coefficient for change with adherence to a traditional diet in the AA genotype was significant for all three tags.

When considering the change in BMI and fasting glucose by genotype (AA, AG, and GG) for African Americans and Mexican Americans (Table 5.6), the dietary patterns' associations with BMI and fasting glucose were more pronounced. The Western diet associations with BMI and fasting glucose were much greater in the GG genotype compared to the other two genotypes among African Americans. In this ethnic group, the traditional diet appears to be negatively associated with BMI for all genotypes in any tag. Also, the inverse association estimates between the traditional diet and fasting glucose were greater for the GG genotype than the other genotypes.

In Mexican Americans, there was no significant change in BMI based on diet and genotype for all three tags. However, it is apparent that the positive association between the Western diet and BMI in this group is related to the presence of the G allele and suggested no association in traditional diet adherence and BMI with G allele carriers. Although the traditional diet did not appear to be associated with BMI in participants with the AA or AG genotype, among the GG genotype it was positively associated with BMI. Nonetheless, the positive association estimate was much smaller than the estimate of the Western diet with BMI in the GG genotype. With the GG genotype, the negative change in fasting glucose associated with traditional diet almost approached significance for all three tags.

Table 5.6 Longitudinal analysis results by ethnicity and Proglucagon SNPs (Dominant model) for Diet Adherence with BMI and Fasting Glucose: MESA

	Body Mass Index					Fasting Glucose!				
European American	**N**	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs5647										
AA										
Western Diet	2226	0.002	-0.042	0.046	0.929	2131	0.179	-0.154	0.511	0.293
AG/GG										
Western Diet	101	0.018	-0.147	0.183	0.829	97	0.633	-0.368	1.634	0.215
Rs11897425										
AA										
Western Diet	2217	0.001	-0.043	0.045	0.976	2123	0.172	-0.162	0.506	0.312
AG/GG										
Western Diet	110	0.055	-0.120	0.230	0.536	105	0.612	-0.345	1.569	0.210
Rs13010545										
AA										
Western Diet	2144	0.001	-0.044	0.046	0.963	2054	0.190	-0.149	0.529	0.272
AG/GG										
Western Diet	174	0.008	-0.143	0.159	0.915	165	0.158	-0.812	1.129	0.749
	Body Mass Index					**Fasting Glucose!**				
Chinese American	**N**	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs5647										
AA										
Traditional Chinese Diet	448	-0.002	-0.026	0.023	0.898	397	-0.260	-0.501	-0.019	0.034
Western Diet	448	0.019	-0.075	0.114	0.691	397	0.200	-1.196	1.597	0.778
AG/GG										
Traditional Chinese Diet	263	0.014	-0.003	0.031	0.100	239	-0.154	-0.478	0.169	0.349
Western Diet	263	0.049	-0.091	0.189	0.490	239	-0.914	-2.103	0.275	0.132
Rs11897425										
AA										
Traditional Chinese Diet	444	-0.003	-0.028	0.022	0.802	393	-0.257	-0.502	-0.012	0.040
Western Diet	444	0.003	-0.094	0.100	0.956	393	0.069	-1.330	1.468	0.923
AG/GG										
Traditional Chinese Diet	267	0.016	-0.001	0.032	0.073	243	-0.155	-0.476	0.165	0.343
Western Diet	267	0.081	-0.049	0.212	0.222	243	-0.728	-1.920	0.464	0.231
Rs13010545										
AA										
Traditional Chinese Diet	440	0.000	-0.025	0.025	0.9999	390	-0.257	-0.499	-0.014	0.038
Western Diet	440	0.016	-0.079	0.110	0.746	390	0.206	-1.190	1.602	0.773
AG/GG										
Traditional Chinese Diet	268	0.013	-0.004	0.030	0.142	243	-0.156	-0.477	0.164	0.339
Western Diet	268	0.055	-0.084	0.195	0.435	243	-0.943	-2.132	0.245	0.120
	Body Mass Index					**Fasting Glucose!**				
African American	**N**	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs5647										
AA										
Traditional African American Diet	1073	0.005	-0.014	0.024	0.596	918	-0.005	-0.151	0.141	0.943
Western Diet	1073	0.027	-0.035	0.088	0.395	918	-0.140	-0.657	0.378	0.597
AG/GG										
Traditional African American Diet	260	0.035	-0.008	0.078	0.115	225	-0.019	-0.493	0.454	0.936
Western Diet	260	0.058	-0.085	0.201	0.427	225	-0.636	-1.636	0.364	0.212
Rs11897425										
AA										
Traditional African American Diet	654	0.014	-0.010	0.038	0.262	563	-0.038	-0.178	0.102	0.597
Western Diet	654	0.012	-0.057	0.081	0.734	563	-0.097	-0.557	0.364	0.680
AG/GG										
Traditional African American Diet	680	0.009	-0.017	0.035	0.486	581	0.008	-0.306	0.323	0.958
Western Diet	680	0.066	-0.029	0.161	0.172	581	-0.553	-1.500	0.394	0.253
Rs13010545										
AA										
Traditional African American Diet	686	0.012	-0.011	0.036	0.301	585	-0.026	-0.184	0.133	0.750
Western Diet	686	0.032	-0.039	0.103	0.383	585	0.113	-0.406	0.632	0.669
AG/GG										
Traditional African American Diet	647	0.010	-0.016	0.037	0.436	558	-0.006	-0.303	0.290	0.966
Western Diet	647	0.036	-0.056	0.129	0.442	558	-0.839	-1.713	0.036	0.060
	Body Mass Index					**Fasting Glucose!**				
Mexican American	**N**	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs5647										
AA										
Traditional Mexican Diet	337	0.0002	-0.008	0.008	0.955	282	-0.029	-0.112	0.055	0.501
Western Diet	337	0.062	-0.013	0.138	0.104	282	-1.044	-2.517	0.428	0.165
AG/GG										
Traditional Mexican Diet	374	-0.001	-0.007	0.005	0.780	302	-0.049	-0.161	0.062	0.385
Western Diet	374	-0.012	-0.099	0.074	0.782	302	0.903	-1.449	3.256	0.452
Rs11897425										
AA										
Traditional Mexican Diet	329	0.001	-0.007	0.009	0.768	277	-0.016	-0.086	0.054	0.655
Western Diet	329	0.056	-0.020	0.131	0.148	277	-0.426	-1.248	0.396	0.309
AG/GG										
Traditional Mexican Diet	382	-0.002	-0.008	0.004	0.566	307	-0.059	-0.174	0.057	0.320
Western Diet	382	-0.006	-0.091	0.079	0.893	307	0.467	-2.079	3.013	0.719
Rs13010545										
AA										
Traditional Mexican Diet	320	0.001	-0.008	0.009	0.879	266	-0.027	-0.114	0.059	0.539
Western Diet	320	0.061	-0.015	0.137	0.118	266	-1.123	-2.617	0.371	0.141
AG/GG										
Traditional Mexican Diet	388	-0.001	-0.007	0.005	0.700	315	-0.050	-0.159	0.060	0.375
Western Diet	388	-0.010	-0.096	0.075	0.813	315	0.966	-1.363	3.296	0.416

Models** adjusted for all diet (large serving size score and total caloric intake), demographic characteristics (age, gender, education, and immigration status), behavioral characteristics (total moderate and vigorous physical activity, alcohol consumption, and smoking status), and European ancestry
!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

Table 5.7 Longitudinal (GEE) analysis results by ethnicity and Proglucagon SNPs (Genotype) for Diet Adherence (Traditional and Western) with BMI and Fasting Glucose: MESA

African American										
	Body Mass Index					**Fasting Glucose!**				
	N	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs11897425										
AA										
Traditional African American Diet	654	0.014	-0.010	0.038	0.262	563	-0.038	-0.178	0.102	0.597
Western Diet	654	0.012	-0.057	0.081	0.734	563	-0.097	-0.557	0.364	0.680
AG										
Traditional African American Diet	550	0.006	-0.022	0.034	0.690	468	-0.046	-0.422	0.330	0.811
Western Diet	550	0.085	-0.020	0.190	0.111	468	-0.572	-1.679	0.536	0.311
GG										
Traditional African American Diet	130	0.018	-0.050	0.086	0.604	113	0.227	-0.139	0.593	0.224
Western Diet	130	-0.059	-0.283	0.165	0.607	113	-0.437	-1.356	0.482	0.351
Rs13010545										
AA										
Traditional African American Diet	686	0.012	-0.011	0.036	0.301	585	-0.026	-0.184	0.133	0.750
Western Diet	686	0.032	-0.039	0.103	0.383	585	0.113	-0.406	0.632	0.669
AG										
Traditional African American Diet	538	0.009	-0.019	0.037	0.546	465	-0.049	-0.405	0.307	0.788
Western Diet	538	0.047	-0.055	0.149	0.368	465	-1.069	-2.093	-0.046	0.041
GG										
Traditional African American Diet	109	0.022	-0.044	0.089	0.511	93	0.170	-0.135	0.475	0.275
Western Diet	109	-0.045	-0.268	0.179	0.696	93	0.258	-0.820	1.335	0.639
Mexican American										
	Body Mass Index					**Fasting Glucose!**				
	N	**β for Change**	**95% CI**		**P-value**	**N**	**β for Change**	**95% CI**		**P-value**
Rs5647										
AA										
Traditional Mexican Diet	337	0.0002	-0.008	0.008	0.955	282	-0.029	-0.112	0.055	0.501
Western Diet	337	0.062	-0.013	0.138	0.104	282	-1.044	-2.517	0.428	0.165
AG										
Traditional Mexican Diet	292	-0.002	-0.009	0.005	0.594	234	-0.003	-0.150	0.144	0.965
Western Diet	292	-0.023	-0.122	0.076	0.647	234	1.560	-1.232	4.352	0.273
GG										
Traditional Mexican Diet	82	0.002	-0.009	0.013	0.753	68	-0.159	-0.331	0.013	0.070
Western Diet	82	0.087	-0.093	0.267	0.342	68	-1.808	-5.406	1.790	0.325
Rs11897425										
AA										
Traditional Mexican Diet	329	0.001	-0.007	0.009	0.768	277	-0.016	-0.086	0.054	0.655
Western Diet	329	0.056	-0.020	0.131	0.148	277	-0.426	-1.248	0.396	0.309
AG										
Traditional Mexican Diet	295	-0.003	-0.010	0.005	0.462	234	-0.013	-0.165	0.138	0.862
Western Diet	295	-0.020	-0.119	0.080	0.700	234	1.062	-2.074	4.198	0.507
GG										
Traditional Mexican Diet	87	0.001	-0.010	0.012	0.859	73	-0.170	-0.342	0.002	0.053
Western Diet	87	0.084	-0.085	0.252	0.332	73	-1.787	-5.022	1.448	0.279
Rs13010545										
AA										
Traditional Mexican Diet	320	0.001	-0.008	0.009	0.879	266	-0.027	-0.114	0.059	0.539
Western Diet	320	0.061	-0.015	0.137	0.118	266	-1.123	-2.617	0.371	0.141
AG										
Traditional Mexican Diet	294	-0.003	-0.010	0.005	0.470	235	-0.002	-0.149	0.145	0.974
Western Diet	294	-0.035	-0.138	0.068	0.503	235	1.722	-1.132	4.575	0.237
GG										
Traditional Mexican Diet	94	0.002	-0.009	0.013	0.755	80	-0.147	-0.306	0.013	0.071
Western Diet	94	0.133	-0.034	0.299	0.118	80	-1.450	-4.565	1.664	0.361

Models** adjusted for all diet, demographic, behavioral characteristics, and European ancestry

!Participants taking medications affecting hemoglobin A1c, fasting Glucose, or fasting Insulin were excluded from these models

The associations between traditional and Western diets with relative risk and incidence of type 2 diabetes appeared to be modified by the presence of the G allele. Gene-diet interaction p-values less than 0.10 were found for incidence of type 2 diabetes in Chinese, Mexican, and African Americans (Table 5.7). In Mexican Americans, similar gene-diet interaction p-values were found for the Western diet associated with ever type 2 diabetes (prevalent or incident).

Stratified analysis by G allele for relative risk and Cox regression for European Americans was not possible due to the low values of G allele frequency and prevalent/incident type 2 diabetes cases. However, among Chinese Americans, the relative risk of type 2 diabetes associated with a traditional diet was consistently greater for G allele carriers than non-carriers. When considering the Western diet, relative risk estimates for type 2 diabetes were greater among the AA genotype than AG/GG genotypes. Similarly, the hazard ratios suggested a protective effect of a Western dietary pattern for type 2 diabetes in this group, although they were not statistically significant. This is likely due to the fact that MESA Chinese participants rarely consumed the Western diet indicator foods. However, a traditional diet was significantly protective for incidence of type 2 diabetes among G allele carriers in Chinese Americans (Full models, Rs5647: Hazard Ratio (HR) = 0.58, 95% CI = 0.34 – 0.98; and Rs11897425: HR = 0.59, 95% CI = 0.36 – 0.96).

In African Americans, the associations with the Western diet had consistently greater estimates than the traditional diet even though the difference by genotype was not consistent (Table 5.8). Unfortunately, we were unable to investigate these associations by the three genotypes, which appear to be the best genetic model in this population, because of the small number of GG genotype and number of incident cases.

In Mexican Americans, G allele carriers constantly had greater relative risk and hazard ratio estimates for type 2 diabetes associated with Western diet compared to the AA genotype.

Table 5.7 Wald P-values for Interaction of Diet Adherence (Traditional and Western) and Proglucagon SNPs (DOMINANT model) with Ever (Prevalent and Incident) and Incident type 2 diabetes by ethnicity: MESA

	Ever Type 2 Diabetes			Incident Type 2 Diabetes		
	Total	# Ever T2D	Interaction P-value	Total	# Incident T2D	Interaction P-value
European American						
Rs5647						
Western diet	2381	274	0.427	2165	130	0.711
Rs11897425						
Western diet	2381	274	0.403	2165	130	0.738
Rs13010545						
Western diet	2372	274	0.200	2156	129	0.249
Chinese American						
Rs5647						
Traditional diet	762	149	0.335	612	45	0.065
Western diet	762	149	0.740	612	45	0.736
Rs11897425						
Traditional diet	762	149	0.263	612	45	0.079
Western diet	762	149	0.623	612	45	0.758
Rs13010545						
Traditional diet	759	149	0.199	609	44	0.565
Western diet	759	149	0.806	609	44	0.688
African American						
Rs5647						
Traditional diet	1371	342	0.674	1065	94	0.379
Western diet	1371	342	0.596	1065	94	0.326
Rs11897425						
Traditional diet	1372	342	0.653	1065	94	0.561
Western diet	1372	342	0.350	1065	94	0.033
Rs13010545						
Traditional diet	1371	342	0.885	1064	94	0.314
Western diet	1371	342	0.332	1064	94	0.450
Mexican American						
Rs5647						
Traditional diet	759	217	0.554	564	62	0.084
Western diet	759	217	0.175	564	62	0.081
Rs11897425						
Traditional diet	759	217	0.432	564	62	0.126
Western diet	759	217	0.043	564	62	0.065
Rs13010545						
Traditional diet	756	217	0.636	561	62	0.091
Western diet	756	217	0.088	561	62	0.088

*Models adjusted for all diet (large serving size score and total caloric intake).

Conclusion

Although traditional ethnic and Western dietary patterns appear to be associated with obesity and type 2 diabetes, genetic susceptibility may have influenced these associations. Ethnic differences in genetic susceptibility for type 2 diabetes, by themselves, were not associated with the risk of or risk factors for type 2 diabetes. Since health disparities for obesity and type 2 diabetes have become noticeable within the last few decades and these differences have not been apparent historically, it is understandable that no associations were found when only considering the proglucagon gene. However, dietary patterns have drastically changed in the last 30 to 40 years, which may have led to the genetic susceptibility for obesity and type 2 diabetes to become apparent in these populations. It is possible that since participants were non-diabetic, a younger cohort, and from one location, the associations observed by Carlson et al were a result of a population which adhered more to a Westernized dietary pattern than the MESA participants.

While these findings need to be further examined in future studies, the trends found here suggest that it is unlikely that all the results occurred by chance. We found significant associations across glycemic traits and risk of type 2 diabetes, suggesting a true relationship in combined effects of diet and the G allele in the proglucagon gene. These associations prevailed regardless of our limitations with lack of actual rs6732914 genotyping and dietary measurement error. Although we used three tags with good correlation ($R^2 \approx 0.8$), they are not a perfect measure of rs6732914 genotype. This imprecision would introduce a random measurement error that usually biases results towards the null [90]. Although food frequency questionnaires have been considered a somewhat reliable method for capturing overall dietary patterns, they are a subjective tool and prone to non-random misclassification bias, with different reporting according to BMI level. Under-reporting of high caloric foods, such as the indicator foods of a Western diet, and over-reporting “healthy foods”, such as fruit and vegetables, are associated with overweight and obese BMIs [91-93]. This type of non-random misclassification makes it difficult to observe associations between diet and BMI or with BMI related outcomes. Along with these challenges, stratification of all analyses by race and then by G allele restricted our sample size, particularly in the incidence of type 2 diabetes analysis where we were unable to stratify by genotype. However, we observed associations with the gene-diet interaction in the pre-hypothesized direction across ethnic groups.

This study has limitations. First, the associations observed with the baseline measures are of a cross-sectional design and we cannot assume temporality with diet and glycemic traits. However, the FFQ attempted to capture diet from the previous year and changes in dietary habits among population of this age range are not common unless medically recommended. Nonetheless, we did limit analysis with hemoglobin A1c, fasting glucose, and fasting insulin outcomes to participants not taking medications which affect these levels, excluding anyone currently being treated for diabetes. Therefore, we reduced the amount of bias that resulted from medically recommended dietary changes. Still, the relative risk analysis took into account the combination of medical history and incident cases of type 2 diabetes. Among the prevalent cases, we do not have data on date of diagnosis or whether great dietary changes occurred after diagnosis. Although the temporal assumptions were met in Chapter 4, investigating proglucagon SNPs with risk of type 2 diabetes, the relative risk analysis considering dietary measures are vulnerable to reverse causality bias. As a result, among Chinese Americans who were less likely to consume a Western dietary pattern and more likely to adhere to medically recommended dietary changes (Chapter 2), the Western diet appeared to be protective for risk of type 2 diabetes in this group. To further investigate if BMI is in the association pathway between the proglucagon gene's interaction with diet and type 2 diabetes, we analyzed the gene-diet interaction with ever and incident type 2 diabetes adjusted for BMI. We found that while keeping BMI constant, the relative risk and hazard ratio results were the same. Significant associations remained significant and the estimates did not change substantially.

Implications of Results and Future Research

This is the first project to provide evidence of a gene-diet interaction contributing to ethnic health disparities in obesity and type 2 diabetes. We also tested the associations and interactions using pre-specified traditional and Western dietary patterns to show indications of how dietary changes in the past few decades may have led to ethnic risk differences of these chronic diseases. Our results indicated that ethnic minority populations who retained their traditional ethnic dietary patterns did not have increased risk of obesity or type 2 diabetes, while risk increased for those who adjusted to a Western diet. These findings need to be replicated in other multi-ethnic studies. The methodology of this project could be used to investigate other ethnic health disparities of dietary adherence with chronic disease such as in cardiovascular disease and hypertension.

An issue which will need to be considered in future genetic research of chronic diseases is the inclusion of behavioral characteristics, such as diet and physical activity, in analytic models. If we were only to rely on the genetic analysis to determine whether genetic variations in the proglucagon gene were associated with glycemic traits and incidence of type 2 diabetes, we would have concluded null findings. Depending on the nature of the gene, it could be possible that other genetic research in type 2 diabetes or cardiovascular disease might have missed real associations because of the disregard of their interaction with diet and possibly physical activity, especially among multi-ethnic populations. This study emphasizes the need to conduct gene-environment studies when evaluating associations with genes.

Based on the results found in this project, greater efforts disseminating the negative health effects of a Western diet should be made for ethnic minority populations at high risk of obesity and type 2 diabetes. Since there is a wide body of evidence documenting the adverse effects of the Western diet on obesity and type 2 diabetes, future studies should focus on the specific food items that are responsible for these associations. Could it be that foods of a Western diet tend to be comprised of high fat, sugar, salt, total calories, red meat, or overly processed items compared to traditional ethnic diets? Although the traditional ethnic diets did not use large amounts of fat, sugar, or salt; these items were not restricted and were utilized in food preparation. Therefore, the differences between Western and traditional diets could very well be amounts of processed versus non-processed foods consumed. Further investigation of processed foods is warranted.

One obstacle that may impede replacement of a Western dietary pattern with a traditional diet would be the convenience of Western food items. Along with dietary changes in the past few decades, drastic societal changes have occurred. Historically, it was common that one parent, primarily the mother, would stay home with the family and home-cooked meals were the norm. This was also apparent in our focus groups among the older generations. However, in today's society, it is difficult to sustain a family on one income. With many households comprised of all working adults, the time to prepare home-cooked meals is constrained. Therefore, the conveniences of fast affordable prepared foods found in the Western diet, such as from fast food chains or restaurants, have become part of societal culture. Returning to traditional diets and methods of preparation may not be compatible in today's culture. For this reason, policy changes should be made which provide guidelines on the foods being sold in these establishments with a primary focus on the use of non-processed foods. Additionally, food companies and grocery stores may want to consider providing the traditional foods of the ethnic populations they are serving.

Future obesity and type 2 diabetes prevention efforts among ethnic minority communities should consider promotion of traditional ethnic diets. When it comes to obesity, public health recommendations have focused on a "healthy" diet consisting of low-fat, low-carbohydrate, and low-calorie foods with great changes away from traditional ethnic diets. The findings of this project provide scientific evidence that adherence to traditional diets may help prevent or delay the onset of obesity and type 2 diabetes, and that the "healthy" diet recommendations currently in place may not necessarily be the best among ethnic minority populations. In many of these communities, traditional diets would be widely accepted increasing overall diet adherence.

References

1. Centers for Disease Control and Prevention. National diabetes fact sheet: National estimates and general information on diabetes in the United States, 2011. 2011.

2. Centers for Disease Control and Prevention. Differences in prevalence of obesity among black, white, and Hispanic adults---United States, 2006 - 2008. *MMWR*. 2009;58:740-741-744.

3. Zhang Q, Wang Y, Huang ES. Changes in racial/ethnic disparities in the prevalence of type 2 diabetes by obesity level among US adults. *Ethn Health*. 2009;14(5):439-457. doi: 10.1080/13557850802699155.

4. Holst JJ. The physiology of glucagon-like peptide 1. *Physiol Rev*. 2007;87(4):1409-1439. doi: 10.1152/physrev.00034.2006.

5. Baggio LL, Huang Q, Brown TJ, Drucker DJ. Oxyntomodulin and glucagon-like peptide-1 differentially regulate murine food intake and energy expenditure. *Gastroenterology*. 2004;127(2):546-558.

6. Sinclair EM, Drucker DJ. Proglucagon-derived peptides: Mechanisms of action and therapeutic potential. *Physiology (Bethesda)*. 2005;20:357-365. doi: 10.1152/physiol.00030.2005.

7. Williams DL, Baskin DG, Schwartz MW. Evidence that intestinal glucagon-like peptide-1 plays a physiological role in satiety. *Endocrinology*. 2009;150(4):1680-1687. doi: 10.1210/en.2008-1045.

8. Ranganath LR. Incretins: Pathophysiological and therapeutic implications of glucose-dependent insulinotropic polypeptide and glucagon-like peptide-1. *J Clin Pathol*. 2008;61(4):401-409. doi: 10.1136/jcp.2006.043232.

9. Aulinger B, D'Alessio D. Glucagon-like peptide 1: Continued advances, new targets and expanding promise as a model therapeutic. *Curr Opin Endocrinol Diabetes Obes*. 2007;14(1):68-73. doi: 10.1097/MED.0b013e328013e79e.

10. Stanley S, Wynne K, Bloom S. Gastrointestinal satiety signals III. glucagon-like peptide 1, oxyntomodulin, peptide YY, and pancreatic polypeptide. *Am J Physiol Gastrointest Liver Physiol*. 2004;286(5):G693-7. doi: 10.1152/ajpgi.00536.2003.

11. Pannacciulli N, Bunt JC, Koska J, Bogardus C, Krakoff J. Higher fasting plasma concentrations of glucagon-like peptide 1 are associated with higher resting energy expenditure and fat oxidation rates in humans. *Am J Clin Nutr*. 2006;84(3):556-560.

12. Delzenne NM, Cani PD, Neyrinck AM. Modulation of glucagon-like peptide 1 and energy metabolism by inulin and oligofructose: Experimental data. *J Nutr*. 2007;137(11 Suppl):2547S-2551S.

13. Burcelin R, Cani PD, Knauf C. Glucagon-like peptide-1 and energy homeostasis. *J Nutr*. 2007;137(11 Suppl):2534S-2538S.

14. Egan JM, Montrose-Rafizadeh C, Wang Y, Bernier M, Roth J. Glucagon-like peptide-1(7-36) amide (GLP-1) enhances insulin-stimulated glucose metabolism in 3T3-L1 adipocytes: One of several potential extrapancreatic sites of GLP-1 action. *Endocrinology*. 1994;135(5):2070-2075.

15. Wynne K, Bloom SR. The role of oxyntomodulin and peptide tyrosine-tyrosine (PYY) in appetite control. *Nat Clin Pract Endocrinol Metab*. 2006;2(11):612-620. doi: 10.1038/ncpendmet0318.

16. Wynne K, Park AJ, Small CJ, et al. Subcutaneous oxyntomodulin reduces body weight in overweight and obese subjects: A double-blind, randomized, controlled trial. *Diabetes*. 2005;54(8):2390-2395.

17. Wynne K, Park AJ, Small CJ, et al. Oxyntomodulin increases energy expenditure in addition to decreasing energy intake in overweight and obese humans: A randomised controlled trial. *Int J Obes (Lond)*. 2006;30(12):1729-1736. doi: 10.1038/sj.ijo.0803344.

18. NEEL JV. Diabetes mellitus: A "thrifty" genotype rendered detrimental by "progress"? *Am J Hum Genet*. 1962;14:353-362.

19. Prentice AM, Hennig BJ, Fulford AJ. Evolutionary origins of the obesity epidemic: Natural selection of thrifty genes or genetic drift following predation release? *Int J Obes (Lond)*. 2008;32(11):1607-1610. doi: 10.1038/ijo.2008.147.

20. Irwin DM. Molecular evolution of proglucagon. *Regul Pept*. 2001;98(1-2):1-12.

21. Siervo M, Wells JC, Cizza G. The contribution of psychosocial stress to the obesity epidemic: An

evolutionary approach. *Horm Metab Res*. 2009;41(4):261-270. doi: 10.1055/s-0028-1119377.

22. Berthoud HR. Interactions between the "cognitive" and "metabolic" brain in the control of food intake. *Physiol Behav*. 2007;91(5):486-498. doi: 10.1016/j.physbeh.2006.12.016.

23. Carulli L, Rondinella S, Lombardini S, Canedi I, Loria P, Carulli N. Review article: Diabetes, genetics and ethnicity. *Aliment Pharmacol Ther*. 2005;22 Suppl 2:16-19. doi: 10.1111/j.1365-2036.2005.02588.x.

24. Abate N, Chandalia M. The impact of ethnicity on type 2 diabetes. *J Diabetes Complications*. 2003;17(1):39-58.

25. Southam L, Soranzo N, Montgomery SB, et al. Is the thrifty genotype hypothesis supported by evidence based on confirmed type 2 diabetes- and obesity-susceptibility variants? *Diabetologia*. 2009;52(9):1846-1851. doi: 10.1007/s00125-009-1419-3.

26. Prentice AM. Early influences on human energy regulation: Thrifty genotypes and thrifty phenotypes. *Physiol Behav*. 2005;86(5):640-645. doi: 10.1016/j.physbeh.2005.08.055.

27. Prentice AM, Rayco-Solon P, Moore SE. Insights from the developing world: Thrifty genotypes and thrifty phenotypes. *Proc Nutr Soc*. 2005;64(2):153-161.

28. Watve MG, Yajnik CS. Evolutionary origins of insulin resistance: A behavioral switch hypothesis. *BMC Evol Biol*. 2007;7:61. doi: 10.1186/1471-2148-7-61.

29. Velasquez-Mieyer PA, Cowan PA, Perez-Faustinelli S, et al. Racial disparity in glucagon-like peptide 1 and inflammation markers among severely obese adolescents. *Diabetes Care*. 2008;31(4):770-775. doi: 10.2337/dc07-1525.

30. Reimer RA, McBurney MI. Dietary fiber modulates intestinal proglucagon messenger ribonucleic acid and postprandial secretion of glucagon-like peptide-1 and insulin in rats. *Endocrinology*. 1996;137(9):3948-3956.

31. Massimino SP, McBurney MI, Field CJ, et al. Fermentable dietary fiber increases GLP-1 secretion and improves glucose homeostasis despite increased intestinal glucose transport capacity in healthy

dogs. *J Nutr*. 1998;128(10):1786-1793.

32. Romero-Gwynn, E. and Gwynn, D. Dietary patterns and acculturation among Latinos of Mexican descent. *JSRI Research Report*. 1997;23:1-2-8.

33. Mainous AG,3rd, Diaz VA, Geesey ME. Acculturation and healthy lifestyle among Latinos with diabetes. *Ann Fam Med*. 2008;6(2):131-137. doi: 10.1370/afm.814.

34. Tonstad S, Butler T, Yan R, Fraser GE. Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. *Diabetes Care*. 2009;32(5):791-796. doi: 10.2337/dc08-1886.

35. Reimer RA, Russell JC. Glucose tolerance, lipids, and GLP-1 secretion in JCR:LA-cp rats fed a high protein fiber diet. *Obesity (Silver Spring)*. 2008;16(1):40-46. doi: 10.1038/oby.2007.16.

36. Wang ET, de Koning L, Kanaya AM. Higher protein intake is associated with diabetes risk in South Asian Indians: The Metabolic Syndrome and Atherosclerosis in South Asians Living in America (MASALA) study. *J Am Coll Nutr*. 2010;29(2):130-135.

37. Paniagua JA, de la Sacristana AG, Sanchez E, et al. A MUFA-rich diet improves posprandial glucose, lipid and GLP-1 responses in insulin-resistant subjects. *J Am Coll Nutr*. 2007;26(5):434-444.

38. Roshania R, Narayan KM, Oza-Frank R. Age at arrival and risk of obesity among US immigrants. *Obesity (Silver Spring)*. 2008;16(12):2669-2675. doi: 10.1038/oby.2008.425.

39. Ahn MK, Juon HS, Gittelsohn J. Association of race/ethnicity, socioeconomic status, acculturation, and environmental factors with risk of overweight among adolescents in California, 2003. *Prev Chronic Dis*. 2008;5(3):A75.

40. Kaplan MS, Huguet N, Newsom JT, McFarland BH. The association between length of residence and obesity among Hispanic immigrants. *Am J Prev Med*. 2004;27(4):323-326. doi: 10.1016/j.amepre.2004.07.005.

41. Novotny R, Williams AE, Vinoya AC, Oshiro CE, Vogt TM. US acculturation, food intake, and obesity among Asian-Pacific hotel workers. *J Am Diet Assoc*. 2009;109(10):1712-1718. doi: 10.1016/j.jada.2009.07.013.

42. Yeh MC, Viladrich A, Bruning N, Roye C. Determinants of Latina obesity in the United States: The role of selective acculturation. *J Transcult Nurs*. 2009;20(1):105-115. doi: 10.1177/1043659608325846.

43. Pierce BL, Austin MA, Crane PK, et al. Measuring dietary acculturation in Japanese Americans with the use of confirmatory factor analysis of food-frequency data. *Am J Clin Nutr*. 2007;86(2):496-503.

44. Neuhouser ML, Thompson B, Coronado GD, Solomon CC. Higher fat intake and lower fruit and vegetables intakes are associated with greater acculturation among Mexicans living in Washington state. *J Am Diet Assoc*. 2004;104(1):51-57. doi: 10.1016/j.jada.2003.10.015.

45. Narayan KM, Aviles-Santa L, Oza-Frank R, et al. Report of a national heart, lung, and blood institute workshop: Heterogeneity in cardiometabolic risk in Asian Americans in the U.S. opportunities for research. *J Am Coll Cardiol*. 2010;55(10):966-973. doi: 10.1016/j.jacc.2009.07.075.

46. Kandula NR, Diez-Roux AV, Chan C, et al. Association of acculturation levels and prevalence of diabetes in the Multi-Ethnic Study of Atherosclerosis (MESA). *Diabetes Care*. 2008;31(8):1621-1628. doi: 10.2337/dc07-2182.

47. Dixon LB, Sundquist J, Winkleby M. Differences in energy, nutrient, and food intakes in a US sample of Mexican-American women and men: Findings from the third National Health and Nutrition Examination Survey, 1988-1994. *Am J Epidemiol*. 2000;152(6):548-557.

48. Park SY, Murphy SP, Sharma S, Kolonel LN. Dietary intakes and health-related behaviours of Korean American women born in the USA and Korea: The Multiethnic Cohort Study. *Public Health Nutr*. 2005;8(7):904-911.

49. Unger JB, Reynolds K, Shakib S, Spruijt-Metz D, Sun P, Johnson CA. Acculturation, physical activity, and fast-food consumption among Asian-American and Hispanic adolescents. *J Community Health*. 2004;29(6):467-481.

50. Gordon-Larsen P, Harris KM, Ward DS, Popkin BM, National Longitudinal Study of Adolescent Health. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: The National Longitudinal Study of Adolescent Health. *Soc Sci Med*. 2003;57(11):2023-2034.

51. Schulz LO, Bennett PH, Ravussin E, et al. Effects of traditional and Western environments on prevalence of type 2 diabetes in Pima Indians in Mexico and the U.S. *Diabetes Care*. 2006;29(8):1866-1871. doi: 10.2337/dc06-0138.

52. Liese AD, Nichols M, Sun X, D'Agostino RB,Jr, Haffner SM. Adherence to the DASH diet is inversely associated with incidence of type 2 diabetes: The Insulin Resistance Atherosclerosis Study. *Diabetes Care*. 2009;32(8):1434-1436. doi: 10.2337/dc09-0228.

53. Takeuchi M, Okamoto K, Takagi T, Ishii H. Ethnic difference in inter-east Asian subjects with normal glucose tolerance and impaired glucose regulation: A systematic review and meta-analysis focusing on fasting serum insulin. *Diabetes Res Clin Pract*. 2008;82(3):383-390. doi: 10.1016/j.diabres.2008.09.002.

54. Cushman M, Cornell ES, Howard PR, Bovill EG, Tracy RP. Laboratory methods and quality assurance in the Cardiovascular Health Study. *Clin Chem*. 1995;41(2):264-270.

55. Mayer-Davis EJ, Vitolins MZ, Carmichael SL, et al. Validity and reproducibility of a food frequency interview in a multi-cultural epidemiology study. *Ann Epidemiol*. 1999;9(5):314-324.

56. Bild DE, Bluemke DA, Burke GL, et al. Multi-Ethnic Study of Atherosclerosis: Objectives and design. *Am J Epidemiol*. 2002;156(9):871-881.

57. Kurian AK, Cardarelli KM. Racial and ethnic differences in cardiovascular disease risk factors: A systematic review. *Ethn Dis*. 2007;17(1):143-152.

58. Baruth M, Wilcox S, Egan BM, Dowda M, Laken M, Warren TY. Cardiovascular disease risk factor clustering among African American adults. *Ethn Dis*. 2011;21(2):129-134.

59. Taylor HA,Jr, Coady SA, Levy D, et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. *Obesity (Silver Spring)*. 2010;18(8):1638-1645. doi: 10.1038/oby.2009.407.

60. Eamranond PP, Wee CC, Legedza AT, Marcantonio ER, Leveille SG. Acculturation and cardiovascular risk factor control among Hispanic adults in the United States. *Public Health Rep*. 2009;124(6):818-824.

61. Perez-Escamilla R. Acculturation, nutrition, and health disparities in Latinos. *Am J Clin Nutr*. 2011;93(5):1163S-7S. doi: 10.3945/ajcn.110.003467.

62. Li Y, He Y, Lai J, et al. Dietary patterns are associated with stroke in Chinese adults. *J Nutr*. 2011;141(10):1834-1839. doi: 10.3945/jn.111.143883.

63. Menotti A, Alberti-Fidanza A, Fidanza F, Lanti M, Fruttini D. Factor analysis in the identification of dietary patterns and their predictive role in morbid and fatal events. *Public Health Nutr*. 2011:1-8. doi: 10.1017/S1368980011003235.

64. Gardener H, Wright CB, Gu Y, et al. Mediterranean-style diet and risk of ischemic stroke, myocardial infarction, and vascular death: The Northern Manhattan Study. *Am J Clin Nutr*. 2011;94(6):1458-1464. doi: 10.3945/ajcn.111.012799.

65. Jinlin F, Binyou W, Terry C. A new approach to the study of diet and risk of type 2 diabetes. *J Postgrad Med*. 2007;53(2):139-143.

66. Imamura F, Lichtenstein AH, Dallal GE, Meigs JB, Jacques PF. Generalizability of dietary patterns associated with incidence of type 2 diabetes mellitus. *Am J Clin Nutr*. 2009;90(4):1075-1083. doi: 10.3945/ajcn.2009.28009.

67. Kim HS, Park SY, Grandinetti A, Holck PS, Waslien C. Major dietary patterns, ethnicity, and prevalence of type 2 diabetes in rural Hawaii. *Nutrition*. 2008;24(11-12):1065-1072. doi: 10.1016/j.nut.2008.05.008.

68. Kiple KF, Ornelas KC. *The cambridge world history of food.* Cambridge, UK; New York: Cambridge University Press; 2000.

69. Albala K. Katz SH, ed. *Encyclopedia of food and culture.* Vol 1. New York: Charles Scribner's Sons; 2003:522-523. http://go.galegroup.com/ps/i.do?id=GALE%7CCX3403400181&v=2.1&u=wash_main&it=r&p=GVRL&sw=w.

70. Cho YA, Shin A, Kim J. Dietary patterns are associated with body mass index in a Korean

population. *J Am Diet Asso*c. 2011;111(8):1182-1186. doi: 10.1016/j.jada.2011.05.003.

71. Boggs DA, Palmer JR, Spiegelman D, Stampfer MJ, Adams-Campbell LL, Rosenberg L. Dietary patterns and 14-y weight gain in African American women. *Am J Clin Nut*r. 2011;94(1):86-94. doi: 10.3945/ajcn.111.013482.

72. Maskarinec G, Novotny R, Tasaki K. Dietary patterns are associated with body mass index in multiethnic women. *J Nut*r. 2000;130(12):3068-3072.

73. Paradis AM, Godin G, Perusse L, Vohl MC. Associations between dietary patterns and obesity phenotypes. *Int J Obes (Lond*). 2009;33(12):1419-1426. doi: 10.1038/ijo.2009.179.

74. Rezazadeh A, Rashidkhani B. The association of general and central obesity with major dietary patterns of adult women living in Tehran, Iran. *J Nutr Sci Vitaminol (Tokyo*). 2010;56(2):132-138.

75. Fogli-Cawley JJ, Dwyer JT, Saltzman E, et al. The 2005 dietary guidelines for Americans and risk of the metabolic syndrome. *Am J Clin Nut*r. 2007;86(4):1193-1201.

76. Bullo M, Garcia-Aloy M, Martinez-Gonzalez MA, et al. Association between a healthy lifestyle and general obesity and abdominal obesity in an elderly population at high cardiovascular risk. *Prev Me*d. 2011;53(3):155-161. doi: 10.1016/j.ypmed.2011.06.008.

77. Goulet J, Lapointe A, Lamarche B, Lemieux S. Effect of a nutritional intervention promoting the Mediterranean food pattern on anthropometric profile in healthy women from the Quebec City metropolitan area. *Eur J Clin Nut*r. 2007;61(11):1293-1300. doi: 10.1038/sj.ejcn.1602647.

78. Issa C, Darmon N, Salameh P, Maillot M, Batal M, Lairon D. A Mediterranean diet pattern with low consumption of liquid sweets and refined cereals is negatively associated with adiposity in adults from rural Lebanon. *Int J Obes (Lond*). 2011;35(2):251-258. doi: 10.1038/ijo.2010.130.

79. Ard JD, Grambow SC, Liu D, et al. The effect of the PREMIER interventions on insulin sensitivity. *Diabetes Car*e. 2004;27(2):340-347.

80. Brinkworth GD, Noakes M, Keogh JB, Luscombe ND, Wittert GA, Clifton PM. Long-term effects of a high-protein, low-carbohydrate diet on weight control and cardiovascular risk markers in obese

hyperinsulinemic subjects. *Int J Obes Relat Metab Disor*d. 2004;28(5):661-670. doi: 10.1038/sj.ijo.0802617.

81. Douglas CC, Norris LE, Oster RA, Darnell BE, Azziz R, Gower BA. Difference in dietary intake between women with polycystic ovary syndrome and healthy controls. *Fertil Steri*l. 2006;86(2):411-417. doi: 10.1016/j.fertnstert.2005.12.054.

82. Anderson AL, Harris TB, Tylavsky FA, et al. Dietary patterns, insulin sensitivity and inflammation in older adults. *Eur J Clin Nut*r. 2012;66(1):18-24. doi: 10.1038/ejcn.2011.162; 10.1038/ejcn.2011.162.

83. Gu Y, Luchsinger JA, Stern Y, Scarmeas N. Mediterranean diet, inflammatory and metabolic biomarkers, and risk of Alzheimer's disease. *J Alzheimers Di*s. 2010;22(2):483-492. doi: 10.3233/JAD-2010-100897.

84. Bos MB, de Vries JH, Feskens EJ, et al. Effect of a high monounsaturated fatty acids diet and a Mediterranean diet on serum lipids and insulin sensitivity in adults with mild abdominal obesity. *Nutr Metab Cardiovasc Di*s. 2010;20(8):591-598. doi: 10.1016/j.numecd.2009.05.008.

85. Michalsen A, Lehmann N, Pithan C, et al. Mediterranean diet has no effect on markers of inflammation and metabolic risk factors in patients with coronary artery disease. *Eur J Clin Nut*r. 2006;60(4):478-485. doi: 10.1038/sj.ejcn.1602340.

86. Wu T, Zhao BR, Bound MJ, et al. Effects of different sweet preloads on incretin hormone secretion, gastric emptying, and postprandial glycemia in healthy humans. *Am J Clin Nut*r. 2012;95(1):78-83. doi: 10.3945/ajcn.111.021543.

87. Geraedts MC, Troost FJ, Tinnemans R, Soderholm JD, Brummer RJ, Saris WH. Release of satiety hormones in response to specific dietary proteins is different between human and murine small intestinal mucosa. *Ann Nutr Meta*b. 2010;56(4):308-313. doi: 10.1159/000312664.

88. Geraedts MC, Troost FJ, Fischer MA, Edens L, Saris WH. Direct induction of CCK and GLP-1 release from murine endocrine cells by intact dietary proteins. *Mol Nutr Food Re*s. 2011;55(3):476-484. doi: 10.1002/mnfr.201000142; 10.1002/mnfr.201000142.

89. Kaji I, Karaki S, Tanaka R, Kuwahara A. Density distribution of free fatty acid receptor 2 (FFA2)-expressing and GLP-1-producing enteroendocrine L cells in human and rat lower intestine, and increased cell numbers after ingestion of fructo-oligosaccharide. *J Mol Histo*l. 2011;42(1):27-38. doi: 10.1007/s10735-010-9304-4.

90. White E, Armstrong BK, Saracci R, Armstrong BK. *Principles of exposure measurement in epidemiology : Collecting, evaluating, and improving measures of disease risk factors*. Oxford; New York: Oxford University Press; 2008.

91. Paalanen L, Mannisto S, Virtanen MJ, et al. Validity of a food frequency questionnaire varied by age and body mass index. *J Clin Epidemio*l. 2006;59(9):994-1001. doi: 10.1016/j.jclinepi.2006.01.002.

92. Crozier SR, Inskip HM, Godfrey KM, Robinson SM. Dietary patterns in pregnant women: A comparison of food-frequency questionnaires and 4 d prospective diaries. *Br J Nut*r. 2008;99(4):869-875. doi: 10.1017/S0007114507831746.

93. Marks GC, Hughes MC, van der Pols JC. Relative validity of food intake estimates using a food frequency questionnaire is associated with sex, age, and other personal characteristics. *J Nut*r. 2006;136(2):459-465.

Appendix A: MESA Food Frequency Questionnaire

Multi-Ethnic Study of Atherosclerosis

Exam 5

Food Frequency Questionnaire

Participant ID:

Visit Date: __ __ / __ __ / __ __ __ __

Acrostic: __ __ __ __ __ __ __

INSTRUCTIONS:

The questions on this form are about your usual eating habits over the last year. Please follow the directions and complete the questionnaire.

Try to complete the questionnaire in one sitting, but feel free to take short breaks if you are getting tired. If you have any questions, you may call ____________________ at ____________________.

Please bring this questionnaire with you to the clinic when you come for your scheduled exam on ____________________.

A member of the clinic staff will review the questionnaire with you during your exam, giving you an opportunity to ask questions or make any clarifications you feel are important.

Please answer the questions by filling in the bubbles using a **NO. 2 PENCIL**. Be sure to fill in the bubbles completely. If you make a mistake, just erase the mistake and fill in the correct bubble.

Please indicate **BOTH** frequency **AND** serving size for each food and beverage item listed.

Like This: ●

Not Like This: ⊗ ✓

4842435987

First, please answer these questions:

How many times per day do you usually eat, including both meals & snacks?

○ 0 ○ 1 ○ 2 ○ 3
○ 4 ○ 5 ○ 6 ○ 7
○ 8 ○ 9+

How many times per week do you eat at restaurants for meals, including fast-food and take-out?

○ 0 ○ 1 ○ 2 ○ 3
○ 4 ○ 5 ○ 6 ○ 7
○ 8 ○ 9+

The following pages include a list of foods and a place for you to tell us how often you typically eat the food and whether your usual serving size is small, medium or large.

A. For each line, fill in the bubble that best describes **HOW OFTEN** you eat the foods.

B. Then, fill in the bubble that best describes your **USUAL SERVING SIZE**. Simply mark "small", "medium", or "large" compared to what seems typical for other men or women about your age.

EXAMPLE: John eats 1 medium-sized banana, 5 days a week.

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Time Per Month	2-3 Times Per Month	1 Time Per Week	2 Times Per Week	3-4 Times Per Week	5-6 Times Per Week	1 Time Per Day	2+ Times Per Day	Small	Medium	Large
Bananas, plantains	○	○	○	○	○	○	●	○	○	○	●	○

IF YOU DON'T EAT THE FOOD, you may leave the serving size blank.

If you don't recognize the name of a food, you probably don't eat it and can mark "Rare or Never."

Please include foods that you eat at home and at restaurants, as well as TV dinners and other frozen foods.

No one remembers everything about what they eat. Just relax and answer to the best of your ability. Thank you very much for taking the time to fill out this questionnaire!

1619435986

FRUITS AND JUICES

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
Fruits Eaten During The Months When They Are In Season												
1. Peaches, apricots, nectarines, plums	○	○	○	○	○	○	○	○	○	○	○	○
2. Cantaloupe, mango, papaya	○	○	○	○	○	○	○	○	○	○	○	○
3. Strawberries, blueberries, other berries	○	○	○	○	○	○	○	○	○	○	○	○
All Other Fruits, Eaten All Year												
4. Apples, apple sauce, pears	○	○	○	○	○	○	○	○	○	○	○	○
5. Bananas, plantains	○	○	○	○	○	○	○	○	○	○	○	○
6. Oranges, grapefruit, tangerines, kiwi	○	○	○	○	○	○	○	○	○	○	○	○
7. Dried fruits including raisins, prunes, figs, apricots	○	○	○	○	○	○	○	○	○	○	○	○
8. Any other fruit (pineapple, persimmon, grapes, other melon, canned peaches, fruit cocktail, etc.)	○	○	○	○	○	○	○	○	○	○	○	○
Fruit Juices												
9. Orange juice, grapefruit juice	○	○	○	○	○	○	○	○	○	○	○	○
10. Any other fruit juice (apple, grape, punch, kool-aid, guava juice, etc.)	○	○	○	○	○	○	○	○	○	○	○	○

CEREAL AND OTHER BREAKFAST FOODS
(please include here even if you eat these foods at times other than breakfast)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
11. Eggs, omlettes, huevos rancheros	○	○	○	○	○	○	○	○	○	○	○	○
12. Sausage, chorizo, scrapple, bacon	○	○	○	○	○	○	○	○	○	○	○	○
13. Pancakes, waffles, French toast	○	○	○	○	○	○	○	○	○	○	○	○
14. Oatmeal	○	○	○	○	○	○	○	○	○	○	○	○
15. Other hot cereal (grits, cream of wheat, mush, congee)	○	○	○	○	○	○	○	○	○	○	○	○
16. Cold Cereal	○	○	○	○	○	○	○	○	○	○	○	○

16a. ***IF YOU EAT COLD CEREAL***, what is the name of the cold cereal that you eat most often? ______

Clinical use only: ☐☐☐

BREADS

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
17. White bread or rolls (hamburger buns, bagels, pita, English muffins, etc.)	○	○	○	○	○	○	○	○	○	○	○	○
18. Dark, whole grain breads or rolls (hamburger buns, bagels, pita, English muffins, etc.)	○	○	○	○	○	○	○	○	○	○	○	○
19. Bran muffins	○	○	○	○	○	○	○	○	○	○	○	○
20. Biscuits, other muffins, croissants, corn bread, hush puppies	○	○	○	○	○	○	○	○	○	○	○	○
21. Margarine or mayonnaise on bread or rolls	○	○	○	○	○	○	○	○	○	○	○	○
22. Butter on bread or rolls	○	○	○	○	○	○	○	○	○	○	○	○

SNACKS

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
	Average Last Year									Your Serving Size		
23. Potato, corn or tortilla chips	○	○	○	○	○	○	○	○	○	○	○	○
24. Crackers, pretzels, popcorn	○	○	○	○	○	○	○	○	○	○	○	○
25. Almonds, walnuts, pecans, other nuts	○	○	○	○	○	○	○	○	○	○	○	○
26. Sunflower, pinyon, other seeds	○	○	○	○	○	○	○	○	○	○	○	○
27. Peanuts, peanut butter	○	○	○	○	○	○	○	○	○	○	○	○

CHEESE, YOGURT

28. Cottage or ricotta cheese	○	○	○	○	○	○	○	○	○	○	○	○
29. Cheddar, American, Chihuahua, Swiss, cream cheese, cheese spreads, other cheese	○	○	○	○	○	○	○	○	○	○	○	○
30. Plain yogurt (unflavored)	○	○	○	○	○	○	○	○	○	○	○	○
31. Flavored yogurt	○	○	○	○	○	○	○	○	○	○	○	○

31a. ***IF YOU EAT YOGURT*** (plain or flavored), how often is it low-fat or fat-free?

- ○ Seldom/never
- ○ Sometimes
- ○ Often/always

SOUPS

32. Cream soups including chowders, potato and cheese soups	○	○	○	○	○	○	○	○	○	○	○	○
33. Pea, lentil, black bean, potajes soups	○	○	○	○	○	○	○	○	○	○	○	○
34. Miso soup or sauce with soybean paste	○	○	○	○	○	○	○	○	○	○	○	○
35. Other soups including vegetable beef, tomato, egg drop, chicken noodle	○	○	○	○	○	○	○	○	○	○	○	○

SALADS, VEGETABLES AND BEANS
(not including vegetables in mixed dishes - these are included later)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
36. Tossed salad with iceberg or light green lettuce	○	○	○	○	○	○	○	○	○	○	○	○
37. Tossed salad with spinach, romaine or dark greens, cooked spinach, turnip greens, collards	○	○	○	○	○	○	○	○	○	○	○	○
38. Tomatoes (cooked or raw), tomato juice	○	○	○	○	○	○	○	○	○	○	○	○
39. Avocado, guacamole	○	○	○	○	○	○	○	○	○	○	○	○
40. Carrots	○	○	○	○	○	○	○	○	○	○	○	○
41. Broccoli, cabbage, cauliflower, brussel sprouts, sauerkraut, kimchee	○	○	○	○	○	○	○	○	○	○	○	○
42. Green beans, peas, snow peas	○	○	○	○	○	○	○	○	○	○	○	○
43. Corn, hominy	○	○	○	○	○	○	○	○	○	○	○	○
44. Winter squash, acorn squash	○	○	○	○	○	○	○	○	○	○	○	○
45. Pinto, black, baked, butter or red beans, pork and beans, black-eyed peas	○	○	○	○	○	○	○	○	○	○	○	○
46. Any other vegetables including summer squash, zucchini, asparagus, mixed vegetables	○	○	○	○	○	○	○	○	○	○	○	○

RICE AND POTATOES

47. White, Mexican or sticky rice	○	○	○	○	○	○	○	○	○	○	○	○
48. Brown or wild rice	○	○	○	○	○	○	○	○	○	○	○	○
49. Fried rice	○	○	○	○	○	○	○	○	○	○	○	○

RICE AND POTATOES (Continued)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
50. French fries, fried potatoes, hash browns	○	○	○	○	○	○	○	○	○	○	○	○
51. Boiled, baked, mashed or other potatoes, turnips	○	○	○	○	○	○	○	○	○	○	○	○
52. Sweet potatoes, yams	○	○	○	○	○	○	○	○	○	○	○	○
53. Margarine or oil on vegetables, rice or potatoes	○	○	○	○	○	○	○	○	○	○	○	○
54. Butter on vegetables, rice or potatoes	○	○	○	○	○	○	○	○	○	○	○	○

CHINESE FOOD AND TOFU

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
55. Oriental noodles with meat (saimen, ramen, wonton mein)	○	○	○	○	○	○	○	○	○	○	○	○
56. Chinese dumplings, spring roll, dim sum (not fried), Chinese bun with meat, sausage and vegetables	○	○	○	○	○	○	○	○	○	○	○	○
57. Chow mein	○	○	○	○	○	○	○	○	○	○	○	○
58. Stir-fried beef, pork or chicken with vegetables, including beef broccoli	○	○	○	○	○	○	○	○	○	○	○	○

58a. *IF YOU EAT THE FOOD* item listed above, which does it contain? Check all that apply.

○ Pork ○ Chicken ○ Beef

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
59. Stir-fried shrimp or fish with vegetables	○	○	○	○	○	○	○	○	○	○	○	○
60. Stir-fried tofu or tempeh with vegetables	○	○	○	○	○	○	○	○	○	○	○	○
61. Stir-fried vegetables (no meat)	○	○	○	○	○	○	○	○	○	○	○	○

MEXICAN FOOD

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
62. Burritos or quesadillas with no meat	○	○	○	○	○	○	○	○	○	○	○	○
63. Burritos, quesadillas or fajitas with meat, poultry or seafood	○	○	○	○	○	○	○	○	○	○	○	○

63a. *IF YOU EAT THE FOOD* item listed above, which does it contain? Check all that apply.

- ○ Meat (including pork, beef or lamb)
- ○ Poultry (including turkey or chicken)
- ○ Seafood (including crab, shrimp or lobster)

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
64. Enchiladas, tamales, tacos or nachos with no meat	○	○	○	○	○	○	○	○	○	○	○	○
65. Enchiladas, tamales, tacos or nachos with meat, poultry or seafood	○	○	○	○	○	○	○	○	○	○	○	○

65a. *IF YOU EAT THE FOOD* item listed above, which does it contain? Check all that apply.

- ○ Meat (including pork, beef or lamb)
- ○ Poultry (including turkey or chicken)
- ○ Seafood (including crab, shrimp or lobster)

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
66. Picadillo, carne quisada, menudo	○	○	○	○	○	○	○	○	○	○	○	○
67. Arroz con pollo	○	○	○	○	○	○	○	○	○	○	○	○
68. Chile with meat and beans	○	○	○	○	○	○	○	○	○	○	○	○
69. Red chile con carne with meat	○	○	○	○	○	○	○	○	○	○	○	○
70. Green chile con carne with meat	○	○	○	○	○	○	○	○	○	○	○	○
71. Refried beans as a side dish	○	○	○	○	○	○	○	○	○	○	○	○
72. Salsa, pico de gallo	○	○	○	○	○	○	○	○	○	○	○	○
73. Flour or corn tortilla on the side	○	○	○	○	○	○	○	○	○	○	○	○

NOODLES, CASSEROLES, ITALIAN SPAGHETTI AND PIZZA

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
74. Pasta with cream sauce or cheese (no meat), including macaroni and cheese, quiche, pesto	○	○	○	○	○	○	○	○	○	○	○	○
75. Pasta with cream sauce, cheese and meat, poultry or seafood, including tuna noodle casserole	○	○	○	○	○	○	○	○	○	○	○	○

75a. ***IF YOU EAT THE FOOD*** item listed above, which does it contain? Check all that apply.

- ○ Beef
- ○ Pork
- ○ Poultry (including chicken and turkey)
- ○ Seafood (including crab, shrimp or lobster)
- ○ Tuna (as in tuna noodle casserole)

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
76. Pasta with tomato sauce (no meat), including spaghetti and lasagna	○	○	○	○	○	○	○	○	○	○	○	○
77. Pasta with tomato sauce and meat, poultry or seafood, including spaghetti and lasagna	○	○	○	○	○	○	○	○	○	○	○	○

77a. ***IF YOU EAT THE FOOD*** item listed above, which does it contain? Check all that apply.

- ○ Meat (including pork, beef or lamb)
- ○ Poultry (including turkey or chicken)
- ○ Seafood (including crab, shrimp or lobster)

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
78. Pizza	○	○	○	○	○	○	○	○	○	○	○	○

OTHER MIXED DISHES

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
79. Meat, chicken or turkey stew, pot pie or empanada	○	○	○	○	○	○	○	○	○	○	○	○

79a. *IF YOU EAT THE FOOD* item listed above, which does it contain? Check all that apply.

○ Meat (including pork, beef or lamb)
○ Poultry (including turkey or chicken)

80. Fish stew or seafood gumbo, paella	○	○	○	○	○	○	○	○	○	○	○	○
81. Chicken salad, tuna salad or egg salad	○	○	○	○	○	○	○	○	○	○	○	○
82. Pasta salad, macaroni salad, potato salad, cole slaw	○	○	○	○	○	○	○	○	○	○	○	○

MEAT AND POULTRY

(not including meats in the mixed dishes listed above)

83. Hamburger, cheeseburger, meat loaf, hash	○	○	○	○	○	○	○	○	○	○	○	○
84. Beef, pork or lamb steaks, roasts, barbeque or ribs	○	○	○	○	○	○	○	○	○	○	○	○
85. Ham hocks, pigs' feet, chicarones	○	○	○	○	○	○	○	○	○	○	○	○
86. Ham, hot dogs, bologna, salami, other lunch meats	○	○	○	○	○	○	○	○	○	○	○	○
87. Roasted, broiled, baked or ground chicken or turkey	○	○	○	○	○	○	○	○	○	○	○	○

MEAT AND POULTRY (Continued)

Type of Food	Average Last Year: Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Your Serving Size: Small	Medium	Large
88. Fried chicken	○	○	○	○	○	○	○	○	○	○	○	○
89. Liver including chicken livers, other organ meats	○	○	○	○	○	○	○	○	○	○	○	○
90. Gravies made with meat or poultry drippings	○	○	○	○	○	○	○	○	○	○	○	○

FISH (not including fish in the mixed dishes listed above)

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
91. Fried fish or fish sandwich, fried shrimp, calamari	○	○	○	○	○	○	○	○	○	○	○	○
92. Shrimp, lobster, crab, oysters, mussels (not fried)	○	○	○	○	○	○	○	○	○	○	○	○
93. Tuna, salmon, sardines (including sashimi or sushi)	○	○	○	○	○	○	○	○	○	○	○	○
94. Other broiled, steamed, baked or raw fish (trout, sole, halibut, poke, grouper)	○	○	○	○	○	○	○	○	○	○	○	○

SWEETS

Type of Food	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
95. Sugar, jelly, jam, molasses on bread or in cereal	○	○	○	○	○	○	○	○	○	○	○	○
96. Regular ice cream	○	○	○	○	○	○	○	○	○	○	○	○
97. Frozen yogurt, low-fat ice cream, ice milk, sherbert	○	○	○	○	○	○	○	○	○	○	○	○
98. Dessert made with tofu	○	○	○	○	○	○	○	○	○	○	○	○
99. White doughnuts, cookies, cakes, pastries, Pop Tarts, Chinese desserts, Mexican desserts	○	○	○	○	○	○	○	○	○	○	○	○

SWEETS (Continued)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1 Per Month	2-3 Per Month	1 Per Week	2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	2+ Per Day	Small	Medium	Large
100. Pure chocolate candy bar or packet (e.g., Hershey's, M&M's, Dove chocolate bar)	○	○	○	○	○	○	○	○	○	○	○	○
101. Chocolate doughnuts, cookies, cakes, brownies or mixed chocolate candy bars (e.g. Snickers, 3 Musketeers, Butterfinger)	○	○	○	○	○	○	○	○	○	○	○	○
102. Other candy including hard candy, licorice, other non-chocolate candy bars	○	○	○	○	○	○	○	○	○	○	○	○
103. Pies	○	○	○	○	○	○	○	○	○	○	○	○
104. Pudding, custard, flan	○	○	○	○	○	○	○	○	○	○	○	○

BEVERAGES

NOTE: CHOICES FOR <u>AVERAGE LAST YEAR.</u> THE BEVERAGE SECTION BELOW ARE DIFFERENT FROM THE FOOD SECTION ABOVE.
When you answer these questions about milk, include ONLY beverages; <u>DO NOT include milk that you use on your cereal.</u>

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1-3 Per Month	1 Per Week	2-4 Per Week	5-6 Per Week	1 Per Day	2-3 Per Day	4-5 Per Day	6+ Per Day	Small	Medium	Large
105. Whole milk	○	○	○	○	○	○	○	○	○	○	○	○
106. 2% milk or buttermilk	○	○	○	○	○	○	○	○	○	○	○	○
107. Skim milk or 1% milk	○	○	○	○	○	○	○	○	○	○	○	○

Beverages (Continued)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1-3 Per Month	1 Per Week	2-4 Per Week	5-6 Per Week	1 Per Day	2-3 Per Day	4-5 Per Day	6+ Per Day	Small	Medium	Large
108. Sweetened condensed milk	○	○	○	○	○	○	○	○	○	○	○	○
109. Soy milk	○	○	○	○	○	○	○	○	○	○	○	○
110. Coke, Pepsi, 7-up or other carbonated beverages (not diet)	○	○	○	○	○	○	○	○	○	○	○	○
111. Sweetened mineral water (not diet)	○	○	○	○	○	○	○	○	○	○	○	○
112. Diet Coke, Diet Pepsi, Diet 7-up or other diet carbonated beverages	○	○	○	○	○	○	○	○	○	○	○	○
113. Unsweetened mineral water	○	○	○	○	○	○	○	○	○	○	○	○
114. Instant breakfast, Ensure, Slimfast	○	○	○	○	○	○	○	○	○	○	○	○
115. Hot chocolate	○	○	○	○	○	○	○	○	○	○	○	○
116. Cafe latte, cafe au lait made with low-fat or skim milk	○	○	○	○	○	○	○	○	○	○	○	○

Beverages (Continued)

Type of Food	Average Last Year									Your Serving Size		
	Rare or Never	1-3 Per Month	1 Per Week	2-4 Per Week	5-6 Per Week	1 Per Day	2-3 Per Day	4-5 Per Day	6+ Per Day	Small	Medium	Large
117. Cafe latte, cafe au lait made with whole milk	○	○	○	○	○	○	○	○	○	○	○	○
118. Coffee (regular or decaffeinated) not including latte, cafe au lait	○	○	○	○	○	○	○	○	○	○	○	○
119. Herbal tea	○	○	○	○	○	○	○	○	○	○	○	○
120. Black or green tea	○	○	○	○	○	○	○	○	○	○	○	○
121. Low-fat or skim milk in coffee or tea	○	○	○	○	○	○	○	○	○	○	○	○
122. Whole milk in coffee or tea	○	○	○	○	○	○	○	○	○	○	○	○
123. Cream, half-and-half or non-dairy creamer in coffee or tea	○	○	○	○	○	○	○	○	○	○	○	○
124. Sugar or honey in coffee or tea (not including artificial sweetners)	○	○	○	○	○	○	○	○	○	○	○	○
125. Wine	○	○	○	○	○	○	○	○	○	○	○	○
126. Non-alcoholic beer	○	○	○	○	○	○	○	○	○	○	○	○
127. Beer	○	○	○	○	○	○	○	○	○	○	○	○
128. Liquor or mixed drinks	○	○	○	○	○	○	○	○	○	○	○	○

The next few questions will help us understand the kind of food you eat.
If you never eat the food, please mark "I Do Not Eat The Food".

	I Do Not Eat The Food	SELDOM or NEVER	SOMETIMES	OFTEN or ALWAYS
How often do you eat the skin on chicken?	○	○	○	○
How often do you eat the fat on meat?	○	○	○	○
If you eat ground beef, how often is it lean or extra lean ground beef?	○	○	○	○
How often do you add salt to food at the table?	○	○	○	○
If you eat fresh fruit (not including oranges or bananas), how often do you eat the peel?	○	○	○	○
If you eat potatoes, how often do you eat the skin?	○	○	○	○
If you eat salads, how often do you use either diet salad dressing or no salad dressing?	○	○	○	○
If you drink juice, how often do you drink calcium-fortified juice?	○	○	○	○
If you drink juice, how often do you drink Vitamin C-fortified juice?	○	○	○	○
Not all dark or wheat breads are 100% whole grain. If you eat dark or wheat bread or rolls, how often is it 100% whole grain?	○	○	○	○

Continued:

	I Do Not Eat The Food	SELDOM or NEVER	SOMETIMES	OFTEN or ALWAYS
If you eat hot dogs, bologna or other lunch meats, how often are they low-fat?	○	○	○	○
If you eat snacks such as chips or popcorn, how often are they low-fat?	○	○	○	○
If you eat bacon or sausage, how often is it low-fat?	○	○	○	○
If you eat cheese, how often is it low-fat cheese?	○	○	○	○
If you eat yogurt, how often is it low-fat yogurt?	○	○	○	○
If you eat cookies or cake, how often are they low-fat cookies or cake?	○	○	○	○
If you eat fresh fruit or drink fruit juice, how often is that fruit or fruit juice "organically grown" (fruit or fruit juice with a "USDA Organic" label, purchased locally from an "organic farm", or grown without pesticides in a home garden)?	○	○	○	○
If you eat fresh vegetables, how often are those vegetables "organically grown" (vegetables with a "USDA Organic" label, purchased locally from an "organic farm", or grown without pesticides in a home garden)?	○	○	○	○

__IF YOU SOMETIMES, OFTEN, OR ALWAYS__ eat organically grown fruit, fruit juice or vegetables, how long have you been doing so?

- ○ More than 10 years
- ○ 5-10 years
- ○ 1-5 years
- ○ Less than 1 year

3093435984

The next few questions are about using fat in cooking. <u>If someone else does the cooking, please answer to the best of your knowledge.</u>

	Average Last Year								
	Less Than 1 Per Week	1-2 Per Week	3-4 Per Week	5-6 Per Week	1 Per Day	1 1/2 Per Day	2 Per Day	3 Per Day	4+ Per Day
How often is fat or oil used in cooking the foods you eat? For example in sauteing, stir frying or frying eggs, meat or vegetables?	○	○	○	○	○	○	○	○	○

What kind of fat or oil is usually used in cooking? (You <u>may select two fats</u> used in sauteing, stir frying or frying food)

- ○ Don't know
- ○ Soft margarine (tub or liquid)
- ○ Stick margarine or shortening
- ○ Butter
- ○ Lard, fatback, bacon fat, fat from hamburger
- ○ Pam or no oil
- ○ Olive oil
- ○ Canola oil
- ○ Coconut oil
- ○ Other oil (such as vegetable, corn, sesame, sunflower or safflower)

If you eat refried beans or pinto beans, what kind of oil or fat is used in cooking the beans? (You <u>may select two choices</u>)

- ○ Don't know / Don't eat beans
- ○ Soft margarine (tub or liquid)
- ○ Stick margarine or shortening
- ○ Butter
- ○ Lard, fatback, bacon fat, fat from hamburger
- ○ Pam or no oil
- ○ Olive oil
- ○ Canola oil
- ○ Coconut oil
- ○ Other oil (such as vegetable, corn, sesame, sunflower or safflower)

What kind of fat do you usually add to vegetables, potatoes, etc. at the table? (You <u>may select two choices</u>)

- ○ Don't add fat
- ○ Soft margarine (tub or liquid)
- ○ Stick margarine or shortening
- ○ Butter
- ○ Lard, fatback, bacon fat
- ○ Olive oil
- ○ Canola oil
- ○ Coconut oil
- ○ Other oil (such as vegetable, corn, sunflower or safflower)
- ○ Sour cream

Is there any other food that you eat **at least once a week** that you have not seen listed in the previous pages?

○ Yes ○ No

List:

Is there anything else that you would like to tell us about your eating habits?

○ Yes ○ No

Clinical Use Only:

EDITOR: Review form for completeness and consistency, complete missing items and obtain clarifications.

Comments?
○ 1 None
○ 2 Yes, no review needed
○ 3 Yes, Diet Data Center review needed (questionable accuracy, etc.)

Comments/Notes:

Is review by Diet Data Center required for coding food items? ○ No ○ Yes

For MESA Field Center Use Only:

Form Completed:

○ 1 Self at home **(returned in clinic)**
○ 2 Self at home **(sent after exam)**
○ 3 Self **(during exam)**
○ 4 By telephone **(lead interview after exam)**
○ 5 In Clinic **(interviewer administration)**

__ __ / __ __ / __ __ __ __
Date

Interviewer ID: Reviewer ID: Data Entry ID:

6188435982