3-30-2011

The Effect of Glycemic Index and Glycemic Load on Glucose Control, Lipid Profiles and Anthropometrics Among Low-Income Latinos With Type 2 Diabetes: A Dissertation

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The Effect of Glycemic Index and Glycemic Load on Glucose Control, Lipid Profiles and Anthropometrics among Low-income Latinos with Type 2 Diabetes

A Dissertation Presented

By

Lauren Gellar

Submitted to the Faculty of the University of Massachusetts Graduate School of Biomedical Sciences, Worcester in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

(March, 30th and 2011)

Clinical and Population Health Research

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Clinical and Population Health Research
(March, 30th, 2011)

Acknowledgments

I would like to thank my dissertation mentor Dr. Lori Pbert for her patience, genuine care and faith in me over the past three years. She has given me confidence and motivated me to continue when times were difficult. I thank her for her fantastic listening skills, your ability to help me see things from a different perspective and your constant flow of positive energy.

I am very grateful to my dissertation committee, Dr. Milagros Rosal, Dr. Chuck Lidz, Dr. Joe DiFranza, Dr. Yunsheng Ma and Dr. Kim Gans. Their time, assistance, feedback and support are greatly appreciated. Thank you.

I would like to give a special thank you to Dr. Tonja Nansel. Over the past 8 years she has given me tremendous support and guidance. I am so very grateful. Additionally, I would like to thank the researchers at NICHD/PBR, Dr. Bruce Simons-Morton, Dr. Ron Ianotti and Dr. Denise Haynie for their support, and insight over the years.

I want to thank my friends and family who were there for me. I know that this was a difficult time, I truly appreciate all of the hours spent supporting and motivating me to reach the finish line.

ABSTRACT

Background

The incidence of type 2 diabetes has increased dramatically, particularly among Latinos. While several studies suggest the beneficial effect of lowering glycemic index and glycemic load in patients with type 2 diabetes, no data exists regarding this issue in the Latino population. The purpose of this study was to determine the effect of lowering glycemic index and glycemic load on diabetes control, lipid profiles and anthropometrics among Latinos with type 2 diabetes.

Methods

Subjects participated in a 12 month randomized clinical trial. The intervention targeted diabetes knowledge, attitudes and behavioral capabilities related to diabetes self management with content including nutrition and physical activity. The nutrition protocol emphasized reduction in glycemic index, fat, salt and portion size and increase in fiber. The control group was given usual care. Measurements included Hba1c, fasting glucose, total cholesterol (TC), low density lipoproteins (LDL) and high density lipoproteins (HDL), HDL:LDL ratio, TC:HDL ratio, waist circumference and BMI and were collected at baseline, 4 and 12-months.

Results

Two hundred fifty two Latino adults with type 2 diabetes participated in the study. Baseline mean HbA1C was 8.98% (SD=1.87), BMI was 34.76 kg/cm (SD=6.94), age was 56 (SD=11.18) years and 76% were female. Reduction in glycemic index was positively associated with a reduction in logHbA1c (p=0.006), HDL:LDL ratio (p=0.037)

and waist circumference (p=0.003) overtime, but not with fasting glucose, TC, LDL and HDL, TC:HDL ratio, body weight or BMI. No significant associations were found between glycemic load and any measures.

Conclusion

Results suggest that lowering glycemic index may have a positive effect on some markers of diabetes control, lipid profiles and anthropometrics among Latinos with type 2 diabetes, but not others. While statistically significant reductions in GI and GL were noted, the actual reduction was small. Thus, greater reduction in GI and GL may be needed for clinical significance and greater effect on metabolic outcomes. Future research should target populations with higher baseline GI and GL.

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CHAPTER I

Proposal

Specific aims

The incidence of type 2 diabetes (T2D) has increased at a dramatic rate over the past several decades. This chronic illness is reaching epidemic proportions in the United States, currently affecting approximately 12.9% of the adult US population [1]. Latinos suffer higher rates of T2D [1], and higher rates of uncontrolled T2D [2, 3] which fosters long-term microvascular complications and an eventual increase in macrovascular complications including cardiovascular disease and stroke [4].

Blood glucose response to the ingestion of carbohydrate-containing foods has been shown to vary dramatically depending on various factors. The glycemic index (GI) is the value given to carbohydrate-containing foods indicating the blood glucose response they elicit [5]. Lower GI foods are foods, which provoke a slower, more sustained blood sugar response; GL is a combination of the GI and the quantity of carbohydrate in a food. Results of recent clinical trials suggests that consumption of a low GI (LGI) diet may result in improved diabetes control compared to a high GI(HGI) diet in individuals with T2D [6-10]. Additionally, results of several large epidemiological studies suggest a protective effect of lowering GL on diabetes risk [11, 12]. However, no clinical trial has investigated the effects of a low GL (LGL) diet compared to a high GL (HGL) diet in adults with T2D. Furthermore, no study has investigated the effects of lowering GI in Latinos. Given that Latinos have a high prevalence of T2D and that consumption of LGI or LGL foods may result in improved glycemic control, an

examination of the quality of carbohydrate intake among Latinos with T2D, and the association between GI and GL and clinical endpoints, may have great public health implications.

The goals of this study are to investigate the association of GI and GL on measures of diabetes control, anthropometrics and lipid profiles among low-income Latino individuals with T2D. These research questions will be addressed through secondary analysis of a randomized controlled trial (RCT), *Latinos en Control, which* tested the efficacy of a diabetes self-management intervention that targeted GI and GL among two hundred fifty-two Latino patients of Caribbean origin with T2D. Individuals were recruited from five community health centers in urban areas of central and western Massachusetts. The group-based intervention, targeted diabetes knowledge, attitudes and behavioral capabilities and its content was tailored to the cultural and literacy needs of the population. Personalized coaching was offered within the context of the intervention format (10-minute counseling segments prior to the group start). Assessments were completed at baseline, 4 and 12 months and included three 24-hour dietary recalls, clinical assessments, and demographic and psychosocial interviews. The study's **specific aims** and related **hypotheses** are described below.

1. Determine the effect of GI or GL on glucose control determined by glycosylated hemoglobin (HbA1c) and fasting blood glucose levels.

Hypothesis:

a. Compared to usual care participants, intervention participants will achieve a greater reduction in dietary GI and GL and improved diabetes control.

2. Determine the effect of GI or GL on lipid profile determined by total cholesterol (TC), high density lipoproteins (HDL), low density lipoproteins (LDL), and triglycerides.

Hypothesis:

a. Compared to usual care participants, intervention participants will achieve a greater reduction in dietary GI or GL and improved lipid profiles.

3. Determine the effect of GI or GL on anthropometrics determined by BMI and waist circumference.

Hypothesis:

a. Compared to usual care participants, intervention participants will achieve a greater reduction in dietary GI or GL and improved anthropometric outcomes.

Background and significance

Diabetes prevalence

The incidence of diabetes has increased at a dramatic rate over the past several decades. This chronic illness is reaching epidemic proportions in the United States, currently affecting approximately 12.9% of the adult US population [1] and the burden is not restricted to the United States alone. By the year 2025 it is predicted that the number of individuals living with diabetes worldwide will reach 300 million [13].

Diabetes disease process

T2D is a progressive metabolic disorder. It is often characterized by years of asymptomatic insulin resistance and subsequent hyperglycemia. The result of this continuous glucose dysfunction is destruction of pancreatic beta cells. If these

conditions persist, the emergence of complete T2D will occur. The etiology of T2D is not completely understood. Researchers have proposed two potential mechanisms for the progression to beta-cell death, as seen in T2D. One potential mechanism is the over-secretion of insulin as a result of repetitive hyperglycemic events. The second is that repetitive hyperglycemia itself has a toxic impact on beta cells [14].

Diabetes related complications

Chronically elevated blood glucose and subsequent increased insulin demands foster long-term microvascular complications and an eventual increase in macrovascular complications, including cardiovascular disease and stroke. Recent research indicates that elevated blood glucose, even below the threshold for diabetes, is a leading cause of cardiovascular mortality. According to a recent study, 21% of global ischemic heart disease and 13% of stroke mortality is attributable to higher-than-optimum blood glucose [4].

Latinos and diabetes control

Latinos suffer higher rates of T2D. Results of a recent study suggest that the combined crude prevalence of diagnosed and undiagnosed diabetes is 80% higher in Mexican Americans compared to non-Latino whites after controlling for age and gender [1]. Furthermore, Latinos have high rates of uncontrolled T2D [2, 3] which fosters long-term microvascular complications and an eventual increase in macrovascular complications including cardiovascular disease and stroke [4]. The projected increase in diabetic retinopathy for Latino adults over age 65 with T2D by the year 2050 is 0.5 million [15]. Additionally, projections suggest a 12 fold increase in diabetes related glaucoma in Latino adults over age 65 with T2D by the year 2050 [15].

Medical nutrition therapy for the management of type 2 diabetes

Previous research suggests that improvements in dietary behaviors can have beneficial effects on diabetes management. As a result of this research, professional organizations, which focus on diabetes care offer practice recommendations for diabetes management through dietary behavior change. The American Diabetes Association (ADA) evidence-based treatment guidelines include specific dietary recommendations in conjunction with pharmacological interventions and other self-management strategies (i.e., blood glucose monitoring and physical activity)[16]. Several ADA diet-related recommendations include carbohydrate quality, dietary fat intake and weight management and these are described below.

Carbohydrate Quality

The ADA recommends dietary intake of carbohydrates from various sources including: fruits, vegetables, whole grains, legumes, and low-fat milk. The ADA's current position [16] suggests the use of GI and GL as a strategy for improving diabetes management. Both may offer some benefit over that seen when total carbohydrate is considered alone. Additionally they encourage consumption of a variety of fiber-containing foods, but suggest a lack of evidence to recommend fiber intakes higher than is recommended for the general population.

Dietary Fat

The principle recommendation regarding dietary fat in patient's withT2D is to limit saturated fatty acids, trans fatty acids, and cholesterol intakes to reduce risk for CVD.

Weight Management

Recommendations for dietary management for individuals with T2D emphasize the implementation of lifestyle changes that will improve glycemia, dyslipidemia, and blood pressure. Modest weight loss (5% of body weight) in overweight individuals with T2D has been shown to improve insulin resistance, measures of glycemia, lipid levels and blood pressure [16].

Glycemic Index and Glycemic Load

Blood glucose response to the ingestion of carbohydrate-containing foods has been shown to vary dramatically depending on factors including the molecular structure of the carbohydrate, fiber content, and degree of processing [17]. Refined, highly processed carbohydrates are broken down and absorbed quickly, resulting in a rapid increase in blood glucose, whereas less refined carbohydrates are absorbed more slowly, resulting in a slower, more sustained rise in blood glucose. GI is the value given to carbohydrate-containing foods indicating the blood glucose response they elicit. The GI [5] of a food is defined as the incremental area under the glucose response curve relative to that produced by a standard control food (either glucose or white bread). The GI was developed as a tool to standardize measurement of glycemic responses to ingestion of carbohydrate containing foods. Simplistically, GI is a measure of how much and how fast a carbohydrate containing food raises blood glucose levels. High GI (HGI) foods induce a rapid spike in blood glucose, while low GI (LGI) foods elicit slower, lesser, and more sustained increases in blood glucose levels. Using glucose as referent, HGI foods are foods with GI values greater than or equal to 70, medium GI is 55-69 and LGI is less than 55. The GI of the average diet in the US has increased over time as more highly processed foods are being consumed. [18]. Currently, most commonly consumed

carbohydrates in the United States are high-glycemic carbohydrates. The current mean GI intake of the Latino population has not been reported.

To account for carbohydrate content variation with in foods, GL was introduced in 1997 by Willett and colleagues and can be calculated as the quantity (in grams) of a food's carbohydrate content, multiplied by its GI.[19] HGL foods are foods with GL values greater than or equal to 20, medium GL is 11-19 and LGL is less than or equal to 10.

In healthy individuals, blood glucose level is tightly maintained by homeostatic regulatory systems. However, the physiological effects of ingestion of high glycemic foods challenge these mechanisms. The rapid increase in blood glucose following consumption of a high glycemic meal stimulates insulin release and inhibits glucagon release to a much greater extent than after consumption of a low glycemic meal. This results in exaggerated glucose uptake by skeletal muscle, storage of fat, and inhibition of fat breakdown. The major metabolic fuels – glucose oxidation and free fatty acids – are suppressed. Nutrient absorption from the gastrointestinal tract then declines while the biological effects of insulin release and glucagon suppression persist, resulting in a rapid fall in blood glucose levels, often into the hypoglycemic range. The low levels of metabolic fuels trigger a counter-regulatory hormone response, increasing free fatty acids, and creating a fasting physiological state. Research to date suggests that stimulation of these exaggerated physiological responses repeatedly over time may promote excessive food intake, beta cell dysfunction, dyslipidemia, and endothelial dysfunction; increasing risk for obesity, diabetes, and heart disease [17].

Previous Research

Primary Prevention

Several large cohort studies have investigated the relationship between GI, GL and risk of diabetes. While the majority of these studies have indicated a protective relationship between lowering GI and reduced risk of diabetes, several have not. Results from the Nurses' Health Study [11], the Nurses' Health Study II [20], the Health Professional Follow-up Study [19], the US Black Women Study [21], and the Shanghai Women's Health Study [12] found that higher GI was positively associated with risk of diabetes after adjustment for covariates. However, the Iowa Women's Health study [22] showed no association between higher GI and risk of diabetes. Another study conducted in White and African American adults found no association between GI and risk of diabetes [23]. The results of studies highlighting the relationship between GL and risk of diabetes have also been inconsistent. Results from the Nurses' Health Study [11] and the Shanghai Women's Health Study [12] suggest that higher GL is positively associated with risk of diabetes. In contrast, results from the Health Professional Follow-up Study [19], the US Black Women Study [21] and the Nurses' Health Study II [20] showed no significant relationship between higher GL and risk of diabetes. Additionally, a recent meta analysis of 45 observational studies in adults, suggested that a lower GI diet is associated with lower fasting blood glucose and glycosylated hemoglobin [24].

The participants in the *Latinos en Control* study represent a demographic not addressed by previous studies in this area, one that is known to have elevated rates of T2D and T2D related complications. The Nurses' Health Study investigated the relationship between G and GL in female nurses between 30-55 years at initiation [11] and the relationship GI and GL in young and middle age female nurses aged 24-44 years at initiation [20]. The Health Professional Follow-up Study [19] included only men,

the US Black Women Study [21] included only Black women and the Shanghai Women's Health Study [12] included only Chinese women.

Secondary Prevention

While no clinical trial has assessed the effects of a LGL diet compared to a HGL diet in individuals with T2D, one study [25] did examine the effects of a LGL diet compared to a HGL diet on risk factors for T2D in healthy overweight adults. The results showed no significant differences in diabetes risk factors between the HGL and LGL groups after the 6-month weight loss intervention. One possible explanation for the lack of difference between the two groups is that the participants did not have diabetes, thus not enough metabolic dysfunction to impact a change in outcomes.

Several clinical trials [6, 8-10, 26-29] have investigated the effect of lowering dietary GI on metabolic and anthropometric outcomes in subjects with T2D, results have been inconsistent. Nevertheless, findings from several of these studies suggest that incorporation of GI principles into diabetes care has substantial promise for improving management of T2D without evidence of adverse effects. Most of the studies comparing LGI diets to HGI diets on individuals with T2D [6, 9, 28, 29] have been conducted with small samples and for short duration, most lasting less than 6 weeks for each dietary condition [6, 9, 26-29]. All but one were conducted among patients with variable or uncontrolled type 2 diabetes [6-9, 26-29]. While several studies have shown greater improvements in diabetes control with a LGI diet compared to a HGI diet [6-10] several have not [26, 27, 29]. Two studies investigated the impact of a LGI diet compared to an HGI diet on anthropometric outcomes in individuals with T2D. Results of one study suggest that body weight did not differ significantly between diets [10]; another found no

difference in lean or fat mass between the two diets [9]. Several studies have shown improvements in lipid profiles, including HDL, LDL and TC [9, 26, 29] while no study showed an improvement in triglycerides. One study showed no improvement in any lipid marker[6].

The largest and longest clinical trial assessed the effect of a LGI dietary intervention compared to either a HGI or a low- carbohydrate dietary intervention in well-controlled individuals with T2D. One hundred and sixty two subjects participated in a 1 year multicenter, randomized controlled trial in which the impact of the 3 diets (a low GI, a high GI and a low carbohydrate diet) on HbA1c, blood glucose, lipids, and CRP were assessed. The results suggested that body weight and HbA1c did not differ significantly between diets. Fasting glucose was higher, but 2-h postprandial glucose was lower after 12 mo of the low-GI diet. One potential reason for the lack of difference in HbA1C between the HGI and LGI dietary prescriptions is that the subjects in this study had optimal HbA1C levels at baseline, thus reduction in HbA1C may have been difficult to attain [10].

Summary of significance

While many epidemiological studies suggest the beneficial effect of reducing dietary GI or GL in patients with T2D, little data exists regarding this issue in the Latino population. While several clinical trials [6, 8-10, 26-29] have investigated the association between lowering dietary GI and diabetes related health outcomes of patient's with T2D, the results have been inconsistent. Furthermore, only one clinical trial has assessed metabolic or anthropometric outcomes in Latinos with T2D and no clinical trial has

assessed the effects of lowering GL on metabolic or anthropometric outcomes in individuals with T2D.

This proposed investigation addresses several limitations of the previous research in this area. First, the target population is comprised of Latinos with poorly controlled T2D, a population in which this research question has not been previously investigated. Therefore, the results of this study will address a significant health concern within a population at great risk. Second, the duration of this intervention, 1 year, is longer than all but one previous clinical trial [10]. While results of a few shorter trials do suggest a positive impact of lowering GI on metabolic outcomes in adults with T2D [6-10], the longer term effects need to be investigated. Third, while Wolever et al. [10] conducted a 1 year trial, the sample included Canadian adults with well controlled T2D; it is possible that reducing GI or GL in adults with poorly controlled T2D over an extended period of time may result in greater reductions in metabolic and anthropometric outcomes compared to individuals with well controlled T2D at baseline.

CHAPTER II

The Association between Glycemic Index, Glycemic Load and Glycemic Control among Low-income Latinos with Type 2 Diabetes

ABSTRACT

Background

Type 2 diabetes has increased dramatically over the past decades. Latinos suffer higher rates of type 2 diabetes compared to non-Latino whites. While many studies suggest the beneficial effect of reducing glycemic index (GI) and glycemic load (GL) in patients with type 2 diabetes, little clinical data exists regarding this issue in the Latino population.

Purpose

To determine the effect of a 12 month diabetes self-management intervention on GI and GL intake and the effect of changes in GI and GL on glucose control determined by glycosylated hemoglobin (HbA1c) and fasting blood glucose levels among low-income Latino adults with type 2 diabetes.

Methods

The 12 month intervention targeted diabetes knowledge, attitudes and behavioral capabilities and its content was culturally and literacy tailored. Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour dietary recalls, clinical assessments, and demographic and psychosocial interviews. Multivariate random effects analyses were used to test the association between GI and GL with HbA1c and fasting blood glucose overtime.

Results

252 Latinos with type 2 diabetes participated in the study. The baseline mean (SD) HbA1c was 8.98 (1.87), age was 56 (11.18) years, and 76.6 % were female. A significant reduction in mean GI and GL ($p<0.001$, $p<0.001$, respectively) was noted at 4 months in the treatment group compared to the control group; at 12 months this reduction only remained significant for mean GL ($p<0.001$). A reduction in GI was associated with a reduction in logHbA1c ($p=0.006$), but not with fasting blood glucose ($p=0.138$). No significant associations between GL and HbA1c or fasting blood glucose were observed ($p=0.124$, $p= 0.604$, respectively).

Conclusion

Results suggest that the Latinos en Control intervention was effective in lowering GI and GL, though changes were most pronounced in the short term and were maintained only for GL. This study adds to the evidence suggesting that lowering dietary GI may enhance type 2 diabetes control in an understudied population of low income Latinos.

INTRODUCTION

The incidence of type 2 diabetes (T2D) has increased at a dramatic rate over the past several decades. This chronic illness is reaching epidemic proportions in the United States, currently affecting approximately 12.9% of the adult US population [1]. By the year 2025, it is predicted that the number of individuals living with diabetes will reach 300 million worldwide [13].

Latinos suffer higher rates of T2D then non-Latino Whites. Results of a recent study suggest that the combined crude prevalence of diagnosed and undiagnosed diabetes is 80% higher in Mexican Americans compared to non-Latino whites after controlling for age and gender [1]. Furthermore, Latinos have high rates of uncontrolled T2D [2, 3] which fosters long-term microvascular complications and an eventual increase in macrovascular complications including cardiovascular disease and stroke [4]. Additionally, researchers have projected an additional 500,000 cases of diabetic retinopathy and a 12-fold increase in diabetes related glaucoma among Latino adults over the age of 65 by 2050 [15].

Blood glucose response to the ingestion of carbohydrate-containing foods has been shown to vary dramatically depending on various factors. The glycemic index (GI) is the value given to carbohydrate-containing foods indicating the blood glucose response they elicit [5]. Lower GI foods are foods which provoke a slower, more sustained blood sugar response. Glycemic load (GL) is a combination of the GI and the quantity of carbohydrate in a food. Recent clinical trials suggest that consumption of a low GI diet may result in improved diabetes control compared to a high GI diet in

individuals with T2D [6-10]. Moreover, several large epidemiological studies suggest a protective effect of lowering GL on diabetes risk [11, 12]. However, no clinical trial has investigated the effects of a low GL diet compared to a high GL diet in adults with T2D. Furthermore, only one other study has investigated the effects of lowering GI in Latinos [28]. Given that Latinos have a high prevalence of T2D and that consumption of low GI or low GL foods may result in improved glycemic control, an examination of the quality of carbohydrate intake among Latinos with T2D, and the association between GI and GL and clinical endpoints is of great importance. The purpose of this study was to determine the effect of a diabetes self management intervention on GI and GL, and the effect of these changes on glucose control as assessed by glycosylated hemoglobin (HbA1c) and fasting blood glucose levels among low-income Latinos with T2D.

METHODS

Study Participants

Patients with T2D were recruited from five community health centers (CHC) in urban areas of central and western Massachusetts. At each CHC, a trained site research coordinator overseen by the research team was responsible for completing the recruitment processes. Subjects were included if they: were diagnosed with T2D;had an HbA1c level $\geq$ 7.5; were currently being treated with diet, oral hypoglycemics or insulin and, if they were currently on insulin, they must have had a history of prior therapy with diet alone or oral hypoglycemic agents; were Latino origin; were $\geq$ 18 years old; had a telephone in home or easy access to one; were able to understand and participate in the study protocol and functionally capable of meeting the physical activity goals;

understood and could provide informed consent; and were given physician approval to participate in the study. Subjects were excluded if they: had a history of diabetic ketoacidosis; current gestational diabetes; were unable or unwilling to provide informed consent; had any plans to move out of the area within the 12-month study period; required intermittent glucocorticoid therapy within the past 3 months; experienced an acute coronary event within the previous 6 months or had any medical condition that precluded adherence to study dietary recommendations or had any major psychiatric illness.

Determination of subject eligibility and recruitment was conducted in several stages. First, health care providers at participating CHCs were notified of the study and their approval for the site research coordinator to access patient medical records for screening purposes was obtained. Second, a review of the medical records of potentially eligible patients' was completed. For patients determined to be medically eligible to participate, approval and a signature on the recruitment letter was obtained from their primary care physician. Third, a letter describing the study was mailed to the patients who received primary care physician approval. Prior to participation in the study written informed consent was obtained from all participants. Once the baseline assessment was completed, participants were randomized to either the usual care condition or to *Latinos En Control* intervention condition. Randomization was completed at the level of the individual and stratified by CHC site, gender, baseline HbA1c levels and insurance status. Within each strata, participants were randomized in randomly allocated blocks of size 2, 4 and 6 using a reallocation program [30] version 7.0 (Stata Corporation, College Station, TX). Block randomization was used to ensure blinding of

the allocation sequence. The study protocol was approved by the University of Massachusetts Medical School's and the Baystate Medical Center's Institutional Review Boards.

Intervention

Participants in the intervention condition, Latinos en Control, participated in a one year, group based intervention, consisting of two phases: an intensive phase with 12 weekly sessions followed by a maintenance phase with 8 monthly sessions. An outline of the self-management curriculum is presented in Table 1. The intervention targeted diabetes knowledge (e.g., effect of foods of different GI on diabetes control), attitudes (e.g., self-efficacy for dietary change) and behavioral capabilities (i.e., skills needed to make lifestyle changes) with its content tailored to the cultural and literacy needs of this population. Personalized coaching was offered during 10-minute counseling segments prior to the start of each group.

The dietary component of the intervention used the metaphor of a traffic light to simplify complex concepts. Foods frequently consumed by Latinos were classified based on their GI, fat, salt, and fiber content into categories of "green", "yellow," or "red" foods. A "food guide" which included pictures of these foods within the corresponding "traffic light colors" was developed and provided to all participants. Additionally, participants were given a graphic of a plate which displayed the ideal balance of colors at any given meal. Explained simplistically, the color green classified recommended foods which were lower in calories, saturated or trans-fat and sodium content and were of lower GI. "Yellow" foods were medium in calories, saturated or trans-fat and sodium content and were of medium GI. "Red" foods were higher in calories, saturated or

trans-fat and sodium content and were of higher GI. To impact GL, reduction of portion sizes was emphasized and all participants received a set of measuring cups. Subjects participated in multiple interactive sessions including: healthy cooking methods for ethnic foods, label reading, a supermarket tour, group meals where measuring cups were used for modeling appropriate portion sizes and guided discussions explored taste and appeal of the foods, the ease of preparation, and strategies to incorporate new cooking methods at home. Participants were provided with and instructed in the use of glucose meters and step counters.

Usual care was defined as diabetes care as currently delivered at the CHC. Therefore, participants in the usual care group received medical therapy as determined to be appropriate by their healthcare providers. Healthcare providers received all laboratory reports for all participants regardless of their study condition.

Measurement

Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour recalls, clinical assessments, and demographic and psychosocial interviews at each time point. Dietary intake and physical activity [31] were assessed via three unannounced telephone administered 24-hour recalls. Multiple recalls are used to assess day-to-day intra-individual variations in the behaviors of interest [32]. The Minnesota Nutrition Coordinating Center's (UM-NCC) Nutrition Data System for Research software (NDS-R) was used to collect and analyze the 24-hour dietary recall data [33]. At each assessment visit, fasting blood samples were drawn for analysis of TC, LDL, HDL and triglycerides, fasting glucose, and HbA1c. Body Mass Index (BMI) was calculated as weight in kg divided by height in cm^2. Weight was

assessed with a Tanita BWB800S Digital Physicians Scale and Height was asses with a Seca Road Rod Portable Stadiometer. Waist circumference was measured in centimeters to 0.1 cm**.** Waist circumference was measured twice and the mean value was used in the analyses. Two blood pressure measurements were taken using a Dinamap XL automated BP monitor. All medications and supplements were recorded. Demographic and additional data were collected via self-reported survey, including; age, gender, education level, and duration of diabetes. In order to account for the potential effect of medications on blood glucose, lipids, and weight, two pharmacists compiled the medication used by study participants based on whether they had a positive or adverse effect on these outcomes. In addition, glucose lowering agents were combined to construct a diabetes medication intensity score. This score was based on the type of oral hypoglycemics taken and/or dose and type of insulin taken. Possible scores ranged from 0- 6.5, with a higher score equating to greater number or dose of medication/insulin. Participants were compensated with 30 dollars at each assessment timepoint.

Statistical Analysis

All analyses were performed using STATA version 11 (StataCorp, College Station, TX). Results are expressed as means with 95% confidence intervals (CIs) for continuous variables and n(%) for categorical variables. Descriptive statistics were calculated for continuous covariates (age, BMI, physical activity, blood pressure, medication score), exposure variables (GI, GL), and outcomes (HbA1c, fasting blood glucose). The natural logarithm of HbA1c was used in the multivariate analyses

because the distribution was skewed. Although GI and GL were continuous variables, for univariate statistical inferences, data were stratified by baseline GI and GL quartile and compared differences of baseline demographic and clinical data using Chi-Square or ANOVA tests.

Four separate random effects regression models were developed with either the outcome being log (HbA1c) or fasting blood glucose and the primary predictor of interest being the exposure variable of GI or GL (ie, a model examining the effect of GI on HbA1c adjusted for other confounders, followed by a model examining GL on HbA1c and then repeated for fasting blood glucose). Each model was controlled for age, gender, mean arterial blood pressure, total energy intake, physical activity, diabetes medication intensity score, lipid increasing and decreasing drugs, and weight increasing and decreasing drugs and study arm. A backward elimination process was used for each model, until only significant variables remained. Additionally, linear regression was used to determine the association between change in glycemic index and glycemic load with change in logHbA1c and fasting blood glucose from baseline to 4 months follow-up.

The primary multivariate analysis was a complete case analysis in which patient records with missing values were not in the regression models. To investigate the potential effect of missing data, two imputed sensitivity analyses were completed. The first analysis was intention to treat analysis, which included all 252 randomized participants, with the baseline observation carried forward when missing values were present. The second method relied on multiple imputation by chained equations (MICE) analysis [34]. No differences were found between the analyses. Thus, results using complete data are presented herein.

RESULTS

Baseline Characteristics

The participant flow diagram is shown in Figure 1. A total of 252 Latino adults with T2D participated in the study, 128 randomized to the control condition and 124 to the intervention condition. Table 2 presents baseline demographic and clinical data stratified by baseline GI and GL quartiles determined by the average of the three baseline dietary recalls. The baseline mean (SD) HbA1c was 8.98% (±1.87%), age was 56.0 (±11.2) years, and 76% were female. There was a significant difference in HbA1c by GI quartile. Subjects in the lowest quartile of GI had significantly lower mean HbA1c compared to those in the other three quartiles (8.23% vs. 9.35%, 9.04% and 9.20%, p=.005) but this pattern was not found with the GL quartiles. Significantly more females were in the lowest quartile for GL (90% vs.78%, 73%, 88%, p=.033), but there was no gender difference by GI quartile.

At baseline, 44% of subjects were taking oral hypoglycemic medications only, 40% were taking oral agents and insulin, 9% were taking insulin therapy only and 7% were taking no medications. The distribution of the medication intensity score did not differ across GI or GL quartiles. GI intake at baseline ranged from 46.58-76.02 (glucose reference) and GL intake at baseline ranged from 30.14-299.42.

Intervention Effects

Glycemic Index

Figures 2 and 3 illustrate the change in GI and GL over time by treatment group compared to the control group. A significant reduction (baseline minus 4 month value) in

mean GI was seen in the treatment group at 4 months (treatment -2.57 (7.25) vs. control 0.87 (5.95), p<0.001). However, while this trend remained, the difference between conditions was no longer statistically significant at 12 months (treatment -0.63 (7.15) vs. control 0.42 (5.96) vs., p=0.27). Subjects in the highest quartile of GI at baseline showed greater reduction in GI compared to all other quartiles at 4 months (treatment 0.5 (6.80) vs. control -4.84 (5.4), p<0.001) and 12 months (treatment 1.48 (6.2) vs. control -5.22 (4.9), p<0.001). Subjects in the lowest GI quartile at baseline increased GI at 4 months (treatment -2.06 (6.55) vs. control 2.97 (6.55), p<0.001), and 12 months (treatment -2.09(5.38) control 5.67(6.26), p<0.001) compared to other quartiles.

Glycemic Load

A significant reduction in mean GL was seen in the treatment group compared to the control group at 4 months (treatment -20.42 (46.87) vs. control 7.41 (44.12), p <0.001), and at 12 months (treatment-14.62 (46.82) vs. control 6.48(43.15), p <0.001). Like what was observed with GI, subjects in the highest GL quartile at baseline decreased GL at 4 months (treatment 4.29 (38.87) vs. control -37.53 (56.35), p<0.001) and 12 months (treatment 8.69 (38.22) vs. control -39.66 (48.48), p<0.001) and those in the lowest GL quartile at baseline increased GL at 4 months (treatment-2.07 (6.56) vs. control 2.98(6.27), p<0.001) and 12 months (treatment -2.09 (5.38)vs. control 5.66(6.26), p<0.001).

There was no statistically significant association between change in glycemic index or glycemic load with change in HbA1c or fasting blood glucose from baseline to 4 months follow up.

Overall Association of Glycemic Index and Glycemic Control

Table 3 and Table 4 present the results of the multivariate random effects regression models. A decrease in GI was associated with a statistically significant decrease in the logHbA1c (0.003, 95%CI [0.001 to 0.006], p=0.009), but not with fasting blood glucose (0.736, 95%CI [-0.237 to 1.710], p=0.138).

Overall Association of Glycemic Load and Glycemic Control

No significant associations between GL and HbA1c or fasting blood glucose were found (0.000, 95%CI[-0.000 to 0.001],p=0.189, and 0.035, 95%CI[-0.097 to 0.166], p= 0.604, respectively).

DISCUSSION

While several studies have shown greater improvements in glycemic control with a low GI diet compared to a high GI diet [6-10] several have not [26, 27, 29]. Most of the studies comparing low GI diets to high GI diets on individuals with T2D [6, 9, 28, 29] have been conducted with small samples and for short duration, most lasting less than 6 weeks for each dietary condition [6, 9, 26-29]. The largest and longest clinical trial assessed the effect of a low GI dietary intervention compared to either a high GI or a low-carbohydrate dietary intervention in individuals with well-controlled T2D [35]. One hundred sixty two subjects were followed for 1year as part of this randomized controlled trial (in which the impact of the three diets on glycemic control assessed by HbA1c, blood glucose, lipids, and CRP were assessed). The results suggested that body weight and HbA1c did not differ significantly between the low GI, high GI and low-carbohydrate

diets. Fasting glucose was higher, but 2 hour postprandial glucose was lower after 1 year of the low-GI diet compared to the other two diets. One potential reason for the lack of difference in HbA1c between the high GI and low GI dietary prescriptions is that the subjects in this study had optimal HbA1c levels at baseline, thus reduction in HbA1c may have been difficult to attain [10]. Only one study has previously investigated the effect of lowering GI in Latino subjects with T2D. Jimenez-Cruz et al. [28] conducted a 6-week crossover study feeding study in which 14 overweight and obese Mexicans with T2D were given a low-GI diet, containing Mexican-style foods and then a high GI diet. The results suggest improvements in HbA1c during the low GI diet, compared to the high GI diet.

Glycemic Index

High GI foods are foods with GI values greater than or equal to 70, medium GI is 55-69 and low GI is less than 55. Currently, most commonly consumed carbohydrates in the United States are refined, higher-glycemic carbohydrates [18].The typical Western style diet contains many starchy foods such as potatoes, white breads and rice most of which have a GI greater than 70 (glucose reference). However, the mean GI intake for all subjects in this study at baseline was 61 (range 46.58-76.02), which is classified as medium GI. Thus, the mean GI in this population was lower than expected.

Subjects with the highest GI at baseline showed greater reduction in GI at each time point. Alternatively, subjects with the lowest GI increased GI at each time point. These data suggest that interventions which target reducing GI may be more effective in individuals with higher GI intake. Perhaps targeting Latinos for reduction in GI alone is not as efficacious as targeting the reduction of portion size, which would result in a

reduction in GL. Additionally, while changes in GI were statistically significant, the absolute reduction in GI was very small. Greater reductions in GI might be needed to see a more significant reduction in clinical biomarkers. However, as this population had a lower mean baseline GI, it is possible that greater reductions in this population are not feasible.

HbA1c

A reduction in GI was positively associated with the reduction in logHbA1c (0.003, 95%CI [0.001 to 0.006], p=0.006) overtime. The GI coefficient suggests that a one unit reduction in GI (in its original units of measurement) would result in a 0.3% decrease in HbA1c. Research suggests that a reduction as small as 1% in mean HbA1c can reduce risk of diabetes related complications. For example, a decrease of 21% for diabetes-related death, 14% for myocardial infarction and 37% for microvascular complications has been noted with a1% decrease in HbA1c [36]. Furthermore, since the relationship between HbA1c and diabetes related complications is continuous, any reduction in HbA1c would be beneficial [37]. There was no significant association found between GL and logHbA1c. Additionally, results suggest that as physical activity increased, HbA1c decreased.

Fasting blood glucose

There was no association between GI and fasting blood glucose overtime. However, when the relationship between fasting blood glucose and GI quartile was analyzed, a significant increase in fasting blood glucose was noted between the lowest quartile and the second lowest quartile. Additionally, results of that analysis suggest a

trend of increasing fasting blood glucose with increasing GI quartile. No significant associations between GL and HbA1c or fasting blood glucose were found.

The results of this study are subject to several limitations. First, dietary data were collected via self report. Second, 24-hour dietary recall was conducted in Spanish and translated by the assessor into English. Third, previous research suggests underreporting of dietary intake in Latino populations [38]. Fourth, all study participants were from Massachusetts, and thus represent a limited geographic range; all subjects were Latino, thus results may not be applicable to all racial and ethnic groups or those in other states. Finally, the majority of subjects were Puerto Rican. Previous research has suggested that variations exist between subgroups of Latinos and generalizations regarding Latinos as a single ethnic group should be made with caution.

This study addressed several understudied yet important research questions that may help inform dietary recommendations for the treatment of T2D in low income Latino adults. This is the first study to assess GI and GL in a Latino population using repeated 24 hour dietary recalls at multiple time points. Results suggest that tailored interventions that target reducing GI and GL among Latinos with T2D can be effective, though changes were most pronounced in the short term. A reduction in GI was associated with a reduction in HbA1c. An association between a reduction in GL with a reduction in HbA1c was not evident. This study adds to the evidence suggesting that lowering dietary GI may enhance T2D glycemic control in among Latinos.

Table 1

Latinos En Control Diabetes Self-Management (DSM) Curriculum: Session Objectives and Topics

Session number	Intensive Phase
1	Rapport with patients; individual assessments of: diabetes self management (DSM) history; DSM goals and incentives; expectations and commitment for the program; family support and resources for DSM; rationale for DSM; begin
2	Group cohesiveness (i.e., icebreaking exercises); what is diabetes; meeting and working with a new health care provider; physical activity self-monitoring (step counters); begin walking and physical activity self-monitoring.
3	Attitudes toward healthy eating; healthiest foods ("Green" section of the Traffic Light Food Guide); communicating with dietitians; begin self-monitoring of food intake.
4	Review of "Green" foods; portion control ("Yellow" section of the Traffic Light Food Guide); common challenges to self-monitoring of food intake.
5	Review dietary concepts introduced up to now; behavior changes made up to now; foods to avoid or eat infrequently and in small amounts ("Red" section of the Traffic Light Food Guide); management of hypoglycemia and self-management; communicating with health care providers
6	Mid-program review: physical activity, dietary concepts, self-monitoring, understanding and practice of self-management for glucose control, management of hypoglycemia.
7	Medication adherence; cholesterol and blood pressure; diabetes complications; barriers and resources to self-management; what to ask from health care providers.
8	Foot care; infections; smoking; stress management; getting support from the health care system.
9	Food labels and label reading skills; saturated fat, sodium and fiber.
10	Food Shopping, Quick meals.
11	Review food shopping strategies; heart healthy eating; management of sick days; following provider recommendations.
12	Program review; future challenges to maintenance; keeping in touch with health care providers.
	Maintenance Phase
13	Review of self-management concepts; continuing to increase physical activity
14	Progress toward healthy eating; new ideas for increasing healthiest foods; continuing to self-monitor self-management behaviors; problem-solving challenges as a group.
15	Managing challenges to portion control and avoiding unhealthy foods; Moving more.
16	Review of self-management experiences.
17	Medication adherence; cardiovascular risk factors and diabetes complications.
18	Staying healthy and reducing stress.
19	Future challenges to maintenance of behavior change.
20	Review and graduation

Table 2
Baseline Characteristics (mean and percentages) by Quartile of Glycemic Index and Glycemic Load

	Quartile dietary GI					Quartile dietary GL				
	1(lowest)	2	3	4(highest)		1(lowest)	2	3	4(highest)	
N	59	60	59	60	p	59	60	59	60	p
Range	46.58-58.23	58.24-60.99	61.00-64.32	64.33-76.02		30.14-95.40	95.41-119.99	120.20-151.88	151.89-299.42	
Intervention Group	38.98	50.00	49.15	56.67	0.284	45.76	50.00	50.85	48.33	0.949
Glycemic Index	na	na	na	na		59.06	60.63	61.64	62.56	**0.001**
Glycemic Load	111.04	122.68	129.72	143.36	**0.002**	na	na	na	na	
Age (yrs)	56.56	57.15	56.42	52.6	0.101	59.10	58	54.22	51.42	**P<.001**
Gender (% Female)	76.27	80.00	81.36	71.67	0.588	89.83	78.33	72.88	68.33	**0.033**
Medication Intensity Score	2.92	2.92	2.71	3.11	0.660	2.99	3.05	2.864	2.77	0.804
Physical Activity	12.02	13.32	11.06	13.99	0.068	12.69	11.88	12.29	13.61	0.524
Marital Status (%)										
Not married	63.79	56.90	63.79	54.24	0.631	70.69	62.71	52.54	52.63	0.134
Income (%)										
<10,000$	50.94	64.15	54.90	52.00		52.00	64.81	54.72	50.00	
10,000-20,000$	43.40	26.42	37.25	40.00		40.00	29.63	37.74	40.00	
>20,000$	5.66	9.43	7.84	8.00	0.697	8.00	5.56	7.55	10.00	0.815
Education (%)										
<= high school	76.27	81.67	76.27	70.00	0.523	74.58	80.00	77.97	71.67	0.721
Family history of DM										
Yes	81.03	86.44	79.31	84.75	0.721	81.36	79.66	83.05	87.72	0.689
HbA1c (%)	8.23	9.35	9.04	9.20	**0.005**	8.74	8.82	9.20	9.07	0.511
FBG (mmol/L)	152.36	173.30	172.49	175.50	0.241	163.06	163.88	173.53	173.37	0.754
BMI (kg/m)	34.60	35.06	35.29	34.24	0.847	34.94	33.08	35.01	36.20	0.100
Waist circumference (cm)	110.67	112.22	113.30	111.24	0.749	110.46	107.98	113.14	115.93	**0.012**
Mean Arterial Pressure (mm/Hg)	96.18	98.62	96.03	95.09	0.380	97.18	98.25	95.23	95.26	0.391
Total cholesterol (mg/dl)	180.24	177.67	183.05	181.67	0.926	193.61	170.25	177.78	181.12	0.036
HDL cholesterol (mg/dl)	44.24	43.23	44.66	44.43	0.829	46.64	43.88	42.93	43.12	0.086
LDL cholesterol (mg/dl)	106.53	103.52	104.43	108.86	0.867	119.63	98.56	100.21	104.97	**0.007**
VLDL cholesterol (mg/dl)	27.59	30.22	28.20	28.14	0.751	27.31	27.39	29.29	30.21	0.602
Triglyceride (mg/dl)	153.73	162.60	162.78	145.12	0.787	142.47	141.42	177.36	163.03	0.214
Total Energy (kcal)	1640.12	1683.05	1711.07	1767.84	0.665	1091.57	1513.56	1856.21	2334.01	**P<.001**
Total Carbohydrate (grams)	221.87	221.13	221.40	227.24	0.971	137.25	192.75	236.30	324.19	**P<.001**
Total Fiber (grams)	17.36	15.19	14.21	13.54	**0.005**	10.91	14.50	14.83	19.95	**P<.001**
Soluble Fiber (grams)	4.95	4.67	4.41	4.12	0.165	3.24	4.34	4.489	6.06	**P<.001**
Insoluble Fiber (grams)	12.19	10.37	9.64	9.33	**0.002**	7.62	10.02	10.21	13.62	**P<.001**
Total Fat (grams)	51.53	58.31	59.68	64.24	**0.050**	37.32	51.45	66.45	78.42	**P<.001**
Saturated fat (grams)	17.07	18.49	19.59	19.03	0.411	12.11	16.46	21.40	24.16	**P<.001**
Trans fatty Acids	2.21	2.95	3.18	3.21	0.015	1.802	2.62	3.30	3.82	**P<.001**

Table 3
Multivariate Random Effects Analyses of the Relationship between Glycemic Index and Glycemic Load with Glycemic Control

Covariate	Coef.	95% CI	P>|z|
Glycemic Index and logHbA1c n=560			
Glycemic Index	0.003	0.001 to 0.006	0.009
Lipid lowering drugs	-0.031	-0.057 to -0.004	0.022
Age	-0.004	-0.007 to -0.002	<0.001
BMI	-0.004	-0.007 to -0.001	0.005
Physical activity	-0.004	-0.006 to -0.002	<0.001
Medication Intensity Score	0.024	0.014 to 0.035	<0.001
Arm	-0.046	-0.089 to -0.002	0.041
Time	-0.025	-0.038 to -0.012	<0.001
Constant	2.381	2.141 to 2.620	<0.001
Glycemic Index and Fasting Blood Glucose n=560			
Glycemic Index	0.736	-0.237 to 1.710	0.138
Lipid lowering medication	-10.680	-20.324 to -1.037	0.030
Age	-1.937	-2.573 to -1.300	<0.001
BMI	-1.485	-2.433 to -0.536	0.002
Physical activity	-1.095	-1.931 to -0.259	0.010
Medication Intensity Score	4.909	1.226 to 8.592	0.009
Constant	284.735	200.255 to 369.215	<0.001
Glycemic Load and logHbA1c n=562			
Glycemic Load	0.000	-0.000 to 0.001	0.189
Lipid decreasing drugs	-0.032	-0.059 to -0.005	0.020
Medication Intensity Score	0.023	0.012 to 0.033	<0.001
Physical activity	-0.003	-0.005 to -0.001	0.005
Arm	-0.055	-0.100 to -0.009	0.018
Time	-0.025	-0.039 to -0.012	<0.001
Constant	2.149	2.076 to 2.222	<0.001
Glycemic Load and Fasting Blood Glucose n=560			
Glycemic Load	0.035	-0.097 to 0.166	0.604
Lipid decreasing drugs	-11.028	-20.703 to -1.353	0.025
Medication Intensity Score	4.900	1.200 to 8.601	0.009
BMI	-1.457	-2.409 to -0.505	0.003
Age	-1.949	-2.594 to -1.304	<0.001
Physical activity	-1.105	-1.943 to -0.267	0.010
Constant	325.220	262.341 to 388.098	<0.001

Figure 1 Participant Flow Diagram

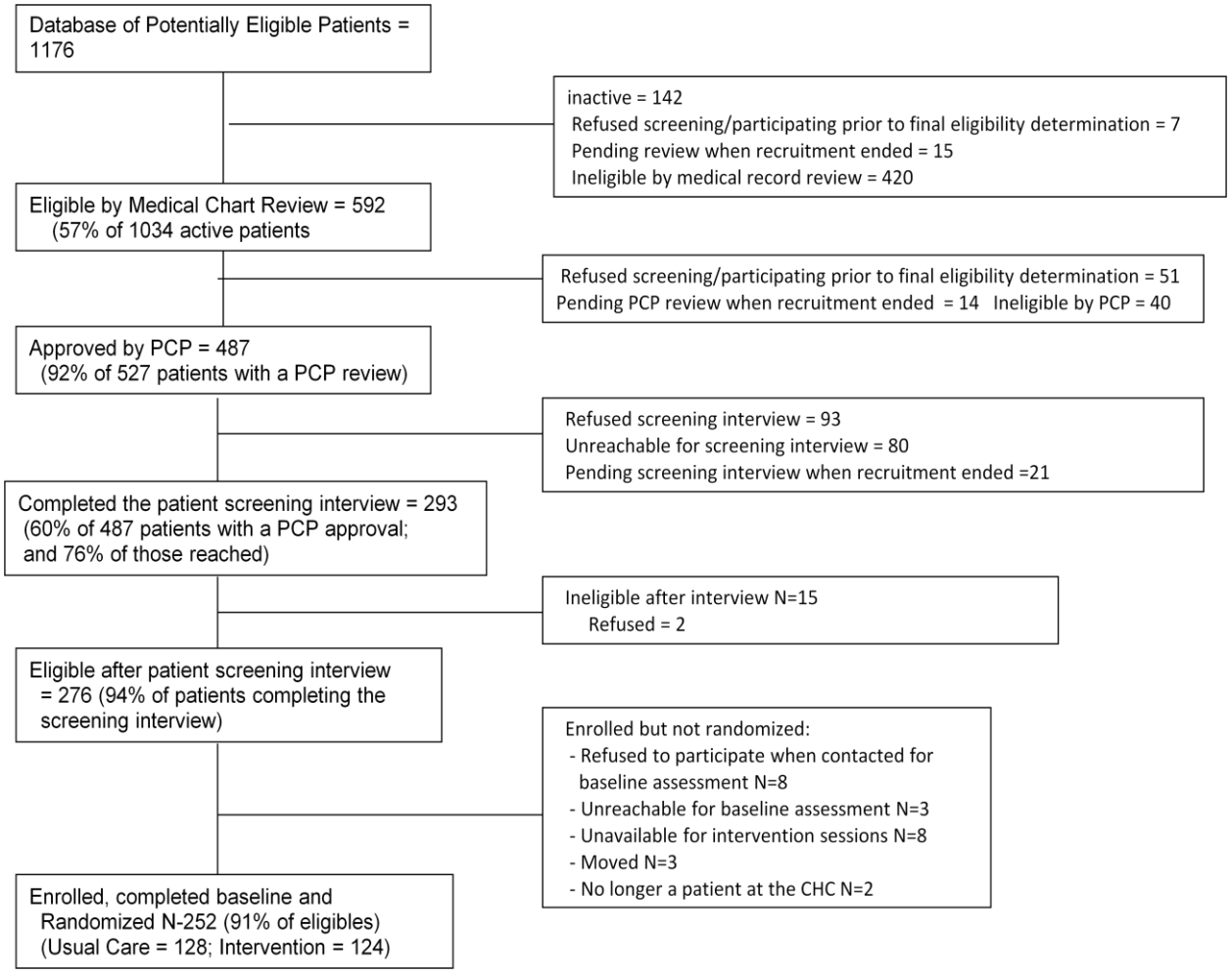


Figure 2

Change within Glycemic Index Quartile from Baseline to 4 Months and 12 Months by Baseline Glycemic Index and Treatment Condition

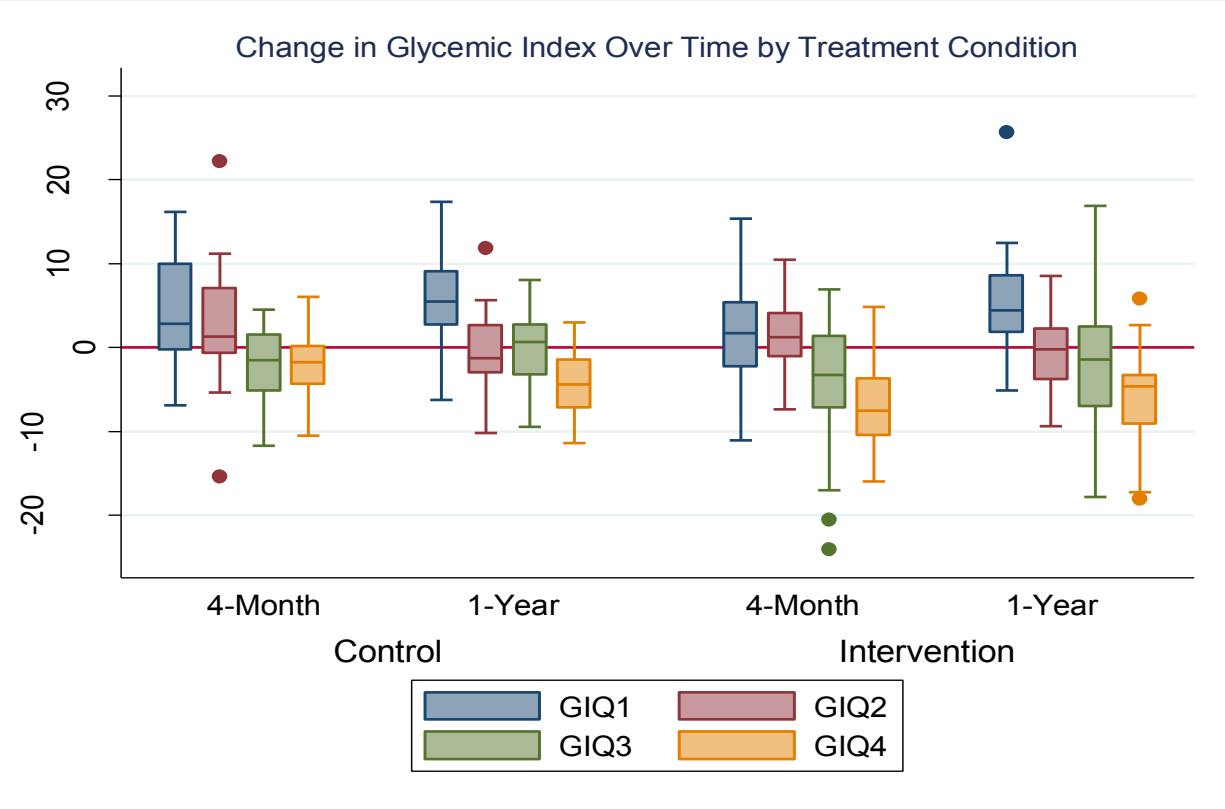
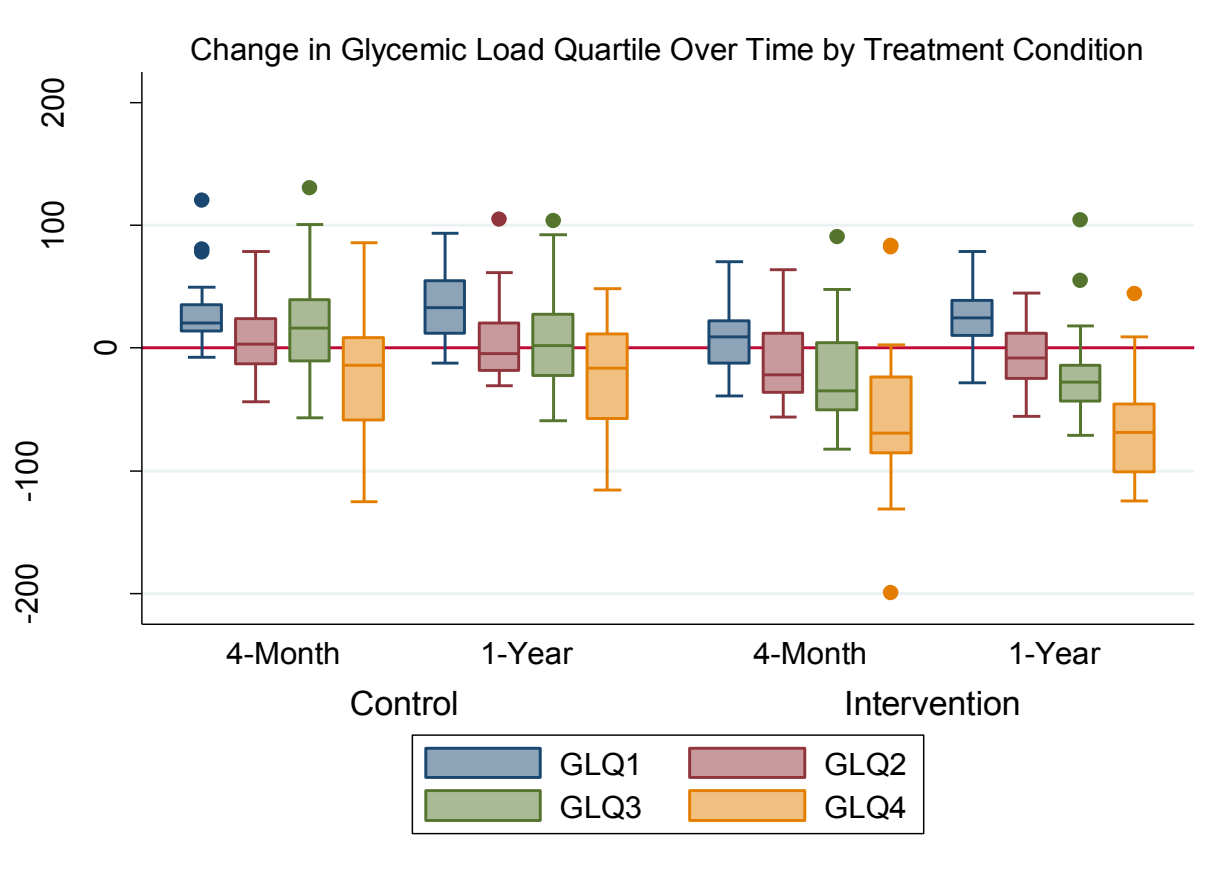


Figure 3

Change within Glycemic Load Quartile from Baseline to 4 Months and 12 Months by Baseline Glycemic Load and Treatment Condition



Chapter III

The Association between Glycemic Index, Glycemic Load and Lipid Profiles among Low-income Latinos with Type 2 Diabetes

Abstract

Background

Cardiovascular disease is the leading cause of mortality in individuals with type 2 diabetes and these individuals often have earlier presentation of cardiovascular disease than individuals without diabetes. Thus, reduction in cardiovascular disease risk factors in individuals with type 2 diabetes would be beneficial. While studies suggest the beneficial effect of reducing dietary glycemic index and glycemic load on diabetes control in patients with type 2 diabetes, little clinical data exists regarding the effect on blood lipids.

Purpose

The purpose of this study was to determine the effect of changes in glycemic index and glycemic load on lipid profiles determined by high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, total cholesterol (TC), TC: HDL ratio, HDL:LDL ratio and triglyceride levels among low-income Latino individuals with type 2 diabetes.

Methods

Latino patients with type 2 diabetes participated in a 12 month randomized clinical trial testing the efficacy of a diabetes self-management intervention. The group-based intervention targeted diabetes knowledge, attitudes and behavioral capabilities and its content was tailored to the cultural and literacy needs of the population. Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour dietary

recalls, a fasting blood sample, clinical assessments, and demographic and psychosocial interviews at each time points. Multivariate random effects analyses were used to test the association between GI and GL with lipid profiles overtime.

Results

A total of 252 Latino adults with type 2 diabetes participated in the study. The baseline mean (SD) HbA1C was 8.98% (±1.87), age was 56 (±11.2) years, 76 % were female. A reduction in glycemic index was positively associated with improvement in HDL:LDL ratio (P=0.05), but not with levels of HDL, LDL, TC, or triglyceride levels. No significant associations between glycemic load and any lipid outcomes were observed.

Conclusion

While the results of this study suggest a benefit of lowering glycemic index on one marker of the lipid profile, no beneficial effect of lowering glycemic index was noted for the majority of lipid profile markers and results showed no beneficial effect of lowering glycemic load on lipid profiles.

INTRODUCTION

The incidence of T2D has increased at a dramatic rate over the past several decades [13] and Latinos suffer higher rates of T2D. Results of a recent study suggest that the combined crude prevalence of diagnosed and undiagnosed diabetes is 80% higher in Mexican Americans compared to non-Latino whites after controlling for age and gender [1]. Latinos have high rates of uncontrolled T2D [2, 13] which fosters long-term microvascular complications and an eventual increase in macrovascular complications including CVD [3]. Thus, reduction in CVD risk factors in individuals with T2D would be beneficial.

Various causal factors for the increased CVD risk in patients with T2D have been posited including genetics, hyperglycemia, obesity, hypertension and dyslipidemia. The prevalence of dyslipidemia is high in patients with T2D [39-41] and typically these patients have fasting hypertriglyceridaemia and postprandial lipemia. Potential physiological pathways by which dyslipidemia may cause diabetic vascular complications and disease have been well studied [42-48]. Multiple theories have been reported such as: increased oxidative stress, vascular inflammation, insufficient or altered actions of insulin, hormones, and inflammatory cytokines [42, 43, 47].

In healthy individuals, blood glucose level is tightly maintained by homeostatic regulatory systems. However, the physiological effects of ingestion of high glycemic foods challenge these mechanisms. The rapid increase in blood glucose following consumption of a high glycemic index meal stimulates insulin release and inhibits glucagon release to a much greater extent than after consumption of a low glycemic index meal. This results in exaggerated glucose uptake by skeletal muscle, storage of

fat, and inhibition of fat breakdown. The major metabolic fuels (glucose oxidation and free fatty acids) are suppressed. Nutrient absorption from the gastrointestinal tract then declines while the biological effects of insulin release and glucagon suppression persist, resulting in a rapid fall in blood glucose levels, often into the hypoglycemic range. The low levels of metabolic fuels trigger a counter-regulatory hormone response, increasing free fatty acids, and creating a fasting physiological state. Research to date suggests that stimulation of these exaggerated physiological responses repeatedly over time may promote excessive food intake, beta cell dysfunction, dyslipidemia, and endothelial dysfunction; increasing risk for CVD [17].

Results of observational studies suggest a beneficial effect of lower GI and GL diets on lipid profiles including triacyglycerol levels and HDL [49-53]. However, few experimental studies have investigated the effect of reducing dietary GI and GL on lipid profiles in patients withT2D, and no study has investigated the effects of lowering GI and GL in Latinos. Given that Latinos have a high prevalence of T2D and that consumption of low GI or low GL foods may result in improved lipid profiles, an examination of the quantity and quality of carbohydrate intake among Latinos with T2D, and the association between GI and GL and clinical endpoints, may have great public health implications. The purpose of this study was to determine the effect of GI and GL on lipid profiles among low-income Latino individuals with T2D.

Methods

Study Participants

Patients with T2D were recruited from five community health centers (CHC) in urban areas of central and western Massachusetts. At each CHC, a trained site research coordinator overseen by the research team was responsible for completing the recruitment processes. Subjects were included if they: were diagnosed with T2D;had an HbA1c level $\geq$ 7.5; were currently being treated with diet, oral hypoglycemics or insulin and, if they were currently on insulin, they must have had a history of prior therapy with diet alone or oral hypoglycemic agents; were Latino origin; were $\geq$ 18 years old; had a telephone in home or easy access to one; were able to understand and participate in the study protocol and functionally capable of meeting the physical activity goals; understood and could provide informed consent; and were given physician approval to participate in the study. Subjects were excluded if they: had a history of diabetic ketoacidosis; current gestational diabetes; were unable or unwilling to provide informed consent; had any plans to move out of the area within the 12-month study period; required intermittent glucocorticoid therapy within the past 3 months; experienced an acute coronary event within the previous 6 months or had any medical condition that precluded adherence to study dietary recommendations or had any major psychiatric illness.

Determination of subject eligibility and recruitment was conducted in several stages. First, health care providers at participating CHCs were notified of the study and their approval for the site research coordinator to access patient medical records for screening purposes was obtained. Second, a review of the medical records of potentially eligible patients' was completed. For patients determined to be medically eligible to participate, approval and a signature on the recruitment letter was obtained

from their primary care physician. Third, a letter describing the study was mailed to the patients who received primary care physician approval. Prior to participation in the study written informed consent was obtained from all participants. Once the baseline assessment was completed, participants were randomized to either the usual care condition or to *Latinos En Control* intervention condition. Randomization was completed at the level of the individual and stratified by CHC site, gender, baseline HbA1c levels and insurance status. Within each strata, participants were randomized in randomly allocated blocks of size 2, 4 and 6 using a reallocation program [30] version 7.0 (Stata Corporation, College Station, TX). Block randomization was used to ensure blinding of the allocation sequence. The study protocol was approved by the University of Massachusetts Medical School's and the Baystate Medical Center's Institutional Review Boards.

Intervention

Participants in the intervention condition, Latinos en Control, participated in a one year, group based intervention, consisting of two phases: an intensive phase with 12 weekly sessions followed by a maintenance phase with 8 monthly sessions. An outline of the self-management curriculum is presented in Table 1. The intervention targeted diabetes knowledge (e.g., effect of foods of different GI on diabetes control), attitudes (e.g., self-efficacy for dietary change) and behavioral capabilities (i.e., skills needed to make lifestyle changes) with its content tailored to the cultural and literacy needs of this population. Personalized coaching was offered during 10-minute counseling segments prior to the start of each group.

The dietary component of the intervention used the metaphor of a traffic light to simplify complex concepts. Foods frequently consumed by Latinos were classified based on their GI, fat, salt, and fiber content into categories of “green”, “yellow,” or “red” foods. A “food guide” which included pictures of these foods within the corresponding “traffic light colors” was developed and provided to all participants. Additionally, participants were given a graphic of a plate which displayed the ideal balance of colors at any given meal. Explained simplistically, the color green classified recommended foods which were lower in calories, saturated or trans-fat and sodium content and were of lower GI. “Yellow” foods were medium in calories, saturated or trans-fat and sodium content and were of medium GI. “Red” foods were higher in calories, saturated or trans-fat and sodium content and were of higher GI. To impact GL, reduction of portion sizes was emphasized and all participants received a set of measuring cups. Subjects participated in multiple interactive sessions including: healthy cooking methods for ethnic foods, label reading, a supermarket tour, group meals where measuring cups were used for modeling appropriate portion sizes and guided discussions explored taste and appeal of the foods, the ease of preparation, and strategies to incorporate new cooking methods at home. Participants were provided with and instructed in the use of glucose meters and step counters.

Usual care was defined as diabetes care as currently delivered at the CHC. Therefore, participants in the usual care group received medical therapy as determined to be appropriate by their healthcare providers. Healthcare providers received all laboratory reports for all participants regardless of their study condition.

Measurement

Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour recalls, clinical assessments, and demographic and psychosocial interviews at each time point. Dietary intake and physical activity [31] were assessed via three unannounced telephone administered 24-hour recalls. Multiple recalls are used to assess day-to-day intra-individual variations in the behaviors of interest [32]. The Minnesota Nutrition Coordinating Center's (UM-NCC) Nutrition Data System for Research software (NDS-R) was used to collect and analyze the 24-hour dietary recall data [33]. At each assessment visit, fasting blood samples were drawn for analysis of TC, LDL, HDL and triglycerides, fasting glucose, and HbA1c. Body Mass Index (BMI) was calculated as weight in kg divided by height in cm^2. Weight was assessed with a Tanita BWB800S Digital Physicians Scale and Height was asses with a Seca Road Rod Portable Stadiometer. Waist circumference was measured in centimeters to 0.1 cm**.** Waist circumference was measured twice and the mean value was used in the analyses. Two blood pressure measurements were taken using a Dinamap XL automated BP monitor. All medications and supplements were recorded. Demographic and additional data were collected via self-reported survey, including; age, gender, education level, and duration of diabetes. In order to account for the potential effect of medications on blood glucose, lipids, and weight, two pharmacists compiled the medication used by study participants based on whether they had a positive or adverse effect on these outcomes. In addition, glucose lowering agents were combined to construct a diabetes medication intensity score. This score was based on the type of oral hypoglycemics taken and/or dose and type of insulin taken. Possible scores ranged from 0- 6.5, with a higher score equating to greater number or dose of

medication/insulin. Participants were compensated with 30 dollars at each assessment timepoint.

Statistical Analysis

All analyses were performed using STATA version 11. (StataCorp, College Station, TX) Results are expressed as means with 95% confidence intervals (CIs). Descriptive statistics were calculated for continuous covariates (age, BMI, physical activity, blood pressure, medication score), exposure variables (GI, GL), and outcomes (HDL, LDL, TC, TC:HDL ratio, HDL:LDL ratio and triglyceride). The natural logarithm of triglycerides was used in the multivariate analyses because the distribution was skewed. Although GI and GL were continuous variables, for univariate statistical inferences, baseline demographic and clinical data were stratified by baseline GI and GL quartile and compared differences by Chi-Square or ANOVA tests.

Four separate random effects models were developed with either the outcome being HDL cholesterol, LDL cholesterol, total cholesterol, HDL:LDL ratio and log triglyceride and the primary predictor of interest being the exposure variable of GI or GL (ie, a model examining the effect of GI on HDL adjusted for other confounders, followed by a model examining GL on HDL and then repeated for LDL, TC, TC:HDL ratio, HDL:LDL ratio and log triglyceride. Each model was controlled for age, gender, mean arterial blood pressure, total energy intake, physical activity, diabetes medication intensity score, lipid increasing and decreasing drugs, and weight increasing and decreasing drugs and study arm. A backward elimination process was used for each model, until only significant variables remained. Additionally, linear regression was used

to determine the association between change in glycemic index and glycemic load with change in HDL, LDL, TC, HDL:LDL ratio, TC:HDL ratio and log triglyceride from baseline to 4 months follow-up.

The primary multivariate analysis was a complete case analysis in which patient records with missing values were not in the regression models. To investigate the potential effect of missing data, two imputed sensitivity analyses were completed. The first analysis was intention to treat analysis, which included all 252 randomized participants, with the baseline observation carried forward when missing values were present. The second method relied on multiple imputation by chained equations (MICE) analysis [34]. No differences were found between the analyses. Thus, results using complete data are presented herein.

RESULTS

Baseline Characteristics

The participant flow diagram is shown in Figure 1. A total of 252 Latino adults with T2D participated in the study. Although all lipid outcomes were continuous variables in these analyses, for purposes of baseline inference, baseline demographic and clinical data were stratified by baseline HDL, LDL and TC (see Table 2a). The baseline mean (SD) HbA1C was 8.98 % (±1.87), age was 56 (±11.18) years, 76 % were female. There was a significant difference in HDL, LDL and TC quartile by gender. Significantly more females were in the highest quartile for HDL, LDL and TC compared to men. There was a significant difference in Hba1c and fasting blood glucose by

quartile of LDL and TC but not HDL. Those in the highest quartile of LDL had significantly higher HbA1c and fasting blood glucose levels compared to those in the lower quartiles. Additionally there was a significant difference in waist circumference by HDL.

Change in GI and GL

A significant reduction (baseline minus 4 month value) in mean GI was seen in the treatment group at 4 months (treatment -2.57 (7.25) vs. control 0.87 (5.95), p<0.001). However, while this trend remained, the difference between conditions was no longer statistically significant at 12 months (treatment -0.63 (7.15) vs. control 0.42 (5.96) vs., p=0.27). A significant reduction in mean GL was seen in the treatment group compared to the control group at 4 months (treatment -20.42 (46.87) vs. control 7.41 (44.12), p <0.001), and at 12 months (treatment-14.62 (46.82) vs. control 6.48(43.15), p <0.001). There was no statistically significant association between change in glycemic index or glycemic load with change in HDL, LDL, TC, HDL;LDL ratio, TC:HDL ratio or log triglycerides from baseline to 4 months follow up.

Overall Association of Glycemic Index and Lipid Profiles

Table 3a and Table 4a illustrate the results of the multivariate longitudinal random effects model analyses. A reduction in GI was positively associated with improvement in HDL:LDL ratio (0.003, 95%CI [0.000 to 0.006], p=0.039) overtime, but not with individual lipid markers: HDL, LDL, TC or log triglycerides (-0.026, 95%CI [-0.121 to 0.060] p=0.597, and (-0.011, 95%CI [-0.42 to 0.40] p=0.96, and -0.04, 95%CI [-0.53 to 0.46] p=0.88,and 0.002, 95%CI [-0.005 to 0.008], p=0.58, respectively) or TC:HDL ratio 0.01, 95%CI[-0.005 to 0.024], p=0.21 over time.

Overall Association of Glycemic Load and Lipid Profiles

No significant associations between GL and any lipid outcomes were found (TC 0.03, 95%CI[-0.04 to 0.12],p=0.36, and HDL -0.001, 95%CI[-0.015 to 0.012], p= 0.826, and LDL 0.03, 95%CI[-0.03 to 0.09],p=0.28, and HDL:LDL ratio 0.00, 95%CI[-0.00 to 0.00],p=0.62 and TC:HDL ratio 0.00, 95%CI [-0.001 to 0.003], p=0. 262 and log triglycerides 0.00 , 95%CI[-0.00 to 0.00],p=0.08) overtime.

DISCUSSION

The results of this study showed that a reduction in GI was positively associated with improvement in HDL:LDL ratio, although this improvement was moderate. The utility of HDL:LDL ratio for prediction of CVD risk has been debated. Since the impact of increased LDL and decreased HDL on CVD risk is well established, it has been suggested that the HDL:LDL ratio is a good measure of atherosclerosis risk [54, 55]. However, others have suggested that absolute values of HDL and LDL are more accurate predictors and are better suited for clinical practice. A patient's HDL:LDL ratio should be above 0.3%, ideally being above 0.4%. In our sample the mean HDL:LDL ratio at baseline was 0.47% with mean HDL 44.3 mg/dl and LDL 106.6 mg/dl. Thus at baseline, on average, participants had low HDL and borderline normal LDL levels, just as previous research has suggested.

No significant associations between GI with HDL or LDL, TC, TC:HDL ratio or triglycerides over time were noted and no significant associations between GL and any lipid outcome over time were found. One possible explanation for the lack of effect of GI and GL on HDL or LDL, TC or triglycerides is that the decrease in GI and GL may not have been clinically significant. The absolute reduction in both GI and GL was very

small (at 4 months treatment -2.57 (7.25) vs. control 0.87 (5.95), p<0.001 and at 12 months treatment -0.63 (7.15) vs. control 0.42 (5.96) vs., p=0.27). Greater reductions in GI and GL might be needed to see a significant change in lipid levels. However, as this population had a relatively low mean baseline GI (61, glucose reference) greater reductions may be difficult to achieve.

Another possible explanation for the lack of effect may be the physiological pathway in which changes in GI and GL impact lipid outcomes. If the primary pathway is through a reduction in hyperglycemia or hyperinsulinemia, changes in these markers would need to occur before significant changes in lipids would be observed. Analyses of glycemic control in this sample showed a beneficial effect of lowering GI on HbA1c but not fasting glucose levels, and only in the short term (see chapter 3). Markers of hyperinsulinemia were not assessed. Thus, it is plausible that in this sample decreases in blood glucose levels or insulin levels were not great enough to have an impact on all but one lipid marker.

Similar to our findings, several previous studies have reported beneficial effects of lowering GI on one or two lipid markers, but not others. Several studies have shown improvements in HDL or LDL and TC [6, 8, 9, 26, 29, 56-58] while no studies showed an improvement in triglycerides and one study showed no improvement in any lipid marker [6]. Furthermore, results of recent meta-analyses of the effect of low GI diets on markers of CVD risk were inconsistent [59, 60]. One meta analysis reported that low GI diets had beneficial effects on LDL and TC but not on HDL or triglycerides among adults with T2D [60]. While another showed no beneficial effect of low GI diets on LDL or HDL,

or triglyceride level and weak evidence for reductions in TC [59]. Neither review included any studies which assessed the effect of GI on TC:HDL ratio or HDL:LDL ratio.

A one year randomized clinical trial Wolever et al. (2008) [10] assessed the effect of a low GI dietary intervention compared to either a high GI or a low- carbohydrate dietary intervention in well-controlled individuals with T2D. One hundred and sixty two subjects participated in a multicenter trial in which the impact of the three diets on glycemic control assessed by HbA1c, blood glucose, lipids, and C-reactive protein were assessed. The results suggested a significant difference in TC:HDL but not HDL, LDL, triglycerides and TC [10]. Only one study has previously investigated the effect of lowering GI in Latino subjects with T2D. Jimenez-Cruz et al. [28] conducted a 6-week crossover feeding study in which 14 overweight and obese Mexicans with T2D were given a low-GI diet, containing Mexican-style foods and then a high GI diet. The results showed no significant differences in TC, HDL or LDL, or triglycerides between the two dietary conditions. To our knowledge no clinical trial has assessed the effects of lowering GL on lipid outcomes.

The results of this study are subject to several limitations. First, dietary data were collected via self report. Previous research suggests underreporting of dietary intake in Latino populations [38]. Second, 24-hour dietary recalls were conducted in Spanish and translated by the assessor into English. Third, all study participants were from Massachusetts and thus represent a limited geographic range and all subjects were Latino, thus results may not be applicable to all racial and ethnic groups or those in other states. Finally, the majority of subjects were Puerto Rican. Previous research has

suggested that variations exist between subgroups of Latinos thus generalizations regarding Latinos as a single ethnic group should be made with caution.

Implications for future research

Hypotheses regarding the physiological pathway by which reduction in GI and GL may impact lipids have been suggested. However, it remains unclear why reduction in GI and GL would impact some lipids and not others. Previous research has highlighted alterations in lipid quantity and quality among patients with diabetes. It is possible that lowering GI and GL could have beneficial effects on qualitative features of lipid particles, such as LDL size, thus further research in this area is warranted. Furthermore, several studies have shown that lowering GI and GL can improve markers along the causal pathway. For example, Pittas et al. [25] showed that a moderate decline in C-reactive protein, a marker for low-level inflammation, has been associated with lower GI/GL diets. However, another study showed no association between GI, GL and CRP [61]. Reduction in GL has been associated with improvements in plasminogen activator inhibitor- 1, a measure of procoagulant activity [62]. Future research should address the possible effects of GI and GL on variables along hypothesized causal pathways, such as oxidative stress and vascular inflammation. CVD is the leading cause of mortality in individuals with T2D. Thus, reduction in CVD risk factors in individuals with T2D would be beneficial. Similar to the results of previous research, the results of this study were inconsistent. Further research on the effects of GI and GL on lipid outcomes is warranted.

Table 1a
Latinos En Control Diabetes Self-Management (DSM) Curriculum: Session Objectives and Topics

Session number	Intensive Phase
1	Rapport with patients; individual assessments of: diabetes self management (DSM) history; DSM goals and incentives; expectations and commitment for the program; family support and resources for DSM; rationale for DSM; begin
2	Group cohesiveness (i.e., icebreaking exercises); what is diabetes; meeting and working with a new health care provider; physical activity self-monitoring (step counters); begin walking and physical activity self-monitoring.
3	Attitudes toward healthy eating; healthiest foods ("Green" section of the Traffic Light Food Guide); communicating with dietitians; begin self-monitoring of food intake.
4	Review of "Green" foods; portion control ("Yellow" section of the Traffic Light Food Guide); common challenges to self-monitoring of food intake.
5	Review dietary concepts introduced up to now; behavior changes made up to now; foods to avoid or eat infrequently and in small amounts ("Red" section of the Traffic Light Food Guide); management of hypoglycemia and self-management; communicating with health care providers
6	Mid-program review: physical activity, dietary concepts, self-monitoring, understanding and practice of self-management for glucose control, management of hypoglycemia.
7	Medication adherence; cholesterol and blood pressure; diabetes complications; barriers and resources to self-management; what to ask from health care providers.
8	Foot care; infections; smoking; stress management; getting support from the health care system.
9	Food labels and label reading skills; saturated fat, sodium and fiber.
10	Food Shopping, Quick meals.
11	Review food shopping strategies; heart healthy eating; management of sick days; following provider recommendations.
12	Program review; future challenges to maintenance; keeping in touch with health care providers.
	Maintenance Phase
13	Review of self-management concepts; continuing to increase physical activity
14	Progress toward healthy eating; new ideas for increasing healthiest foods; continuing to self-monitor self-management behaviors; problem-solving challenges as a group.
15	Managing challenges to portion control and avoiding unhealthy foods; Moving more.
16	Review of self-management experiences.
17	Medication adherence; cardiovascular risk factors and diabetes complications.
18	Staying healthy and reducing stress.
19	Future challenges to maintenance of behavior change.
20	Review and graduation

Table 2a
Baseline Characteristics (mean and percentages) by Quartile of HDL Cholesterol, LDL Cholesterol and Total Cholesterol

	Quartile HDL Cholesterol					Quartile LDL Cholesterol				
	1	2	3	4	p	1	2	3	4	p
range	25-37	38-42	43-49	50 -84		18-80	81-102	103-125	126-258	
n	61	63	62	66		60	61	62	61	
Intervention Group	44.26	52.38	51.61	48.48	0.80	50.00	40.98	50.00	57.38	0.35
Glycemic Index	60.47	61.29	61.32	60.80	0.76	60.52	61.24	61.04	61.09	0.89
Glycemic Load	134.32	125.99	127.27	119.65	0.41	136.52	118.46	126.94	125.15	0.24
Age (yrs)	54.44	57.97	55.66	55.79	0.36	56.95	55.74	56.55	54.92	0.76
Gender (%) (Female)	54.10	80.95	79.03	90.91	**P<.001**	60.00	77.05	85.48	85.25	**0.00**
Medication Score	2.80	2.873	2.85	3.11	0.74	2.95	2.74	3.10	2.950	0.70
Physical Activity	13.02	12.76	12.31	12.37	0.93	12.10	14.34	11.93	11.963	0.13
Marital Status (%) (NM)	54.10	66.13	53.33	69.84	0.14	50.85	61.67	72.41	59.02	0.12
Income ($) <10,000	52.83	62.30	53.06	51.85		59.18	55.77	52.73	54.72	
10,000-20,000	32.08	31.15	42.86	42.59		34.69	36.54	40.00	35.85	
>20,000	15.09	6.56	4.08	5.56	0.28	6.12	7.69	7.27	9.43	0.99
Education (<= high school)	72.13	73.02	75.81	80.30	0.70	76.67	75.41	77.42	72.13	0.91
HbA1c (%)	9.14	8.80	8.77	9.21	0.43	8.65	8.88	8.88	9.53	**0.05**
FBG (mmol/L)	175.60	160.29	164.47	174.48	0.56	151.00	163.92	169.74	190.57	**0.02**
BMI (kg/m)	34.73	34.62	36.19	33.58	0.21	33.73	35.55	36.05	33.64	0.12
Waist Circumference	112.03	111.15	115.84	107.93	**0.01**	110.72	112.90	114.14	108.93	0.17
Mean Arterial Pressure(mm/Hg)	96.23	96.76	96.08	96.87	0.97	96.35	95.98	95.17	98.61	0.39
Total Cholesterol	166.45	181.94	175.08	201.23	**P<.001**	133.00	161.95	185.21	236.85	**P<.001**
HDL Cholesterol	na	na	na	na		42.75	43.18	44.15	47.85	**0.01**
LDL Cholesterol	95.71	106.77	103.47	119.00	**0.01**	na	na	na	na	
Triglyceride	198.84	174.14	129.76	123.91	**P<.001**	128.78	135.67	140.68	160.74	0.07
Total Energy (kcal)	1820.72	1682.90	1663.91	1639.68	0.31	1813.06	1618.74	1663.49	1693.49	0.30
Total Carbohydrate	256.42	247.60	232.00	236.89	0.77	244.42	206.51	221.93	218.92	0.08
Total Fiber	16.33	15.46	14.75	13.78	0.15	17.56	13.99	14.55	14.18	**0.01**
Total Fat	63.81	57.00	56.33	56.89	0.32	60.20	57.28	56.59	58.51	0.88
Saturated Fat	19.73	17.98	18.10	18.41	0.67	18.68	18.66	18.37	18.15	0.99
Trans fatty Acids	3.09	2.79	2.83	2.84	0.84	2.69	3.00	2.83	2.96	0.83

Table 3a

Multivariate Random Effects Analyses of the Relationship between Glycemic Index with Lipid Profiles

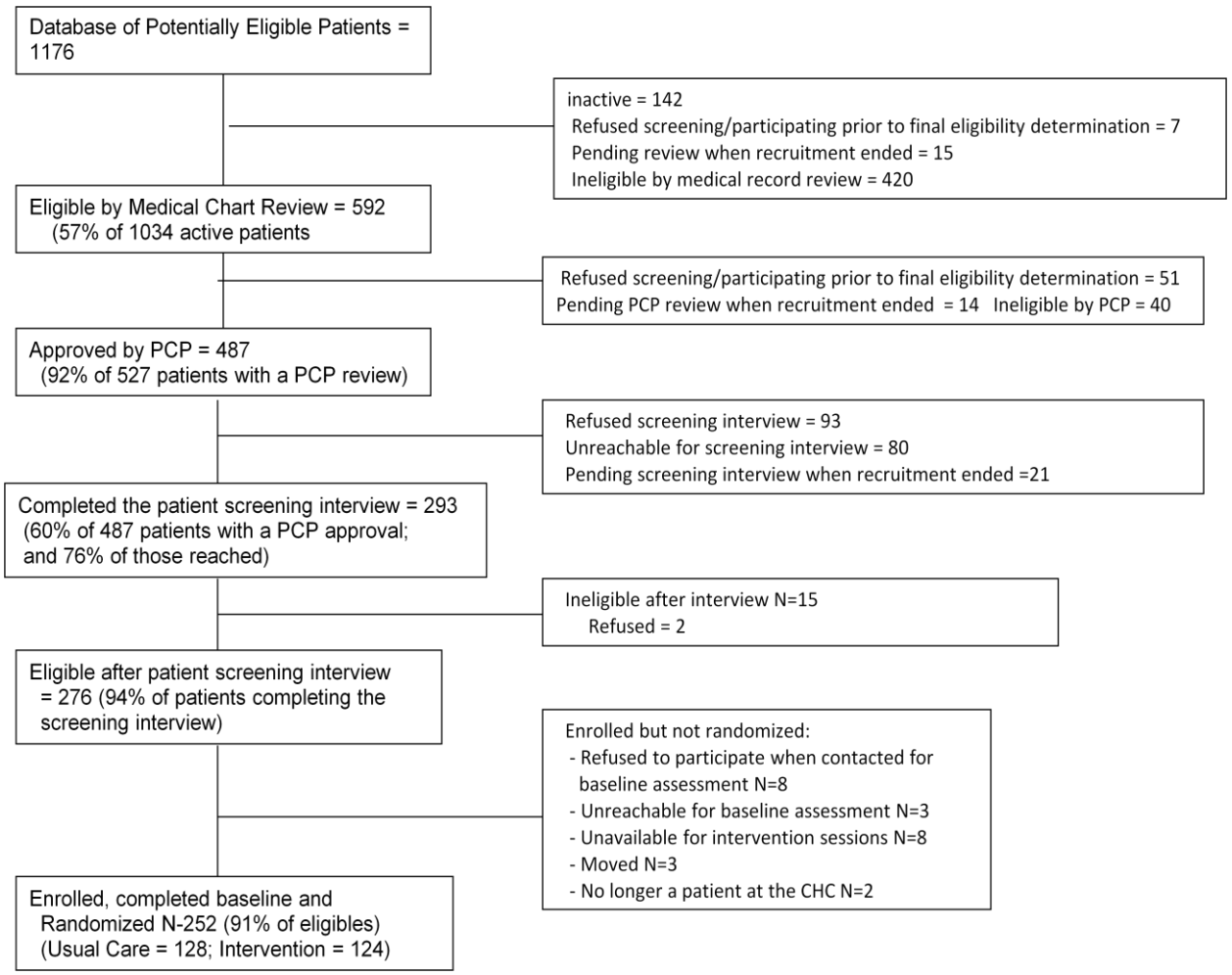
Glycemic Index and Total Cholesterol			
Covariate	Coef.	95% CI	P>|z|
Glycemic Index	-0.04	-0.53 to 0.46	0.88
Gender	-14.90	-27.21 to -2.60	0.02
Lipid lowering drugs	-31.75	-38.59 to -24.90	<0.001
BMI	-0.87	-1.54 to -0.20	0.01
Mean arterial pressure	0.33	0.07 to 0.58	0.01
Physical activity	-0.48	-0.93 to -0.02	0.04
Constant n=560	225.39	176.74 to 274.05	<0.001
Glycemic Index and HDL Cholesterol			
Glycemic Index	-0.03	-0.13 to 0.07	0.55
Gender	-6.39	-8.78 to -4.00	<0.001
Physical activity	0.08	0.03 to 0.13	0.002
Constant n=622	46.66	38.88 to 54.43	<0.001
Glycemic Index and LDL Cholesterol			
Glycemic Index	-0.01	-0.42 to 0.40	0.96
Gender	-12.51	-22.68 to -2.34	0.02
Lipid lowering drugs	-27.89	-33.53 to -22.25	<0.001
BMI	-0.73	-1.27 to -0.18	0.01
Constant n=547	164.08	129.84 to 198.31	<0.001
Glycemic Index and Total Cholesterol:HDL Cholesterol Ratio			
Glycemic Index	0.01	-0.005 to 0.024	0.210
Lipid lowering drugs	-0.77	-0.960 to -0.572	<0.001
Constant n=568	4.06	3.168 to 4.957	<0.001
Glycemic Index and HDL:LDL Cholesterol Ratio			
Glycemic Index	0.003	0.000 to 0.006	0.039
Lipid lowering drugs	0.125	0.088 to 0.162	<0.001
Time	0.016	0.001 to 0.030	0.036
Constant n=549	0.214	0.044 to 0.384	0.014
Glycemic Index and Log Triglycerides			
Glycemic Index	0.00	-0.01 to 0.01	0.58
Lipid lowering drugs	-0.12	-0.21 to -0.04	0.01
Age	-0.01	-0.02 to -0.00	0.003
Physical activity	-0.01	-0.02 to -0.00	0.004
Constant n=562	5.43	4.89 to 5.98	<0.001

Table 4a

Multivariate Random Effects Analyses of the Relationship between Glycemic Load with Lipid Profiles

Covariate	Coef.	95% CI	P>|z|
Glycemic Load and Total Cholesterol			
Glycemic Load	0.03	-0.04 to 0.11	0.36
Gender	-15.80	-28.26 to -3.35	0.01
Lipid lowering drugs	-31.99	-38.85 to -25.13	<0.001
BMI	-0.89	-1.56 to -0.22	0.01
Mean arterial pressure	0.33	0.07 to 0.59	0.01
Physical activity	-0.47	-0.93 to -0.02	0.04
Constant n=560	220.44	180.25 to 260.63	<0.001
Glycemic Load and HDL Cholesterol			
Glycemic Load	-0.001	-0.015 to 0.012	0.826
Gender	-6.402	-8.810 to -3.993	<0.001
Mean arterial pressure	0.082	0.033 to 0.131	0.001
Time	0.593	0.113 to 1.073	0.016
Constant n= 622	44.183	38.584 to 49.782	<0.001
Glycemic Load and LDL Cholesterol			
Glycemic Load	0.03	-0.03 to 0.09	0.28
Gender	-13.34	-23.63 to -3.04	0.01
Lipid lowering drugs	-28.15	-33.80 to -22.50	<0.001
BMI	-0.74	-1.29 to -0.19	0.01
Constant n=547	161.17	135.72 to 186.63	<0.001
Glycemic Load and Total Cholesterol:HDL Ratio			
Glycemic Load	0.00	-0.001 to 0.003	0.262
Lipid lowering drugs	-0.77	-0.968 to -0.579	<0.001
Constant n=568	4.48	4.184 to 4.785	<0.001
Glycemic Load and HDL:LDL Ratio			
Glycemic Load	0.000	-0.000 to 0.001	0.541
Lipid lowering drugs	0.125	0.087 to 0.162	<0.001
Time	0.015	0.000 to 0.030	0.045
Constant n= 549	0.374	0.315 to 0.434	<0.001
Glycemic Load and Log Triglycerides			
Glycemic Load	0.00	-0.00 to 0.00	0.08
Lipid lowering drugs	-0.13	-0.22 to -0.04	0.004
Age	-0.01	-0.01 to -0.00	0.01
Physical activity	-0.01	-0.01 to -0.00	0.01
Constant n=562	5.41	5.03 to 5.79	<0.001

Figure 1 Participant Flow Diagram



CHAPTER IV

The Association between Glycemic Index, Glycemic Load and Anthropometrics among Low-income Latinos with Type 2 Diabetes

ABSTRACT

Background

Obesity is an independent risk factor for the development of cardiovascular disease frequently associated with hypertension, dyslipidemia, and insulin resistance, and is prevalent among individuals with type 2 diabetes and in Latino populations. Improvements in anthropometrics, such as BMI and waist circumference, have been shown to result in improved insulin sensitivity. Few clinical trials have investigated the association between lowering glycemic index or glycemic load and anthropometrics in patients with type 2 diabetes and none with Latinos.

Purpose

The purpose of this study was to determine the effect of reducing glycemic index or glycemic load on anthropometrics determined via BMI, body weight and waist circumference among low-income Latino individuals with type 2 diabetes.

Methods

Latino patients with type 2 diabetes participated in a 12 month randomized clinical trial testing the efficacy of a diabetes self-management intervention. The group-based intervention targeted diabetes knowledge, attitudes and behavioral capabilities and its content was tailored to the cultural and literacy needs of the population. Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour dietary

recalls, clinical assessments, and demographic and psychosocial interviews at each time point. Multivariate random effects analyses were used to test the association between GI and GL with anthropometrics overtime.

Results

A total of 252 Latino adults with type 2 diabetes participated in the study. The baseline mean ± SD HbA1C was 8.98% ± 1.87, age was 55.98 ± 11.18 years, and 76.59% were female. A reduction in glycemic index was positively associated with the reduction in waist circumference (p=0.003), but not with BMI (p=0.244) or body weight (p=0.456). No significant associations between glycemic load and BMI, body weight or waist circumference were found (p=0.474, p=0.079 and p=0.127, respectively) overtime.

Conclusion

While the results of this study suggest a benefit of lowering glycemic index on one anthropometric marker, no beneficial effect of lowering glycemic index was associated with other anthropometric markers and results showed no beneficial effect of lowering glycemic load on any of the anthropometric measures.

INTRODUCTION

Latinos suffer higher rates of overweight and obesity compared to non-Latino whites. According to data from 2003-2004 the prevalence of overweight and obesity among adults over the age of 20 years, was 64.2% for Non-Latino Whites compared to 73.4% for Mexican Americans [63]. The International Day for Evaluation of Abdominal Adiposity (IDEA) Study of a primary care population within Latin America and the Caribbean region reported that nearly 70% of the primary care patients were overweight or obese. Abdominal obesity, defined as waist circumference ≥90 for men and ≥80 cm for women, was present in 70% of men and 76% of women [64].

The increases in overweight, obesity and abdominal adiposity are associated with T2D [64]. Results of The IDEA study suggest that the prevalence of T2D increased across BMI and waist circumference groups. Age adjusted odds ratios for T2D by BMI were 1.20 for overweight men and 1.61 for overweight women and 1.90 for obese men and 2.77 for obese women compared to normal weight individuals. Age adjusted odds ratios for T2D by waist circumference were WC ≥90/80 vs <90/80 cm 1.63 for men and 2.86 for women and WC >102/88 vs ≤102/88 cm1.68 for men and 2.53 for women [64]. Despite the elevated prevalence and the extreme health and financial burden associated with overweight, obesity and T2D, successful prevention and treatment of these conditions remains a challenge.

Previous research suggests that improvements in dietary behaviors can have beneficial effects on diabetes management. The American Diabetes Association's (ADA) evidence-based treatment guidelines include specific dietary recommendations in conjunction with pharmacological interventions and other self-management strategies

(i.e., blood glucose monitoring and physical activity) [16]. Recommendations for dietary management for individuals with T2D emphasize the implementation of lifestyle changes that will improve body weight, glycemia, and dyslipidemia. Modest weight loss (≥5% of body weight) in overweight individuals with T2D has been shown to improve insulin resistance, measures of glycemia, and lipid profiles [65]. The ADA recommends dietary intake of carbohydrates from various sources including: fruits, vegetables, whole grains, legumes, and low-fat milk. The ADA's current position [16] suggests the use of the glycemic index (GI) and glycemic load (GL) as a strategy for improving diabetes management. Both may offer some benefit over that seen when total carbohydrate is considered alone.

Blood glucose response to the ingestion of carbohydrate-containing foods has been shown to vary dramatically depending on factors including the molecular structure of the carbohydrate, fiber content, and degree of processing [17]. Refined, highly processed carbohydrates are broken down and absorbed quickly, resulting in a rapid increase in blood glucose, whereas less refined carbohydrates are absorbed more slowly, resulting in a slower, more sustained rise in blood glucose. GI is the value given to carbohydrate-containing foods indicating the blood glucose response they elicit. The GI [5] of a food is defined as the incremental area under the glucose response curve relative to that produced by a standard control food (either glucose or white bread). To account for carbohydrate content variation with in foods, GL was introduced in 1997 by Willett and colleagues and can be calculated as the quantity (in grams) of a food's carbohydrate content, multiplied by its GI [19]. Previous research has suggested that lowering GI might increase satiety, which in turn would decrease caloric intake and

result in weight loss. Other hypotheses have been suggested such as changes in postprandial blood glucose, as high GI foods produce exaggerated glycemic and insulinemic responses followed by a hypoglycemic state, potentially increasing hunger [17]. The purpose of this study was to determine the effect of GI and GL on anthropometrics determined via BMI, body weight and waist circumference among low-income Latino individuals with T2D.

METHODS

Study Participants

Patients with T2D were recruited from five community health centers (CHC) in urban areas of central and western Massachusetts. At each CHC, a trained site research coordinator overseen by the research team was responsible for completing the recruitment processes. Subjects were included if they: were diagnosed with T2D;had an HbA1c level $\geq$ 7.5; were currently being treated with diet, oral hypoglycemics or insulin and, if they were currently on insulin, they must have had a history of prior therapy with diet alone or oral hypoglycemic agents; were Latino origin; were $\geq$ 18 years old; had a telephone in home or easy access to one; were able to understand and participate in the study protocol and functionally capable of meeting the physical activity goals; understood and could provide informed consent; and were given physician approval to participate in the study. Subjects were excluded if they: had a history of diabetic ketoacidosis; current gestational diabetes; were unable or unwilling to provide informed consent; had any plans to move out of the area within the 12-month study period; required intermittent glucocorticoid therapy within the past 3 months; experienced an

acute coronary event within the previous 6 months or had any medical condition that precluded adherence to study dietary recommendations or had any major psychiatric illness.

Determination of subject eligibility and recruitment was conducted in several stages. First, health care providers at participating CHCs were notified of the study and their approval for the site research coordinator to access patient medical records for screening purposes was obtained. Second, a review of the medical records of potentially eligible patients' was completed. For patients determined to be medically eligible to participate, approval and a signature on the recruitment letter was obtained from their primary care physician. Third, a letter describing the study was mailed to the patients who received primary care physician approval. Prior to participation in the study written informed consent was obtained from all participants. Once the baseline assessment was completed, participants were randomized to either the usual care condition or to *Latinos En Control* intervention condition. Randomization was completed at the level of the individual and stratified by CHC site, gender, baseline HbA1c levels and insurance status. Within each strata, participants were randomized in randomly allocated blocks of size 2, 4 and 6 using a reallocation program [30] version 7.0 (Stata Corporation, College Station, TX). Block randomization was used to ensure blinding of the allocation sequence. The study protocol was approved by the University of Massachusetts Medical School's and the Baystate Medical Center's Institutional Review Boards.

Intervention

Participants in the intervention condition, Latinos en Control, participated in a one year, group based intervention, consisting of two phases: an intensive phase with 12 weekly sessions followed by a maintenance phase with 8 monthly sessions. An outline of the self-management curriculum is presented in Table 1. The intervention targeted diabetes knowledge (e.g., effect of foods of different GI on diabetes control), attitudes (e.g., self-efficacy for dietary change) and behavioral capabilities (i.e., skills needed to make lifestyle changes) with its content tailored to the cultural and literacy needs of this population. Personalized coaching was offered during 10-minute counseling segments prior to the start of each group.

The dietary component of the intervention used the metaphor of a traffic light to simplify complex concepts. Foods frequently consumed by Latinos were classified based on their GI, fat, salt, and fiber content into categories of “green”, “yellow,” or “red” foods. A “food guide” which included pictures of these foods within the corresponding “traffic light colors” was developed and provided to all participants. Additionally, participants were given a graphic of a plate which displayed the ideal balance of colors at any given meal. Explained simplistically, the color green classified recommended foods which were lower in calories, saturated or trans-fat and sodium content and were of lower GI. “Yellow” foods were medium in calories, saturated or trans-fat and sodium content and were of medium GI. “Red” foods were higher in calories, saturated or trans-fat and sodium content and were of higher GI. To impact GL, reduction of portion sizes was emphasized and all participants received a set of measuring cups. Subjects participated in multiple interactive sessions including: healthy cooking methods for ethnic foods, label reading, a supermarket tour, group meals where measuring cups

were used for modeling appropriate portion sizes and guided discussions explored taste and appeal of the foods, the ease of preparation, and strategies to incorporate new cooking methods at home. Participants were provided with and instructed in the use of glucose meters and step counters.

Usual care was defined as diabetes care as currently delivered at the CHC. Therefore, participants in the usual care group received medical therapy as determined to be appropriate by their healthcare providers. Healthcare providers received all laboratory reports for all participants regardless of their study condition.

Measurement

Measurements were collected at baseline, 4 and 12-month follow-up and included three 24-hour recalls, clinical assessments, and demographic and psychosocial interviews at each time point. Dietary intake and physical activity [31] were assessed via three unannounced telephone administered 24-hour recalls. Multiple recalls are used to assess day-to-day intra-individual variations in the behaviors of interest [32]. The Minnesota Nutrition Coordinating Center's (UM-NCC) Nutrition Data System for Research software (NDS-R) was used to collect and analyze the 24-hour dietary recall data [33]. At each assessment visit, fasting blood samples were drawn for analysis of TC, LDL, HDL and triglycerides, fasting glucose, and HbA1c. Body Mass Index (BMI) was calculated as weight in kg divided by height in cm^2. Weight was assessed with a Tanita BWB800S Digital Physicians Scale and Height was asses with a Seca Road Rod Portable Stadiometer. Waist circumference was measured in centimeters to 0.1 cm**.** Waist circumference was measured twice and the mean value was used in the analyses. Two blood pressure measurements were taken using a

Dinamap XL automated BP monitor. All medications and supplements were recorded. Demographic and additional data were collected via self-reported survey, including; age, gender, education level, and duration of diabetes. In order to account for the potential effect of medications on blood glucose, lipids, and weight, two pharmacists compiled the medication used by study participants based on whether they had a positive or adverse effect on these outcomes. In addition, glucose lowering agents were combined to construct a diabetes medication intensity score. This score was based on the type of oral hypoglycemics taken and/or dose and type of insulin taken. Possible scores ranged from 0- 6.5, with a higher score equating to greater number or dose of medication/insulin. Participants were compensated with 30 dollars at each assessment timepoint.

Statistical Analysis

All analyses were performed using STATA version 11. (StataCorp, College Station, TX) Results are expressed as means with 95% confidence intervals (CIs). Descriptive statistics were calculated for continuous covariates (age, physical activity, blood pressure, medication score), exposure variables (GI, GL), and outcomes (BMI body weight and waist circumference). Although GI and GL were continuous variables, for univariate statistical inferences, we stratified baseline demographic and clinical data by baseline GI and GL quartile and compared differences by Chi-Square or ANOVA tests.

Four separate random effects regression models were developed with either the outcome being BMI or waist circumference, and the primary predictor of interest being

the exposure variable of GI or GL (ie, a model examining the effect of GI on BMI adjusted for other confounders, followed by a model examining GL on BMI and then repeated for waist circumference). Each model was controlled for age, gender, mean arterial blood pressure, total energy intake, physical activity, diabetes medication intensity score, lipid increasing and decreasing drugs, and weight increasing and decreasing drugs and study arm. A backward elimination process was used for each model, until only significant variables remained. Additionally, linear regression was used to determine the association between change in glycemic index and glycemic load with change in BMI, body weight and waist circumference from baseline to 4 months follow-up.

The primary multivariate analysis was a complete case analysis in which patient records with missing values were not in the regression models. To investigate the potential effect of missing data, two imputed sensitivity analyses were completed. The first analysis was intention to treat analysis, which included all 252 randomized participants, with the baseline observation carried forward when missing values were present. The second method relied on multiple imputation by chained equations (MICE) analysis [34]. No differences were found between the analyses. Thus, results using complete data are presented herein.

RESULTS

Baseline Characteristics

The participant flow diagram is shown in Figure 1. A total of 252 Latino adults with T2D participated in the study. Although all anthropometric outcomes were continuous variables in these analyses, for purposes of baseline inference, we stratified

baseline demographic and clinical data by baseline quartile of BMI and waist circumference (see Table 2b). The baseline mean (SD) BMI was 34.76 kg/cm² (±6.94), waist circumference was 111.69cm (±13.99), body weight was 192.17 lb (±39.94), age was 56 years (±11.18), and 76 % were female. Baseline mean total energy intake was 1700.73 Kcal., mean GI was 61, and mean GL was 127. At baseline there was a significant difference in BMI quartile by gender. Notable was that subjects in the highest quartile of BMI and waist circumference had significantly higher diabetes medication intensity scores compared to those in the other three quartiles (p=0.05 and p=0.02, respectively). At baseline 44% of subjects were taking oral hypoglycemic medications only, 40% were taking oral medication and insulin, 9% were taking insulin therapy only and 7% were taking no medications. Subjects in the highest waist circumference quartile had significantly higher GL compared to the other three quartiles (p=0.05).

Change in GI and GL

A significant reduction (baseline minus 4 month value) in mean GI was seen in the treatment group at 4 months (treatment -2.57 (7.25) vs. control 0.87 (5.95), p<0.001). However, while this trend remained, the difference between conditions was no longer statistically significant at 12 months (treatment -0.63 (7.15) vs. control 0.42 (5.96) vs., p=0.27). A significant reduction in mean GL was seen in the treatment group compared to the control group at 4 months (treatment -20.42 (46.87) vs. control 7.41 (44.12), p <0.001), and at 12 months (treatment-14.62 (46.82) vs. control 6.48(43.15), p <0.001). There was a significant association between change in glycemic index and change in waist circumference from baseline to 4 months follow up. There was no statistically

significant association between change in glycemic index or glycemic load with change in BMI or body weight from baseline to 4 months follow up.

Overall Association of Glycemic Index and Anthropometrics

Table 3b illustrates the results of the multivariate longitudinal random effects model analyses. A reduction in GI was positively associated with the reduction in waist circumference (0.154, 95%CI [0.053 to 0.256, p=0.003), but not with BMI (-0.024, 95%CI [-0.064 to 0.016], p=0.244) or body weight (0.062, 95%CI [-0.101 to 0.225], p=0.456) overtime.

Overall Association of Glycemic Load and Anthropometrics

No significant associations between GL and BMI, body weight or waist circumference were found (-0.002, 95%CI [-0.008 to 0.004], p=0.474, and 0.021, 95%CI [-0.002 to 0.045] p=0.079) and 0.012, 95%CI [-0.003 to 0.028], p= 0.127, respectively) overtime.

DISCUSSION

The result of this study showed that a reduction in GI was positively associated with improvement in waist circumference but not with BMI or body weight. No significant associations between GL and any anthropometric outcomes were noted. Similar to our findings, several previous clinical trials conducted among adults with T2D have reported beneficial effects of lowering GI on some anthropometric outcomes, but not others. Three studies have investigated the impact of a low GI diet compared to a high GI diet on anthropometric outcomes in individuals with T2D. Results of one study suggest that body weight did not differ significantly between diets [10]; another found no difference in lean or fat mass between the two diets [9]. Only one study has previously investigated the effect of lowering GI in Latino subjects with T2D. Jimenez-Cruz et al. [28] conducted

a 6-week crossover feeding study in which 14 overweight and obese Mexicans Americans with T2D were given a low-GI diet, containing Mexican-style foods and then a high GI diet. The results showed that BMI and body weight significantly decreased during the low GI diet compared to the high GI diet. Unlike the *Latinos En Control* study, the previous research on this topic was conducted with small sample sizes and the dietary conditions were of short duration, most lasting less than 6 weeks.

Previous research suggests that increased BMI is associated with hypertension, dyslipidemia, T2D, and insulin resistance [66, 67]. However, BMI does not assess body fat distribution which might be a stronger predictor of metabolic risk. Abdominal fat can be accessed through various measures such as waist circumference or waist-to-hip ratio. Data suggests that increased waist circumference is associated with increased risk for metabolic diseases including metabolic syndrome and CVD, independent of BMI [68, 69]. Furthermore, observational studies suggest that elevated waist circumference levels, even among adults with a normal BMI, have a two to three fold increase in CVD risk and premature death [70-72].

Recent research suggests that within the Latino population, waist circumference is associated with increased rates of cancer, stroke, myocardial infarction and all-cause mortality [68, 73, 74]. One study reported that increased waist circumference is positively associated with clustering of multiple metabolic syndrome factors (including fasting blood glucose, triglycerides, blood pressure, waist circumference and HDL levels) in Latino men and increased fasting insulin concentrations in Latino women [75].

Recently, a National Institute of Health expert panel and the NCEP ATP III criteria suggested that waist circumference measures of >102 cm for men and >88 cm

for women be used to identify individuals with increased risk for obesity related co-morbidities [76, 77]. The mean waist circumference for individuals in this study was 111.85 cm for females and 111.11cm for males. In comparison, results of the IDEA study showed that the mean waist circumference in a Latin American primary care population, which was predominantly overweight and obese, was 96.4 and 89.7 cm for men and women [64]. Thus subjects in the *Latinos en Control* trial had very high mean waist circumference. The result of this study showed that a reduction in GI was positively associated with improvement in waist circumference. A 1 unit decrease in GI (in its original units of measurement) resulted in a 0.15 cm. decrease in waist circumference.

The result of this study showed no association between GI and BMI or body weight and no association between GL and any anthropometric outcomes. One possible explanation for the lack of effect of GI and GL on BMI and body weight and the minimal effect of waist circumference is that the decrease in GI and GL may not have been clinically significant. The mean GI of this population was 61 (glucose reference), which is lower than expected. Additionally the absolute reduction in both GI and GL was very small in the present study. Greater reductions in GI and GL might be needed to see a more significant reduction in anthropometric outcomes. However, as this population had a lower mean baseline GI greater reductions may be difficult.

Another possible explanation for the lack of significant findings may be that while the physiological mechanisms by which GI and GL impact blood glucose are well established, the mechanisms by which GI and GL impact anthropometrics are less understood. Previous research has suggested that lowering GI might increase satiety,

which in turn would decrease caloric intake and result in weight loss. A recent analysis of 32 studies showed that low GI foods have a higher satiating effect than high GI foods [78]. However, due to a large number of confounding variables within the included studies, the authors were unable to conclude that low GI diets mediate changes in body weight. Thus, the mechanism by which GI affects satiety is unclear. Possible hypotheses have been posited such as changes in postprandial blood glucose or regulator hormones. Compared to low GI foods, high GI foods produce exaggerated glycemic and insulinemic responses followed by a hypoglycemic state, potentially increasing hunger [17].

The results of this study are subject to several limitations. First, dietary data were collected via self report. Second, 24-hour dietary recall was conducted in Spanish and translated by the assessor into English. Third, previous research suggests underreporting of dietary intake in Latino populations [38]. Fourth, all participants were from Massachusetts, and thus represent a limited geographic range; all subjects were Latino, thus results may not be applicable to all racial and ethnic groups or those in other states. Finally, the majority of subjects were Puerto Rican. Previous research has suggested that variations exist between subgroups of Latinos thus generalizations regarding Latinos as a single ethnic group should be made with caution.

This study addressed a significant health concern within a population at great risk. Overweight and obesity are independent risk factors for the development of CVD. Latinos suffer higher rates of overweight and obesity and subsequent T2D compared to non-Latino whites. While the results of this study suggest a benefit of lowering glycemic index on one anthropometric marker, no beneficial effect of lowering glycemic index was

associated with other anthropometric markers and results showed no beneficial effect of lowering glycemic load on any of the anthropometric measures. Two important issues which should be strongly considered in future research are the baseline GI and GL of the target population, and the ability to achieve clinically significant reductions in GI and GL.

Table 1b
Latinos En Control Diabetes Self-Management (DSM) Curriculum: Session Objectives and Topics

Session number	Intensive Phase
1	Rapport with patients; individual assessments of: diabetes self management (DSM) history; DSM goals and incentives; expectations and commitment for the program; family support and resources for DSM; rationale for DSM; begin
2	Group cohesiveness (i.e., icebreaking exercises); what is diabetes; meeting and working with a new health care provider; physical activity self-monitoring (step counters); begin walking and physical activity self-monitoring.
3	Attitudes toward healthy eating; healthiest foods ("Green" section of the Traffic Light Food Guide); communicating with dietitians; begin self-monitoring of food intake.
4	Review of "Green" foods; portion control ("Yellow" section of the Traffic Light Food Guide); common challenges to self-monitoring of food intake.
5	Review dietary concepts introduced up to now; behavior changes made up to now; foods to avoid or eat infrequently and in small amounts ("Red" section of the Traffic Light Food Guide); management of hypoglycemia and self-management; communicating with health care providers
6	Mid-program review: physical activity, dietary concepts, self-monitoring, understanding and practice of self-management for glucose control, management of hypoglycemia.
7	Medication adherence; cholesterol and blood pressure; diabetes complications; barriers and resources to self-management; what to ask from health care providers.
8	Foot care; infections; smoking; stress management; getting support from the health care system.
9	Food labels and label reading skills; saturated fat, sodium and fiber.
10	Food Shopping, Quick meals.
11	Review food shopping strategies; heart healthy eating; management of sick days; following provider recommendations.
12	Program review; future challenges to maintenance; keeping in touch with health care providers.
	Maintenance Phase
13	Review of self-management concepts; continuing to increase physical activity
14	Progress toward healthy eating; new ideas for increasing healthiest foods; continuing to self-monitor self-management behaviors; problem-solving challenges as a group.
15	Managing challenges to portion control and avoiding unhealthy foods; Moving more.
16	Review of self-management experiences.
17	Medication adherence; cardiovascular risk factors and diabetes complications.
18	Staying healthy and reducing stress.
19	Future challenges to maintenance of behavior change.
20	Review and graduation

Table 2b
Baseline Characteristics (mean and percentages) by Quartile of BMI and Waist Circumference

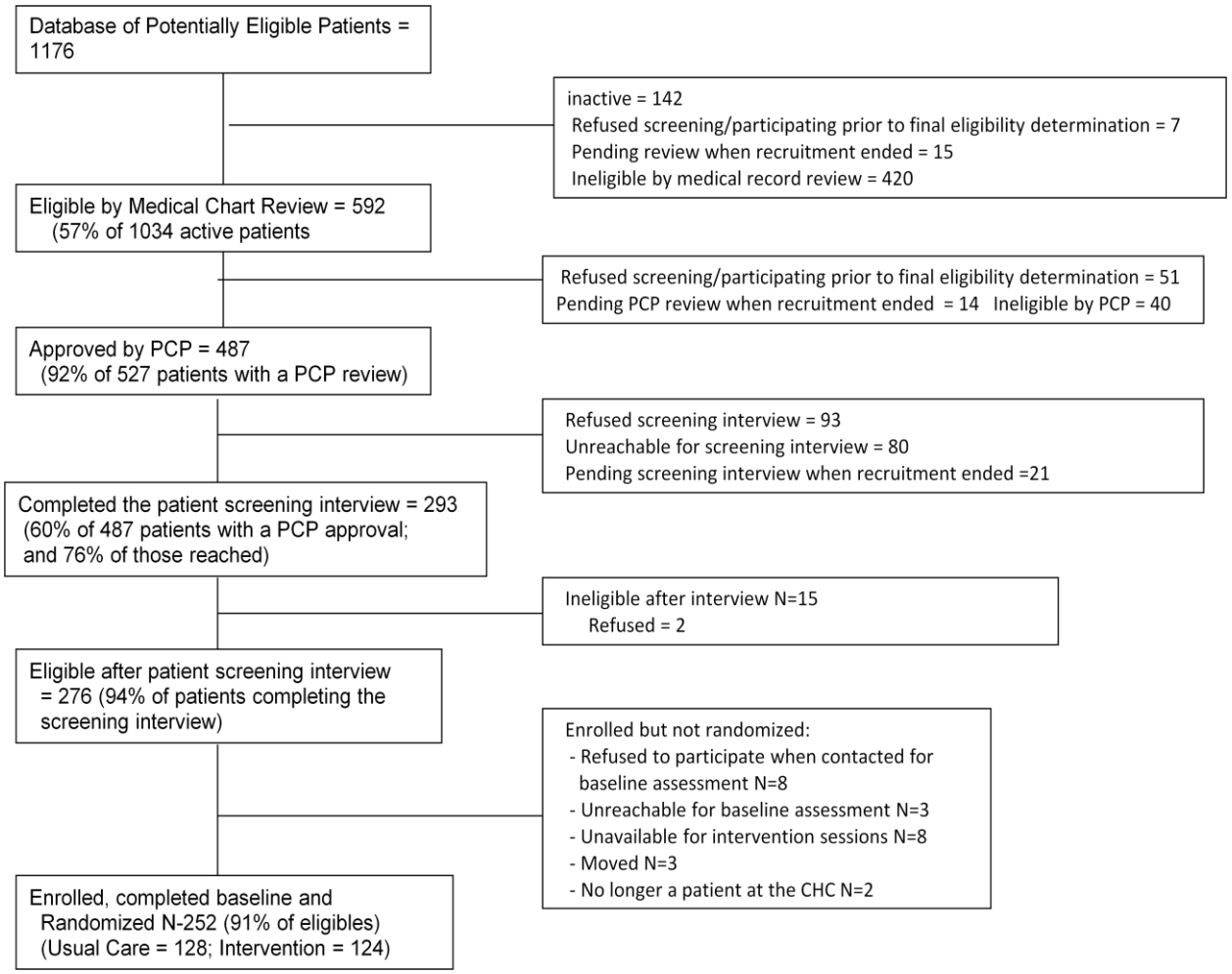
	Quartile BMI					Quartile WC				
	1(lowest)	2	3	4(highest)	p	1(lowest)	2	3	4(highest)	p
range	19.2-29.9	30.0-33.5	33.5-38.9	39.0-55.7		78.7-114.5	95.0-123.6	99.0-148.7	107-163.5	
n	62	62	62	63		62	63	63	63	
Intervention	51.61	46.03	44.44	53.97	0.67	53.23	46.03	50.79	46.03	0.80
Glycemic Load	121.86	116.25	138.10	129.39	0.06	118.30	124.28	122.45	141.15	**0.05**
Glycemic Index	61.18	60.51	61.17	60.94	0.88	60.32	61.65	60.64	61.14	0.50
Age	57.97	57.76	54.95	53.47	0.06	56.71	57.90	55.77	53.75	0.20
Gender (Female)	64.52	74.60	77.78	88.89	**0.02**	75.81	73.02	79.37	77.78	0.85
Medication	2.572	3.10	2.67	3.31	**0.05**	2.44	2.71	3.22	3.27	**0.02**
Physical	13.85	12.30	11.16	13.29	0.12	14.77	11.02	13.05	11.82	**0.01**
Marital Status (Not married)	59.02	62.30	53.23	68.85	0.35	61.67	58.06	66.13	57.38	0.74
Income										
<10,000	48.00	65.52	57.41	48.15		50.00	56.14	60.38	53.70	
10,000-20,000	42.00	29.31	33.33	44.44		38.46	36.84	33.96	33.96	
>20,000	10.00	5.17	9.26	7.41	0.50	11.54	7.02	5.66	7.41	0.92
Education										
<= high school	74.19	82.54	76.19	69.84	0.41	74.19	84.13	73.02	71.43	0.34
HbA1c (%)	9.02	9.1	8.62698	9.17	0.34	9.01	8.94	8.91	9.10	0.94
FBG (mmol/L)	176.25	158.71	163.66	176.63	0.39	168.92	163.17	167.29	175.78	0.80
BMI (kg/m)	na	na	na	na		28.46	31.764	35.65	43.08	**0.00**
WC	97.68	107.40	113.33	128.15	**0.00**	na	na	na	na	
Mean Arterial	98.84	96.05	96.41	94.70	0.23	95.42	98.26	97.02	95.25	0.40
Total cholesterol	180.16	188.60	181.32	177.08	0.55	183.45	184.90	181.92	176.94	0.79
HDL cholesterol	44.87	45.87	42.90	43.65	0.29	46.61	43.60	44.06	43.05	0.15
LDL cholesterol	106.44	109.98	105.85	105.13	0.90	105.88	110.30	107.38	103.75	0.81
VLDL	26.19	30.38	30.13	26.61	0.19	27.95	30.53	26.41	28.46	0.43
Triglyceride	160.95	161.89	155.83	146.27	0.85	155.69	161.27	152.68	155.21	0.98
Total Energy	1669.69	1605.75	1797.89	1719.96	0.30	1646.87	1624.27	1691.88	1837.87	0.17
Total	215.48	206.38	240.85	227.12	0.09	211.74	215.72	217.34	246.14	0.07
Total Fiber	16.15	14.10	14.87	15.13	0.36	16.05	14.34	14.65	15.28	0.47
Soluble Fiber	4.822	4.354	4.367	4.61	0.58	4.87	4.29	4.26	4.76	0.28
Insoluble Fiber	11.22	9.60	10.29	10.38	0.27	11.09	9.80	10.27	10.39	0.47
Total Fat	56.82	55.24	60.49	60.89	0.54	57.28	53.88	58.40	64.26	0.15
Saturated fat	17.79	18.02	18.77	19.53	0.68	18.12	17.39	18.14	20.58	0.19
Trans fatty Acids	2.68	2.89	2.81	3.15	0.61	2.90	2.63	2.79	3.23	0.37

Table 3b

Multivariate Random Effects Analyses of the Relationship between Glycemic Index and Glycemic Load with Anthropometrics

Glycemic Index and Anthropometrics			
Glycemic Index and BMI			
Covariate	Coef.	95% CI	P>|z|
Glycemic Index	-0.024	-0.064 to 0.016	0.244
Age	-0.129	-0.205 to -0.053	0.001
Gender	-3.025	-5.041 to -1.008	0.003
Constant	47.207	41.640 to 52.774	<0.001
Glycemic Index and Body Weight			
Glycemic Index	0.062	-0.101 to 0.225	0.456
Age	-1.291	-1.714 to -0.867	<0.001
Gender	11.366	0.116 to 22.616	0.048
Constant	246.249	216.723 to 275.774	<0.001
Glycemic Index and Waist Circumference			
Covariate	Coef.	95% CI	P>|z|
Glycemic Index	0.154	0.053 to 0.256	**0.003***
Lipid increasing drugs	1.160	0.263 to 2.056	0.011
Constant	101.586	95.161 to 108.010	<0.001
Glycemic Load and Anthropometrics			
Glycemic Load and BMI			
Covariate	Coef.	95% CI	P>|z|
Glycemic Load	-0.002	-0.008 to 0.004	0.474
Age	-0.129	-0.205 to -0.053	0.001
Gender	-2.996	-5.018 to -0.974	0.004
Constant	46.013	40.976 to 51.050	<0.001
Glycemic Load and Body Weight			
Glycemic Load	0.021	-0.002 to 0.045	0.079
Age	-1.276	-1.701 to -0.851	<0.001
Constant	260.515	236.062 to 284.967	<0.001
Glycemic Load and Waist Circumference			
Covariate	Coef.	95% CI	P>|z|
Glycemic Load	0.012	-0.003 to 0.028	0.127
Lipid increasing drugs	1.164	0.259 to 2.069	0.012
Constant	109.459	106.756 to 112.162	<0.001

Figure 1 Participant Flow Diagram



CHAPTER V

CONCLUSION

This study aimed to answer several understudied yet important research questions that may help inform dietary recommendations for the treatment of T2D in Latino adults. The goals of this study were to investigate the association of GI and GL on measures of diabetes control, anthropometrics and lipid profiles among low-income Latino individuals with T2D. These research questions were addressed through secondary analysis of an RCT, *Latinos en Control,* which tested the efficacy of a diabetes self-management intervention that targeted GI and GL among two hundred fifty-two Latino patients of Caribbean origin with T2D. Data from the *Latinos en Control* study provided a unique opportunity to conduct a secondary data analysis to compare the effects of reducing GI and GL on metabolic and anthropometric outcomes among low income Latinos with T2D.

Results showed that a reduction in glycemic index from baseline to 12 months was positively associated with a reduction in logHbA1c ($p=0.006$), HDL: LDL ratio ($p=0.037$) and waist circumference ($p=0.003$), but not with fasting glucose, triglycerides, TC, LDL and HDL, TC:HDL ratio or BMI. No significant associations were observed between glycemic load and any of the outcomes measured.

The results of this study are similar to those found in previous research among patients with T2D. Several studies have shown that a lower GI diet is associated with greater improvements in glycemic control [6-10] while several have not [26, 27, 29], several studies have shown no improvements in anthropometrics [9, 10] while one study did [28],and several studies have shown improvements in lipid profiles, including HDL, LDL

and TC [9, 26, 29] while one study showed no improvement in any lipid marker [6]. The results of the research to date suggest that the effects of lower GI and GL on anthropometric and metabolic outcomes among adults with T2D have been inconsistent. Further research is warranted.

Implications for Future Research and Practice

To our knowledge this is the first study to assess ab-libitum GI and GL in a Latino population using repeated 24 hour dietary recalls at multiple time points. A major finding this research was that the mean GI of this population was 61 (glucose reference), which is lower than expected, as most carbohydrate containing foods consumed in the United States are refined, higher-glycemic carbohydrates [18].The typical Western style diet contains many starchy foods such as potatoes, white breads and rice most of which have a GI greater than 70 (glucose reference). It is possible that differences in the food-ways of the Latino population differ from that of the general US population; further research in this area is warranted. Another possible explanation for the findings of this study was that the absolute reduction in both GI and GL was very small in the present study. Greater reductions in GI and GL might be needed to see a more significant reduction in metabolic and anthropometric outcomes. Two important issues which should be strongly considered in future research are the baseline GI and GL of the target population, and the ability to achieve clinically significant reductions in GI and GL.

Over the past 10 years, research into the concept of GI has increased significantly, building the body of available evidence. However, in reviewing the research conducted to date, it is apparent that several methodological issues will need to be addressed in future research. First, more precise dietary measurement tools, which systematically

assess individual dietary GI intake, need to be developed and validated. Second, future GI research should utilize validated methodologies and databases for determining the GI of diets increasingly diverse populations.

From a clinical practice perspective, opponents of the GI have suggested that the concept is too difficult to understand and incorporate into dietary change. While the scientific concept of GI is complex, teaching the principles of the concepts does not need to be. Clinicians should emphasize the replacement of high GI foods with low and medium GI foods. A similar approach can be taken in regards to GL. Another criticism is that some low GI foods are high in fat, which is a great concern for patients with T2D due to their increased risk of CVD. However, this is not the case when focusing on whole, unprocessed low GI foods, such as vegetables, fruits, intact or minimally processed whole grains, and legumes, all of which are associated with improved cardiovascular health. GI should not be the sole criteria by which to select a diet; but when considered along with nutrient density and other relevant factors may be a useful construct for improving dietary quality and decreasing morbidity and mortality.

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