AN ABSTRACT OF THE THESIS OF

Julia Silva Sobolik for the degree of Honors Baccalaureate of Science in Biology and Honors Baccalaureate of Arts in International Studies in Biology presented on May 30, 2007. Title: Analysis of the Prevalence of Type 2 Diabetes in Mexicans and Mexican Americans.

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Eric R. Hill

Non-insulin dependent diabetes mellitus (NIDDM), commonly known as type 2 or delayed onset diabetes, is a recognized growing global epidemic, which is connected to cultural and behavioral factors, such as diet, exercise, obesity, and genetics. In a recent survey of both men and women in Mexico City, the prevalence of type 2 diabetes was found to be 14.9 % and in this same survey of Mexican Americans, there was found to be 25.7 % prevalence. It is possible to see with these statistics that there are particularly high rates of type 2 diabetes in Mexicans and, furthermore, an even more elevated incidence is found in Mexican Americans.

While type 2 diabetes and obesity both have genetic and environmental determinants, research has shown that with healthy diets and active lifestyles, genetic predispositions to these diseases can be reversed. This research strongly suggests a relationship to the acculturation process—changing behavior and assimilation to the diet, behaviors, and lifestyles of a particular society—in the United States and indicates a correlation between the adverse affects of the American culture and health. There is a higher prevalence of type 2 diabetes in Mexican Americans than in Mexicans, due to the acculturation process experienced in the United States, in addition to the cultural and behavioral factors found in both populations of genetics, physical activity, and high obesity rates.

Key Words: Type 2 diabetes, Mexican Americans, and Acculturation
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Analysis of the Prevalence of Type 2 Diabetes in Mexicans and Mexican Americans

by

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Julia S. Sobolik, Author

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Dedication

This thesis is dedicated to my loving Mother and Father, Susan and Dennis, who have shared with me their incredible passion for life and shown me the importance of hard work, compassion, modesty, and the pursuit of our dreams.

Introduction:

The purpose of this thesis is to address an array of questions pertaining to type 2 diabetes in Mexicans and Mexican Americans. The following areas to be explored include: the high prevalence of type 2 diabetes in Mexico and the factors that contribute to the elevated and increasing occurrence of this disease; the differences in the type 2 diabetes epidemic between the two populations of Mexicans and Mexican Americans while looking at various studies and a subset population of Pima Indians; and the factors that contribute to the higher instance of type 2 diabetes in Mexican Americans here in the United States, as opposed to those rates found in Mexico. In addition to concentrating on these questions, the different types of diabetes will be introduced, the role of insulin will be explained, and the integral roles of genetics and cultural factors, such as diet, obesity, and physical activity, will be discussed. This thesis approaches these topics in a social science context, and in this way, the acculturation process and culture are defined broadly. In this analysis, type 2 diabetes will be used interchangeably with non-insulin dependent diabetes mellitus and can be abbreviated as NIDDM.

The inspiration for this thesis came from a three month summer medical internship in a private medical clinic called Banco de Medicamentos in Morelia, Michoacán, Mexico. Ten weeks were spent shadowing one doctor, in particular, on visits to elderly patients in their homes in surrounding areas of Morelia, as they were unable to come into the clinic themselves. Approximately every two to three weeks, each patient would be revisited for a general wellness examination and supplied with new medications. In addition to viewing diagnosis techniques, patient care, and the bedside manner of doctors in the native language, this experience provided an opportunity to see disease trends in Mexico and the apparent prevalence of illnesses such as diabetes, hypertension, high blood pressure, and complications associated with the nervous system. Another interesting problem encountered was the discrepancy between the directions and medicine assigned to patients and the complete disregard the patients had for the doctors' instructions; for example, instead of following recommendations of eating a healthy diet low in sugars and exercising regularly, many patients did the complete opposite, in addition to forgetting to take their medication. It was due to this shadowing and interaction with patients that additional questions arose as to the effects of socioeconomic, behavioral, and cultural factors on type 2 diabetes.

Type 2 diabetes is a growing, global epidemic. This is of particular importance in Mexico because in the year 2000, diabetes was the 11th most frequent cause of hospitalization and the second most common cause of hospital mortality (Rull, 2005). Jiménez-Cruz, 2004, contributes additionally to these statistics by stating that NIDDM is the leading cause of adult non-obstetric hospital admissions and hospital mortality, and is the third cause of mortality nationwide in Mexico (p. 1213). The slight differences in these two statistics have been recognized and are based on the age of the respective reference—they were both deemed important to include, despite possible discrepancies. In Mexico, type 2 diabetes is the principal cause of death in women and the second among men since the year 2000 (Rull, 2005). As the result of a nationwide population based survey, there has been a 25% increase in type 2 diabetes over a seven-year period and, by the year 2025, it is expected that close to 11.7 million Mexicans will be diagnosed with diabetes (Rull, 2005). Type 2 diabetes is associated with older age, obesity, family history of diabetes, history of gestational diabetes, impaired glucose metabolism, physical inactivity, and race/ethnicity (CDC). It is evident from these and other statistics provided below that type 2 diabetes is not a disease to take lightly. This is especially obvious with growing obesity rates and the increasing number of Mexicans transitioning to American diets with higher caloric and more readily available foods. As has been shown through numerous studies, obesity is a high risk factor for type 2 diabetes, in addition to lifestyle factors, such as amount of physical activity, and genetics. Research supports explanations for the diabetes epidemic in Mexico, such as the combination of increased food availability, decreased physical activity, greater life expectancy, undernourishment early in life, and genetic predisposition. The higher prevalence of NIDDM in Mexican Americans is due to the above listed factors, in addition to the acculturation process in the United States in subsequent generations. Barceló (2001) supports this hypothesis by further describing the increase in the incidence of type 2 diabetes in the Americans as resulting from multiple factors involved in lifestyle changes related to modern life such as the decrease in physical activities and obesity resulting from a predominance of hypercaloric diets (300).

There is a higher prevalence of type 2 diabetes in Mexican Americans than in Mexicans due to the acculturation process experienced in the United States, in addition to the cultural and behavioral factors found in both populations related to genetics, amount of physical activity, and high obesity rates.

Background:

Who are the Mexican people?

As part of this thesis, it is crucial not only to comprehend the different components of diabetes and the factors which contribute to its ever-increasing incidence in Mexico and in the Mexican American population, but additionally, to understand the Latino culture. The basis of this study is to look at the shared genetic link between Mexicans and Mexican Americans and if possible, to trace the origins of behaviors, such as physical activity, and the historical patterns of food. Although Mexicans and Mexican Americans as general population entities remain very similar based on genetics and ancestors of Spanish and indigenous descent, there are various behavioral and cultural factors which create differences in the prevalence of non-insulin dependent diabetes. This study hopes to identify, more specifically, the factors which contribute to the increase in prevalence of type 2 diabetes in Mexican Americans and to illustrate that it is possible to override a predisposition to diabetes in Mexicans and Mexican Americans alike, by consuming a balanced diet, exercising regularly, and maintaining a healthy body mass index (BMI). While type 2 diabetes is a serious, growing epidemic globally, awareness and knowledge of how to prevent and combat this disease is also exceedingly important.

The question of who the Mexican people are has been posed before, but continues to lack a definitive answer. Instead, the Mexican population originates from a combination of indigenous peoples such as the Mayans, Aztecs, Olmecs, and Teotihuacans with Spanish blood during the Spanish conquest of Hernan Cortes in 1520 and has continued to this day as in all countries, with global genetic mixing. This has created a blend of diverse traits genetically and phenotypically expressed in each and every Mexican. The extent of this integration is such a large part of the history of Mexico that the term for this blend of people is *mestizo*. This is similar to the United States, which has traditionally been described as a "mixing-pot" of cultures, nations, and ethnicities. Furthermore, one of the primary attempts of this thesis is to try to illustrate the phenomenon that occurs when people of different cultures interact and vestiges of the original culture remain in the newly created civilization. Sincretismo is the process by which two distinct cultures or religions fuse together creating an assimilation of different and distinct elements such as the merging of the Spanish and indigenous people in Mesoamerica. Similarly, just as Mexicans are an array of diverse people living in Mexico of Spanish and indigenous descent, Mexican Americans are defined as residents of the United States of Mexican origin. The U.S. Census defines origin as, "the heritage, nationality group, lineage, or country of birth of the person or the person's parents or ancestors before their arrival in the United States" (Zamalloa, 2006, p.1). This process of moving to the United States and changing geography alters many traditional Mexican behaviors and customs. In this way, Mexican Americans can be viewed as taking on some of the American culture. To a certain degree, they are Mexicans being acculturated to the distinct society of the United States. Despite the sharing of similar genetics between Mexicans and Mexican Americans, the difference in the prevalence of type 2 diabetes between these two populations illustrates that behaviors are key factors in the increase in prevalence of this disease. This is to say that with each passing generation Mexican Americans become more and more American, and with changes in diet and limited physical activity—parts of the acculturation process—these factors contribute to the higher prevalence of NIDDM in Mexican Americans.

Foods

Just as the origin and history of the Mexican population has been discussed, it is important to briefly consider the cultural aspect of diet. Traditionally, Mexican diets demonstrate a reliance on beans, rice, and tortillas with the supplemental use of dairy products, meats, and oils (Aldrich, 2000, 53). As previously mentioned, traditional diet patterns are changing with globalization and the migration process. Studies in Mexico have shown an increase in availability and intake of calories, cholesterol, saturated fat, and total fat with higher socio-economic status (Zamalloa, 2006, p.8). This also reflects and potentially contributes to the low micronutrient quantities, due to poor consumption of fruits and vegetables throughout the country (Zamalloa, 2006, p.8). Through her research, Zamalloa identifies the nutrients most likely to be inadequately provided in the Mexican diet, such as calcium, iron, vitamin A, folacin, and vitamin C, due to lower consumption of dairy products, leafy green vegetables, orange vegetables, liver and organ meats, dairy products, and fruits. This pattern of eating seems to continue in the first generation as Mexican Americans migrate to the United States (2006, p.37). An emphasis on low-fat dairy products and small amounts of vegetable oil in cooking can also contribute to large dietary improvements (Aldrich, 2000, 53). Additionally, diets and nutrition patterns in the United States have been rapidly changing, with direct health implications for all Americans. The habit of dining out has increased over the past two decades and typically these foods contain more fat, saturated fat, and less fiber than foods prepared at home. Expanding portion size has also become more prevalent in Mexico and the United States since 1970, and appears to contribute to the rising epidemic of obesity (Zamalloa, 2006, p.8). The following is a comprehensive list of examples of healthy foods in a diabetes diet (A.D.A.M): apples, beans, berries, broccoli, carrots, eggs, fish, garlic, ginger, grains, grapes, nuts, onions, oranges, sweet potatoes, soy, spinach, tea, and tomatoes. It was seen in Mexico that very few of these foods were actually consumed and only grains, eggs, onions, and fruits were eaten frequently. The diet of Mexicans can be improved with subtle dietary changes and the inclusion of additional foods for a more balanced diet.

Types of Diabetes

The World Health Organization (WHO) published updated criteria in 1985 for the diagnosis of diabetes mellitus. According to this updated WHO classification of diabetes, there are two major forms of diabetes, type 1 and type 2, formerly known as insulin-dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM) respectively. Type 1 diabetes is characterized by an acute, often severe, onset—mainly in children and young adults—and requires insulin treatment. Type 1 develops when pancreatic beta cells, which are responsible for making the hormone insulin and regulating blood glucose, are destroyed by the body's immune system (CDC). Eventually insulin deficiency is absolute and, without insulin to move glucose into cells, blood glucose levels become excessively high, a condition known as hyperglycemia.

Because the body cannot utilize the sugar, it is lost in the urine and weakness, weight loss, and excessive hunger and thirst result from this “starvation in the midst of plenty” (A.D.A.M, 2006).

Type 2 diabetes is the most common form of the diabetes disease, accounting for approximately 90% to 95% of all cases. In contrast to type 1, type 2 diabetes usually begins as insulin resistance, a disorder in which insulin can attach normally to receptors on liver and muscle cells, but certain mechanisms prevent insulin from moving glucose into the cells where it can be utilized. (A.D.A.M, 2006). As the need for insulin increases, the pancreas gradually loses the ability to produce enough insulin to overcome the resistance and abnormal rises in blood sugar after a meal are particularly damaging to the body. Eventually, this cycle of elevated glucose further impairs and possibly destroys beta cells, stopping insulin production completely and causing fully developed diabetes. Due to this, NIDDM appears mainly in adults and can be treated in a variety of ways, including a dietary regimen, oral hypoglycemic agents, insulin, or a combination of these (Barceló, 2001, 301). Additionally, lifestyle changes, such as increased exercise and dramatic weight loss in obese/overweight individuals are treatment strategies.

Another important subcategory to type 2 diabetes is gestational diabetes, which is defined as glucose intolerance first diagnosed during pregnancy (Barceló, 2001). Gestational diabetes occurs most frequently in African Americans, Mexican Americans, and Native Americans and is more common among obese women. 5% to 10% of women with gestational diabetes are found to have type 2 diabetes after pregnancy and women with gestational diabetes have a 20% to 50% chance of developing diabetes in the next 5-10 years (CDC). While it has been shown type 1 diabetes cannot be prevented, type 2 diabetes can be successfully avoided. The Diabetes Prevention Program (DPP), an important trial sponsored by the National Institutes of Health, showed that type 2 diabetes can be delayed or prevented in overweight adults with pre-diabetes, including Mexican Americans who have genetic NIDDM predispositions. Pre-diabetes is a condition where blood glucose levels are higher than normal but are yet to be high enough for a diagnosis of diabetes. The risk factors for pre-diabetes are the same as those previously listed for type 2 diabetes. As shown in the DPP study, diabetes was preventable by losing 5 to 7 percent of body weight, exercising consistently for 30 minutes per day at five times per week, choosing healthier foods, and limiting the amount of calories and fat in the diet (www.ndep.nih.gov).

Obesity Definition: Malnutrition

Composed of both undernutrition and overnutrition, malnutrition has complex biological, as well as socioeconomic and cultural determinants. Overnutrition and obesity result from an imbalance between energy intake and expenditure (Rivera, 2003, p. 3). This imbalance often arises from intaking energy-dense and low fiber diets in combination with reduced physical activity. This is especially linked to urbanization, economic growth, changes in technology for work, and changes in lifestyle and leisure (Rivera, 2003, p. 3).

Economic Development and Urbanization

Catch-up growth is defined as development and weight gain during childhood after early years of malnutrition. This has been identified as a high risk factor for the development of obesity and diabetes in adulthood particularly as the available evidence indicates this is a state of hyperinsulinemia. This state is "characterized by a disproportionate recovery of fat later in adulthood rather than lean (muscle) tissue" (Jiménez-Cruz, 2004, p.1213). This phenomenon has been seen particularly among Mexican children from low socioeconomic groups that are typically transitioning from rural to urban areas, which tend to have more access to energy-dense fatty foods (Jiménez-Cruz, 2004, p.1213). Rull (2005) describes the diabetes epidemic as being closely associated with crucial social and environmental changes beginning during the 1940's when a large proportion of the population moved from rural to urban areas. The rural population decreased from 40.5% to 26.8% over a 40-year time span between 1950 and 1990 and, as a result, there was a significant change in diet and amount of physical activity in a large portion of the population. An example of this is seen in the considerable differences with respect to diet composition between rural and urban environments. Seen in the late 1990's, "calories were obtained mainly from carbohydrates (diet composition = carbohydrates 64%, proteins 12.1% and fat 22.7%) in rural areas [and] in contrast, people living in the cities consumed higher amounts of fat; the caloric contribution of fat was 27.6 and 33% in low- and middle- income areas, respectively" (Rull, 2005, p.188). Furthermore, the substitution of cars and buses for extended walking, consumption of calorie-dense foods and soft drinks, and the introduction and popularization of television, computer, and video games have all contributed to this simultaneous social and cultural change. As a result, the prevalence of obesity among Mexicans has increased, now affecting close to 30% of adults and 12% of children. A staggering statistic states that only 30% of the population has a body mass index <25 kg/m^2 (Rull, 2005, p.189). Martorell (2005) contributes by saying economic development and urbanization are the engines of the "nutrition transition"(p.1), which have led to increased availability of cheap sources of fat (vegetable oils), more eating away from home, and the sedentary nature of modern jobs.

Cultural Patterns and Beliefs

Cultural patterns play an important role in determining human obesity. As new values about body weight arise from migrating to other cultures, these may be assimilated to varying degrees as migrants become acculturated. Particularly in a study by Khan, the relationship between socioeconomic status, defined as the rank or position of an individual in society, acculturation, and relative body weight were analyzed. Socioeconomic status was determined through income/employment, education, and acculturation was measured through language preference and generation status. Given that acculturation is a multidimensional phenomenon, these analyses show that combinations of various components of the acculturation process have a different impact on behaviors and characteristics, such as body weight.

Thrifty Gene Hypothesis

Geneticist James V. Neel asked over 30 years ago why a gene with such debilitating consequences as diabetes was not eliminated through natural selection. He reasoned that if this gene had been advantageous under specific environmental conditions in the past, then this would explain the preservation of what is today a deleterious gene. This illustrates the point that what was once beneficial, may now be detrimental. It is important to recognize that the genes associated with diabetes may have benefits in the long term which have not been realized, or additionally, are associated with other circumstances not in consideration. In the thrifty gene hypothesis, Neel postulated that “genes promoting rapid insulin response to a plasma glucose stimulus prevented energy loss by converting excess glucose to stored fat” (Szathmáry, 1994, p.464). Without such a storage mechanism, excess glucose is excreted in the urine through the process of glucose homeostasis. Although it is assumed excess glucose was not a regular condition for our hunter and gatherer ancestors (depending on where they were located), occasionally, this did take place. Once stored as fat, energy could then be released when food availability was restricted. It is possible to see how bearers of these “thrifty genes” had a selective advantage in situations of fasting conditions and, according to evolution, explains how these genes were maintained in the genome and propagated in subsequent generations. However, with a continuous and ample food supply produced by cultural and environmental changes, this quick insulin response was maladaptive.

It is hypothesized that these altered conditions led to the development of obesity and hyperinsulinemia, and excess insulin provoked “insulin antagonists that eventually produced β-cell exhaustion” (Szathmáry, 1994, p.464). Based on current understanding of the pathophysiology of diabetes, new pathways have been proposed, keeping the basics of the thrifty gene model. One such pathway, believed to operate in Pima Indians, "is the existence of a genetically determined greater than normal difference in the insulin sensitivity of glucose and lipid metabolic pathways" (Szathmáry, 1994, 464). In this case, more resistance to entry of insulin-mediated glucose may be found in peripheral tissues (i.e. skeletal tissues), while others are not (i.e. adipose tissue). With this modification, hyperinsulinemia would still be provoked due to hyperglycemia and obesity (Szathmáry, 1994, p.464). Szathmáry describes that lifestyle changes in diet, obesity, body fat patterning, and physical activity form the environment for the emergence of NIDDM phenotype in individuals with the requisite genotype. The changes that contribute to this disease could begin gradually with increasing sedentary patterns and diminishing of physical exercise. In addition to this, increasing calorie intake, shifting in the distribution of body fat, and the development of obesity are contributing factors to type 2 diabetes (Szathmáry, 1994, 470). Szathmáry concludes it is highly likely that the sooner physical activity decreases and the "caloric intake/obesity triad" impacts life, the greater the risk of NIDDM (Szathmáry, 1994, 470).

Methods:

The research for this thesis was conducted by exclusively referencing and comparing peer-reviewed scholarly articles. No primary research data were collected, although the inspiration for this thesis was derived from hands-on medical shadowing of diabetic patients. Search fields, such as "diabetes mellitus", "type 2 diabetes", "Mexicans", "Mexican Americans", "epidemiology of diabetes mellitus", and "obesity" were used interchangeably in all possible combinations to search within databases and e-journals, such as Academic Search Premier and Medline, available through Oregon State University Valley Library. In addition to these articles, the most recent statistics were collected from the World Health Organization on the prevalence of obesity and amount of physical activity in Mexico and the United States. The support for this thesis was derived by connecting the results found in each individual academic article with the recent statistics based on nationwide surveys for both Mexico and the United States. In the majority of the studies analyzed, the evaluations were standardized following the procedures of the San Antonio Heart Study in which each subject's blood was sampled after a 12- to 14- hour fast for the measurements of serum lipid and plasma glucose concentrations. A 2- hour post-challenge glucose value was measured in all cases without either a previous diagnosis of diabetes or a fasting glycemia >126 mg/dL (Rull, 2005, p.190).

Recent survey statistics were collected from the World Health Organization for both Mexico and the United States on the prevalence of body mass index (BMI) ≥ 30 kg/m^2, mean BMI, and physical inactivity prevalence. In addition to these, median physical activity statistics were compiled from rural and urban Mexico. Although the sample sizes for the prevalence of body mass index (BMI) ≥ 30 kg/m^2 and mean BMI surveys for the United States and Mexico were different, with Mexico having approximately 9,000 more individuals, the surveys were comparable. Tests were completed the same year, 2003. Both rural and urban populations were tested. Surveys were conducted at the national level and definition and data type parameters were consistently defined. Physical inactivity prevalence was chosen for the comparison between the two countries—in place of median physical activity—because both were national surveys conducted in 2003 with similar rural and urban sample populations. These surveys were considered to be the most appropriate to compare, although there were several differences in the study parameters.

The WHO uses intensity, duration, frequency, and/or period to set cut-off points between physically inactive and active people. Intensity usually expresses the subjective feeling of how "hard" a physical activity is perceived by a person. Examples of intensity of physical activity are light, moderate, or vigorous. Duration is the length of time spent in participating in physical activity (e.g., 30 minutes per occasion). Frequency is defined as the number of times participating in physical activity per time (e.g., 2 times per week). The period means the time span which is covered by the survey (e.g., the last week). In addition, physical activity can be measured in different domains. Domain means the context in which a person participates in physical activity (e.g., leisure time or work). In the Mexico physical inactivity prevalence survey, the domain was total, definition code was IPAQ inactive, and the period was in the previous week. IPAQ-inactive is defined by the WHO as not meeting any of the following three criteria: 1) 3 or more days of vigorous activity for at least 20 minutes per day; 2) 5 or more days of moderate-intense activity or walking for at least 30 minutes per day; and 3) 5 or more days of any combination of walking, moderate-intense, and vigorous-intense activities achieving a minimum for at least 600 MET-min/week. Information on physical activity and energy expenditure of a population can be reported as a median or mean value, (mean hours of activity per week, or median MET-minutes per week). Metabolic equivalent (MET), is used to describe the intensity of activities. One MET is defined as the energy spent sitting quietly (equivalent to (4.184kJ) per kg per hour), while, moderate activity corresponds to 3-6 METs, and vigorous activity to >6 METs (who.int).

The Mexico physical inactivity prevalence study contrasted with the U.S. physical inactivity prevalence survey, which instead, used an unspecified domain, definition code of inactive, and the period was in the previous month. Furthermore, the sample size of the U.S. survey exceeded that of the Mexico survey by approximately 84,000 individuals. Once again, these surveys were the most similar, though the apparent differences and the possible changes in the results due to these discrepancies have been recognized. Physical inactivity prevalence was selected over median physical activity, due to the lack of similar, available surveys in the United States and Mexico on median physical activity. Median physical activity was selected to compare rural and urban Mexico, because the same survey measurements of median total MET-minutes per week were used and these were the most recent surveys available.

Although the process of acculturation is complex and is influenced by many factors, in this investigation, acculturation was studied based on language. During interviews, the use of Spanish or English determined the degree of acculturation of the individual; this also includes the native language spoken in the home environment. Also in this thesis, the term prevalence was used to represent the number of people diagnosed with type 2 diabetes or obesity (BMI > 30 kg/m^2) and was represented as a percentage out of the total population.

Results:

Population-Based Studies:

Obesity in U.S. Hispanics.

The objective of this study was to examine the relationship between acculturation and obesity in the United States Hispanics population, while controlling socioeconomic status. Acculturation was measured by language preference and generation and socioeconomic status by income and education. The mean and standard deviation of BMI (kg/m^2) was 25.9 ± 4.4 (kg/m^2) in Mexican American men. For Mexican American women, the corresponding value was 26.6 ± 5.8 (kg/m^2). Linear regression models of BMI, which included acculturation, income, education and other covariates, were carried out—refer to Table 3. In this study, generation was significantly related to BMI in Mexican Americans. Second generation Mexican American men increased BMI by 1.15 (kg/m^2), ($P<0.001$), and second generation Mexican American women increased BMI by 1.76 (kg/m^2), ($P<0.001$). Third generation Mexican American women experienced a BMI increase of 1.83 (kg/m^2), ($P<0.001$), and third generation Mexican American men increased BMI by 0.83 (kg/m^2), ($P<0.01$) (Khan, 1997, p.94). BMI was greater for second and third generations relative to first generation Mexican American men and women (Khan, p. 93-94).

Type 2 Diabetes in Mexico, Projections from Early Growth to Adulthood.

The number of individuals diagnosed with type 2 diabetes, represented as a percentage of the total population, is steadily increasing in Mexico, according to Jiménez-Cruz (2004). In Mexico, the percentage of the population with type 2 diabetes increased from 8.8% in 1993 to 11.4% in 1999. Additionally, among the southern states of Mexico, where there is a high occurrence of undernutrition and the largest population of Mexican Indians, there was an increase from 6.6% to 14.4% over the same time span of six years. As was previously discussed, obesity is one of the key factors contributing to type 2 diabetes, and is also increasing rapidly in Mexico, with the prevalence of obesity rising from 55% to 62% of adults between 1993 and 2000. Between 1989 and 1998, the prevalence of overweight and obese individuals also increased from 77.8% to 79.9% among 35- to 64-year-old men and women in the low-income Mexico City urban population (Jiménez-Cruz, 2004, p.1213), refer to Table 1.

The Mexico City Study.

The Mexico City study was a population-based study of type 2 diabetes in six low-income neighborhoods in Mexico City. The purpose of this study was to provide evidence (statistics) that an increasing number of Mexicans are being diagnosed with type 2 diabetes. Of 3,326 eligible men and non-pregnant women aged 35-64 years, 2,813 completed a home interview and 2,282 (68.5%) completed a baseline medical examination during 1990-1992. This study included an evaluation 7 years later, which was completed by 1,764 (77.3%) subjects. The baseline prevalence (percentage of the population) with NIDDM was 12.9% (Rull, 2005, 190).

The National Survey of Chronic Diseases.

This was a nationwide, cross-sectional study representative of the Mexican population, testing individuals from 417 cities. The sample was representative of the Mexican urban population, which in 1990 constituted 71% of the population. Information was obtained from 15,607 subjects with a response rate of 83%. The prevalence of NIDDM was 9.2% for women and 8.7% for men. When combined with the prevalence (% of population) of impaired fasting glucose (5.2%) and a glucose range of (110-125.9 mg/dL), which indicates a high likelihood of diabetes after further testing, the total prevalence reached 14.1% (14.4% in men and 13.9% in women). Overweight and obese statistics were also gathered during this study. Although these specific data were not available, Rull determined increased body weight was associated with type 2 diabetes. Compared to lean individuals, men and women with BMI of 25-29.9 kg/m^2 had increased chances of 1.61 and 2.06, respectively, for developing type 2 diabetes. For obese men and women, BMI > 30 kg/m^2, the corresponding chances of developing type 2 diabetes were 3.08 and 3.78 greater, respectively (Rull, 2005, p.190). The results of this study indicate that there may be a relationship between increased weight and type 2 diabetes.

Mexican National Health Survey 2000.

This study consisted of a structured, randomized, nationally representative Mexican sample, compared with a 1993 Mexican urban survey and the US Third National Health and Nutrition Examination Survey (NHANES III) of non-Hispanic whites. BMI was calculated as weight (kg) divided by the square of height (m). Waist circumference (WC) was measured at the midpoint between the "highest point of the iliac crest and the lowest part of the coastal margin at the mid-axillary line, to the nearest 0.1 cm."(Sánchez-Castillo, 2004, p.51). In this study, waist and waist/hip circumference were used as indices for abdominal obesity taking into account BMI. WC cut-off points were also used from the WHO criteria, 88 cm for women and 102 cm for men, to identify abdominal obesity. The results demonstrated that many Mexican adult men and women were overweight (41.3% and 36.3%, respectively) or obese (19.4% and 29.0%, respectively), similar to those in the U.S. in 1988-1992, though exceeding those of the 1993 Mexican survey. Abdominal obesity affected 46.3% of men (WC ≥ 94 cm) and 81.4% of women (WC ≥ 80 cm). There was a high prevalence of abdominal obesity in normal-weight, with co-morbidities relating better to WC than to body mass index (BMI) in both sexes. This study concluded that the high percentage of obesity—especially abdominal obesity—in Mexicans is associated with increased prevalence of NIDDM at levels comparable with or even higher than those in NHANES III of non-Hispanic whites (Sánchez-Castillo, 2004, 53). Table 4 (Sánchez-Castillo, 2004, 56) illustrates the prevalence of diabetes assessed in relation to body mass index (BMI) and waist circumference (WC), comparing Mexican men and women aged 20-69 years from the National Health Survey, 2000, with similar age-adjusted data from the US Third National

Health and Nutrition Examination Survey of non-Hispanic Whites. This revealed higher BMI and WC related to NIDDM prevalence in Mexican adults than in US adults with significant differences between American and Mexican women. From this, it is evident that body weight (expressed as BMI), is an important predictor of the prevalence of NIDDM (Sánchez-Castillo, 56).

The relationship of NIDDM to WC also revealed higher prevalence rates of NIDDM in Mexican than in US adults of comparable WC values (Sánchez-Castillo, 57). Abdominal obesity prevalence assessed by WC and taking into account BMI was much higher in Mexicans, particularly in women, than in the US adults. Taking into account upper WC cutoff points—88 cm for women and 102 cm for men according to the WHO—there was a much higher (21.7%) rate of abdominal obesity in Mexican women, even among those of normal BMI, than in US women (10%). Men had comparable rates (Mexicans 1.4% vs. Americans 3.0%). Table 5 illustrates the maximum amount of variance in type 2 diabetes prevalence with each factor waist circumference, body mass index, age, and height. For NIDDM in men, the first factor explaining most of the variance in the prevalence of type 2 diabetes (81.75%) includes the variables of WC, BMI, and height and the second factor depends on positive correlation with age. Contrastingly, in women, WC and BMI are the important variables in the first factor, contributing to the 76% of explained variance, but the second factor includes a negative correlation with age and a positive effect of height.

Guadalajara, Jalisco, Mexico.

In a cross-sectional study set in a hospital and a school of medicine in Guadalajara, Jalisco, Mexico, the objective was to identify early metabolic defects and insulin sensitivity in a group of Mexicans with a family history of NIDDM in first and second degree on the paternal side. The subjects were 20 healthy, non-obese, 19-20 year-olds, born in Mexico, and with a family history of NIDDM in first and second degree in the paternal branch. These 20 youths were compared to 20 control individuals. Clinical results of the subjects in both groups revealed that they did not differ in regard to sex, age, body weight, height, BMI, and blood pressure. Within a metabolic profile, only total cholesterol was slightly decreased in control subjects.

Pima Indians in Mexico and the U.S.

Using oral glucose tolerance tests and assessments for obesity, physical activity, and other risk factors, adult Pima-Indian and non-Pima populations in the Sierra Madre Mountains of Mexico were examined. These results were compared to those from Pima Indians in Arizona, where both Pima populations were typed for DNA polymorphisms to establish their genetic similarity (Schulz, 2006, p.1866). In the Mexican Pima Indians, the age- and sex-adjusted prevalence of type 2 diabetes (6.9%) was significantly less than that in the U.S. Pima Indians (38%) and was similar to that of non-Pima Mexicans (2.6%). The age- and sex-adjusted prevalence of type 2 diabetes in the U.S. Pima Indians was 5.5 times higher than that in the Mexican Pima Indians ($P<0.01$) and 16 times higher than that in the non-Pima Mexicans ($P<0.01$). The differences in prevalence of obesity between the Pima Indians in the U.S. and the non-Pima Indians in Mexico paralleled the large difference in diabetes prevalence. It was found that the prevalence of obesity was similar between the Mexican Pima Indians and non-Pima Mexicans (7% in men and 20% in women) and (9% in men and 27% in women) respectively, but was much lower than the U.S. Pima Indians, (63.8% in men and 74.8% in women). Obesity was 10 times more frequent in U.S. Pima men and >3 times more frequent in the women than in the Mexican Pima counterparts (Schulz, 2006, p.1869).

In both Mexican groups, physical activity measured as activity (hours/week) was much higher than in the U.S. Pima Indians, ($P<0.0001$) independent of sex and age. 89 non-Pima Mexican males were tested to reveal 30.4 (hr/week) average physical activity. Non-Pima Mexican women, (sample size = 99) had 23.8 (hr/week) average activity. These activity averages were comparable to Mexican Pima Indians with 32.9 (hr/week) and 22.0 (hr/week) for males (sample size = 105), and females (sample size = 116), respectively. U.S. Pima Indians had less physical activity with 12.1 (hr/week) and 3.1 (hr/week) for males (sample size = 316), and females (sample size = 412), respectively. Moderate to heavy physical activity (hr/week) was approximately 2.5 times higher in the Pima Mexican men and 7 times higher in the Pima Mexican women, than in the U.S. Pima-Indian equivalents.

Type II Diabetes in Mexico City and San Antonio, Texas.

In this study, a random sample of 35-to 64-year-old Mexican American men and women living in several low income barrio neighborhoods of San Antonio was compared to similarly aged Mexicans living in a low income colonia of Mexico City (Colonia Liberales). The purpose was to study genetic and environmental determinants of non-insulin dependent diabetes using World Health Organization criteria and genetic susceptibility inferred from percentages of Native American admixture. "The prevalence of diabetes was 45% higher in San Antonio men and 31% higher in San Antonio women than in Mexico City men (12.5%) and women (14.9%), respectively" (Stern, 1992, p.489). This difference was statistically significant (age- and sex-adjusted prevalence ration 1.36, P = 0.006). Despite the fact that genetic susceptibility was similar in the two cities, as inferred from the admixture estimates, this excess was still observed. It was also shown that Mexicans were leaner, as measured by body mass index (BMI) and skin folds, and Mexican women consumed fewer total calories than Mexican American women, although there was no difference found in men in caloric intake. Additionally, residents of Mexico City ate less fat (18%-19% of total vs. 31%-32% in San Antonio, P<0.001), more carbohydrate (64%-65% vs. 49%, P<0.001), and were more physically active than the San Antonio Mexican Americans (Stern, 1992, p.484). Mexicans had a lower total cholesterol, but appeared to consume more refined sugar and had higher triglyceride and fasting insulin concentrations than Mexican Americans (all P<0.002). Please refer to Tables 7 and 8.

World Health Organization (WHO) Statistics.

The most recent survey statistics were collected from the World Health Organization for Mexico and the Unites States on obesity prevalence, mean BMI, physical inactivity rates, and mean physical activity rates. The prevalence of BMI ≥ 30kg/m^2 for Mexicans in the combined age group of 20 years and older was found to be 28.1% and 18.6% for men and women, respectively. This compared with men and women from the United States under the same survey stipulations with 26.6% and 32.2%, respectively. The idea that, as a whole, Mexicans are leaner than Americans is further supported by the mean BMI (kg/m^2) in which Mexican women average 27.5 kg/m^2 and Mexican men average 26.4 kg/m^2, which compared to 28.2 and 27.8 kg/m^2 for women and men in the United States, respectively. Please refer to Tables 9-12. Table 17 and Figure 3 further illustrate this general pattern with greater BMI in people of the United States, compared to Mexicans. In addition to these survey statistics, data were collected from the WHO from similar rural and urban populations in Mexico. Please refer to Tables 13 and 14 for these statistics. In the urban, Mexican population, for both sexes, the median total minutes per week was 4,932, which compared to both sexes in the rural, Mexican population of 6,426 median total minutes per week.

Physical inactivity prevalence was also compared between similar populations in Mexico and the United States (Tables 15 and 16). Physical inactivity prevalence was defined by the WHO as the percentage of the population not meeting any of the following three criteria: 1) 3 or more days of vigorous activity for at least 20 minutes per day; 2) 5 or more days of moderate-intense activity or walking for at least 30 minutes per day; and 3) 5 or more days of any combination of walking, moderate-intense or vigorous-intense activities achieving a minimum of at least 600 MET-min/week. For both sexes in Mexico, the inactivity prevalence was 16.8% and the inactivity prevalence in the United

States for both sexes was 24.6%. This signifies that not only do people in the United States tend to have higher BMI rates, but they are almost 10% less active than Mexicans.

Incidence and Prevalence of Type 2 Diabetes in the Americas

The purpose of this study was to present the incidence and prevalence of type 2 diabetes in the Americans as found through a review of published information. The prevalence (% of population) of type 2 diabetes in Mexican-Americans (25.7%) was twice as high as for non-Hispanic whites (12.7%). U.S. Pima Indians in Arizona have the highest percentage of diabetes in the Americas and one of the highest in the world. After adjusting for age and sex with the world population as the standard, the prevalence of type 2 diabetes for Pima Indians 25 years of age or older in 1982-1990 was 51.4% overall for males and females (Barceló, 2001, 304). In addition to the high rates seen in the Pima Indian population in the state of Arizona, there is a high prevalence of type 2 diabetes observed in other Native American populations in Canada, Native River Desert (16.3% for males and females, respectively), Native, Lac Simon (23.9%, males, and 48.6%, females), in the ethnic/minority groups of non-Hispanic African Americans (19.8%), and Mexican-Americans (25.7%). This trend of high percentages of type 2 diabetes in populations where their ancestors originate from other cultures and countries calls into question the role of acculturation—changing behavior and assimilation to the diet, behaviors, and lifestyles of the United States—and potentially indicates the adverse affects of the American culture on health.

Mexican National Nutrition Survey 1999.

The purpose of this article was to discuss the main results and conclusions from the Mexican National Nutrition Survey 1999. Length/height and weight data in children <5 years were transformed into z-scores using reference data from the WHO and Center for Disease Control and Prevention. Children were classified as underweight, stunted, and wasted "when their z-scores were < -2 for weight-for-age, length/height-for-age and weight-for-length/height, respectively. Children < 5 years were classified as overweight when their z-scores > +2 for weight-for-length"; classification of overweight and obesity in children 5-11 years and non-pregnant women used the Body Mass Index (kg/m^2) (Rivera, 2003, p.5). This survey revealed one of every five children < five years of age (17.7%) was stunted (Rivera, 2003, p.7). On the opposite spectrum, the national prevalence of overweight children < 5 years old in Mexico was 5.3%. In children 5-11 years of age, the prevalence was 19.5%. The combined prevalence of overweight and obese women 18-49 years of age was 59.6% at the national level. These nutrition statistics indicate Mexico continues to have problems with overweight and underweight children respectively, and a large portion of females over the age of 18 are either overweight or obese.

Center for Disease Control and Prevention.

"Diabetes and Mexicans: Why the Two are Linked" was an article produced by the CDC, which addresses the possible connection between ancestral genetics, the "thrifty gene hypothesis", obesity, and the "type 2 diabetes pandemic" (Martorell, 2005, p.2). Martorell contributes to the study of Pima Indians in Arizona with the idea of the powerful role of intergenerational mechanisms, specifically, the risk of developing diabetes in adulthood as a result of prenatal exposure to diabetes. Among adults aged 20 to 24 years, the percentage of type 2 diabetes was found to be 1.4% if their mother was free of diabetes, 8.6% if she was prediabetic, and 45.5% if she had gestational diabetes (p.3). It was additionally found that 70% of individuals between the ages of 25 to 34 years with prenatal exposure developed type 2 diabetes (Martorell, 2005, p.3).

Acculturation Erodes the Diet Quality of U.S. Hispanics.

In a comparative dietary study at the University of California Berkeley, researchers Sylvia Guendelman and Barbara Abrams analyzed diet quality of immigrants and the following generations of Mexican Americans. These were then compared to non-Hispanic Americans using the Hispanic Health and Nutrition Evaluation Survey of 1982-1984 and the National Health and Nutrition Evaluation Survey of 1976-1980. Also discussed in connection to this study was another investigation completed by the USDA Economic Research Service. In this research, the relationship was compared between Hispanic ethnicity, income, and education levels and the intake of fat, saturated fat, and cholesterol. This study sought to separate the direct effects of Hispanic ethnicity from the indirect effect of less nutrition knowledge as a result of lower income and education (Aldrich, 2000, 53).

In another study based on the 1994-1996 Continuing Survey of Intake by Individuals (CSF II), the quality of Hispanic diets was analyzed based on acculturation.

In this study, Spanish was used as the basis for determining acculturation in that it was possible to compare the diets of non-acculturated Hispanics (Spanish speakers) with acculturated Hispanics (English speakers) and non-Hispanic whites, based on whether or not the individual was interviewed in Spanish. Scores based on the US Department of Agriculture's (USDA) Healthy Eating Index (HEI) were used to determine if diet quality deteriorates due to acculturation (Table 6). Developed by the Center for Nutrition Policy and Promotion, the HEI measured how well a diet conforms to ten dietary recommendations in the *Dietary Guidelines for Americans* and the food guide pyramid. A score within the range of 81-100 indicated a good diet, with 100 representing a perfect diet. Refer to Table 6 for additional HEI information. Six populations were examined using this scoring, which included adult and youth Hispanic English speakers, adult and youth Hispanic Spanish speakers, and adult and youth non-Hispanic whites. Although all six populations fall below the 81-100 good diet range, Spanish speakers eat more healthful diets than non-Hispanic whites and Hispanic English speakers.

Adult Spanish speakers averaged 65.11 on the HEI, which exceeded the 63.41 average of non-Hispanic whites and the 62.73 average of English speaking Hispanic adults. Even more striking were the results from Spanish speaking youths with a score of 69.44 compared to the average non-Hispanic white youth with a score of 66.49 and Hispanic English speakers with 64.96 on the HEI (Aldrich, 2000, 54). In this study, it was shown that differences in fat, cholesterol, and fiber intake contribute to the HEI scores of Spanish speakers as "adult Spanish speakers average approximately 4.6 grams per day less total fat and 1.9 grams per day less saturated fat than non-Hispanic whites" (Aldrich, 2000, 54). The consumption of cholesterol by Spanish speakers exceeds recommended levels in contrast to the consumption of the other groups that stay below recommended levels. Although not within the scope of this thesis, further research on the connection between cholesterol intake above recommended levels, obesity, and NIDDM could prove to be very interesting. Spanish speakers consume approximately 3.4 grams more of fiber per day than non-Hispanic whites, but the Spanish speakers still remain short of the standard of 25 grams per day, averaging only 19.4 grams. Hispanic English speakers fall behind Spanish speakers with 16.5 grams of fiber per day.

Discussion:

The purpose of this thesis was to investigate several questions pertaining to type 2 diabetes, Mexicans, Mexican Americans, obesity, and lifestyle/cultural factors such as, diet and physical activity. While type 2 diabetes and obesity were emphasized, diet and physical activity fell under the umbrella of cultural and environmental determinants. Throughout this thesis, many correlations and relationships were discovered relating directly to type 2 diabetes, but further research is needed to create concrete relationships. As we have seen in the *introduction* and *background* sections of this analysis, there are several other contributing factors, such as, obesity, unhealthy diets, high amounts of physical inactivity, and genetic susceptibility that contribute to the incidence and development of type 2 diabetes. Furthermore and of crucial concern, childhood malnutrition, such as undernutrition, obesity, pregestational obesity, and gestational diabetes have been shown to relate to the development of NIDDM later in life.

Significance of Obesity in U.S. Hispanics.

Martorell (2005) describes Mexican Americans as one of the most overweight groups in one of the "fattest nations on earth" (p.2). Three out of four Mexican American adults (aged >20 years) were either overweight or obese at the end of the 20th century. For Mexican Americans, it has been shown that cultural influences on subsequent generations affect body weight. Therefore, this analysis and other research propose that when adequate measures are available, BMI is associated with acculturation in Mexican

Americans even after controlling for demographic and socioeconomic variables. Most importantly, the basic relationships of BMI with SES did not change with the addition of acculturation indicators and no significant interactions between SES and acculturation indicators were found (Martorell, 2005, p.1). This provides evidence of the independent effects of culture and SES on BMI for US Hispanics.

Despite economic and educational disadvantages, the US Hispanic population, which includes Mexican Americans, has a health and mortality record remarkably better in some respects—such as lower incidence of cancer and cardiovascular disease—than the general American population. This identifies the relationship that if traditional Mexican diet patterns contribute to this positive health record, then an adaptation to typical American eating patterns may lead to an erosion of this solid health record. The Census Bureau defines Hispanics as those who indicate their origins as Mexican-American, Chicano, Mexican, Puerto Rican, Cuban, and central or South American. It has been shown by examining Hispanic diets, that Hispanics, who do not use English, eat healthier diets than do acculturated Hispanics (those who use English). In this particular study and thesis investigation, the terms healthy diet relate to the USDA suggested Food Pyramid. Although this article uses Hispanics as the general comparative group, this is inclusive of Mexican Americans and, therefore, the discovered results will be applied directly to the Mexican American population as a whole.

Importance of Type 2 Diabetes in Mexico, Projections from Early Growth to Adulthood.

Jiménez-Cruz (2004) indicates that "pregestational obesity and gestational diabetes, which are associated with high birth weight, are both risk factors for later obesity, [and] type 2 diabetes" (p. 1213). This article claims that the third reason as to why the prevalence of diabetes is surging in Mexico is based upon new evidence from longitudinal studies in several countries stating there is a high risk for the development of obesity and diabetes when malnourishment occurs early in life and is followed by catch-up growth during childhood (Jiménez-Cruz, 2004, p.1213). Although mortality rates due to infectious disease have been dramatically decreased due to government programs and food availability, which lower the prevalence of undernourishment *in utero* and the first years of life, this rate still remains higher than in developed countries. However, infectious diseases remain a large problem by affecting a considerable number of children and decreasing the opportunity for normal childhood growth and development.

Implications of the Mexico City Study and the National Survey of Chronic Diseases.

This is directly relevant to the diabetes epidemic, because "exposure to undernourishment early in life is a risk factor for development of diabetes" (Rull, 2005, p.189). This has been illustrated with native Americans and other non-Caucasian populations, where Indians (for example) have a diabetes prevalence of 2% when living in their own communities but, become "the most susceptible subjects, reaching prevalence >10% when they move to an urban environment. Mexican Americans are the group with the highest prevalence of diabetes in the U.S."(Rull, 2005, 189).

Importance of the Mexican National Health Survey 2000.

The results of the Mexican National Health Survey indicate that there is a genetic susceptibility to insulin resistance, obesity, and type 2 diabetes in Mexican and Mexican Americans related to their Amerindian (Native American) heritage. While a high prevalence of so-called thrifty genes (genotype) may impact susceptibility to insulin resistance and obesity, there may also be maternal factors including "multiple nutritional deficiencies which induce epigenetic changes *in utero* and during postnatal life" (Sánchez-Castillo, 2004, 54). This research by Sánchez-Castillo indicates early and long term limitations to height growth, such as poor maternal nutrition and limited postnatal animal protein intake, are not related to Mexicans' propensity to type 2 diabetes. Instead, it has been shown, independent of height, that low protein maternal feeding induces pancreatic changes, thereby reducing insulin secretion capacity (Sánchez-Castillo, 59). It was shown over 30 years ago in a study entitled "Persistent impairment of insulin secretion and glucose tolerance after malnutrition" (Sánchez-Castillo, 59) that protein-energy malnutrition in children caused pancreatic damage which seemed not to recover in insulin production even after rehabilitation and reestablishment of normal body composition. This research indicates there is a strong correlation between the high incidence of type 2 diabetes in Mexicans and their apparent susceptibility to abdominal fat (Table 4). Further research is needed to directly link abdominal fat distribution to an increase prevalence of type 2 diabetes, although excess weight and obesity are proven contributors to the expression of NIDDM. It is not clear why abdominal obesity is prevalent in Mexico, but in a parallel study, adult Guatemalans with similar childhood diets were more prone to abdominal obesity. This research proposes children nutritionally disadvantaged in early life have a predisposition to abdominal obesity (Sánchez-Castillo, 59).

Significance of Guadalajara, Jalisco, Mexico.

Although the primary defect resulting in the development of non-insulin dependent diabetes mellitus remains controversial, "there are at least two recognized pathological defects: insulin resistance and a relative insulin deficiency" (Gonzalez-Ortiz, 1997). In this study, three measurements were conducted to objectively identify insulin resistance. These included serum insulin, insulin/glucose ratio, and insulin tolerance test (ITT). Here it was shown that the measurements of insulin resistance and hyperinsulinemia were not affected by a strong family history of NIDDM in the paternal branch. Insulin resistance is a marker for NIDDM and generally appears 15-25 years or more before the onset of clinical diabetes. Due to the young ages of the studied population, this may explain the variability within insulin sensitivity values obtained for both groups, because the insulin-resistant phenotype may not be expressed entirely at this age. In addition to this possible explanation, the youths studied were healthy without other risk factors that contribute to insulin resistance with exception of the paternal history of NIDDM.

It is possible that insulin resistance appears only in people at risk when other risk factors are present (Gonzalez-Ortiz, 1997, 423). Identified in this study, familial NIDDM in the paternal branch may have a lesser influence than that of the maternal, especially since it has been illustrated that intrauterine environment strongly affects the development of diabetes (Gonzalez-Ortiz, 1997, p.423). The results of this study in summary show that in a group of healthy young Mexicans with a strong family history of NIDDM in the paternal branch, there are no differences in insulin sensitivity as compared to those without family history of NIDDM. The significance of these results is that, by eliminating other contributing factors, such as obesity, poor diets, and high amounts of inactivity, even a strong genetic predilection to NIDDM can be overcome. This is to say, if genetics can be reversed with a healthy lifestyle, then environmental/cultural factors, such as physical activity and diet, are the culprits for the high incidence of type 2 diabetes in both Mexicans and Mexican Americans.

Significance of the Pima Indian Study.

Type 2 diabetes and obesity have been shown to have genetic and environmental determinants. The objective of the study between Adult Pima-Indians, non-Pima Mexicans, and Pima Indians in Arizona was to analyze the specific effects of traditional and western environments on the prevalence of type 2 diabetes. Schulz concludes that "despite geographic separation, linguistic studies, and the current genetic distance, estimates indicate that they share a very similar genetic background and therefore, in all likelihood, carry similar diabetes and obesity susceptibility genes" (2006, p.1869). The much lower prevalence of type 2 diabetes and obesity in the Pima Indians in Mexico than the U.S. indicates that, even in populations genetically prone to these diseases, their development is mostly determined by environmental circumstances. It is most likely that the five-fold difference in the diabetes prevalence on the part of U.S. Pima Indians is attributed only to differences in lifestyle and the environment. It was found in the dietary study of the Mexican groups that a simple diet centered on beans, wheat flour tortillas, corn tortillas, and potatoes was most common, with much higher fiber and lower fat content than the diet reported for the U.S. Pima Indians.

Furthermore, most of the Mexican Pima Indians' physical activity is occupational in nature, and centered on providing food and sustenance for their families. These people primarily have a subsistence economy and grow most of their own food planting and harvesting crops by hand and plowing with the aid of oxen or mules. Additionally, these physical activities are done by both men and women (Schulz, p.1869). It is proposed that despite differences in dietary composition, the most striking difference between these Pima Indian populations is the disparity in energy balance due to physical activity. In contrast to the Mexican Pima Indians, the U.S. Pima Indians now have a more typical rural U.S. lifestyle with very low amounts of occupational physical activity (Schulz, 2006, p.1870). The majority of individuals have access to vehicle transportation, farming with machines, and foods purchased in local supermarkets. This study also strongly indicates that type 2 diabetes is largely preventable and provides evidence that lifestyle changes associated with westernization play a major role in the growing global incidence of type 2 diabetes. The results from this study provide further evidence for the negative effects of development and westernization, due to the fact that the Mexican Pima Indians live in a remote region only recently accessible by roads in the Sierra Madre Mountains and they have experienced relatively little recent change in environmental conditions, in contrast to the U.S. Pima Indians of Arizona. This study concludes that types 2 diabetes can be prevented, even in a genetically highly susceptible populations, and is preventable in environments which promote "low levels of obesity and high amounts of physical activity" (Schulz, 2006, p.1870).

Implications of Type II Diabetes study in Mexico City and San Antonio.

This study revealed a 36% greater prevalence of diabetes among San Antonio Mexican Americans than among Mexicans in Mexico City. It was also seen that the two populations were genetically similar based on admixture estimates. Mexicans were leaner than their Mexican American counterparts, based on BMI and skin folds, and Mexican women consumed fewer total calories than Mexican American women. Mexicans had higher triglyceride and fasting insulin concentrations than Mexican Americans ($P<0.002$). This is hypothesized to result for the high carbohydrate diet, which stimulates carbohydrate-induced hypertriglyceridemia. High blood levels of triglycerides were not offset by the greater physical activity and leanness of the Mexicans, compared to the Mexican Americans, which is evidence for the cause of relatively high rates of type 2 diabetes in Mexico. Refer to tables 7 and 8. Although Mexicans of both sexes preformed significantly less leisure-time physical activity than San Antonio men and women, their work-related and total physical activities were significantly greater. Although extracurricular exercise may be valued differently in Mexico than in the United States, there is an overall, large amount of fitness embedded in the Mexican culture (through work) which contrasts to that of the Mexican Americans studied.

Between the two populations, in this study the most remarkable behavioral difference was the lower fat and higher carbohydrate consumption in Mexico City. Research in animal studies has shown that high fat diets promote obesity. This is hypothesized to operate similarly in humans which might explain, in part, the high prevalence of obesity in Mexican Americans due, in general, to their larger consumption of fats compared to Mexicans. This is supported by cross-sectional surveys which indicate that individuals who consume diets containing a high percentage of calories from fat have an increased degree of adiposity, compared to those who consume high-carbohydrate diets (Stern, 1992, p.490). Furthermore, dietary intervention studies reveal that individuals on high-fat diets simultaneously consume more calories and gain more weight or lose less weight, than those on low-fat diets. This reinforces and provides evidence that dietary fat may contribute to the development of type 2 diabetes. Interestingly, while Mexican Americans tend to "consume more total fat and less total carbohydrate than their compatriots in their country of origin" (Stern, 1992, p.490), they appear to decrease their intake of refined sugars. This contrasts with Mexicans in which per capita sugar consumption exceeds the United States by 49%. Because Mexicans in Mexico City have fewer cases of diabetes, despite this higher intake of refined sugars, these findings "tend to exonerate refined sugars as a cause of type 2 diabetes" (Stern, 1992, p.490). The results of this study strongly mirror the results of the study in Guadalajara, Jalisco, Mexico of a group Mexicans with a family history of NIDDM in first and second degree on the paternal side in that both indicate environmental factors can override genetic susceptibility in the expression of type 2 diabetes.

Importance of the WHO Statistics.

The most recent statistics from the WHO revealed the prevalence of BMI ≥ 30kg/m^2 for Mexicans in the combined age group of 20 years and older to be 28.1% and 18.6% for men and women, respectively. This compared with men and women from the United States under the same survey stipulations of 26.6% and 32.2%, respectively. These survey statistics illustrate that by comparing the United States and Mexico, the entire United States population has a higher prevalence of obesity (% of population). As Mexicans transition to the United States and become accustomed to American foods and lifestyles, there is the possibility the same pattern of increased obesity will be seen in the Mexican Americans.

Data on physical activity was also collected from similar rural and urban Mexico populations. The purpose of these data was to illustrate that development, globalization, and transitioning to cities from rural, farm areas contributes to a decrease in physical activity and combined with an increased access to energy-dense foods, an increase in the prevalence of obesity and potentially type 2 diabetes. In the urban, Mexican population, for both sexes the median total minutes per week was 4,932, which compared to both sexes in the rural, Mexican population 6,426 median total minutes per week. This significant difference in amount of physical activity between the two populations reveals that there is, in fact, a decrease in physical activity between rural and urban life (measured in median total minutes per week). This might potentially contribute to the increasing prevalence of obesity and type 2 diabetes in the Mexican population as more individuals make this transition. In the comparison between the two countries on physical inactivity prevalence, for both sexes in Mexico, the physical inactivity prevalence was 16.8% and the physical inactivity prevalence in the United States for both sexes was 24.6%. This signifies that not only do people in the United States tend to have higher BMI rates but they are almost 10% less active than Mexicans. The results of the data from the World Health Organization illustrate that, in general, people in the United States are heavier and exercise less than Mexicans. This can be hypothesized to directly relate to the decrease in diet quality and increase in obesity and type 2 diabetes prevalences experienced by Mexicans moving to the United States during the acculturation process.

Implications of the Incidence and Prevalence of Type 2 Diabetes in the Americas.

The prevalence of type 2 diabetes for Pima Indians 25 years of age or older in 1982-1990 was 51.4% for males and females (Barceló, 2001, 304), (Table 2). Native American populations in Canada, non-Hispanic African Americans, and Mexican-Americans in the United States are also disproportionately affected by type 2 diabetes. Although this cannot be directly connected, it is possible to insinuate that this high incidence (% of population) of type 2 diabetes in Mexican Americans, non-Hispanic African Americans, and other Native American populations is related to the migration and changing diet, behaviors, and lifestyles of their ancestors. The Mapuche Indians of Chile who, in 1985, were nearly free of type 2 diabetes, showed in 2000 prevalence rates of 3.2% and 4.5% among males and females, respectively. These results suggest that an acculturation process including low amounts of physical activity and hypercaloric diets can lead to dramatic increases in NIDDM rates (Barceló, 2001, 306).

Significance of Mexican National Nutrition Survey 1999.

Despite development and an increase in food availability, Mexico paradoxically retains problems with malnutrition. Stunting continues to be an important public health problem with one of every five children < five years of age (17.7%) stunted (Rivera, 2003, p.7). On the opposite end of the spectrum, obesity is an increasing epidemic with the national prevalence of overweight children < 5 years old being 5.3% and children 5-11 years of age, it is 19.5%. The combined prevalence of overweight and obese women 18-49 years of age was 59.6% at the national level, which indicates that not only will children be at higher risk to become overweight due to environmental conditions, but they may additionally, be susceptible to gestational diabetes in the womb, and genetic predispositions to both obesity and type 2 diabetes (Rivera, 2003, p.11-12).

Importance of the Center for Disease Control and Prevention.

As we have seen with the comparison of Mexican Americans in the Hispanic Health and Nutrition Examination Survey 1982-1984 (HHANES) and NHANES III, there are a large number of overweight Mexican Americans. While many physical factors determine body weight, it is stated that “social factors must be considered as among the most important, if not the most significant influence upon the prevalence of obesity today” (Khan, 1997, 91). In Arizona, Pima Indian adults aged 20 to 24, were found have 1.4% type 2 diabetes if their mother was free of diabetes, 8.6% if she was prediabetic, and 45.5% if she had gestational diabetes (p.3). This strongly supports that the hyperglycemic intrauterine environment created by gestational diabetes is an important determinant of early onset type 2 diabetes, and is potentially above any transmissible genetic proclivity (Martorell, 2005, p.3). The genetic predisposition for having diabetes in the Mexican population becomes evident with environmental changes.

Significance of the Acculturation Erodes the Diet Quality of U.S. Hispanics.

It is thought that diet could contribute to the lower-than-expected incidence of cancer and cardiovascular disease in the US Hispanic population, because the quality of diet surpasses that of non-Hispanics. From this study, they concluded that as women of Mexican origin transition from first to the second generation, the quality of diet deteriorates and is similar to that of white, non-Hispanic women (Aldrich, 2000, 53). Interestingly, lower incomes were found to be associated with less healthful diets (fast food) among non-Hispanics, and more healthful diets were found among first-generation Mexican Americans. Hispanic ethnicity was strongly correlated to fat reduction, including saturated fat, and cholesterol intake. This positive reduction was reversed, to a certain degree, by the indirect effects of less knowledge of nutrition and healthy diets as a consequence of lower levels of education and income. This study provides evidence that Hispanic populations, including Mexican Americans, have generally healthy diets according to the Food Guide Pyramid due, in part, to their Mexican/Hispanic heritage and culture. It was additionally shown through this study that Spanish speakers' higher HEI scores are not the result of better nutritional knowledge, although they do attach more importance to having a healthful diet. This contrasts with non-Hispanic whites who record more dietary knowledge, less emphasis on the importance of a healthful diet, and lower HEI scores (Aldrich, 2000, 54). While it is hypothesized that the limited nutritional knowledge of Spanish speakers is due to the limited access to advertising and labeling information in English, it is thought that non-Hispanic whites have higher incomes which may lead to convenience foods and "eating out" more frequently. These foods more likely have increased fat and cholesterol levels with less fiber then home-prepared foods. While income was not analyzed in this particular study or in this thesis, it is possible to see this trend in the general population of increased consumption of convenience fast foods.

Conclusion:

Research has shown that type 2 diabetes has both environmental and genetic determinants. In the Pima Indian study by Schulz, genetically similar Mexican Pima Indians were compared to U.S. Pima Indians. Although these two populations share a common genetic background, they have dramatically different lifestyles. From this study, it was concluded that the large difference in prevalence of type 2 diabetes between the two populations was based primarily on environmental determinants. In this context, environmental determinants refer to all factors which are not genetically based and are instead, associated with lifestyle, such as diet and physical activity. Because foods and the emphasis placed on exercise vary considerably between different countries, in this thesis, physical activity and diet both fell under the umbrella of "culture". In this way, culture, environmental determinants, and acculturation are all synonymous.

Notwithstanding, based on the numerous studies analyzed in this thesis, evidence indicates the importance of eating a healthful diet and exercising regularly in order to prevent type 2 diabetes regardless of a strong predilection towards this disease. Other factors have also been identified as showing a strong correlation to type 2 diabetes. These include: obesity, particularly in the abdominal region; transitioning from rural to urban areas with decreased physical activity and increased access to energy-dense fast and convenience foods; the intrauterine environment created by gestational diabetes; and malnutrition early in life contributing to impaired insulin secretion and glucose tolerance. Although the process of acculturation is complex and is influenced by linguistic, social, and cultural factors, and economic changes, transitioning to the American lifestyle has been shown to negatively affect Hispanic health. It has been illustrated that Mexican Americans are, on average, more than twice as likely to have diabetes as non-Hispanic whites of similar age (www.ndep.nih.gov) and, at the close of this investigation, there is evidence that acculturation to the American lifestyle is partially responsible. While acculturation is a long-term process during which individuals simultaneously learn and modify certain aspects of their values, norms, and behavior, including diet and lifestyle, it is important to recognize that this progression varies with ethnicity and generation (Zamalloa, 2006, p.9).

Zamalloa also proposes that people moving from developing countries frequently incorporate elements of the developed country when interacting with their culture. This interaction often leads to the adoption of unhealthy habits and lifestyles, in an attempt to assimilate completely to the new society. An outcome of this analysis has been to highlight the effect of genetics in the acculturation process, and the manner in which men and women are affected differently. Although not within the scope of this investigation, gender roles potentially contribute to women spending significant time in occupational, household, and family activities, and less time in recreational and physical conditioning activities (Zamalloa, 2006, p.11). Through the analysis of numerous studies, it has been found that, in general, populations moving from a traditional to a more modern or westernized environment experience higher rates of type 2 diabetes. The factors involved in this migration process which are believed to contribute the most to the expression and prevalence of type 2 diabetes include: increased consumption of calories; high consumption of total and saturated fats; large consumption of refined sugars; decreased consumption of carbohydrates and fiber; and decreased physical activity (Stern, 1992, p.484).

Continuing Research

In the *background* section it was proposed that although people and cultures combine and blend to form new identities, parts of their respective backgrounds remain in the newly formed culture or identity. By studying Mexican heritage and the connection to Spain, it is possible to determine if Spanish ancestry contributes to the genetic susceptibility of Mexicans to NIDDM. Among the European countries Spain has one of the highest prevalence of type 2 diabetes (Rull, 2005). Although this connection was outside of the scope of this analysis, an interesting study would be to look at the prevalence of NIDDM in the Spanish population and relate key genetic sequences in both populations. In this way, Spanish genetics may be partly responsible for the high incidence of type 2 diabetes in all Mexican populations, including Mexican Americans. One proposal to combat the rising prevalence of obesity and type 2 diabetes in Mexico is to include more adequate prenatal care for obese and overweight mothers with gestational diabetes, enhanced monitoring of growth and nutrition during postnatal period, and intervention programs to educate and promote physical activity and healthy eating at pre-school and grade school levels.

Through this research and numerous other studies, obesity has extensively and clearly been connected as one of the major factor contributors to developing type 2 diabetes. Of particular interest, a recent study analyzed the effect of the β_3 adrenergic receptor on obesity in Mexican Americans. Located on chromosome 8, the β_3 adrenergic receptor regulates energy expenditure and lipolysis and it has been shown that a missense mutation in this gene, characterized by the replacement of tryptophan by arginine at codon 64 (Trp64Arg), is associated with obesity in some studies. Using a paired sibling design to minimize variability due to genetic background, Mitchell and associates concluded that the Trp64Arg variant is associated with obesity in this Mexican American population. With further research, these results may help to explain, in addition to lifestyle and environmental factors, the cause of the high prevalence of obesity in Mexican Americans and even genetically similar Mexicans.

More research is needed to identify a direct relationship between the acculturation process and the development of obesity and type 2 diabetes. Two experiment considerations are the analysis of vitamin D intake at specific longitudes to determine potential relationships between the prevalence of type 2 diabetes and location. In addition to this, although Mexicans consume more refined sugar than Americans, the use of high fructose corn syrup inside and outside of the United States may reveal interesting correlations between health and type 2 diabetes.

One of the major conclusions of this investigation has been that environmental factors can override genetic predispositions for obesity and diabetes and that there is hope for a healthier United States and Mexican American population. This optimism is found in a new food pyramid entitled the Latin American Diet Pyramid, which recommends traditional foods as better for health, emphasizing the benefits of grains, such as maize, quinoa and plantains, and tropical fruits, such as mangos and papayas. The 16-page pamphlet called “Camino Magico” or Magic Road is a campaign launched by the Latino Nutrition Coalition which provides ideas for dishes for all three meals of the day, ways to read and interpret labels and nutrition facts, and shopping lists. This project addresses issues, such as acculturation to American diets and cuisine and being educated in healthy foods. With this new information, Latin Americans can hopefully adopt a healthy diet and balance between traditional, Mexican foods, and those of the American culture, avoiding the negative effects of acculturation on diet and health.

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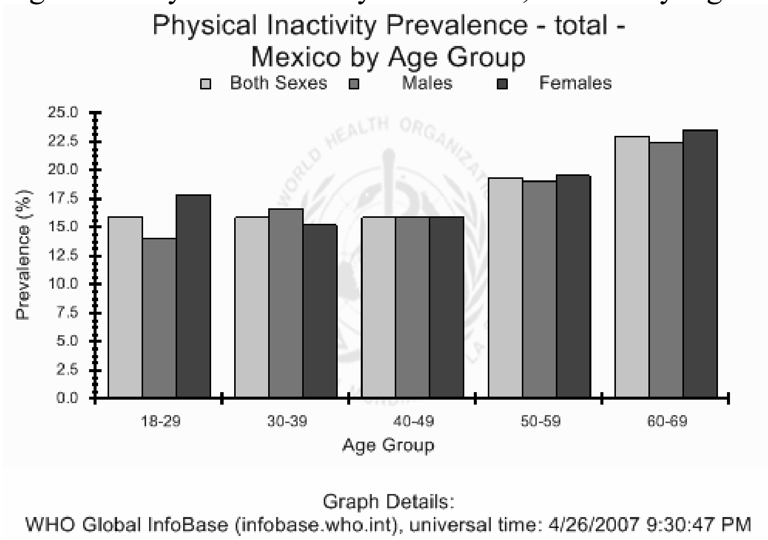
Appendices

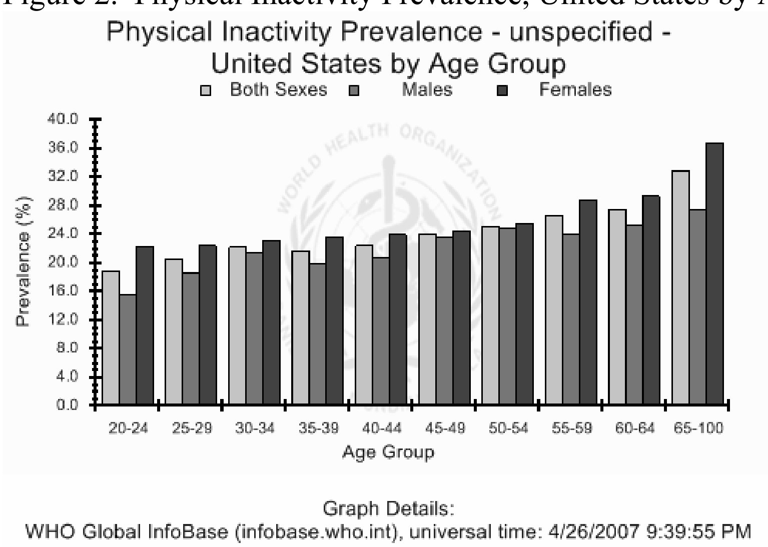
Appendix A

Figure 1. Physical Inactivity Prevalence, Mexico by Age Group



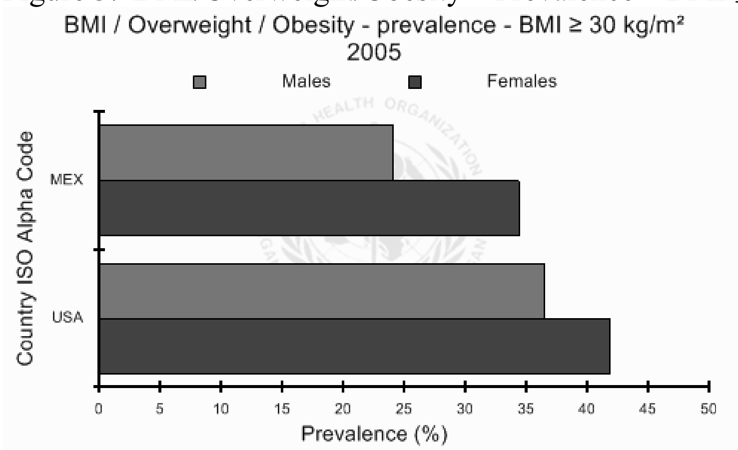
World Health Survey, Mexico, 2003, Physical Inactivity Prevalence, Domain = Total, Definition Code = IPAQ Inactive, Period = Last Week, National Study, both rural and urban populations

Figure 2. Physical Inactivity Prevalence, United States by Age Group



Behavioral Risk Factor Surveillance System, 2003 Physical Inactivity Prevalence, Unspecified Domain, Definition Code = Inactive, Period: Last Month, United States, National Study, both rural and urban.

Figure 3. BMI/Overweight/Obesity—Prevalence—BMI ≥ $30kg/m^2$



Appendix B

Table 1. Trends of diabetes and overweight in Mexico (Jiménez-Cruz, 2004, 1214).

Disorder	Source	Age-group (years)	Cutoff	Prevalence (%)
Diabetes Fasting blood glucose Any blood glucose Fasting blood glucose Any blood glucose	1992-1993 2000	20-69 20-69	≥7 mmol/l ≥11 mmol/l ≥ 7 mmol/l ≥ 11 mmol/l	8.5 10.7
Glucose impairment Fasting blood glucose Any blood glucose			≥6.1-7 mmol/l ≥7-11 mmol/l	12.7
Overweight	1992-1993 2000	20-69 20-69		35 38
Obesity	1992-1993 2000	20-69 20-69	≥ 30 mmol/l ≥ 30 mmol/l	20 24.4
Overweight/ obesity	1992-1993 2000	20-69 20-69	≥ 25 mmol/l ≥ 25 mmol/l	55 62.4

Table 2. % Prevalence of Type 2 Diabetes Among Populations in the Americas (Barceló, 2001, 305)

Country	Population, reference	Crude rates (95% CI)			Adjusted rates (95% CI)		
		Male	Female	Both	Male	Female	Both
Mexico	Mexico City (26)	10.6	14.8	13.0	11.9 (8.0-17.2)	17.9 (13.5-23.5)	14.9 (11.9-18.6)
	Mexico City (27)	6.6	11.0	8.7	8.7 (5.7-12.8)	12.0 (8.6-16.4)	10.4 (8.1-13.3)
United States	General Population (28)	14.8	13.8	14.3	14.7 (12.8-16.5)	13.1 (11.4-14.8)	13.9 (12.6-15.2)
	Non-Hispanic	-	-	-	13.9 (11.3-	11.5 (9.1-13.9)	12.7 (11.0-

	Whites (28)				16.5)		14.5)
	Non-Hispanic African Americans (28)	-	-	-	19.5 (15.3-23.7)	20.1 (15.9-24.4)	19.8 (16.8-22.8)
	Mexican-Americans (28)	-	-	-	24.0 (19.4-28.6)	27.5 (22.6-32.3)	25.7 (22.4-29.1)
	Pima Indians (30)	-	-	-	50.2 (47.8-52.7)	52.6 (50.3-54.9)	51.4 (49.7-53.1)
Canada	Native, River Desert (25)	17.6	16.3	-	16.3 (7.9-24.7)	16.3 (9.0-23.6)	-
	Native, Lac Simon (25)	22.2	44.3	-	23.9 (12.9-34.9)	48.6 (38.4-58.8)	-

Table 3. Obesity in US Hispanics, LK Khan, 1997 Regression Models for BMI as function of Socioeconomic and Acculturation indicators and adjusting for age.

Mexican American		
Coeff (SE)	Men (n = 1418)	Women (n = 1723)
Education (y)	-0.00 (0.04)	-0.05 (0.04)
Poverty Index Ration	0.00 (0.00)	-0.00 (0.00)**
Employment	0.16 (0.32)	1.22 (0.28)***
Marital status	-0.83 (0.30)**	-0.40 (0.27)
Language	-0.05 (0.15)	-0.56 (0.18)**
2nd Generation	1.15 (0.34)***	1.76 (0.39)***
3rd Generation	0.83 (0.31)	1.83 (0.37)***
	R-square = 0.008	R-square = 0.13

*P<0.05; **P<0.01; ***P<0.001
Employment: 0= employed and 1 = unemployed
Marital status: 0 = married and 1 = unmarried

Table 4. Prevalence of diabetes assessed in relation to body mass index (BMI) and waist circumference (WC), CP Sánchez-Castillo, 2005.				
	Men		Women	
	Mexico	U.S.	Mexico	U.S.
BMI (kg/m2)				
21-22	4.3*	0.4	6.4*	0.3
23-24	1.2	1.4	5.1	3.4
25-26	6.1*	2.2	6.8*	1.1
27-28	9.7*	3.9	10.8*	6.2
29-30	4.7	6.9	13.0*	5.0
>30	10.6	11.5	17.3*	10.4
WC (cm)				
70-74	3.9*	0.0	7.7*	0.0
75-79	5.9*	0.4	0.8	0.2
80-84	1.0	1.0	4.3	2.5
85-89	5.0*	0.1	6.6*	3.3
90-94	6.4*	1.0	11.9*	2.8
95-99	2.9	1.6	9.2*	4.6
100-104	11.9	8.5	11.9	9.4
105+	9.9	10.9	21.7*	11.9

* Significant difference between national groups: P<0.05. The overall diabetes prevalence was 0, 2.6, and 13.8% in 20-29, 30-49, and 50-69 year old US men, respectively, compared with 0.8, 6.4, and 16.7% in Mexican men. Comparable prevalences for US women were 1.3, 2.6, and 9.3% compared with 2.6, 9.2, and 29.6% for Mexican women.

Table 5. Sánchez-Castillo, 2004, Factor Loading Patterns.				
	Factor Loading			
	Diabetes Mellitus			
	Men		Women	
Variable	Factor 1	Factor 2	Factor 1	Factor 2

Waist circumference (cm)	0.946	0.113	0.961	-0.067
Body mass index (kg/m2)	0.888	-0.316	0.919	-0.067
Age (years)	0.006	0.942	0.326	-0.630
Height (m)	0.661	0.388	0.130	0.862
% of total variance	81.7	28.7	76.0	28.7

"Factor loading patterns after orthogonal rotation of principal components for the anthropometric values and age in relation to type 2 diabetes (NIDDM) in men and women in the factor analysis. Each factor (set of factors) accounts for a maximum amount of variance in NIDDM prevalence. Factor loadings are equivalent to a Pearson's correlation coefficient between each variable and the factor. Factor loadings | ≥0.4| (numbers in bold type), which share a least 15% of variance with the factor, were used in interpretation and analysis. The value of factor loading indicates the importance of a variable in the definition of the pattern" "Sánchez-Castillo, 2004"

Table 6. Hispanic Spanish Speakers Score Highest on Healthy Eating Index (Aldrich, 2000)

Population	Healthy Eating Index scores	
	Age 18 and over	Under 18
Non-Hispanic White Hispanic Spanish speakers Hispanic English speakers	63.41 65.11 62.73	66.49 69.44 64.96

*Score of 100 indicates a perfect diet; scores in the range of 81-99 indicate a good diet; scores in the range of 51-80 indicate a diet that needs improvement; and scores of 50 or under indicate a poor diet.

The Healthy Eating Index score is the sum of 10 components, each representing different aspects of a healthful diet:

- **Components 1-5** measure the degree to which a person's diet conforms to the USDA's Food Guide Pyramid serving recommendations for the five major food groups: Grains group (bread, cereal, rice, and pasta), vegetables group, fruits group, milk group (milk, yogurt, and cheese), and meat group (meat, poultry, fish, dry beans, eggs, and nuts).
- **Component 6** measures total fat consumption as a percentage of total food energy (calorie) intake.
- **Component 7** measures saturated fat consumption as a percentage of total food energy intake.
- **Component 8** measures total cholesterol intake.
- **Component 9** measures total sodium intake.

- **Component 10** examines variety in a person's diet.

The maximum score of each component is 10, with a minimum score of zero. Intermediate scores were computed proportionately. The maximum overall score for the 10 components combined is 100. High component scores indicate intakes close to recommended ranges or amounts; low component scores indicate less compliance with recommended ranges or amounts.

Table 7. Age-adjusted behavioral variables in San Antonio (SA), Texas, barrio Mexican Americans and in Mexico City (MC), Stern, 1992

	Men		Women		Age-adjusted P-value	
	SA	MC	SA	MC	Sex	City
n† Total calories (kcal)	51 2678 ± 113	282 2689 ± 48	77 2322 ± 92	362 1966 ± 42	SA:0.051 MC:<0.001	M:0.91 W:<0.001
Calories (%) Protein Fat Carbohydrate Alcohol	14.4 ± 0.3 31.0 ± 0.7 49.4 ± 1.0 3.1 ± 0.5	14.7 ± 0.1 18.4 ± 0.3 63.6 ± 0.4 2.9 ± 0.2	16.5 ± 0.2 32.6 ± 0.6 49.0 ± 0.8 0.2 ± 0.4	15.6 ± 0.1 19.0 ± 0.3 65.3 ± 0.4 0.3 ± 0.2	SA:<0.001 MC:<0.001 0.035 0.007 <0.001	M:0.36 W:0.001 <0.001 <0.001 0.94
Sugar avoidance (0-5)	1.77 ± 0.14	1.09 ± 0.06	2.58 ± 0.12	1.60 ± 0.05	<0.001	<0.001
Physical activity n† Leisure-time METs Work-related METs Total METs	44 166 ± 8 116 ± 11 282 ± 8	226 154 ± 3 136 ± 5 290 ± 3	65 163 ± 7 94 ± 9 257 ± 6	303 146 ± 3 131 ± 4 277 ± 3	0.026 0.29 <0.001	0.007 <0.001 0.004

Table 8. Prevalence of NIDDM in SA, Texas, barrio Mexican Americans and in MC, Mexico, Stern, 1992

	Men				Women			
	SA		MC		SA		MC	
	n	%	n	%	n	%	N	%

Age-group (years) 35-44 45-54 55-64	9/199 24/121 43/150	7.6 19.8 28.7	8/134 11/92 10/48	6.0 12.0 20.8	29/222 56/235 85/239	13.1 23.8 35.6	10/185 20/116 24/64	5.4 17.2 37.5
Crude rate Age-adjusted rate	76/390	19.5 17.8	29/274	10.6 12.3	170/696	24.4 23.0	54/365	14.8 18.5

Table 9. Prevalence of BMI ≥ 30kg/m2 for Mexico by Age Group (World Health Organization)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI
20-29	3,457	11.8	-	8,448	16.7	-	11,905	14.4	-
30-39	3,124	20.9	-	7,719	29.6	-	10,843	25.5	-
40-49	2,429	23.9	-	5,336	39.9	-	7,765	32.3	-
50-59	1,813	25.5	-	3,658	40.6	-	5,471	33.3	-
60-69	1,383	23.7	-	2,465	36.1	-	3,848	30.3	-
70-79	847	15.4	-	1,312	27.5	-	2,159	21.8	-
80+	321	10.3	-	437	17.0	-	758	14.0	-
20+	**13,374**	**18.6**	**17.9-19.3**	**29,375**	**28.1**	**27.6-28.6**	**42,749**	**23.6**	**23.2-24**

Encuestra Nacional de Salud, Mexico, 2000, National Study, both rural and urban populations, Data Type = prevalence, Definition = 30 kg/m2, World Health Organization; Data Type = body mass index, Definition = mean BMI (kg/m2)

Table 10. Body Mass Index—Mean BMI (kg/m2) Mexico by Age Group, (World Health Organization)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Mean Value kg/m2	± SD	Sample Size (n)	Mean Value kg/m2	± SD	Sample Size (n)	Mean Value kg/m2	± SD
20-29	3,457	25.2	4.5	8,448	25.6	4.9	11,905	25.4	-
30-39	3,124	26.9	4.4	7,719	27.9	5.2	10,843	27.4	-

40-49	2,429	27.5	4.5	5,336	29.3	5.5	7,765	28.4	-
50-59	1,813	27.6	4.7	3,658	29.3	5.5	5,471	28.4	-
60-69	1,383	27.1	4.5	2,465	28.9	5.5	3,848	28.0	-
70-79	847	25.8	4.3	1,312	27.2	5.3	2,159	26.5	-
80+	321	24.8	3.8	437	26.1	4.6	758	25.5	-
20+	**13,374**	**26.4**	**-**	**29,375**	**27.5**	**-**	**42,749**	**27.0**	**-**

Encuestra Nacional de Salud, Mexico, 2000, National Study, both rural and urban populations, Data Type = prevalence, Definition = 30 kg/m2, World Health Organization; Data Type = body mass index, Definition = mean BMI (kg/m2)

Table 11. Prevalence of BMI ≥ 30kg/m2 for United States by Age Group (WHO)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI
20-24	382	19.7	14.9-25.5	357	23.1	18-29	739	21.3	17.3-25.9
25-29	349	19.9	15.6-25.1	310	30.9	24.4-38.3	659	24.9	20.5-2.9
30-34	348	23.6	19.2-28.6	337	29.7	24.1-35.9	685	26.6	22.7-30.9
35-39	376	25.8	21.4-30.8	379	30.1	25.3-35.3	755	27.9	24.1-32
40-44	431	30.0	25.2-35.3	425	32.0	26.4-38.1	856	31.0	26.9-35.3
45-49	365	27.7	22-34.2	384	37.4	30.4-44.9	749	32.8	28.6-37.3
50-54	352	31.8	25.4-38.9	358	35.1	29.9-40.8	710	33.5	29.4-37.9
55-59	254	31.0	24.8-37.8	248	40.3	33.3-47.8	502	35.6	30.4-41.3
60-64	391	39.2	33.7-45	405	41.8	35.6-48.3	796	40.6	37-44.3
65+	1,212	24.6	21.5-28	1,226	29.4	26.3-32.8	2,438	27.4	25-29.9
20+	**4,460**	**26.6**	**24.8-28.4**	**4,429**	**32.2**	**29.9-34.6**	**8,889**	**29.5**	**27.6-31.4**

National Health and Nutrition Examination Survey (NHANES) 2002; both urban and rural populations, United States, World Health Organization, national survey, Data Type = prevalence, Definition = BMI ≥ 30kg/m2; Data Type = body mass index, Definition = mean BMI (kg/m2)

Table 12. Body Mass Index—Mean BMI kg/m2 for U.S. by Age Group (WHO)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Mean Value kg/m2	95% CI	Sample Size (n)	Mean Value kg/m2	95% CI	Sample Size (n)	Mean Value kg/m2	95% CI
20-24	368	26.2	25.6-26.7	352	26.2	25.3-27.1	720	26.2	25.6-26.8
25-29	344	27.0	26.4-27.5	302	27.4	26.6-28.3	646	27.2	26.6-27.7
30-34	337	27.2	26.7-27.8	328	27.6	26.6-28.6	665	27.4	26.8-28
35-39	367	27.8	26.9-28.6	370	28.1	27.1-29.2	737	27.9	27.2-28.7
40-44	424	28.3	27.8-28.9	408	28.3	27.2-29.5	832	28.3	27.6-29
45-49	350	28.4	27.5-29.3	375	28.8	27.6-29.9	725	28.6	27.9-29.3
50-54	345	28.8	28-29.6	351	28.8	27.8-29.7	696	28.8	28.1-29.4
55-59	249	28.5	27.8-29.2	240	29.8	28.7-30.9	489	29.2	28.5-29.8
60-64	371	28.9	28.3-29.5	398	29.7	28.8-30.7	769	29.4	28.8-29.9
65+	1,107	27.8	27.5-28	1,119	27.9	27.5-28.4	2,226	27.9	27.6-28.1
20+	**4,262**	**27.8**	**27.6-28.1**	**4,243**	**28.2**	**27.8-28.5**	**8,505**	**28.0**	**27.7-28.3**

National Health and Nutrition Examination Survey (NHANES) 2002; both urban and rural populations, United States, World Health Organization, national survey, Data Type = prevalence, Definition = BMI ≥ 30kg/m2; Data Type = body mass index, Definition = mean BMI (kg/m2)

Table 13. Rural Mexico Median Physical Activity (WHO)

Age Group	Males		Females		Both Sexes	
	Sample Size (n)	Median Value (total minutes/week)	Sample Size (n)	Median Value (total minutes/week)	Sample Size (n)	Median Value (total minutes/week)
18-29	1,033	8,532.0	1,557	4,746.0	2,590	5,892.0
30-39	968	10,080.0	1,300	5,544.0	2,268	7,680.0
40-49	609	8,640.0	838	5,634.0	1,447	6,720.0
50-59	490	10,584.0	630	4,518.0	1,120	6,696.0
60-69	413	4,320.0	451	3,528.0	864	4,066.5
18-69	**3,513**	**8,964.0**	**4,776**	**5,040.0**	**8,289**	**6,426.0**

World Health Survey, Mexico, 2003, Physical Activity Median, National Study, Rural population, Domain = Total, Measurement Units = Minutes, Time Unit = Per Week

Table 14. Urban Mexico Median Physical Activity (WHO)

Age Group	Males		Females		Both Sexes	
	Sample Size (n)	Median Value (total minutes/week)	Sample Size (n)	Median Value (total minutes/week)	Sample Size (n)	Median Value (total minutes/week)
18-29	3,559	5,884.0	5,073	4,170.0	8,632	4,851.0
30-39	3,002	5,760.0	4,105	5,091.0	7,107	5,386.5
40-49	2,145	6,216.0	2,886	4,965.0	5,031	5,337.0
50-59	1,380	4,194.0	2,024	4,158.0	3,404	4,158.0
60-69	1,068	3,186.0	1,411	3,840.0	2,479	3,756.0
18-69	**11,154**	**5,610.0**	**15,499**	**4,524.0**	**26,653**	**4,932.0**

World Health Survey, Mexico, 2003, National Survey, Physical Activity Median, Urban population, Domain = Total, Measurement Unit = Minutes, Time Unite = Per Week

Table 15. United States Physical Inactivity Prevalence (WHO)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI
20-24	5,517	15.6	14-17.3	7,984	22.2	20.6-23.9	13,501	18.9	17.7-20.1
25-29	6,922	18.5	16.8-20.4	10,736	22.4	21-23.9	17,658	20.5	19.3-21.6
30-34	8,579	21.3	19.7-22.9	12,892	23.2	21.9-24.6	21,471	22.2	21.2-23.3
35-39	9,550	19.8	18.3-21.3	13,846	23.5	22.2-24.9	23,396	21.6	20.7-22.7
40-44	11,067	20.8	19.5-22.2	15,978	23.9	22.6-25.2	27,045	22.4	21.4-23.3
45-49	11,011	23.6	22.1-25.2	15,872	24.4	23.1-25.7	26,883	24.0	23-25
50-54	10,642	24.8	23.2-26.4	15,104	25.5	24.1-26.9	25,746	25.1	24.1-26.2
55-59	8,904	24.1	22.5-25.7	13,227	28.8	27.3-30.3	22,131	26.6	25.5-27.7
60-64	7,294	25.4	23.5-27.3	11,232	29.3	27.8-30.8	18,526	27.5	26.3-28.7
65+	19,545	27.4	26.3-28.6	35,123	36.8	35.9-37.7	54,668	32.9	32.2-33.6
20+	**99,031**	**22.2**	**21.7-22.7**	**151,994**	**26.9**	**26.5-27.4**	**251,025**	**24.6**	**24.3-25**

Behavioral Risk Factor Surveillance System, 2003 Physical Inactivity Prevalence, Unspecified Domain, Definition Code = inactive, period: Last Month, United States, national, both rural and urban populations

Table 16. Mexico Physical Inactivity Prevalence (WHO)

Age Group	Males			Females			Both Sexes		
	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI	Sample Size (n)	Prevalence (%)	95% CI
18-29	4,592	14.0	12.4-15.6	6,630	17.9	16.3-19.5	11,222	16.0	14.7-17.3
30-39	3,970	16.6	14.9-18.4	5,405	15.2	13.6-16.8	9,375	15.9	14.6-17.2
40-49	2,754	15.9	13.8-17.9	3,724	16.0	14.0-17.9	6,478	15.9	14.4-17.5
50-59	1,870	19.1	16.5-21.7	2,654	19.5	17.2-21.9	4,524	19.3	17.4-21.2
60-69	1,481	22.5	19.5-25.4	1,862	23.6	20.8-26.3	3,343	23.0	21.0-25.0
18-69	**14,667**	**16.2**	**15.0-17.3**	**20,275**	**17.5**	**16.3-18.7**	**34,942**	**16.8**	**15.8-17.9**

World Health Survey, Mexico, 2003, Physical Inactivity Prevalence, Domain = Total, Definition Code = IPAQ Inactive, Period = Last Week, National Study, both rural and urban populations

Table 17. Comparative Mexico and United States BMI/Obesity/Obesity Prevalence (2005)

Country	Males		Females	
	Age Group	Prevalence (%)	Age Group	Prevalence (%)
Mexico	15+	24.0	15+	34.3
United States	15+	36.5	15+	41.8