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A Modern Examination of Marcus Goldstein's Mexican Immigrant Population Data: Comparisons of Mexican-born and U.S.-born Children and Adults Living in 1930's America and Mexico

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By

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Modern statistical methods were employed in order to test the statistical validity and conclusions of Marcus Goldstein's (1943) original data consisting of nineteen different anthropometric measurements on two different groups of individuals, Mexican immigrants and their children residing in the San Antonio, Texas area and Mexican natives living in central and northern Mexico. Using independent samples T-tests, an analysis of covariance, and an RMET analysis, significant differences among variables compared between Mexican natives and Mexican immigrants and their U.S. born children were identified and interpreted. Variation was attributed to geographical location and length of time spent in the United States. Plasticity of the human skeleton, specifically cranial measurements, were observed.

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CHAPTER I. INTRODUCTION

In 1912 Boas pioneered a study on environmental effects on growth and development by studying changes in the bodily form of descendants of European immigrants in the United States. Primarily written to combat racism and racist ideals of fixed body types, Boas was able to disprove the idea of body typing based on race by convincingly arguing that differences in the environment can have lasting impacts on the growth and development of all human organisms, regardless of race. Following Boas's lead, in 1943 Goldstein published a study conducted on Mexican immigrants and their children in the United States. Like Boas, Goldstein found distinct differences between both the children born in the United States when compared to their Mexican born counterparts, as well as differences between said children and their immigrant parents. To Goldstein, the data was irrevocable proof of Boas's theory that environmental differences affect human physical growth and development. In particular Goldstein found that the US born children were physically larger in overall features including stature and head measurements, and he attributed this difference to greater access to resources during childhood. The general conclusions made by Boas, Goldstein, and others are the basis for this analysis.

Boas's (1912) study was met with both success and criticism. At that time many still held the belief that fixed racial types resulted in heterogeneity of physical growth and its ultimate manifestations in bodily form. Today, race and its associated connotations are still a highly debatable topic; however, the initial criticisms brought forth by Boas's publication have shifted from focusing on race to emphasis on identifying environmental versus genetic factors. Recently there has been several studies reanalyzing Boas's original data and conclusions (Gravlee et. al. 2003; Sparks and Jantz 2002). Using modern statistical techniques scholars have both confirmed

(Gravless et. al. 2003) and disputed (Sparks and Jantz 2002) Boas's original findings and the topic is still widely debated topic in anthropology today.

Much like the abovementioned studies, this study is designed to reanalyze Goldstein's (1943) data using modern statistical techniques in order to test the reliability of his original conclusions. Much like Boas, Goldstein's findings further supported the idea that a different environment can lead to changing patterns of growth and development. Goldstein concluded that children of immigrants experienced an environment more conducive to growth, thus resulting in modified physical features including, among other things, becoming taller than both their parents as well as those children living in Mexico. Numerous studies, to be discussed in a later section, both support and perpetuate the theory that improved environmental conditions can alter physical growth; however, there is an opposing side to this particular debate.

While there are those who believe environmental influences are the primary conduit for variation in physical growth, there are also scholars who believe that genetics have a greater impact on changing growth patterns. Gene flow and natural selection, for example, are thought to leave a much greater impression on growth and development then simply changing the environment. This study analyzes the variation in anthropometric measurements collected by Goldstein for his study and places them in proper context using historical information about environment, genetics and possible selective forces. The goal is to perform a modern statistical analysis on the data in order to evaluate anthropomorphic measurements between Mexican immigrants and their children, along with the children of Mexican natives. Statistical analyses performed lead to tentative conclusions regarding the effects of environment versus genetics with regards to this population.

Using Goldstein's compiled data as the backbone for this analysis, a set of working hypotheses are developed. The first is that when comparing Mexican born children to United States born children there will be significant differences between at least one of the variables with regards to the data. Similarly, there will be significant differences between variables when comparing Mexican immigrants living in the United States and their United States born children. These differences will be evaluated in light of a number of different contexts and situations, with an aim to derive tentative conclusions regarding the influences of genetics or environment. When viewed as a whole, the validity of Goldstein's conclusions will be assessed using both modern statistical techniques as well as historical context.

The initial purpose behind both Boas's and Goldstein's research was to undermine racism and the rigidity of fixed physical typologies while at the same time attribute changes in human growth and development to an ever-changing entity – the environment. As the environment improves, so does the potential for the greatest optimum growth. For anthropologists, it is extremely important to look at growth and development in humans as it allows one to find answers to past human life as well as predict trends for future research. By reanalyzing past studies in modern contexts, a greater understanding of the processes involved in growth and development can be obtained and a multitude of further questions can be posed that might lead to an even greater understanding of the processes of human life and the role that environment or genetics may play. Although this project is meant as a preliminary study on the basic differences of individual measurements in two populations living in different environments, it has the potential to add significant information to the scientific community.

CHAPTER II. BACKGROUND

The United States is a country rich in the history of thousands of cultures spanning hundreds of years and incorporating people from many different countries. The experience of immigration is different for every person; however, the underlying feelings of struggle and the need for acceptance, as well as the amount of energy and perseverance required to provide a better life for his or her children is something that is shared in some way among each group of people who choose to make the United States their home.

Mexican immigrants to American are no exception to this, but its close proximity and Mexico's shared history of war and land disputes with the United States makes the immigration experiences of Mexican immigrants different from those of the European immigrants. Until 1848, Mexico controlled the territory which is now California, Utah, Nevada, Colorado, and parts of New Mexico and Arizona (Meyer and Sherman 1987), having lost Texas to its Anglo inhabitants in a war 12 years earlier in 1836 (Miller 1985). Following the Mexican-American War, Mexico was forced to sell the abovementioned territories to the United States at a cost of 15 million as a condition of peace negotiated through the Treaty of Guadalupe Hidalgo (Miller 1985). With the addition of new territories, American citizens began to slowly trickle in and populate; however, many Mexicans still remained and were given the choice to determine their citizenship (Miller 1985), resulting in a blending of cultures and a confusing identity.

In the late 1930s when Goldstein collected and analyzed anthropometric measurements of Mexican immigrants, many of the immigrants that resided in the United States, especially in border states such as Texas, lived unique existences. Much of their traditional cultural practices, beliefs and language remained focal points in their lives as they had been in Mexico; however, the effort to coexist with Anglo Americans in the United States had also left its own impressions on their daily lives. This chapter will look at the migration experience of the population of lower class Mexican immigrants in the 1930s, a population much like those that Goldstein (1943) and his colleagues would have interviewed, measured and written about. In addition, this chapter will view the experiences of these Mexican immigrants moving to the United States as a whole process, detailing their lives and amenities in both countries while attempting to understand the underlying factors that would cause such a movement and ultimate change in the lives of many migrating families.

Life in Mexico – A History of Migration to the United States

The history of Mexico has been fraught with various groups vying for political control, beginning when Francisco Hernández de Córdoba and his party of 110 Spanish "adventurers" landed on the northeastern section of the Yucatán peninsula in 1517 (Miller 1985). By 1521 Spanish troops had crushed the native population, the Aztecs, and controlled all of Mexico and many of its surrounding areas (Miller 1985). The people of Mexico were not able to gain their independence until 1821 (Miller 1985), after many years of fighting, but even after throwing off Spanish oppression, infighting and power struggles between generals and political powers led to a seemingly endless stream of revolts and totalitarian regimes each having greater detrimental effects on the lowest class of people.

As a country Mexico is representative of some of the most extremes of urban and rural landscape. In the 1930s the capital, Mexico City, exhibited all the signs of a booming cosmopolitan city influenced by Western culture. Two million people, many of whom were foreigners, resided there. In stark contrast was the rest of the country; roughly eighteen million people scattered in about 80,000 small villages usually numbering no more then 100 people (Kibbe 1946). Comprising the majority of the population, the small rural farmers and unskilled laborers composed the lowest class of people in Mexico. These are the people who generally stood the most to lose in times of depression, and were hit the hardest during a particularly tumultuous political period. It is also these people who made up the majority of the migratory and immigrant population.

In the years prior to 1910 the main reason for immigration was, for the most part, purely economical. The California gold rush in 1848 attracted many Mexican immigrants hoping for financial gain, intent on eventually taking their earnings back to Mexico (Martinez 1971). With a tradition of immigration established, the door was open for more Mexicans to migrate to the United States as seasonal workers both in the booming cotton and sugar beet plantations as well as the construction of the Pacific and Santa Fe lines of the railroad in the Southwest. It was not until the years following 1910 with the onset of the escalating Mexican Revolution that Mexican natives began to immigrate to the United States in much larger numbers, and more and more with the intention of making it their permanent home.

The Mexican Revolution began in 1910 primarily because of escalating issues involving poor land management in the form of the "hacienda system" which resulted in inadequate farmable land for about nine to ten million farmers (Miller 1985). For ten years citizens of Mexico from all professions and social classes joined together in rebel groups to overthrow political oppression and instate a number of policies that would for example; redistribute land more equally, instate protective labor laws, expand public education, limit Church power, and much more (Miller 1985). Almost every city and town in Mexico was affected by the fighting, and everywhere people suffered from the lack of food and income. The Revolution had profound effects on immigration to the United States. Impoverishment for all classes was intensified, food was extremely scarce, especially to the lower classes that relied on farming, agricultural production fell off at a significant level, and land mismanagement appeared to be worse then before as private owners bought off much of the redistributed hacienda land from impoverished peasants who could not afford to farm it (Martinez 1971). The number of Mexicans that immigrated to the United States went from 73,528 in 1911 to 98,595 in 1912. By 1917 over one third of a million immigrants, not including those who crossed illegally, had crossed the border into the United States (Duran Ochoa 1955).

By 1920 fighting had largely abated and Mexico had both a new Constitution and President. The ten years of war; however, had taken a large toll on the country, especially on public and social organizations like education (Meyer and Sherman 1987). The 1920s saw a large number of Mexican immigrants who entered the United States, jumping from 34,025 in 1920 to 102,215 in 1924 (Gamio 1930). With Mexico suffering the aftermath of long years of struggle, there was simply more opportunity in America to earn money. The Immigration Act of 1917, passed by the United States, attempted to stop the flow of immigrants; however, many Americans, especially those in businesses that required large amounts of manual labor encouraged Mexican immigration by providing seasonal contracts, higher wages and in some cases small tenant farms to Mexican immigrants. The onset of World War I also necessitated the importation of foreign labor due to the shortage of American men (Martinez 1971). Typically, Mexican immigrants would move to the United States on a seasonal basis with every intent on returning to Mexico; however, the years following the Mexican Revolution saw a number of families immigrate and set up more permanent residences. In fact, many businesses in the habit of using Mexican labor often encouraged such families as it established both the stability of the worker as well as provided even more hands to do a job (Martinez 1971).

The 1920s saw some of the largest number of Mexican immigrants to cross the border into the United States. Towns in Texas, California, Arizona and New Mexico especially were crowded as the migration of Mexicans moved steadily more northward. Families rather then single men made up the majority of those immigrating by this time as greater economic opportunity and jobs contributed to the steady influx of people. Now, more then ever, the United States was forced to look at the sheer numbers of people and reevaluate the place of its social, political and economic institutions and stances in their lives. This is where we find the immigrants that make up the vast majority of Goldstein's (1943) sample. The following sections look at the lives and living conditions of Mexican immigrants in the United States and compares them to those in Mexico.

The Population

Historically, there was a large variety of immigrants from Mexico that moved to the United States. These groups included the aristocratic descendents of the Spanish conquistadors and skilled professionals who represent the middle class of Mexican society, down to the most illiterate and poor of Mexican hacienda farm workers. However, the greatest bulk of the immigrants who traveled to the United States from Mexico were mestizo (of Indian and Spanish backgrounds) and represented the lower classes of Mexican society, specifically the serf or peon on a hacienda (Bogardus 1970; Gamio 1930). Being the majority of the immigrants, it was this group of people who Goldstein (1943) studied for his analysis, and therefore it is this group of people that will be the focus of the current research.

There were a number of characteristics that set the abovementioned group of Mexican immigrants apart from their aristocratic or professional counterparts. To begin with, they were extremely poor upon moving to the United States, and many of them did not possess a knowledge of the English language, nor were they literate in Spanish in most cases. There was also a strong religious and cultural background and way of life that permeated their existence. Upon arrival into the United States many of the lower class of Mexican immigrants refused to give up traditional cultural practices and beliefs for a long time. In many cases it was the children of these immigrants who became truly American by living their lives like Anglos and adopting American customs. Both the intolerance that the immigrants experienced in American cities coupled with the difficult adjustment to a new place bound many Mexican immigrants together in large ethnic groups. The establishment of Mexican sections in many towns was both the conscious and unconscious efforts of intolerant Anglos as well as uncertain Mexican immigrants (Bogardus 1970; Gamio 1930; Kibbe 1946). The following sections look specifically at this group of Mexican immigrants in an attempt to understand the physical and social processes at work on a whole population striving to fit in and understand an alien land.

Life in the United States

For many immigrants the United States represents a dream of a better life for themselves and their children. Not only do they hope for more economic stability with higher paying jobs, but also access to adequate food, health care, housing and public institutions such as education. Mexicans who immigrated to the United States were no exception to this rule, but in many cases they found it hard to adjust in the face of extreme prejudices and intolerance by white residents. Like the Irish, Italian, Chinese and Japanese immigrants before them Mexicans had become the new face of immigration by the 1920s, and many were viewed with resentment wherever they made their homes (Martinez 1971). Banding together in large groups or settlements had been a primary strategy among immigrants of different populations historically to combat intolerance and establish a comfort zone in a foreign country, and Mexican immigrants were no exception.

Many small towns, especially along the Mexican border in states like Texas, were primarily made up of Mexican immigrants and their American born children. These sections were labeled colonias and were generally centered in some of the worst sections of urban areas. The lack of adequate sanitary conditions and poor housing intensified American prejudice against Mexican immigrants, associating them with a low level of existence not up to par with white American society (Martinez 1971). Perhaps the worst offenders of prejudice against Mexican immigrants were the citizens of Texas. By 1930 Texas had a population of 683,681 Mexican immigrants (US Bureau of Labor Statistics 1933), much higher then any other state at the time and thus feeling the effects of accommodating an ever growing immigrant population.

Socioeconomic Conditions of the Mexican Immigrant in the United States

Mexican immigrant labor in the United States was classified into one of three categories: unskilled laborers, skilled laborers and tenant farmers or farmers on shares (Gamio 1930). Unskilled laborers made up the majority of the Mexican immigrant workers and were usually typified by agricultural workers such as cotton, orange or sugar-beet pickers and processors. Skilled laborers represented those class of workers who specialized in some sort of skill or aspect including manufacturers of specific types of raw material, metals or wood as well as tailors and shopkeepers, for example. However, skilled labor in the United States was harder to come by and many of these workers found themselves starting over as an unskilled laborer or supplementing their income as a skilled laborer with various odd jobs. Tenant or share farmers were farmers on a very small scale. These were the more permanent set of Mexican immigrants in the United States and were usually those who have lived there the longest, many times starting out as an unskilled migratory laborer (Gamio 1930). Employment trends among Mexican immigrants and their American born children can be seen in a study done by Grebler et. al.

(1970) which pointed to the disproportionate amount of these groups of people in farm laborer jobs compared to Anglos and nonwhite populations. In addition, Mexican immigrants and their children, even in the 1960s, were vastly underrepresented in white-collar occupations. Factors which contributed to these statements will be discussed below.

Although work in the United States was both hard and at times unstable, if the worker worked seasonal labor it meant dramatic increase in wages from those in Mexico that provided the incentive for many desperate Mexicans to immigrate. As was stated in the above section, two of the foremost reasons to immigrate to the United States were lack of adequate land and sufficient wages or means to make money. The average pay for an unskilled worker in Mexico was about 0.57 cents per day and about $17.67 per month. When that figure is compared to the amount needed to live normally, about $123.74 per month, then it is clear why many people in Mexico were struggling to make ends meet and thinking that migrating to the United States might offer a better life (Gamio 1930). An additional study suggests that the average pay for a Mexican farm laborer was actually much lower at about 0.12 cents per day plus a small ration of corn and beans. The pay for a skilled worker in a city was about 0.32 cents a day (Saenz 1926). In a study done by Gamio (1930) on hundreds of Mexican immigrants living in the United States and their families, he found that the average wage per day for an unskilled worker in the United States was at minimum $1.50. There were also examples of laborers who were paid as high as $6.00 a day depending on both the amount of skill needed to complete a job as well as the specific company. On average Gamio (1930) found that the pay was about $3.38 per day, or about $104.78 per month. When compared to the amount of money that was paid in Mexico for the same job the difference is staggering. In the United States these unskilled workers were being paid six times as much as they were in Mexico.

In a similar study done by Warbuton et. al. (1943) the authors found that of the 342 Mexican immigrant families interviewed in Hidalgo County, Texas many did not earn more then about $5.95 per week. These families were all migratory laborers working a variety of jobs, but were primarily cotton or sugar-beet agricultural workers. Only about half of the families were permanent residents of Texas while the rest migrated across the United States following the farming seasons of different agricultural products. Although these wages are very low in comparison to the above study done by Gamio (1930) it is important to note that Warbuton et. al. (1943) interviewed a number of families who were not restricted to purely agricultural jobs. Of these 80 families the median earnings were about $9.95 per week. Families who had members participating in both agricultural and non-agricultural jobs made about $6.90 per week. It is clear from this study that unskilled laborers working primarily migratory agricultural jobs as cotton pickers, for example, represent the lowest amount earned. Warbuton et. al. (1943) attributes this to the instability of the agricultural seasons as well as the jobs themselves. A bad year for crops could heavily influence the amount of pay received as well as the amount of jobs available. In addition, if much of the time was spent on the move or in search of a job then money was ultimately lost. Although this study brings light of the fact that life in the United States is not always as prosperous as one would think, it must still be kept in mind that there was a reason why even when these families could only bring home about $6.00 per week, they still continued to migrate to the United States. This evidence of the continuous flow of people into the United States each year despite low wages spoke volumes about their previous wages in Mexico.

It is perhaps important to note that even though Mexican workers in the United States were being paid much more then they were in Mexico, they were still not being paid as much as a white worker doing the same job; however, in many cases there were contracts involved which left little room for argument and much room for mistreatment of the workers themselves (Bogardus 1970). In addition, many Mexican workers were not allowed to join American labor unions which may have increased their status in the workplace. The first Mexican labor union in the United States did not develop until 1927 while not achieving any real status until 1928 (Bogardus 1970). Despite its initial successes many American workers and labor unions fought against it, seeing Mexican labor as a way to "keep down" overall labor standards for whites as Mexicans would generally work for much lower pay then white laborers (Bogardus 1970). Lack of proper education was also a factor when it comes to wages earned.

Two other factors that must be taken into account were the cost of living in the United States versus Mexico, and the amount of education received by both the Mexican immigrants and their children. Regarding the former, in many cases Mexican immigrants were impressed by the increase in pay that was available in the United States; however, they did not understand that the cost of living was about two times as high as that of Mexico (Bogardus 1970). In addition to the cost of living, many immigrants were faced with the fact that they did not possess the right educational background or training for many of the higher paying, non-agricultural jobs. This was due in part to the inadequate social and public programs available to immigrants as well as the need for children in immigrant families to become wage earners rather then attend school (Ramirez 1970). However, despite these factors studies have shown (Grebler et. al. 1970) there was a general trend of increasing wages for the subsequent generations of American born children of Mexican descent detailing the amount of potential for a better life available for children born in the United States.

Overall, Mexican immigrants to the United States and their American born children made more money then they would have doing the same type of job in Mexico. Even with the cost of living in the United States, the prejudice and intolerance faced by these immigrants, and the unequal working conditions and wages earned between Mexican immigrants compared to white residents the overriding influx of people into the United States from Mexico bears testimony to the fact that life and the potential for a better life is perhaps greater then it would have been if these people had stayed in Mexico.

Living and Housing Conditions in the United States for the Mexican Immigrant

There is generally some debate among scholars interested in the life of the Mexican immigrant in the United States as to whether or not housing conditions in the United States were actually a fair step above those in Mexico. In the above section it is clear that Mexican workers were earning a good deal more in the United States then in Mexico; however, the higher cost of living in the United States was definitely a factor when looking at households and the availability of domestic conveniences for Mexican immigrants. Regardless, when compared to previous conditions in Mexico, there is substantial evidence that would point towards better housing conditions in the United States.

Housing in Mexico among the lower class of people can be divided into urban or rural settings. In rural districts and towns houses changed little from the time of Spanish occupation. They were generally one or two roomed huts made from locally procurable materials such as adobe, volcanic rock, trunks of trees or sapling, branches, palm-thatch and grass. A Spanish traveler to Mexico, Frances Calderón de la Barca (1954), described rural Mexican landscapes as having a “universal air of dreariness” where most of the “huts showed traces of having been fine buildings in former days,” but were now “roofless and windowless with uncultivated patches that may have once been gardens" (p. 151). Most were without electricity or toilets, generally relying on candles or oil lamps for lighting and outhouses for toilet facilities (Gamio 1930). In addition, in many country houses the floors were of dirt which was attractive to fleas, rodents and other sorts of vermin (Thompson 1921). In contrast, city dwellings were extremely crowded and dirty where large groups of the poorer classes would live together in buildings with one or two room dwellings rather then the one family per house setting in rural towns. Sometimes as few as four and as many as twenty people would share one room, with an average of about seven per room (Thompson 1921). The residents of a building would generally share a community pump, or large mud puddle, for water and a community toilet of the cess-pool type. These urban buildings full of people were labeled the "vecindad," or "neighborhood" with negative connotations (Gamio 1930). They have also been likened to "slum tenements" of the absolute worse conditions (Saenz 1926). Perhaps a third class of households could be established as well, that of the homeless people who lived in large cities. For these people, the ancient hostelries that formally housed horses and stagecoaches became home. Eighty or more people were crammed into horse stalls each night, with the numbers continuing to swell for the time period (Thompson 1921). It is clear that the housing situation for the lower class, be it in a rural or city setting, is far from adequate.

Gamio (1930) recognizes four types of dwellings associated with Mexican immigrants living in the United States. These were classified as small and modern with several rooms, derived from the vecindad of Mexican cities, one or two roomed houses usually made up wood, and poor huts made of wood or tin. Housing type was typically a result of economic status and income, and families averaged about eight people in a house with 3.5 rooms (Goldstein 1943). This average was compared to that of Anglo families living in Texas where the average family had about 4.97 people living in about three rooms (University of Texas Bureau of Research in the Social Sciences 1938). When the numbers are compared there is an obvious difference between the two groups in number of people per number of rooms in a household; however, Goldstein (1943) observed that the children of these Mexican immigrants showed numbers very similar to that of the Anglo families (5.2 people per 2.9 rooms). These comparisons bear testimony to the fact that although housing for some Mexican immigrants may not be marginally better then that in Mexico there was a greater potential for their children to live in improved conditions in the United States.

Perhaps the largest problem facing the housing situation for Mexican immigrants in the United States was overcrowding, despite the survey done by Goldstein (1943) listed above. This can be attributed to a variety of factors including the general large sizes of Mexican immigrant families compared to Anglo families, and the availability of housing in “Mexican colonies.” In many cities in the United States, those in Texas being the foremost, Mexican immigrants were not allowed to own property outside of specifically Mexican areas, or “colonies” (Kibbe 1946) due to extreme racial prejudices of many of the Anglo citizens. In more recent decades, this has ceased to be the case, but the roots of social segregation and intolerance still run deep. Housing in these areas was generally limited, and the dwellings themselves were not of good quality, but progress was consistently made on behalf of housing authorities to improve the quality of housing available to immigrants as well as Anglos (Grebler et. al. 1970).

There were two factors that contributed to better housing in the United States over that in Mexico. These were the availability of public assistance in improving the quality of households, and the high rate of ownership of households among Mexican immigrants (Bogardus 1970; Grebler et. al. 1970; Kibbe 1946). State and local governments in the United States had to face the influx of Mexican immigrants for a considerable period of time. Anytime large groups of people become permanent residents in towns and cities it becomes a huge dilemma for authorities to accommodate them. Although public housing assistance had been a slow process, especially in southwestern states, there were efforts to improve the quality of housing for not only Mexican immigrants, but lower class citizens of every ancestral affiliation. Housing authorities in San Antonio, Dallas, El Paso, Corpus Christi, Dumas, Brownsville and Laredo, Texas set up a number of housing developments in 1944 for Mexican immigrant communities, including a number of public programs and centers in addition to the dwellings (Kibbe 1946). The results of these programs were very promising, with cleaner neighborhoods and improved lives of tenants. After the success of this project, many other towns in Texas and surrounding areas followed suits and launched "slum clearance" projects designed to provide better housing situations for Mexican immigrants and their children (Kibbe 1946).

High rate of ownership of houses among Mexican immigrants was another important factor in producing a better quality of life for their children. Home ownership implies a certain degree of freedom that comes from not owing a landlord a monthly allowance which, in most cases, allowed the owner to use money that would be going to rent on other things. In addition, owning a home would have also allowed the children of these immigrants something in the way of inheritance, especially if the home was surrounded by some land. In either instance, the children of Mexican immigrants were allowed the potential to live a more advantaged lifestyle then they would have in Mexico.

Overall, although housing conditions were still generally poor for most Mexican immigrants living in the United States, there are a number of reasons why living in here would have been a vast improvement over living in Mexico. Perhaps the greatest improvement, mentioned above, was the ability for the immigrant parents to provide more opportunities for better lives for their children.

Access to Health Care in the United States

Health care in Mexico, especially for the lower classes, was not something that was easy to obtain. The overall lack of professional doctors left people in rural settings extremely susceptible to diseases that thrived in dirty, poor conditions. Principle among these diseases was diarrhea, pneumonia, tuberculosis and malaria, contributing to a death rate among Mexicans of 22.4 per thousand, or twice that of the United States' in 1936 (Kibbe 1946). As was stated above, the most important factors in the spread of disease was both the lack of doctors available to treat and administer medications, as well as the squalid conditions facing Mexican peasants. A study done by Kibbe (1946) showed that in 1936 "peasant Mexico had only one doctor for every 6,869 inhabitants." In addition, 84,000 towns and villages "had no medical assistance whatsoever" (p. 58).

Another suitable indicator of the lack of access to appropriate health care was the death rates among children and adults. In 1910 the infant mortality rate was 1.93 times that of the United States. The number steadily increased in the later age categories to about 3.20 times that of the United States in the 30 to 45 years of age category (Thompson 1921). Ten years later in 1921 the rates of mortality had not much improved with studies indicating that nearly half of the living Mexicans were under 20 years of age, one third of the population was living at the age of 30, and only one fifth of the Mexican population lived to the mature age of 40. When this is compared to similar statistics in the United States, where the average age was 35 and half of all citizens lived to be at least 42, the results are staggering (Thompson 1921). In the late 1930s the situation had improved somewhat with an average child mortality rate among Mexicans of three per family compared to Mexican immigrants in the United States who averaged only two child deaths per family (Goldstein 1943). The results of these studies and statistics indicate a surprising lack of longevity and overall poor health among children of Mexican families living in Mexico.

The biggest contrast between access to health care in the United States versus that in Mexico was the availability of both health care and social services in the United States. However, there was still high mortality, especially among infants for Mexican immigrants living in the United States. The biggest causes of public health concern among Mexican immigrants were tuberculosis and diarrhea. The city of San Antonio, Texas, the focus of Goldstein's (1943) study, listed 143 per 100,000 Latin American deaths in 1942. This is compared to 45.6 among Anglo Americans and 88 among African Americans (Texas Summary of Vital Statistics 1942). There were a number of factors involved, chief among them were the poor sanitary conditions faced by a number of Mexican immigrants, especially in the urban districts. Additional factors included the relatively low income of many families, as well as some families' cultural and religious beliefs that may have prevented them from seeking modern medical care (Madsen 1970).

Although conditions appeared to be the same in the United States as they were in Mexico, there were many examples of social service organizations reaching out to poor immigrant areas in order to provide proper health care. The rate of attendance in American hospitals appeared related to the amount of time that the Mexican immigrants had been living in the United States. Outreach by community medical centers and organizations coupled with the education that the children of immigrants were receiving in school about proper hygiene techniques and infectious disease prevention demonstrated that vast improvements could be made in the home (Bogardus 1970).

Although disease and unsanitary conditions still played a major role in the lives of Mexican immigrants living in the United States, there was evidence that through education and community programs they were able to make improvements in the way that they lived. Overall, conditions in the United States were only a marginal improvement from those in Mexico in terms of sickness and disease, especially in border states like Texas whose harsh prejudices against Mexican immigrants coupled with its close proximity to Mexico, made it so that social change and improvement occurred at much slower rates.

Food and Nutrition in the United States

The type of food eaten in Mexico was mostly homogenous throughout the population regardless of class. Corn tortillas, beans and chilies were by far the most popular staple of the Mexican peasant class, but can also be seen in the wealthiest households. The biggest difference between the higher and lower classes with regards to nutrition and food staples was the portion sizes along with differential access by the higher class to a more balanced diet that included meats and vegetables (Thompson 1921). Portions for the lower classes were generally smaller and varied through economic factors as well as the amount of access to a small garden or ranch of some sort. Usually, the types of food did not go beyond tortillas, beans, chilies and one or two vegetables, but occasionally this would be supplemented by chicken, pork, turkey or eggs (Gamio 1930).

Access to a balanced diet was some cause of concern among Mexicans of the lower class. Prior to and for some years following the Mexican Revolution the availability of high quality milk was a large problem due to the lack of fine cattle herds that could survive in the climate along with a general low quality of imported milk (Thompson 1921). Availability of sufficient amounts of meat product was also a problem. This was due to significant factors including the lack of economic resources and adequate food to feed large herds of animals during war time, the overall lack of modern refrigeration in meat processing plants in Mexico, and an extremely archaic method of food distribution (Thompson 1921). Another problem with regards to food in Mexico was the substitution of the chile for adequate vegetables in Mexican diets. The continued, excessive use of chilies in the Mexican diet resulted in digestive track issues as well as acting as an appetite suppressant, something that generally does not bode well in growing children (Thompson 1921). Although lower class Mexicans ate food that was rich in protein and fat, many essential nutrients were lacking causing malnutrition and inadequate dietary supplements for growing children especially.

The biggest difference in the United States for Mexican immigrants with regards to their diets was the availability of relatively inexpensive meat, milk and vegetables as part of the diet. For the most part, these immigrants were consuming much the same food as they were in Mexico, but by including foods that were more affordable in America their diets were more balanced (Gamio 1930). In addition to more balanced diets, there was evidence of a replacement of the chile with other vegetables and spices, especially among the children of immigrants who were born in the United States (Bogardus 1970).

A study done (Kibbe 1946) on elementary school students in a low income area in El Paso, Texas attempted to show what vitamins were primarily lacking in diets of the children of Mexican immigrants. The study found that although a disproportionate number of children were lacking in Vitamins D and C, they were not suffering in large numbers of deficiencies in other vitamins and nutrients. Vitamin C deficiency was due to the lack of adequate fruit and vegetables in the diets of the children, while Vitamin D deficiency was a major public health problem facing the United States in the 1930s and was not affecting solely the children of Mexican immigrants (DeLuca et. al. 2004). Although the aforementioned study did find sufficient problems in the diets of Mexican children, the problem was remedied at the El Paso school by providing the children with free and low cost lunch meals that were rich in nutrients for a balanced diet. The success of that school led the state of Texas to provide funding for other elementary schools to instate similar lunch programs, thus playing a large part in providing good nutrition for children of Mexican immigrants.

Although Mexican immigrants and their children living in the United States were eating the same staple foods as they were in Mexico, more and more were supplementing their diets with balanced foods more readily available in the United States. With the addition of school programs that ensured that children in low income areas were eating a balanced diet, it can be said that the overall diets and nutritional status for immigrants was much less nutritionally restricted then that which they left behind in Mexico.

Climate and Altitude Changes from Mexico to the United States

The majority of Mexican immigrants to come to the United States did so from the Northern and Central areas of Mexico. Specifically, the states of Guanajuato, Jalisco and Michoacan contributed the most to legal immigration in the late 1920s (Gamio 1930). In his study, Goldstein (1943) looks exclusively at Mexican immigrants from the cities of Celaya and Guanajuato in the state of Guanajuato in central Mexico, as well as the cities of Monterrey in Nuevo Leon and Saltillo in Coahuila in northern Mexico. Mexico is extremely diverse in terms of climate and geographical features with the northern regions displaying different characteristics from the central regions. The diversity of climate has the potential to affect adjustment of

Mexican immigrants who moved to the United States, especially those from the central region of Mexico immigrating and living in Texas.

The state of Guanajuato lies in a mountainous region where its cities are situated among altitudes upwards of 6,000 to 7,000 feet. The climate is mild and dry with temperatures ranging from the low 40's in the winter to low 80's in the summer. The city of Saltillo in Coahuila shows similar climate characteristics of Guanajuato, if slightly hotter temperatures and a more dry climate. The altitude is also similar, being about 5,200 feet above sea level. Monterrey in Nuevo Leon has a much hotter, dryer climate than either Guanajuato or Saltillo, and is also much lower in elevation (about 1,700 feet above sea level) (Hammond World Atlas Cooperation 2004).

When looking at similarities and differences between these regions of Mexico and San Antonio, Texas where Goldstein (1943) collected his data on Mexican immigrants, the city of Monterrey appears to be the most closely matched in terms of climate, altitude and weather. Both Guanajuato and Saltillo share fairly similar climate and weather patterns, but altitudes of both cities are much higher then San Antonio (650 feet above sea level). The effects of altitude and climate on growth and development will be discussed in detail later on in this paper; however, it is important to keep the aforementioned statistics in mind when discussing the effects that the environment may or may not have on children of immigrants living in vastly different environments.

Conclusion

Immigration is an experience that should only be looked at as a sum of all parts rather then separate pieces. For Mexican immigrants moving to the United States it is important to take into account all the various changes and transformations, both physical and social or cultural, that occur. This paper will try to do just that. In order to fully understand change, one must take into account all aspects that have the potential to alter or necessitate such change.

Using Goldstein's (1943) data as the basis for this research, this background information was provided to look at Mexican immigration to the United States in a number of different categories including: socioeconomic status, housing conditions, access to health care, diet and nutrition and altitude and climatic changes. By understanding the processes and factors that make up each of these categories the reader will better understand how they may have been working on Mexican populations immigrating to the United States.

CHAPTER III. LITERATURE REVIEW

The idea that social or physical changes in the environment may influence skeletal development has been the focus of many anthropological and biological discussions since Boas's (1912) original publication for the United States Immigration Commission in 1910. In his study Boas (1912) took measurements on hundreds of immigrant families residing in America and performed a number of statistical comparisons between immigrants and sedente populations, as well as the American-born children of immigrants to their parents. The results of his study, primarily a mean comparison analysis, indicated to him that the bodies and crania of the children of these immigrants changed due to the influence of the American environment. Specifically, the human body was a "plastic organism and responsive, within limits, to its total environment" (Goldstein 1943 p. 17). Boas concluded that the American born children of immigrants showed an increased variability and difference from their parents. This difference varied in all European "types" but developed in early childhood and continued throughout life. These changes were due to the influence of the American environment which "makes itself felt with increasing intensity according to the time elapsed between the arrival of the mother and the birth of the child" (Boas 1912 p. 530). Children who were born shortly after their mothers arrived in America showed the most change in bodily measurements, leading Boas (1912) to further conclude that the amount of time spent in the American environment was directly correlated to the degree of change that the child's body would exhibit throughout development. The effects of the environment were therefore as strong, if not stronger then heredity in the formation of human physical characteristics. These findings were almost universally accepted in the anthropological community and cited in many publications dealing with race and racism, which was Boas's initial motivation for the study. Initially, Boas (1912) received much criticism for his results, but was able to effectively dispel most criticisms by pointing out that his study both demonstrated the relatively short amount of time that bodily changes in the children of immigrants in America manifested themselves (typically one generation), and the comparison between said children with their immigrant parents which demonstrated the "instability or plasticity of types" as opposed to permanence (p. 557).

Goldstein's (1943) publication and data analysis mirrored that of Boas's (1912) in both style and results. Using a sample of over 300 families totaling over 1,900 Mexican natives and immigrants living in Mexico and the United States, Goldstein (1943) concluded, based on an analysis of means, that differences between the two groups were present in the majority of all body measurements taken. Cranial and body measurements of Mexican sedentes living in Mexico to that of Mexican immigrants and their children who had moved and currently resided in the San Antonio, Texas area of the United States were compared. Additionally, comparisons were made between Mexican-American children and their immigrant parents. All individuals were of a mixed Indian and Spanish (mestizo) background, with pronounced Indian features. He ultimately concluded that there was a difference between the two populations and that this difference was due to improved situation and lifestyle changes in the American environment which was more conducive to optimal growth. Specifically, differences in stature, cranial and nose dimensions, and weight were the most pronounced among the immigrant and native groups. Stature was especially marked among immigrants and their United States born children. On average, sons were 3.54 cm taller then their fathers, and daughters were 2.64 cm taller then their mothers. Head diameters were slightly longer and broader among immigrants and their children living in the United States compared to those individual living in Mexico, and facial height was found by Goldstein (1943) to be significantly greater among United States born children compared to those born and living in Mexico. Head and facial dimensions, along with stature, were also found to be the most divergent measurements in United States born children compared to both their immigrant parents and their Mexican counterparts living in Mexico.

Goldstein (1943) concluded that the increase in bodily measurements in immigrants, and especially children of immigrants living in the United States, could be attributed to environmental conditions in the United Stats that were more conducive for the greatest optimal growth. Conditions for the opportunity for the greatest optimal growth were observed to better living conditions, greater access to health care, less restriction on nutrition and an overall higher socioeconomic status than that which could have been obtained in Mexico. These conditions were measured based on ethnographic accounts and interviews, personal observations of Goldstein and his various assistants during measuring sessions, as well as numerous historical and present documentations pertaining to population demographics, employment and wage information, and overall living conditions in both Mexico and the United States. Differing climatic conditions were discussed, but not considered to be a large impact (Goldstein 1943). Like Boas's (1912) study, Goldstein (1943) concluded that the influence of the American environment was responsible for the changes seen in the generation of Mexican-American children born in the United States. He, too, believed in the expressed plasticity of the human skeleton, and that the results of his study was proof of both this plasticity and the ability of different environmental influences to manifest themselves the longer a population and subsequent generations were exposed to the new environment.

Goldstein's (1943) study was just one of many studies of that time period that reinforced Boas's original findings of the effects of the environment on the human body, specifically the growing bodies of infants, children and adolescents. Focusing on the children of immigrants living in different environments allowed researchers to plainly see the degree of variability and differences expressed between those children who were born and grew up in an environment completely different from other children as well as their own parents. By studying physical variations in both the process and end result of the growth progression, authors of studies such as Boas's and Goldstein were able to convincingly and successfully conclude that environmental effects allowed for physical variations within populations.

Human growth and development are typically viewed as two separate entities (Bogin 1988; Boyd 1981; Eveleth and Tanner 1990). Bogin (1988) defines growth as a "quantitative increase in size or mass" and development as a "progression of changes, either quantitative or qualitative" (p. 7). In studies where the effects of environment are considered as causes for human variation, growth and development is perceived as the process of physical bodily increase, being acted upon and inherent in all populations. Additionally, it is a process involving biological as well as psychological deviations that manifest themselves throughout the maturing process. Deviations are those changes from "normal" human growth created by various environmental influences. In addition, environmental influences are factors that have some affect on the physical manifestations of growth either positive or negative. These factors are typically defined in human culture as socioeconomic status, dietary and nutritional behaviors, climate and altitude, and disease. Each of these factors has any number of specific subtypes that can be investigated further.

The following sections are designed to provide a review of studies and publications that look at the growth of individuals of numerous different populations in various environments, and the effects that said environments may have on growth and development. In addition, the influence of genetics and heredity in growth and development will be addressed. By providing explanations and analyses of the abovementioned works, a greater understanding of the contexts and influences at work on Goldstein's (1943) Mexican immigrant and native populations will be inferred.

Patterns of Human Growth

In order to understand human growth and development as well as the potential for the human body's plastic response to environmental factors, it is important to have a basic understanding of the processes involved in bone growth. Ultimately, the product of such bone growth (i.e. stature and lengths and widths of the crania and face) is what Goldstein (1943) and others like him captured in their anthropometric measurements of different human populations. Bone growth is essentially a process of absorption and deposition. In the human body growth is regulated by a number of different hormones, each synthesized in specific body tissues. On a smaller level, equally specific growth factors are further synthesized by a multitude of specialized cells whose job it is to stimulate the different growth hormones throughout the body (Bogin 1988). For example, cholecalciferol, or Vitamin D, is the hormone responsible for the calcium absorption process in bone which in turn regulates skeletal metabolism and bone growth (Bogin 1988). Specialized bone cells called osteoclasts absorb old bone tissue while separate cells called osteoblasts produce new bone tissue which ossifies at primary and secondary centers of ossification in different bones, that are present upon birth (White 2000). The continual act of absorption and deposition is intensified during the periods of infancy, childhood and adolescence when the human body is experiencing the most growth, and it is during these times of development and rearrangement that outside factors may induce plastic responses.

The human body experiences three growth periods characterized by their own tempos: infancy (birth to three years of age), childhood (three to 12 years of age) and adolescence (12 to

18 years of age) (Bogin 1988 p. 26). During the infancy period, especially from birth to six months, growth is very rapid as well as predictable regardless of individual or population. This has been attributed to the breast feeding period which supplies the infant with the appropriate nutrients. However, after the weaning period deviations from predictable growth patterns will sometimes occur in populations leading to the "retardation of the hereditary growth potential" in children (Bogin 1988 p. 28). Environmental factors which are primarily thought to achieve such deviations in normal growth have been attributed to: nutrition, illness, socioeconomic status and psychological well-being (Bogin 1988). If the environment causing deviations is not corrected for, normal growth and development can be severely impeded, even with the onset of a late maturity and 'catch up' period. When changes in the environment occur before the normal growth process is completed all individuals in any population are susceptible to observable changes in body form. The more drastic the change in environment the more marked the changes will be, indicating a rapid plastic response on the part of the human body rather then a more gradual genetic adaptation (Kaplan 1954).

Patterns of growth are explained using a variety of theoretical designs. Biological self-regulation and genetic predisposition to predictable patterns of growth and development have been the primary theoretical principles guiding the explanation of the predictable patterns of growth and development in all individuals regardless of population or ancestral affiliation. As briefly mentioned above, studies have shown that the pattern of growth is predictable in all individuals in any population (Johnston 1986); therefore, it has been postulated that there is some common mechanism inherent in all people which is responsible for the biological self-regulation of growth. This would account for the 'catch-up' phenomena of growth that occurs if a child is deprived of 'normal' growing conditions then suffers a late maturity or dramatic increase in growth later on in life (Bogin 1988; Prader et. al. 1963). These growth adjustments mechanisms are present in all children, but both genetics and environmental factors that impede 'normal' growth allow for the variations in bodily sizes among different populations (Bogin 1988). What have interested anthropological and biological scholars alike are the deviations observed when individuals exhibit growth patterns very different from others of the same genetic background. As Goldstein, and Boas before him, believed, different environments could account for the variations in bodily measurements of children living in one environment compared to either their parents or children in a completely different environment. These differences are still present after full maturity and adulthood, suggesting a retarded or unfulfilled optimal growth that even the results of a late maturity or 'catch up' period does not produce similar anthropometric measurements in two different populations. The following sections look at different environmental factors that are primarily thought to produce deviations from normal growth in populations. In many cases the authors convincingly argue that a better environment leads to optimal growth, while unstable or poor conditions tend to impede growth and development leading to an overall smaller group of people compared to their counterparts living in generally better conditions.

Growth and the Environment

Studying growth and its relationship to the environment is incumbent upon the idea of the plasticity of the human body and its responses to various stimuli. Perhaps the best known definitions of plasticity have arisen from Lasker (1969) who refers to it as the third of three levels of human adaptation, the first being the selection of genotypes affecting the genetic constitution of a population, and the second a genetic or ontogenetic adaptation which reduces the necessity for adaptive natural selection. In 1979 Lasker further refined this definition by labeling plasticity as the 'ability' or capacity of the individual to change in response to the environment" (p. 206) to which "permanent effects may occur during the growth period" (p. 208). Although Lasker's definitions refer primarily to permanent human adaptation responses rather then a specific differentiation caused by a plastic response, occurring as the result of a change in environment or occurring as a new, permanent adaptive state, they helped solidify the concept of plasticity in the biological sciences (Bogin 1995:46).

Prior to Lasker's studies of growth, the human body's response to environmental factors had been a much studied and widely debated topic in the scientific community. As early as the 16th century scientific studies on the growth of both fetuses and children emerged as a response to the idea that infants and children were merely miniature adults who only increased in size as they grew (Bogin 1988). After the Renaissance, scholars began to take an interest in how life events in early childhood could impact later development into adulthood. This line of study eventually lead to the first longitudinal study of human growth by Count Philibert du Montbeillard of France in 1759 (Bogin 1988). In the mid 1800s scientists began to take a closer look at the impacts of environment on human growth. Studies performed by Lambert Adolphe Quetelet in 1835, Luigi Pagliani in 1876, H.P. Bowditch in 1875 and finally Boas in 1895 were published as the first studies regarding the growth of children in populations living in different environments using, at that time, modern statistical analyses. Each study found differences between populations which lead the authors to ultimately conclude that changes in environmental factors were in some way responsible for changes in growth patterns which deviated from the norm (Bogin 1988). Ultimately it was Boas's (1912) report which generated enough interest by directly opposing the traditional viewpoint that each individual within a specific population or racial type had a fixed pattern of physical development. From Boas's initial publication numerous like-minded studies were spawned using various populations throughout the world, each pointing towards changes, or the lack of changes, that occurred in human growth and development brought on by specific environments. The potential for growth is inherent in all individuals; however, Boas and his followers agreed that only certain environments would allow this potential to fully express itself.

Socioeconomic Status

Socioeconomic status is an extremely broad category containing a multitude of variables that may affect overall growth and development. Typically the term 'socioeconomic status' refers to the amount of income a particular individual or group of similar individuals earn on a weekly, monthly or yearly basis. From either the lack or abundance of monetary status one can infer a number of other particulars about an individual's social situation. There are usually three categories to which socioeconomic status is broken up; low income or status, middle income or status and high income or status. Low status individuals or groups generally do not have access to optimal facilities, programs or nourishment. Generally the circumstances in which these people live and carry out their lives are poor and in contrast with middle and high status positions. Along with income level, educational background, occupation, family size and place of residence are also factors in determining where one falls in the socioeconomic level, although income is arguably the biggest determinant. Circumstances and comfort levels improve as the status positions ascend, with high status positions affording higher income levels, more educational opportunities, greater access to health care and sanitary living conditions, as well as adequate nutrition. The following studies show that there are marked differences in body size and form among low status individuals and groups compared to those of high status, indicating interconnectivity between socioeconomic status and growth and development.

There is a large body of research measuring the effects of relative socioeconomic status on changes of the human body (Appleton 1927; Bielicki and Welon 1982; Bogin 1995; Bowles 1932; Frisancho et. al. 1975; Goldstein 1943; Ito 1942; Johnston et. al. 1980; Lasker 1952; MacVean 1978; Malina et. al. 1985; Shapiro 1939; Spier 1929). The majority are similar in methodology and typically use occupation or level of educational background of the parents as an indicator of specific level of status. These studies span the world measuring populations of all cultural background and ethnicities, but typically the conclusions reached are similar. Generally, children of lower socioeconomic status are smaller in all bodily measurements and mature much slower then children living in middle, and especially high, socioeconomic conditions. Similarities in the variables that compose socioeconomic status and, therefore, account for the smaller body size and slow development are overwhelmingly attributed to lack of access to social benefits such as adequate health care and education, poor and unsanitary living and working conditions, and insufficient income to buy proper nutritional items to compose a balanced diet. Rather then becoming a secondary factor when looking at environmental indicators as the cause for deviations in normal growth, socioeconomic status is fast becoming a primary concern among scholars looking at developing children in all populations due to the domino effect caused by lack of sufficient income.

Studies dealing with socioeconomic status as an environmental factor typically fall under one of the following categories: generational comparative studies, comparative studies of sedente and immigrant groups living in different environments but of the same population, comparative studies of a population living in the same geographical area but segregated into different income brackets, and finally studies detailing specific indicators of growth failure or success. Although each study looks at socioeconomic status as an environmental factor that influences growth and development in a different way, the results are typically similar as discussed above.

Bowles' (1932) study looking at changes among multiple generations of Harvard University scholars is one of the best examples of research looking at secular trends among generations to determine environmental influence and the tendency towards a greater optimal growth with access to better occupations and educational opportunities. In his study Bowles (1932) found a number of differences of measurements among the grandfathers, fathers and sons, most notably an increase in stature that reached a peak mean increase between the years 1856 to 1865. While stature continued to increase among subsequent generations throughout the years following, the mean increase amounts slowly tapered off, something that Bowles (1932) attributed to a point in which the sample population would reach an equilibrium of their genetic growth potential under normal circumstances. Overall improved living conditions including increased medical attention, sanitation, the addition of luxuries, the abundance of food, better occupations and greater care of the body are noted as being the contributory factors behind the increase in stature. Bowles (1932) refers to the improved environmental conditions as 'modernization' or a general advancement of socioeconomic status of this particular population. Studies such as Bowles' (1932) that look at the effects of socioeconomic status on growth and development using a generational sampling method are unique in that they demonstrate overall secular trends in growth; however, specific indicators of environmental variation are sometimes not as clear. Bowles (1932) gives adequate explanations of an improved socioeconomic situation for the chronological generations of his Harvard University scholar sample, and it is evident that something is indeed at work on the population in order to provide such increase. The connotations associated with Harvard University graduates lend themselves to a high socioeconomic situation, and Bowles' study provides a good example of the influence that the environment plays on body form and the potential for the greatest optimal growth.

There are numerous examples of studies looking at the effects of socioeconomic conditions on non-immigrant and immigrant groups of individuals of the same population living in different geographic areas (Appleton 1927; Bogin 1995; Ito 1942; Lasker 1952; Shapiro 1939; Spier 1929). An increase in wages and more job opportunities providing more advantageous overall conditions of life have been the primary indicators for an overall increase in bodily measurements of the children of immigrants compared to both their parents and non-immigrant populations comprise the results of studies in this second category of study. In general, children of immigrants born in countries, like the United States, where a clear improvement of the environment is evident are taller and have larger overall body measurements including both cranial and amount of tissue in the form of fat and muscle.

Studies conducted on anthropometric measurements of Japanese and Chinese immigrant and non-immigrant families constitute a large majority of studies of the abovementioned category type (e.g. Appleton 1927; Spier 1929; Shapiro 1939; Ito 1942). Additionally, studies have been conducted on European immigrants (Boas 1912) as well as Mexican and South American immigrants (Goldstein 1943; Lasker 1952; Bogin 1995). The basis for each study consisted of the breakdown of a population into at least two groups: non-immigrant and immigrant. Both Shapiro (1939) and Ito (1942) provided more depth to their studies by looking at additional group breakdowns. Ito (1942) looked at Japanese immigrant and non-immigrant populations in four different ways: those who were born to immigrant parents in America, those who were born in Japan but moved as small children to America, those who were born in America but moved as small children to Japan, and finally those who were born and stayed in

Japan. The results of his study were similar to those studies that focused only on the two basic groupings, but were insightful in that the additional two groups fell in a predictable order in between. American born Japanese showed the biggest bodily measurements while those born in Japan but moved to America at a young age showed similar measurements. Those who were born in America but moved to Japan were much smaller, but not as small as those who were born and raised in Japan. By providing the two additional groups, Ito (1942) was able to address the degree of speed in which a move to a changed environment would effect the growth of the human body. This is something that is implied, but not always explicit in studies dealing exclusively with the comparison of immigrant and sedente families.

Perhaps the best known and most widely cited of the Japanese immigration studies is that of Shapiro (1939). In this study he compared three groups of people: Hawaiian born Japanese of immigrant parentage, Japanese born Japanese who immigrated to Hawaii, and Japanese born Japanese who represented the non-immigrant population. All groups were sampled from small farming villages in Japan and many were related. Shapiro (1939:5) viewed the human organism and its surrounding environment as two different entities that were interconnected. The environment was merely a bigger picture that encompassed a large variety of variable factors that would in turn sustain or stimulate the human organism. Using this theoretical perspective as the basis for his analysis, Shapiro (1939) was able to account for the significant differences between Japanese immigrants, the majority of who entered Hawaii as young adults not fully matured, and Japanese non-immigrants, especially in larger cranial and facial measurements. Additionally, the differences among the Hawaiian born children of immigrants took an even more significant increase, especially in stature and cranial and facial measurements. Among the many changes brought on by the move to Hawaii were occupational changes that included a large number of ‘professional’ status individuals compared to the majority of the non-immigrant population who engaged in heavy manual labor. The shift in occupations was responsible for a subsequent shift in economic status that offered higher incomes and a wider variety of luxuries that were not available before. Therefore, children of immigrants usually grew up in much more favorable conditions then they would have if their parents had stayed in Japan. The results of Shapiro’s (1939) study indicated the substantial impact that the environment appeared to have on the human body in a very short period of time. Shapiro (1939) concluded that it was not one single mechanism at work in the overall increase of body size from non-immigrant to Hawaiian born groups; however, it was a blending of both environmental factors foremost, followed by selective migration.

On the point of selective migration Shapiro (1939) attempted to identify a specific type of person who migrated to Hawaii; however, he was only able to validate psychological rather then physiological or social characteristics that would account for a specific migrating group type. There is evidence to suggest that taller people, for example, might be more inclined to migrate (Illsley et. al. 1963; Kobyliansky and Arensburg 1974; Mascie-Taylor 1984), but the evidence in favor of a drastic environmental change in the form of improved socioeconomic status during a critical period of human growth in a short period of time would appear to override any preexisting biases toward taller, bigger migrating people in this study. Also, many of the immigrating subjects in Shapiro’s (1939) sample were related to the non-immigrant population and were raised as children in much the same environment before they immigrated, yet the immigrating group still showed marked increases in bodily measurements compared to the non-immigrants. It would appear that much like Boas’s (1912) analysis of immigrant data, Shapiro’s

(1939) work validated the impact of environment on the human organism as being the primary force behind bodily changes.

While many studies look at the comparison between immigrant and non-immigrant populations living in different geographical areas using the effects of socioeconomic status as the environmental factor, there are still more scholars who choose to look at different groups of people within a population without introducing the migration factor (Bogin and MacVean 1978; Frisancho et. al. 1975; Malina et. al. 1985). Instead, these studies look almost exclusively at the effects of socioeconomic status within a population and do not have to deal with the potential effects of disproportionate selection. This research makes up the third category of socioeconomic environmental studies and can be classified as comparative studies of a population within the same geographical area but grouped into two to three levels of socioeconomic status. Rather then look at socioeconomic status as one of many factors, albeit most the most important one in terms of environmental influences, these studies tend to look at socioeconomic status as the primary grouping variable that can be attributed to any bodily changes or growth deviations in human populations.

Within this research category there appears to be a general consensus as to the variables underlying socioeconomic status. Foremost among them is parental occupation and education followed by parental income, number of family members, and zone of residence. The implications of these variables primarily concern the availability of adequate food for all children, the breakdown of the way income is spent, and overall sanitation and health concerns. These variables can be looked at in a variety of different contexts and within different populations; however, the outcomes of these studies are consistently similar. Low status individuals are smaller in stature and overall body measurements then high status children and typically develop much slower. This is evidenced by a late age at menarche for girls or a retardation in growth spurts leading to a reduced chance to catch up to normal growth even with the onset of late maturity. Much like the abovementioned comparative studies between immigrant and non-immigrant groups, low and high status groups within a population are given differential access to resources which ultimately leads to drastically different body measurements that persist into adulthood.

Studies conducted within a population on high and low income Mexican and South American groups is an area that is particularly well documented (Bogin and MacVean 1978,1981,1983; Frisancho et. al. 1975; Malina et. al. 1985). While Bogin and MacVean (1978,1983) compared measurements on hundreds of high, middle and low income Guatemalan primary school children in order to show that differences in socioeconomic status accounted for differences in growth and development, namely that lower status children were significantly smaller then those of higher status, Frisancho and coworkers' (1975) analysis of lowland and highland Peruvian Quechua groups is particularly interesting in that the authors found a reverse secular trend in the lowland population due to economic instability. Compared to their highland and genetically similar counterparts the lowland Quechua were in the past consistently taller; however, a decline in coffee production and exportation due to crop disease created an economic crisis pushing the lowland population into an economic slump. The dramatic and abrupt decrease in work and income propelled the group of lowlanders into poverty that was not immediately remedied, and ultimately affected the overall environment where subsequent generations were being raised. Compared to the highland population, growth of the lowland Quechua children was extremely delayed, reaching proportions similar to the highland children who exhibited shorter stature due to high altitude conditions. This study effectively showed the dramatic impact of socioeconomic environmental conditions indicated by a reverse trend in growth that essentially circumvented other aspects of the environment, namely the biological adaptation to high altitude conditions.

In their study of Mexican-American socioeconomic distinction, Malina et. al. (1983) found that, like Bogin and MacVean mentioned above, a Mexican-American population living in San Antonio, Texas showed evidence of stature increase with the improvement of socioeconomic class implying more favorable living conditions. The link between increased stature and higher socioeconomic status occurred with the transition into better living conditions, specifically from a low income ‘barrio’ to a high income suburban area. The improved living conditions afforded more combative measures against disease and poor sanitary conditions thus giving Mexican-American transitioning families more chance to grow and develop normally without the presence of negative influences. Similarly, Bielicki and Welon (1982) looked at living conditions for high and low status groups living in Poland. It was found that higher status groups of people living in urban areas were much taller then lower status groups living by subsistence farming. Due to the economic instability of farming and the generally poor condition of Polish agriculture, especially during periods of overall economic instability in the country, children of farmers were much smaller and developed much later then families not relying on farming as a source of income. This study was especially interesting in that like Frisancho et. al. (1975), Bielicki and Welon (1982) looked at the effects of economic collapse, but unlike the former, Poland is a communist country and essentially should be devoid of social stratification. However, due to the economic instability of certain occupations differences in status existed and the same human physiological responses (smaller body size, etc) as one would see in a highly stratified country were also present here. In this particular case the data itself was the primary indicator of social inequalities rather then predetermined classes. It is apparent from all the abovementioned studies that looking at environment through socioeconomic status is not simply a matter of comparing immigrants to sedentes, rather it is a highly diverse process in which numerous contexts need to be considered. This is especially apparent in studies of within group differentiation.

As indicated above, socioeconomic status encompasses a wide variety of variables that lead to deviations in growth and differences in body measurements for certain segments of a given population. The fourth type of study is designed to attempt to break down the larger umbrella of socioeconomic status into specific indicators of either growth failure or success (success indicated by normal growth processes). In many cases these studies are used as the basis for comparison for other studies (Graham et. al. 1980; Johnston et. al. 1973,1974; Malina and Zavaleta 1980), but the majority are designed to look at socioeconomic status as a number of different parts rather then a sum. These studies are not only important as comparative tools, but also permit the exploration and evaluation of the complexities associated with identifying socioeconomic status as a conductor of environmental change.

There are a wide variety of studies citing numerous examples of aspects of socioeconomic status that account for variations in growth and development. The “recycling of poverty” effect (Garn et. al. 1984; Johnston et. al. 1980) is one such example. In any population there is a certain degree of difficulty in transitioning upwards from one social class to the next. When no opportunity is provided, families and their subsequent generations of children continue to live in squalid conditions with no access for optimal growth that usually comes in the form of education which leads to better jobs with more income. With no way to move up, the cycle continues and can be mistakenly viewed as merely a genetic consequence. Parents of children who live in poverty are small, their children are small and with no betterment of their situation their children's children are small. Thus the cycle continues. In this case, the lack of education is indicated as the variable impeding a higher socioeconomic status as well as the continuance of a cycle of poverty.

The breakdown of the economy or political situation, or the inability to change to more modern economic practices are also conditions for the decrease (or failure to increase) in socioeconomic status. Extensive research has been done on the growth and development of certain Chinese and Japanese populations during both pre- and post-World War periods that link deviations in growth and development to the changing economic and political situations that ensued as a result of World War II (e.g. Hoshi and Kouchi 1981; Low et. al. 1982; Matsumoto 1982). Each study found that World War II had a significant delaying effect on both growth rate and development shown by an increased age at the onset of peak height velocity in boys and girls and an increased age at menarche in girls. The years following the war reversed this trend as the economic situation gradually stabilized.

A similar situation, although one that has not shown positive trends as in the Chinese and Japanese post war populations, is that of the Zapotec Indian population in southern Mexico (Malina et. al. 1980). Mexico is a country that has been steadily becoming more modern; however, as Malina et. al. (1980) showed in their study, Native populations such as the Zapotec have been increasingly denied access to such modernization techniques and improvements. Continued persistence of traditional cultural agricultural techniques coupled with the lack of outside influence or help has rendered this population in a state of unchanging body measurements, while the majority of the Mexican population around them was showing a secular change. This apparent freeze in body form is an example of how pervasive socioeconomic status is as an environmental factor. The lack of modernization techniques in the form of improved living conditions and access to food and medical attention as a result of one's status in a community has obvious lasting impacts on the growth and development of a population.

If racism and prejudices cause the lack of aid and modernization propelling a population into the very lowest degree of socioeconomic situation, then the apparent lack of any socioeconomic stratification or variation in a society must have the opposite effect. A study done by Lindgren (1976) on measurements of 740 urban Swedish schoolchildren showed that there were no significant differences in height, weight and developmental indicators. The reasons behind this lack of deviation included the fact that Sweden's political and economic situation allowed every person equal access to numerous health care and social support opportunities. The apparent equal opportunities shared by all individuals created a more even environment that led to similar growth and development standards for all the children sampled.

Studies looking specifically at socioeconomic status as an environmental catalyst for bodily change are numerous and far reaching. Although the concept of socioeconomics is based on a number of different variables and contexts, class and status differences have profound impacts on human populations if conditions are unstable enough to affect the growth and development of the children living in such conditions. The above section broke down the many different kinds of studies that have been performed in order to judge the physiological impacts of living in an ordered society in which ascending levels of social status based on income, occupation, education, and other socioeconomic factors lead to increasingly improved ways of life. The implications of these studies are clear; socioeconomic status measured as an environmental influence has the potential to alter bodily measurements during periods of growth and development in human populations.

Diet, Nutrition and Disease

Growth is essentially a process that revolves entirely around the amount of energy taken in by the human body in the form of food. Fourty-eight essential nutrients are needed by the body in order to grow and develop normally. As stated above, these nutrients are consumed through foodstuffs that provide nutrients that are not naturally produced and allow for normal cell production, multiplication and tissue synthesis processes (Bogin 1988). If essential nutrients are not obtained or a food supply is not adequate, then growth delays will almost always occur in children. Furthermore, if malnutrition or inadequacy of the proper food persists, then the delays suffered will affect the period during which catch-up growth can occur resulting in smaller then average individuals. While the socioeconomic factors may deter the access to proper nutrition, it is the inability to receive such nutrition that is the primary deterrent in achieving normal growth. When the body is deprived of sufficient nutritional content it becomes increasingly more susceptible to diseases. Conversely, many diseases have major impacts on the amount of nutrients that can be consumed and transformed into energy. Formally referred to as the “vicious cycle” model, later replaced by the synergism model, disease, infection, and malnutrition typically occur together in cases of stunted growth seen across populations living in similar, poor conditions. Studies focusing on the above models almost unanimously reached the same conclusions. Multiple infections, poor diet, and limited time between infections, coupled with extremely poor living conditions severely impeded normal growth, while inhibiting the amount of catch up growth experienced (Frongillo 1999; Scrimshaw 2003; Scrimshaw et. al. 1968). Malaria, tuberculosis and diarrhea are diseases that thrive in the unsanitary environments that typify the living conditions for the world’s poor. Coupled with the inability to gain access to an adequate and steady supply of the proper essential nutrients, disease can have lasting implications on the physical makeup of individuals in a population. More often than not disease and improper nutrition are interconnected through a number of outside variables controlled by income level, housing situation and national politics. It is through this network of variables that disease and malnutrition become the catalysts for deviations in human growth above and beyond the genetic make-up of an individual.

Studying disease and malnutrition in human populations is done carefully, using very specific techniques and principles. To directly induce a state of food deprivation is considered to be extremely unethical. Therefore, studies looking at the effects of malnutrition and disease typically fall under 'real life' situations in which the purveyors of the studies work with a specific population or compare populations in a certain context in which periodic food shortages, starvation, the existence of a better diet (used in comparative studies), or the presence of certain diseases have been know to exist or are known to happen on a regular basis. Studies of this type are generally time consuming as the author(s) must stay for long periods of time in order to record a number of different longitudinal measurements at different time periods, or consist of the retrieval of historical documentation from war periods, for example, in which chronic starvation occurred as a result of an outside stress inducer. The results are typically of the same sort as those of socioeconomic studies in that children exposed to malnutrition or diseases that perpetuate malnutrition experience deviations from the normal growth pattern. Growth may slow down or in many cases cease altogether as the body is unable to receive the proper amount of essential nutrients to provide enough energy to continue to grow.

Malnourished children generally do not go through the normal growth spurts, instead suffering a period of late maturity and catch-up growth in which the body attempts to make up for the significant loss of growth opportunity. However, proper catch-up growth will usually only occur if the stressful time period was relatively short and only if unfavorable conditions improve. Catch up growth can either return at a normal or supranormal velocity. Normal implies that the conditions are still far from favorable; however, treatment was effective enough to induce growth. Supranormal velocity implies that favorable conditions returned and that the treatment was superior (Eveleth and Tanner 1990). It is this category of catch-up growth that returns the child into a pattern of normal growth.

The 48 essential nutrients needed to sustain normal growth and development of the human body are broken down into six categories: carbohydrates, lipids, protein, minerals, vitamins and water. Of these six categories two further distinctions can be made; those essential for body maintenance determined by size, body composition and maturation, and those responsible for growth which is a function of new tissue synthesis (Johnston 1980). Each stage of growth has specific recommended daily intakes of protein and energy. If a situation occurs in which a child is not receiving the recommended intake then the body must sacrifice the essential nutrients that would normally go to growth for body maintenance. Marked periods of growth, such as the growth spurt of the adolescent years, require substantial amounts of essential nutrients in order to support growth and body maintenance.

No where else are the impacts of the lack of essential nutrients to facilitate growth more apparent then in studies on starvation. Ivanovsky's (1923) much cited study on the effects of famine on Russian populations is an excellent example of the lasting implications of malnutrition and starvation. In his study of 2,114 individuals living in post World War I Russia, Ivanovsky found that both stature and head dimensions were significantly altered with the lack of adequate nutrition. The intensive fasting of children produced by famine during the war years left his sample population of Russians much smaller then they should have been under normal growth circumstances. Ivanovsky (1923) concluded that starvation had an immediate and permanent effect on the physiological makeup of the studied population. This particular study launched numerous additional studies in the years to follow that looked at the effects of the two World Wars on populations in order to comprehend the response of the human body during periods of extreme food shortages. The primary technique of studying periods of chronic starvation is during war time, with the majority of studies focusing on surviving populations of World Wars I (Howe and Schiller 1952; Keys et. al. 1950; Wolff 1935) and II (Howe and Schiller 1952; Keys et. al. 1950; Kimura 1984; Markowitz 1955). Rationing and famine were the primary inducers of malnutrition on the vast majority of populations living in countries affected by World Wars I and/or II. In all cases studied growth was severely retarded during periods of war followed by a period of catch-up growth during the post war years, especially in larger urban areas that were better prepared to receive aid. Adolescent children appeared to be the most affected by the lack of sufficient food as this is the period during which the most significant growth spurt occurred. Like Ivanovsky's (1923) study, the studies that followed indicated a decrease in bodily measurements as the body, faced with a significant lack of energy conversion slowed growth in order to use the little amount of food consumed for body maintenance. Although many populations were able to return to relatively stable environments after the wars and experience catch-up growth, many people like those in Russia, took many years to reach a somewhat normal environment, leaving permanent, lasting effects on their physiological makeup.

In addition to studies on populations suffering the effects of war, studies looking at the consequences of malnutrition and improper diet on populations suffering from seasonal food shortages, a lack of adequate income in order to buy sufficient food supplies, and the insufficient nutritional values in some traditional cultural foodways are also common. Billewicz and

McGregor (1982) looked at the population and growth rates of two West African villages whose subsistence pattern focused on agriculture. Due to the instability of the seasons and a lack of rain during certain months, these populations suffered from seasonal malnutrition. It was found that during the dry season children would grow at much faster rates, while during the rainy season malaria and parasitic diseases were extremely common, causing a retardation of growth as food intake was extremely affected by the diseases. As the diseases took their toll on the population, the growth rate began to slow during the dry season over the years as it became increasingly harder to catch up for lost growth. As a result both children and adults were much smaller then normal (the authors defined normal as a comparison to British children under stable environmental conditions).

In addition to the seasonal growth shortage study mentioned above, studies looking at the effects on bodily form using socioeconomic status as an indicator of insufficient income to buy enough food have been discussed at length in the above section (for further discussion see Bailey et. al. 1984 and Jenkins 1981). Deviations from studies that look at the differences in access to food between rich and poor groups of people typically look at the effects of giving a poor, malnourished population food supplements designed to return growth back to the normal pattern. Takahashi (1984) looked at a post war sample population in Japan and found that the addition of a more balanced, westernized diet, including meat and milk, was responsible for the increase in height for school boys. In addition, Lasker (1946) looked at the effects of a less nutritionally restricted diet consumed by Chinese children born in America compared to those born in China. Diet was considered by him to be the primary factor in both increased height and head dimensions.

The effects of traditional cultural practices are also strongly felt in studies looking at differences between both whole groups of people as well as individuals within a family. Looking at recent Japanese immigrants and their children born in America, Froehlich (1970) discovered that there were significant variations in bodily measurements within the families of these immigrants, specifically boys were disproportionately bigger then girls. Even though the girls showed an increase in size when compared to their Japanese counterparts living in Japan, Froehlich (1970) attributed the difference in size to the differential access to food within a family due to rigid cultural practices involving rank. Traditionally the males were served first and had their pick of food; however, the females were allowed to only eat the leftovers. Although the food was in general more abundant and a higher quality in America, the persistence of the cultural etiquette allowed a certain amount of variance between males and females in terms of body measurements. Similarly, Behar (1977) looked at children in rural villages in Guatemala who had access to adequate amounts of food, but of a type that was not conductive to proper digestion. This ultimately led to a deficiency in the breakdown of caloric needs resulting in under nutrition and growth retardation. Much like the reliance of the chile as an important food staple used by Mexican populations in both Mexico and America, the Guatemalan populations studied suffered delays in growth not from the lack of food, but the inadequacy of the type of food consumed.

Finally, the role of disease in deviating from normal growth patterns was briefly discussed above; however, it deserves some additional attention. The most common diseases among undernourished, lower income populations are tuberculosis, diarrhea and parasitic diseases such as malaria. Individuals who do not consume the proper nutrients generally have problems fighting disease as the body cannot provide enough energy from proper food in order to do so. In addition, many diseases, such as diarrhea, leach the body of proper nutrition and do not allow for enough intake to overcome the deficit (Keys et. al. 1950). It is therefore quite common to see malnutrition and disease faulted together as the causes for growth delays.

Causes for deviations and delays in growth can be found in a number of different environmental factors; however, malnutrition and disease are perhaps the most significant due to their intimate connection to the physiological responses of the human body. The body produces and compartmentalizes energy in the form of essential nutrients consumed. If not enough food is eaten, or the effects of disease severely compromises the amount of nutrients that are converted into energy, then growth is delayed as a survival mechanism. While many studies may look at the numerous factors that make up socioeconomic status as a indicator of growth retardation, many times it is actually the lack of proper nutrition that is the underlying factor responsible merely because of its close biological relationship to internal workings of the human body.

Climate and Altitude

Biological adaptations to climate and altitude and how the various factors associated with each effect human physical growth are important to discuss as mentioned in the background section of this report. High altitude is defined by Bogin (1988) as those regions situated approximately 9,800 feet or higher above sea level (p. 134). The biological effects of high altitude on the human body are well documented in numerous populations throughout the world. At high altitudes hypoxia, high solar radiation, low humidity, high winds and rough terrain resulting in limitations to agriculture are some of the environmental effects imposed upon populations. Hypoxia, or the lack of sufficient delivery of oxygen to body tissues is the most common biological impediment of normal growth as it renders the cells of the body incapable of natural growth and metabolism (Bogin 1988). Physiological growth responses to high altitude environments include: reduced prenatal growth (Hass et. al. 1982), shorter, lighter children on average (Frisancho and Baker 1970), larger chest dimensions with relation to stature in some instances (Mueller et. al. 1980), and a relationship between length of time spent in high altitudes and stature measurements (shorter children spent more time in high altitudes compared to those who spent less time) (Stinson 1982).

When looking at the effects of a high altitude on the human body it is important to consider a wide variety of factors that may contribute to the overall shortness of stature in a population. For instance, both Bogin (1988) and Eleventh and Tanner (1990) caution against jumping too quickly to the conclusion that altitude is the sole cause of deviations from normal growth. Although the stress of hypoxia on the human body is enough to cause a substantial decrease in the amount of healthy cell production for growth, studies have shown that this may be independent, and in fact sometimes even a have a much lesser impact when looking at the indicators of shorter stature in lowland populations. Studies done by both Clegg et. al. (1972) on high and lowland Ethiopians and Frisancho et. al. (1975) on high and lowland Peruvians indicated that in some cases malnutrition and disease were the primary contributors to a delayed growth rate while the effects of a high altitude had only secondary effects on both the populations studied. In these cases the hypoxia experienced by the highland populations had minor effects on growth and development; however, the effects of malnutrition and disease effectively overrode the biological responses to high altitude and became the primary environmental causes for deviations in growth.

Much like the human body's response to hypoxia, physical adaptations to climate occur in response to heat and cold. More specifically, the body must adjust to extreme temperatures by either dissipating body heat in hot environments or storing heat in cold environments. Changes to the human body brought on by extreme heat occur as the result of attempts to deplete internal heat stress. Typically this dissipation of heat can be done in one of four ways: radiation, conduction, convection or evaporation. Because each technique implies a certain amount of heat exchange, relatively low body weight and volume along with a larger surface area in the form of longer arms and legs relative to trunk size decreases the amount of distance required for the body to exchange and effectively reduce internal heat stress (Bogin 1988). Conversely, in colder environments where it is essential to store heat larger body volume and smaller surface area are biological ideals (Bogin 1988). The abovementioned statements have been tested in numerous studies on populations in both hot and cold climates with similar results (Katzmarzyk and Leonard 1998; Mills 1937,1942; Roberts 1953). Specifically, body volume is generally higher in colder climates while stature and body measurements are typically decreased. The opposite is true for those populations studied in hotter climates.

In addition to general observations in body size, there has also been considerable research on the apparent seasonal growth trends seen in many populations living in differing environments. Specifically, children tend to grow at greater velocities in the summer. This would make perfect sense in light of the above studies of biological responses to cold; however, there is also some debate as to whether or not growth during the summer months is more a response to the degree of sunlight and the synthesis of Vitamin D rather then a release of the energy that has been stored during the winter months as a biological method to keep warm (Bogin 1988). Although many of the studies discussed by Bogin (1988) were unable to conclusively prove one theory over the other, there is still a considerable amount of research in this particular subject that is yet to be performed.

Much like the altitude studies discussed above, the impact of climate on human growth should be considered with caution. Malnutrition, dieting, workload and other cultural practices all must be taken into account when looking at a population's bodily response to climatic conditions. Each has a significant amount of power to change or alter data that may ultimately skew results. While both the effects of altitude and climate have been proven to have some influence on body size and dimensions, more often then not it is a combination of these plus additional factors that allow for significant deviations in individual's bodily measurements within a population.

Growth and Heredity and Genetic Factors

Children are a product of their parents interacting genes; therefore, it is only natural that they would resemble their parents in bodily measurements. As was briefly discussed above, the growth process is regulated by a distinct set of biological systems with which a number of hormones and specific growth cells play the major parts. The endocrine system, or the inherent biological system designed to regulate growth in all human beings, acts in accordance with various stimuli that include both the patterned expression of inherited genes as well as environmental influences (Bogin 1988). While specific genes for growth have not as of yet been identified, many believe that human growth is hinged upon a balance between the genetically inherited pattern of growth as well as the environmental context in which the child grows and develops in. The environment may be the cause of deviations from normal growth, but it is ultimately the genetic component in humans that allows and regulates its boundaries.

The debate between genetics and environment is today still a widely researched topic. Some studies have directly challenged the validity of the results of Boas's (1912) publication, assuming that had modern statistical and heritability tests been available at that time period Boas would not have been so quick to attribute differences between immigrants and their American born children to purely environmental factors (Konigsberg and Ousley 1995; Sparks and Jantz 2002). Regardless of the apparent biological codependency of both genetic and environmental factors, two separate camps have fast been emerging in order to test and retest a number of different populations in order to determine how much weight is held in terms of adult bodily measurements by either genetics or environmental factors. While the above sections dealt with studies that determined that the effects of the environment held considerable sway in the growth process, the following studies look at the genetic determinants of bodily measurements and their contribution to growth and development.

In the 1980s a series of studies were published in an attempt to foresee how changes in growth are affected as a result of heritability factors compared to the considerable amount of research done to determine the effects of environmental factors on deviations in growth. A longitudinal study done by Paganini-Hill et. al. (1981) on the S-leut, an isolated Amish population, indicated that 51 anthropometric measurements showed very high degrees of heritability. Specifically, the circumferential and breadth measurements of the cranium were under the strongest genetic control. Additionally, the authors concluded that the only traits which appeared to be under environmental control were the 'bulk factors' that included fat folds and circumferences of arms and legs (Paganini-Hill et. al. 1981). The apparent overriding influence of genetic expression over environmental factors in this study effectively challenged studies in which the environment was concluded to be the determining factor in bodily measurements, but at the same time did not entirely discount the role in which the environment plays during growth periods. The results of the Paganini-Hill et. al. (1981) study were further corroborated in a previous study performed by Susanne (1977) on 125 Belgium families using 36 anthropometric traits. Like the Paganini-Hill (1981) results, Susanne (1977) concluded that bodily measurements were under considerable genetic pressures with high heritability factors. Additional studies performed by Devor et. al. (1986a,1986b) using 34 anthropometric measurements on Mennonite congregation populations residing in Kansas and Nebraska concluded that there were strong familial correlations and heredity factors involved in the majority of the measurements, excluding body circumferences and skin folds (Devor et. al. 1986a). In the follow up study Devor (1986b) and colleagues encountered much the same results as the initial study, even going further to conclude that "high levels of transmissibility are observed in linear body dimensions" (p. 91).

In more recent studies, the revisitation of Boas's original data has brought into question the role of environment on changing skeletal structure between generations, in favor of a more genetically inclined model. Both Konigsberg and Ousley (1995) and Spark and Jantz (2002) have reanalyzed Boas's data with modern statistical and genetic determinant techniques that suggest variation among recent generations of immigrants should be attributed to genetic variation rather then the change in environment. Konigsberg and Ousley (1995) used a pedigree analysis in their study in order to judge patterns of phenotypic distances between Native American groups sampled in Boas's dataset. Using a series of mathematical equations in which the proportion of additive genetic variance and covariances (G) were proportionately compared to phenotypic variance and covariances (P), the authors concluded that a close fit between the two were observed, indicating a genetic component of heritability in Boas's data that had not been adequately explored.

While Konigsberg and Ousley (1995) suggested that a genetic model of study should not be overlooked when looking at Boas's data, Sparks and Jantz (2002) performed a similar study that incorporated not only heritability testing, but modern statistical techniques as well that included univariate t-tests, least-squares regression, and ANOVA models of analysis. Like Konigsberg and Ousley (1995), Sparks and Jantz (2002) believed that an underlying genetic component to Boas's changing measurements of generations of immigrants living in the United States was more conducive to variation than an environmental explanation. Both the regression and t-test analyses indicated that age, rather then amount of time in the American environment was responsible for the changes in cranial index. The authors interpreted these results to be evidence for an "overall stability of the cranial index in response to changing environment" (p. 14637), concluding that Boas's initial assumptions pertaining to change in bodily structure as a result of a better environment was invalid. In addition, the results of the ANOVA analysis performed by Sparks and Jantz (2002) indicated that variation depended on ethnic group rather then the interdependence of individual effects across groups due to environmental factors. The final test performed, heritability, also concluded that the majority of the phenotypic variation in traits among groups could be attributed to genetic factors (heritability > 0.5). The authors concluded that, overall, variation among individuals in population groups cannot be attributed to environmental changes that affect skeletal plasticity and growth, rather changes in cranial morphology should be attributed to genetic components.

Although these studies all consistently show high genetic factors and heritability with regards to anthropometric traits, they also imply some degree of environmental factors at work in some bodily measurements, even if only as a secondary influence. It is clear that the biological expression of genetic material cannot be left out of analysis; however, the effects of the environment on the endocrine system that regulates growth and development should also not be so easily discounted. With specific genes responsible for the growth process still as of yet unknown, it is important to look at growth deviations and bodily measurements as the possible results of a number of different factors interacting with each other in order to produce a wide variety of distinctly different individuals, physiologically as well as culturally.

Conclusion

Much like immigration experiences should be seen as a sum of all parts, the processes that govern growth and development cannot be interpreted using just one technique or theory. The growth process is inherently biological; however, a large number of factors both environmental and genetic are responsible for various deviations from normal growth which may occur throughout a child's life into adulthood. The very fact that this world is made up of populations of varying shapes and sizes bears testimony to the numerous factors at work on growing children. If genetic expression inherited through one's parents provides the genetic outline for growth potential, then it is the interconnectivity between the genes and the environment as a whole that governs our ultimate body measurements.

CHAPTER IV. MATERIALS AND METHODS

Goldstein's (1943) study represents an accumulation of over three months of extensive data collection and analysis that took place in both Mexico and the United States. Goldstein's study was made possible due to the financial support of the Institute of Latin American Studies at the University of Texas, and was largely a cooperative effort between himself and numerous schools, social programs, medical facilities and social networks throughout both the San Antonio, Texas area and Mexico. In total, Goldstein's collected sample consists of 305 families numbering approximately 1,958 individuals. The following section will describe the sample, as well as the collection methods in greater detail.

Sample

The basis of the analysis for the current study is Goldstein's original data collected in the months prior to the publication of his results and analysis in 1943. Taking over three months to collect, Goldstein performed all measurements on all subjects himself with the cooperation of numerous social organizations, schools, medical facilities and social networks as well as two assistants – Arcadia Hernández and María Rodríguez. As the organizations mentioned above are too numerous to mention and span from Texas to central Mexico, a full list may be obtained from Goldstein's (1943) original publication (p. 7-9). The sample itself is made up of families residing in the San Antonio area of Texas as well as cities of Celaya and Guanajuato in the state of Guanajuato, the city of Monterrey in the state of Nuevo Leon, and the city of Saltillo in the state of Coahuila in Mexico. Two separate groups of people are represented in this sample: immigrant families residing in the United States with at least one American-born child, and non-migrating families residing in Mexico with at least one Mexican-born child. Goldstein collected measurements on a total of 305 families, 176 in Texas and 129 in Mexico. The sample totals 1,958 individuals.

There were a number of requirements for inclusion in Goldstein's sample for analysis. Both biologically and culturally the two groups were as homogenous as possible. Economic status for both were at the lower levels indicated by the societal contexts where each lived, and geographical areas where the majority of the individuals in the immigrant population sampled were born was the same area in which the sedente population sampled resided. Specifically, northern and central Mexican populations were used as these have traditionally been the two areas from which the majority of immigrating people originate. In addition, individuals included all displayed mestizo traits with predominantly Indian characteristics. Mestizos are the majority population in Mexico and are a blending of Spanish and Indian ancestries. Each family had to have at least one parent and one child. The immigrant families living in Texas had to have at least one American-born child and both parents and grandparents had to be born in Mexico, while those in Mexico had at least one Mexican-born child. Whenever possible, it was attempted to use related family members who resided in both areas in order to account for future questions regarding differential selection of migrating peoples and create a sample with a common genetic background.

Anthropometric Measurements

Nineteen individual measurements were collected on each individual in the sample whenever possible. In certain cases, some measurements could not be obtained due to the extreme age of the individual (either too old or too young), or a physical characteristic prohibited a complete measurement. For this analysis the measurements were further narrowed down to ten ones to be used as variables. These variables were chosen based on their relevance to growth.

Particularly, variables indicating measurements in overall bone growth, rather then fat for example, were chosen. The ten variables chosen were: stature, head length (HL), head width (HW), menton-crinion (MC), minimum frontal diameter (MF), menton-nasion (MN), maximum bizygomatic diameter (Biz), bigonial diameter (Big), nose height (NH) and nose width (NW). A description of each of these ten measurements is displayed in Table 1.

In addition to the numerical data presented, a number of grouping variables were set up in order to further classify the data. These were: sex (male or female), status (immigrant or native), familial status (parent or child), and age (broken up into four categories: 5 to 8 years old, 9 to 13 years old, 14 to 18 years old, and over 18 years old). All families were assigned numbers.

Table 1: Description of Anthropometric Measurements Used in this Study

Stature	Standing height using a measuring stick with crossbar.
Head Length (HL)	Measurement of the most prominent point of the glabella to the most distant point on the back of the head (occipital).
Head Width (HW)	Measured wherever it can be found above the plane of the ears.
Menton-Crinion (MC)	Measurement of the lowest point in the median plane of the chin to the point where the hairline meets the midpoint of the forehead.
Minimum Frontal Diameter (MF)	Measurement from one frontal crest to the other across the narrowest part of the forehead.
Menton-Nasion (MN)	Measurement of the lowest point in the median plane of the chin to the nasal root.
Maximum Bizygomatic Diameter (Biz)	Measurement of the maximum diameter between corresponding points on the opposite zygomatic arches.
Bigonial Diameter (Big)	Measurement of the maximum external breadth of the lower jaw.
Nose Height (NH)	Measurement of the deepest part of the nasal bridge to the sub-nasal point (where the nasal septum joins the upper lip).
Nose Width (NW)	Measurement of the greatest diameter measured without pressure between the wings of the nose.

(Goldstein 1943 p. 57)

Families residing in the United States are numbered 1 to 176, and families in Mexico are numbered 200 to 369.

The data was obtained from Goldstein's (1943) publication and was entered into the statistical program SPSS 14.0 (2005). All measurements, excluding stature, were taken by Goldstein using a Martin spreading calipers and were all recorded in millimeters. Stature measurements, also recorded in millimeters, were taken using a measuring stick with a crossbar on top – the standard measuring technique of the time.

Analytical Methods

The sample was separated into two different groups in order to ascertain degrees of differences between variables. The two separate groups were separated based on location (United States or Mexico), while age groups were further separated based on familial relationships (parent or child) in order to compare Mexican immigrants and their US born children. The location grouping variable was used to test individuals of the same age group living in different environments, while the familial status grouping was used to test United States born children to their immigrant parents. Age group separations were based on patterns of growth – early childhood, adolescence, puberty, and adulthood. Any significant differences observed among variables will be evaluated based on their individual contexts with regards to either the environmental or genetic implications.

In order to test the statistical validity of any differences between the populations presented in Goldstein's (1943) data a number of specific tests were performed. The tests each contributed to a greater understanding of the differences involved between the groups separated by location as well as familial status. In order to remove the differences between males and females Z-scores were obtained from the measurements of each variables of each individual in the sample. Z-scores are one type of transformation designed to account for deviations due to a particular divergent category by expressing how far and in what direction any given data diverts from the mean. The overall sample was separated into males and females then Z-scores were obtained for each group. The Z-scores for both males and females were then pooled. By subtracting a population's mean from an individual measurement then dividing the difference by that population's standard deviation, a new data variable (Z-score) is generated in order to obtain a comparison of results of differing normal distributions for each case generated.

T-tests

Independent samples t-test was used in order to compare means of one or more dependent variables for two independent groups. Equal variances are assumed if the 'Significance' value under the 'Levene's Test for Equality of Variables' is greater then .05. If said value is less then .05 then equal variances cannot be assumed. Variables for the two groups are significantly different using a 2-tailed model if $p < .05$, and it cannot be assumed that the two groups have equal measurements.

Five different group comparisons were conducted as t-tests using the Z-scores. The first comparison was between the United States born group living in the United States aged 5 to 8 years old and their Mexican born counterparts living in Mexico, also aged 5 to 8. The second analysis was similar to the above, but the ages ranged from 9 to 13 years old. The third and fourth tests were also similar to the above two, but the ages ranged from 14 to 18 and 19+. The fifth, and last, analysis compared Mexican immigrant parents living in the United States to their United States born children. Only those who were 14 + years of age were considered. The same measurement set was used for all five groupings.

ANCOVA

The next test performed was an analysis of covariance (ANCOVA). This particular test is important as it takes into account the significant effect any one grouping variable may have on the distribution of the sample data. For this analysis the effect of age on the differentiation between groups was taken into account in order to rule out its potential to skew the results of further statistical analysis. Adults of both locations were not included in this analysis, due to the overwhelming sample size of these two groups and their potential to skew significance factors.

The ANCOVA also used the Z-scores generated by SPSS 14.0 (2005). The analysis of covariance test was also performed in SPSS 14.0 (2005) with the fixed factor as the United States/Mexico grouping factor. The covariable was age. The dependent variables were Z-scores of the ten variables used in this analysis.

RMET

The next test performed was a multivariate genetic distance analysis using the RMET 5.0 program developed by John Relethford. This analysis assesses genetic similarity using quantitative data, the R matrix, and Fst. The R matrix measures genetic similarity, based on a weighted mean of 0, both within and among populations, and also calculates the potential for genetic drift, which is the change in the gene pool of a population that occurs by chance (Relethford 1991). Positive values indicate populations more closely-related then average, while negative values indicate the opposite. The genetic distance map is based on the first two principal coordinates and represents the observed mean genetic distance between groups (Relethford and Blangero 1990). RMET 5.0 also performs a Relethford-Blangero analysis that measures the observed within-group phenotypic variance and compares it to the expected variance. A negative residual indicates a lack of gene flow and may indicate the effects of genetic drift, while a positive residual indicates the opposite (Relethford and Blangero 1990). All tests performed are appropriate for this sample as it is made up of two independent groups of ratio data.

All individuals were placed into eight groups: Age1Mexico (Mexican children in the first age category 5 to 8 years), Age1US (U.S.-born children in the first age category 5 to 8 years), Age2Mexico (Mexican children in the second age category 9 – 13 years), Age2US (U.S.-born children in the second age category 9 to 13 years), Age3Mexico (Mexican children in the third age category 14 to 18), Age3US (U.S.-born children in the third age category 14 to 18), Age4Mexico (Mexican adults in the fourth age category 19 +), and Age4US (Mexican immigrants living in the U.S. age 19 +). The ten transformed (Z-scores) anthropometric variables were used for this analysis. Heritability was set at 0.4 based on the average heritability for anthropometrics calculated by Konigsberg and Ousley (1995).

While Goldstein (1943) provided the data, this research is a reanalysis of that data using modern analytical techniques. While each test serves to reinforce another, together they are able display Goldstein's (1943) original data and conclusions using more modern and specific techniques. They are also designed to be a detailed starting point or background for future research. While this analysis serves the purpose of this research adequately, further testing will only serve to enhance the results and conclusions put forward here. The following sections will discuss the results of the above discussed sample and tests in detail, ultimately leading towards a conclusion regarding the statistical validity and results of Goldstein's (1943) original findings.

CHAPTER V. RESULTS

Independent Samples T-Test Results

Independent Samples T-tests were conducted on all age group pairings as well as immigrants and their United States born children. The t-tests compare two independent groups with dependent variables. Before assessing the significance values, Levene's Test was employed to test for the equality of variances among the two groups in the sample. Equal variances are assumed under the Levene's Test for equality of variances if the significance value is greater then 0.05. Variable means for the two groups are considered significantly different if the 2-tailed significance value is $p < 0.05$. As a rule if $p < 0.05$ then it cannot be assumed that the mean measurements of the variables are equal. If the 2-tailed significance value is $p > 0.05$ then the two independent groups being compared are not considered significantly different and are approaching equal values.

A Comparison of United States Born to Mexican Born Children, Aged 5 to 8 Years

The group descriptive statistics (Table 2) provides a summary of all individuals used in this particular sample. The sample sizes, means, and standard deviations are calculated for each variable that was used in the statistical analysis and recorded as a whole. In this case the two groups being compared are children born in the United States and children born in Mexico. All children fall into the age range of 5 to 8 years.

Table 2: Group Statistics for U.S. and Mexican Born Children, Aged 5 to 8 Years

Group Statistics

	US/Mexico	N	Mean	Std. Deviation	Std. Error Mean
Stature	In US	62	1109.10	96.034	12.196
	In Mexico	69	1095.39	68.903	8.295
HL	In US	61	171.57	7.392	.947
	In Mexico	69	169.26	6.572	.791
HW	In US	61	138.89	4.712	.603
	In Mexico	69	137.71	4.759	.573
MF	In US	59	94.14	3.603	.469
	In Mexico	66	92.77	2.945	.362
MC	In US	49	149.61	8.946	1.278
	In Mexico	53	149.42	8.800	1.209
MN	In US	50	97.90	4.782	.676
	In Mexico	53	96.96	5.581	.767
Biz	In US	62	115.90	5.027	.638
	In Mexico	68	113.37	4.029	.489
Big	In US	56	82.79	4.434	.593
	In Mexico	57	80.32	4.285	.568
NH	In US	53	42.06	2.713	.373
	In Mexico	55	41.29	3.258	.439
NW	In US	52	30.50	2.690	.373
	In Mexico	55	29.38	2.139	.288

Table 3 is a comparison of means between United States born children and Mexican born children aged 5 to 8 years. Equal variances are assumed for all variables except stature. Measurements between the two groups are significantly different for head width (p = 0.040), minimum frontal diameter (p = 0.010), maximum bizygomatic diameter (p = .002), bigonial diameter (p = 0.002) and nasal width (p = 0.010).

Table 3: Independent Samples T-test Results, Aged 5 to 8 Years

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Zscore(Stature)	Equal variances assumed	.849	.359	-.852	129	.396	-.15918030	.18674269	-.528655	.21029468
	Equal variances not assumed			-.850	125.590	.397	-.15918030	.18731854	-.529890	.21152933
Zscore(HL)	Equal variances assumed	1.118	.292	.051	128	.959	.00829676	.16134915	-.310960	.32755362
	Equal variances not assumed			.051	121.507	.959	.00829676	.16243148	-.313266	.32985916
Zscore(HW)	Equal variances assumed	.119	.731	2.079	128	.040	.27722068	.13332193	.01342047	.54102089
	Equal variances not assumed			2.076	125.177	.040	.27722068	.13353704	.01293795	.54150342
Zscore(MF)	Equal variances assumed	4.267	.041	2.629	123	.010	.36486112	.13877691	.09016074	.63956150
	Equal variances not assumed			2.649	122.932	.009	.36486112	.13771760	.09225608	.63746616
Zscore(MC)	Equal variances assumed	.593	.443	-1.654	100	.101	-.29742726	.17979065	-.654127	.05927228
	Equal variances not assumed			-1.653	98.885	.102	-.29742726	.17998264	-.654557	.05970247
Zscore(MN)	Equal variances assumed	6.666	.011	2.129	101	.036	.07281532	.03419907	.00497357	.14065707
	Equal variances not assumed			2.144	97.929	.035	.07281532	.03396408	.00541410	.14021654
Zscore(Biz)	Equal variances assumed	1.679	.197	3.088	128	.002	.05728103	.01855212	.02057248	.09398957
	Equal variances not assumed			3.064	120.056	.003	.05728103	.01869553	.02026536	.09429669
Zscore(Big)	Equal variances assumed	.579	.448	3.234	111	.002	.36506930	.11288024	.14138957	.58874903
	Equal variances not assumed			3.232	110.287	.002	.36506930	.11294336	.14124855	.58889006
Zscore(NH)	Equal variances assumed	1.029	.313	1.321	106	.189	.16407791	.12417915	-.082119	.41027515
	Equal variances not assumed			1.327	102.332	.187	.16407791	.12365611	-.081184	.40933966
Zscore(NW)	Equal variances assumed	1.415	.237	2.614	105	.010	.36038970	.13788163	.08699591	.63378350
	Equal variances not assumed			2.592	93.362	.011	.36038970	.13905373	.08427065	.63650876

Summary Table

	5 to 8 Years	9 to 13 Years	14 to 18 Years	19 + Years	Parent – Child
Stature			X	X	X
Head Length					X
Head Width	X		X	X	X
Minimum Frontal Diam.	X		X		
Menton-Crinion					
Menton-Nasion					X
Maximum Bizygomatic Diam.	X		X		X
Bigonial Diam.	X	X	X	X	X
Nasal Height					X
Nasal Width	X		X		X

X = significant difference between groups observed

A Comparison of United States Born to Mexican Born Children, Aged 9 to 13 Years

Table 4 portrays the group statistics for United States born and Mexican born children aged 9 to 13 years. For both groups, all samples sizes, means and standard deviations are calculated for each variable.

The results of the Independent Samples T-test for United States born and Mexican born children aged 9 to 13 years is displayed on Table 5. Equal variances were assumed for all variables. Bigonial diameter is the only measurement between the two groups that is significantly different (p = 0.000).

Table 4: Group Statistics for U.S. and Mexican Born Children, Aged 9 to 13 Years

Group Statistics

	US/Mexico	N	Mean	Std. Deviation	Std. Error Mean
Stature	In US	143	1449.90	1182.650	98.898
	In Mexico	117	1338.55	87.179	8.060
HL	In US	143	176.34	6.715	.562
	In Mexico	116	175.97	6.130	.569
HW	In US	143	141.74	5.160	.432
	In Mexico	116	141.11	5.518	.512
MF	In US	141	97.23	3.750	.316
	In Mexico	116	96.96	3.608	.335
MC	In US	134	160.60	12.796	1.105
	In Mexico	111	159.53	8.186	.777
MN	In US	134	114.07	80.468	6.951
	In Mexico	111	105.86	5.490	.521
Biz	In US	143	131.33	93.879	7.851
	In Mexico	117	121.40	5.205	.481
Big	In US	137	88.80	5.101	.436
	In Mexico	113	86.35	6.078	.572
NH	In US	133	47.29	3.470	.301
	In Mexico	111	46.76	3.279	.311
NW	In US	134	32.90	2.537	.219
	In Mexico	111	32.57	2.418	.230

Table 5: Independent Samples T-test Results, Aged 9 to 13 Years

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Zscore(Stature)	Equal variances assumed	1.429	.233	.982	258	.327	.23423822	.23843668	-.235292	.70376807
	Equal variances not assumed			1.077	157.376	.283	.23423822	.21747557	-.195309	.66378564
Zscore(HL)	Equal variances assumed	3.025	.083	-.182	257	.856	-.01437502	.07919033	-.170320	.14156955
	Equal variances not assumed			-.186	256.760	.853	-.01437502	.07725533	-.166510	.13775975
Zscore(HW)	Equal variances assumed	.270	.604	1.395	257	.164	.14787405	.10601228	-.060889	.35663742
	Equal variances not assumed			1.387	240.511	.167	.14787405	.10658991	-.062095	.35784300
Zscore(MF)	Equal variances assumed	.045	.832	.700	255	.484	.05244525	.07490926	-.095074	.19996484
	Equal variances not assumed			.698	242.383	.486	.05244525	.07514477	-.095575	.20046539
Zscore(MC)	Equal variances assumed	3.956	.048	.027	243	.979	.00229721	.08626072	-.167617	.17221137
	Equal variances not assumed			.027	242.360	.978	.00229721	.08435934	-.163874	.16846828
Zscore(MN)	Equal variances assumed	1.683	.196	1.134	243	.258	.26768416	.23611326	-.197406	.73277401
	Equal variances not assumed			1.245	134.812	.215	.26768416	.21505012	-.157624	.69299248
Zscore(Biz)	Equal variances assumed	2.288	.132	1.103	258	.271	.26683593	.24184885	-.209413	.74308502
	Equal variances not assumed			1.220	142.587	.225	.26683593	.21875836	-.165593	.69926454
Zscore(Big)	Equal variances assumed	.050	.823	3.706	248	.000	.33137241	.08941463	.15526352	.50748129
	Equal variances not assumed			3.669	228.060	.000	.33137241	.09031107	.15342164	.50932318
Zscore(NH)	Equal variances assumed	.331	.565	1.234	242	.219	.11803294	.09567868	-.070436	.30650226
	Equal variances not assumed			1.242	239.073	.216	.11803294	.09506563	-.069240	.30530618
Zscore(NW)	Equal variances assumed	.955	.329	1.486	243	.139	.13655146	.09190476	-.044480	.31758311
	Equal variances not assumed			1.499	240.744	.135	.13655146	.09110969	-.042922	.31602541

Summary Table

	5 to 8 Years	9 to 13 Years	14 to 18 Years	19 + Years	Parent – Child
Stature			X	X	X
Head Length					X
Head Width	X		X	X	X
Minimum Frontal Diam.	X		X		
Menton-Crinion					
Menton-Nasion					X
Maximum Bizygomatic Diam.	X		X		X
Bigonial Diam.	X	X	X	X	X
Nasal Height					X
Nasal Width	X		X		X

X = significant difference between groups observed

A Comparison of United States Born to Mexican Born Children, Aged 14 to 18 Years

Group statistics, including sample sizes, means and standard deviations, are recorded for United States born versus Mexican born children, aged 14 to 18 years, on Table 6 . The table displays these statistics for each variable associated with the two groups.

Table 6: Group Statistics for U.S. and Mexican Born Children, Aged 14 to 18 Years

Group Statistics

	US/Mexico	N	Mean	Std. Deviation	Std. Error Mean
Stature	In US	204	1575.91	84.644	5.926
	In Mexico	148	1549.51	77.385	6.361
HL	In US	204	183.06	7.531	.527
	In Mexico	148	192.06	138.710	11.402
HW	In US	204	145.89	5.427	.380
	In Mexico	148	144.46	5.243	.431
MF	In US	204	105.11	62.269	4.360
	In Mexico	148	98.77	4.314	.355
MC	In US	202	173.11	10.365	.729
	In Mexico	146	171.03	8.632	.714
MN	In US	202	116.03	7.082	.498
	In Mexico	146	114.58	11.177	.925
Biz	In US	203	131.63	6.254	.439
	In Mexico	148	129.36	5.497	.452
Big	In US	204	95.55	6.053	.424
	In Mexico	147	91.71	5.014	.414
NH	In US	203	51.45	3.758	.264
	In Mexico	146	51.51	3.455	.286
NW	In US	203	35.74	2.678	.188
	In Mexico	146	35.08	2.858	.237

The results for the Independent Samples T-test comparing United States born to Mexican born children aged 14 to 18 years are displayed on Table 7. Equal variances are assumed for all variables. Measurements between the two groups are considered significantly different for stature ($p = 0.006$), head width ($p = 0.009$), minimum frontal diameter ($p = 0.020$), maximum bizygomatic diameter ($p = 0.000$), bigonial diameter ($p = 0.000$) and nasal width ($p = 0.008$).

Table 7: Independent Samples T-test Results, Aged 14 to 18 Years

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Zscore(Stature)	Equal variances assumed	.296	.587	2.780	350	.006	.11581837	.04165688	.03388907	.19774767
	Equal variances not assumed			2.794	322.568	.006	.11581837	.04144557	.03428060	.19735613
Zscore(HL)	Equal variances assumed	.475	.491	.226	350	.821	.03265822	.14445492	-.251451	.31676711
	Equal variances not assumed			.200	175.744	.842	.03265822	.16328319	-.289590	.35490646
Zscore(HW)	Equal variances assumed	.856	.356	2.612	350	.009	.24187507	.09260264	.05974743	.42400271
	Equal variances not assumed			2.588	305.940	.010	.24187507	.09345577	.05797764	.42577250
Zscore(MF)	Equal variances assumed	2.006	.158	2.346	350	.020	.33585525	.14313986	.05433279	.61737772
	Equal variances not assumed			2.672	258.307	.008	.33585525	.12568705	.08835354	.58335697
Zscore(MC)	Equal variances assumed	1.296	.256	1.671	346	.096	.10442507	.06249990	-.018502	.22735263
	Equal variances not assumed			1.718	338.301	.087	.10442507	.06077348	-.015116	.22396657
Zscore(MN)	Equal variances assumed	.229	.632	1.677	346	.094	.04831865	.02881555	-.008357	.10499434
	Equal variances not assumed			1.545	213.245	.124	.04831865	.03127406	-.013327	.10996454
Zscore(Biz)	Equal variances assumed	.103	.748	3.684	349	.000	.05164082	.01401741	.02407158	.07921005
	Equal variances not assumed			3.719	327.109	.000	.05164082	.01388643	.02432284	.07895879
Zscore(Big)	Equal variances assumed	5.110	.024	6.652	349	.000	.53490378	.08041451	.37674577	.69306178
	Equal variances not assumed			6.854	341.991	.000	.53490378	.07804237	.38140030	.68840726
Zscore(NH)	Equal variances assumed	.038	.845	-.129	347	.897	-.01042119	.08058324	-.168914	.14807186
	Equal variances not assumed			-.131	324.746	.896	-.01042119	.07965874	-.167134	.14629112
Zscore(NW)	Equal variances assumed	.051	.821	2.673	347	.008	.21200828	.07932155	.05599675	.36801981
	Equal variances not assumed			2.667	309.911	.008	.21200828	.07950442	.05557156	.36844500

Summary Table

	5 to 8 Years	9 to 13 Years	14 to 18 Years	19 + Years	Parent – Child
Stature			X	X	X
Head Length					X
Head Width	X		X	X	X
Minimum Frontal Diam.	X		X		
Menton-Crinion					
Menton-Nasion					X
Maximum Bizygomatic Diam.	X		X		X
Bigonial Diam.	X	X	X	X	X
Nasal Height					X
Nasal Width	X		X		X

X = significant difference between groups observed

A Comparison of Immigrants and United States Born Adults Living in the United States to Mexican Adults Living in Mexico, Aged 19 + Years

Table 8 displays the group statistics for the two groups being compared; both the immigrant and their United States born population of adult individuals living in the United States to Mexican born adults living in Mexico. As with the above tables, sample sizes, means and standard deviations are recorded for each variable.

Table 8: Group Statistics for Immigrant and United States Born Living in the United States and Mexican Born Adults Living in Mexico, Aged 19 + Years

Group Statistics

	US/Mexico	N	Mean	Std. Deviation	Std. Error Mean
Stature	In US	704	1582.37	86.808	3.272
	In Mexico	505	1562.34	105.198	4.681
HL	In US	706	184.09	7.487	.282
	In Mexico	508	186.43	74.089	3.287
HW	In US	705	148.12	6.004	.226
	In Mexico	508	146.50	6.035	.268
MF	In US	699	101.56	4.534	.171
	In Mexico	508	101.93	37.735	1.674
MC	In US	633	180.19	64.258	2.554
	In Mexico	446	177.73	10.458	.495
MN	In US	670	119.39	8.207	.317
	In Mexico	471	120.72	46.447	2.140
Biz	In US	702	135.84	7.044	.266
	In Mexico	509	138.74	74.309	3.294
Big	In US	691	98.34	7.679	.292
	In Mexico	505	95.75	6.372	.284
NH	In US	696	53.46	3.922	.149
	In Mexico	506	53.57	3.932	.175
NW	In US	695	37.16	3.418	.130
	In Mexico	505	36.92	3.612	.161

Table 9: Independent Samples T-test Results for Adults Aged 19 + Living in the United States Compared to Those Living in Mexico

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Zscore(Stature)	Equal variances assumed	.035	.852	3.100	1207	.002	.06270931	.02022838	.02302261	.10239601
	Equal variances not assumed			3.066	1041.489	.002	.06270931	.02045022	.02258098	.10283765
Zscore(HL)	Equal variances assumed	.089	.766	.887	1212	.375	.04597802	.05185998	-.055767	.14772332
	Equal variances not assumed			.817	746.727	.414	.04597802	.05630607	-.064559	.15651506
Zscore(HW)	Equal variances assumed	.002	.967	4.986	1211	.000	.25757709	.05165885	.15622630	.35892788
	Equal variances not assumed			4.978	1085.878	.000	.25757709	.05174398	.15604759	.35910659
Zscore(MF)	Equal variances assumed	.797	.372	1.664	1205	.096	.08770168	.05271928	-.015730	.19113346
	Equal variances not assumed			1.528	727.824	.127	.08770168	.05741314	-.025013	.20041681
Zscore(MC)	Equal variances assumed	.008	.927	-.464	1077	.643	-.02996111	.06454328	-.156606	.09668372
	Equal variances not assumed			-.516	982.100	.606	-.02996111	.05811193	-.143999	.08407671
Zscore(MN)	Equal variances assumed	1.320	.251	-.761	1139	.447	-.04120608	.05412501	-.147402	.06498984
	Equal variances not assumed			-.643	485.037	.520	-.04120608	.06405265	-.167061	.08464885
Zscore(Biz)	Equal variances assumed	4.279	.039	-.949	1209	.343	-.04849263	.05110706	-.148761	.05177575
	Equal variances not assumed			-.810	514.983	.418	-.04849263	.05984466	-.166062	.06907705
Zscore(Big)	Equal variances assumed	3.435	.064	7.198	1194	.000	.34313380	.04767142	.24960474	.43666287
	Equal variances not assumed			7.429	1180.196	.000	.34313380	.04618880	.25251248	.43375512
Zscore(NH)	Equal variances assumed	.541	.462	-1.060	1200	.290	-.04545736	.04290189	-.129628	.03871370
	Equal variances not assumed			-1.054	1066.273	.292	-.04545736	.04313538	-.130097	.03918251
Zscore(NW)	Equal variances assumed	.097	.756	1.345	1198	.179	.06824427	.05073379	-.031293	.16778124
	Equal variances not assumed			1.341	1072.729	.180	.06824427	.05090345	-.031637	.16812590

Summary Table

	5 to 8 Years	9 to 13 Years	14 to 18 Years	19 + Years	Parent – Child
Stature			X	X	X
Head Length					X
Head Width	X		X	X	X
Minimum Frontal Diam.	X		X		
Menton-Crinion					
Menton-Nasion					X
Maximum Bizygomatic Diam.	X		X		X
Bigonial Diam.	X	X	X	X	X
Nasal Height					X
Nasal Width	X		X		X

X = significant difference between groups observed

The results for the Independent Samples T-test for adults aged 19 + living in the United States versus those living in Mexico are displayed in Table 9. Equal variances are assumed for all variables except maximum bizygomatic diameter. Measurements that are considered significantly different between the two groups are: stature (*p* = 0.002), head width (*p* = 0.000) and bigonial diameter (*p* = 0.000).

A Comparison of United States Born Children to their Mexican Immigrant Parents, Aged 14 + Years

The group statistics for the comparison between Mexican Immigrants and their United States born children living in the United States, aged 14 + years, is displayed on Table 10. As above, the two groups are independent and the samples sizes (n), means and standard deviations are recorded on the table.

Table 10: Group Statistics for United States Born Children and Their Immigrant Parents, Aged 14 + Years

Group Statistics

	Parent/Child	N	Mean	Std. Deviation	Std. Error Mean
Stature	Parent	309	1564.73	82.761	4.708
	Child	503	1587.87	84.819	3.782
HL	Parent	310	184.51	7.088	.403
	Child	504	183.22	7.666	.341
HW	Parent	310	148.63	6.111	.347
	Child	504	146.92	5.784	.258
MF	Parent	306	102.05	4.544	.260
	Child	501	102.66	39.886	1.782
MC	Parent	249	178.31	10.733	.680
	Child	495	179.19	72.500	3.259
MN	Parent	282	120.12	8.452	.503
	Child	496	118.06	7.635	.343
Biz	Parent	308	137.02	7.194	.410
	Child	501	133.58	6.804	.304
Big	Parent	301	99.51	6.548	.377
	Child	501	96.44	7.833	.350
NH	Parent	305	54.02	3.879	.222
	Child	498	52.61	3.844	.172
NW	Parent	305	38.14	3.641	.208
	Child	497	35.98	2.843	.128

Table 11 shows the results of the Independent Samples T-test for the abovementioned grouping. Equal variances are assumed for all variables except nose width. The measurements that are significantly different between the two groups are: stature (*p* = 0.000), head length (*p* =

0.007), head width (*p* = 0.000), menton-nasion (*p* = 0.000), maximum bizygomatic diameter (*p* = 0.000), bigonial diameter (*p* = 0.000), nose height (*p* = 0.000) and nose width (*p* = 0.000).

Table 11: Independent Samples T-test Results for United States Born Children and Their Immigrant Parents, Aged 14 + Years

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Zscore(Stature)	Equal variances assumed	17.981	.000	-6.268	906	.000	-.14749061	.02352967	-.193670	-.101312
	Equal variances not assumed			-6.647	849.328	.000	-.14749061	.02218910	-.191043	-.103939
Zscore(HL)	Equal variances assumed	5.585	.018	2.688	908	.007	.12169470	.04526571	.03285713	.21053228
	Equal variances not assumed			2.629	672.917	.009	.12169470	.04629505	.03079459	.21259482
Zscore(HW)	Equal variances assumed	.736	.391	4.577	907	.000	.27342595	.05973743	.15618629	.39066561
	Equal variances not assumed			4.530	700.563	.000	.27342595	.06036040	.15491699	.39193491
Zscore(MF)	Equal variances assumed	.156	.693	1.073	901	.283	.07200560	.06708078	-.059647	.20365836
	Equal variances not assumed			1.204	900.984	.229	.07200560	.05980308	-.045364	.18937514
Zscore(MC)	Equal variances assumed	.022	.881	1.411	833	.159	.11789814	.08355932	-.046113	.28190971
	Equal variances not assumed			1.750	831.019	.080	.11789814	.06736556	-.014329	.25012479
Zscore(MN)	Equal variances assumed	.840	.360	3.728	870	.000	.05432511	.01457083	.02572702	.08292320
	Equal variances not assumed			3.588	578.443	.000	.05432511	.01513911	.02459078	.08405944
Zscore(Biz)	Equal variances assumed	.935	.334	8.200	903	.000	.07353186	.00896721	.05593285	.09113086
	Equal variances not assumed			8.068	683.063	.000	.07353186	.00911349	.05563804	.09142567
Zscore(Big)	Equal variances assumed	.223	.637	6.724	893	.000	.39484510	.05872406	.27959185	.51009835
	Equal variances not assumed			6.974	776.804	.000	.39484510	.05661445	.28370965	.50598055
Zscore(NH)	Equal variances assumed	.353	.552	5.869	897	.000	.29693470	.05059447	.19763737	.39623203
	Equal variances not assumed			5.875	715.621	.000	.29693470	.05053786	.19771452	.39615489
Zscore(NW)	Equal variances assumed	15.978	.000	10.680	896	.000	.58409450	.05468796	.47676308	.69142593
	Equal variances not assumed			10.156	603.850	.000	.58409450	.05751495	.47114088	.69704812

Summary Table

	5 to 8 Years	9 to 13 Years	14 to 18 Years	19 + Years	Parent – Child
Stature			X	X	X
Head Length					X
Head Width	X		X	X	X
Minimum Frontal Diam.	X		X		
Menton-Crinion					
Menton-Nasion					X
Maximum Bizygomatic Diam.	X		X		X
Bigonial Diam.	X	X	X	X	X
Nasal Height					X
Nasal Width	X		X		X

X = significant difference between groups observed

Mean Scores for All Variables in Each Age Category

Figures 1 through 10 display in a graphical format the mean scores for all ten variables broken into the four age categories. The graphs allow visual examination of the data. In all figures, with the exception of head width, menton-crinion, nasal height, and nasal width, there are clear differences between the two groups. For the majority of the variables the population residing in the United States displays the larger measurements; however, head length appears to be the exception to this statement in all four age categories. There is also a noticeable positive incline apparent in all figures with steep rises in age categories 9 to 13 years and 14 to 18 years. As puberty typically occurs at this time, it is only natural to see that jump. Despite this marked increase in dimensions, but the overall patterns stay consistent with one group displaying larger measurements then the other across the age categories. There are some discrepancies with the minimum frontal diameter, head length, menton-nasion, maximum bizygomatic diameter, and nasal height variables in that the United States population displays larger mean measurements for all ages until the 19 + category range. In both cases, the adult Mexican population appears to show the larger mean measurements. As the vast majority of adults in the United States moved there as adults, they were not affected by the different environment as they would have been had they moved to the US as children, still experiencing growth and development. As adults, growth and development had ceased, and the effects of an improved environmental situation would have had no effect.

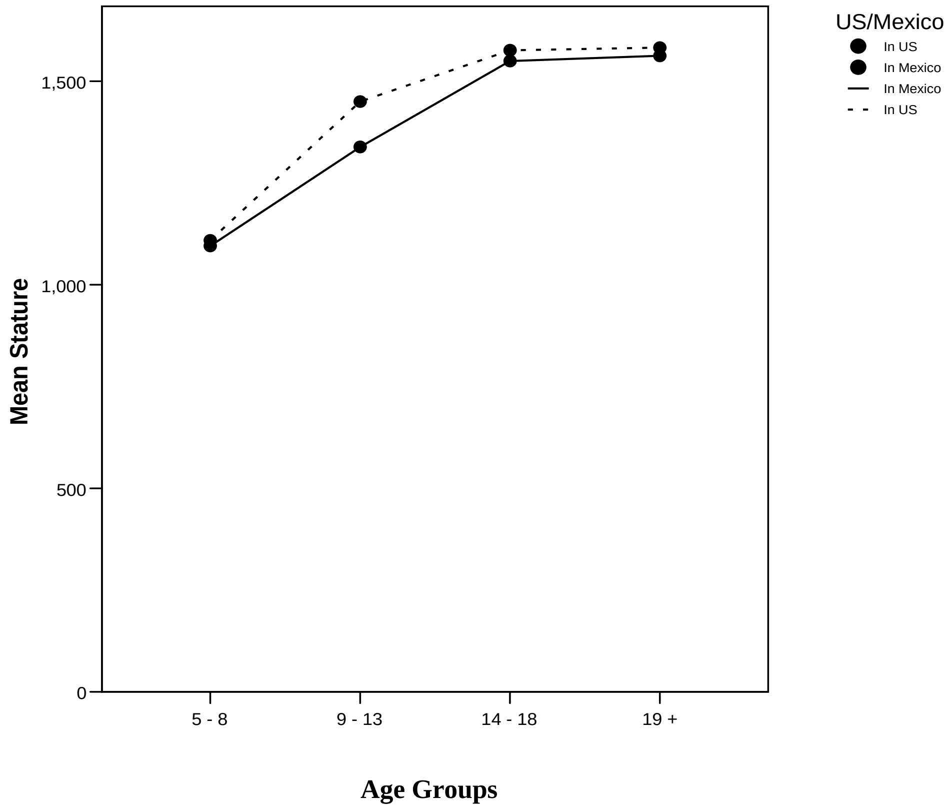

Figure 1: Plot of Mean Stature Scores (Mean Stature in mm)

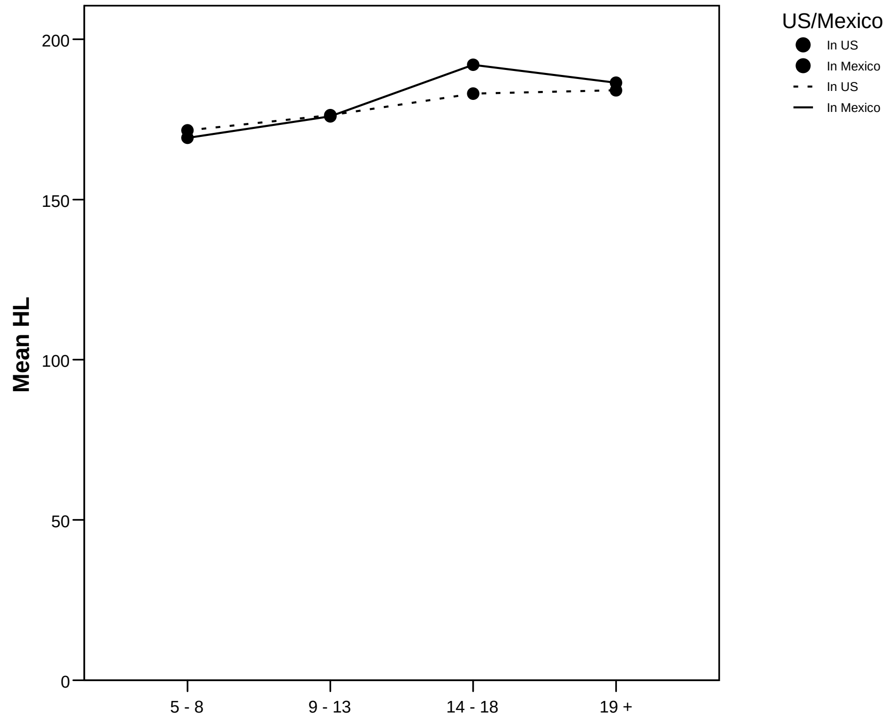

Figure 2: Plot of Mean Head Length Scores (Mean HL in mm)

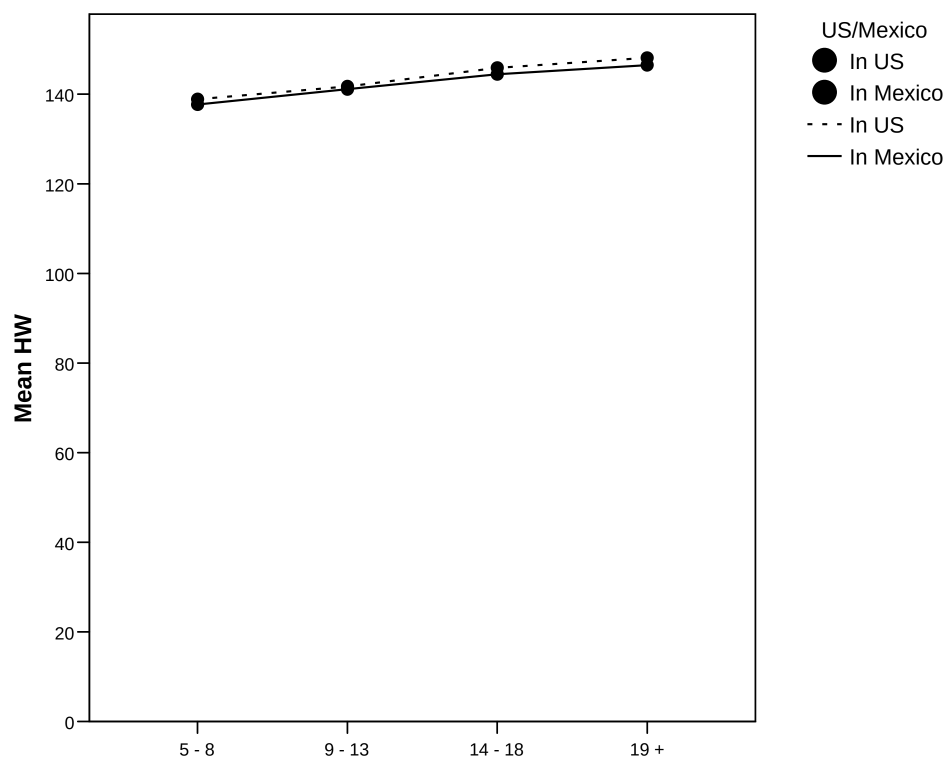

Figure 3: Plot of Mean Head Width Scores (Mean HW in mm)

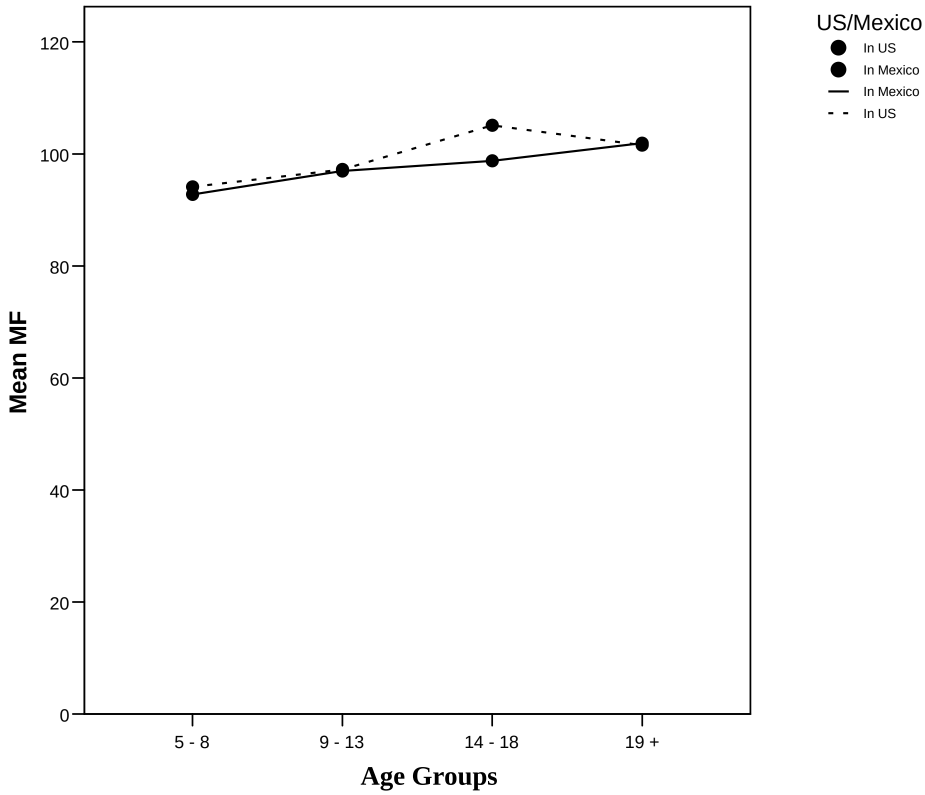

Figure 4: Plot of Mean Minimum Frontal Diameter Scores (Mean MFD in mm)

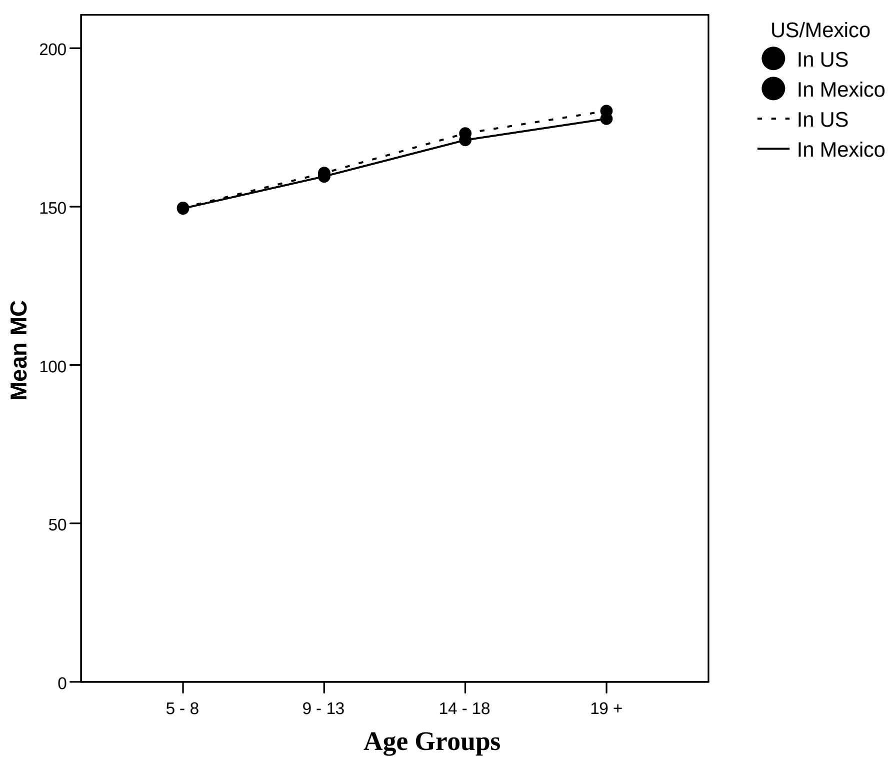

Figure 5: Plot of Mean Menton-Crinion Scores (Mean M-C in mm)

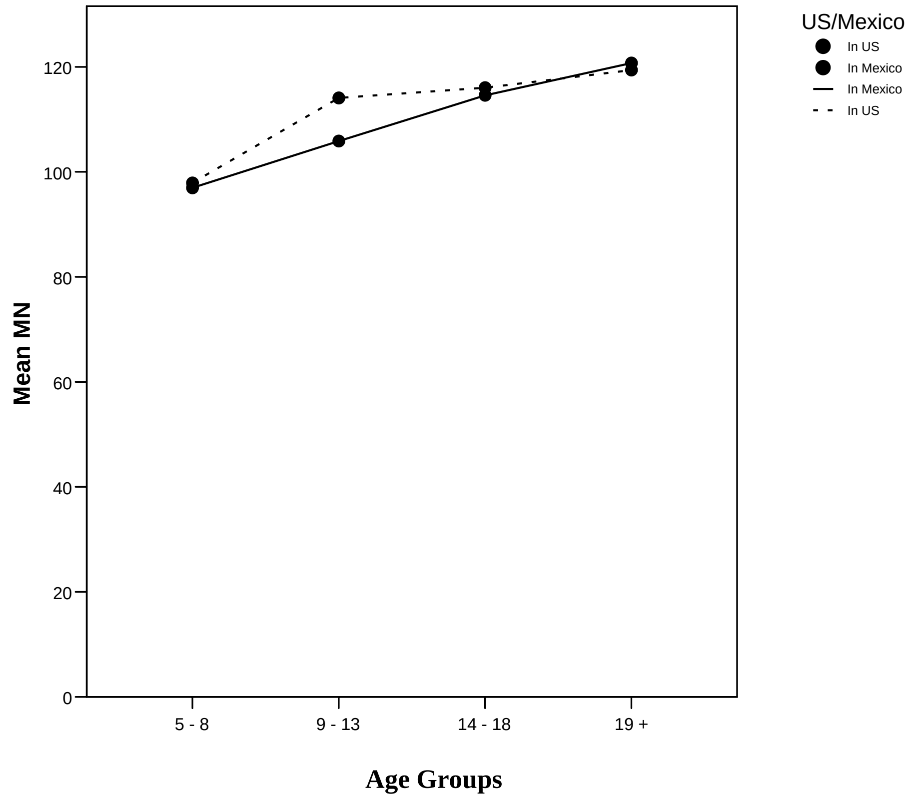

Figure 6: Plot of Mean Menton-Nasion Scores (Mean M-N in mm)

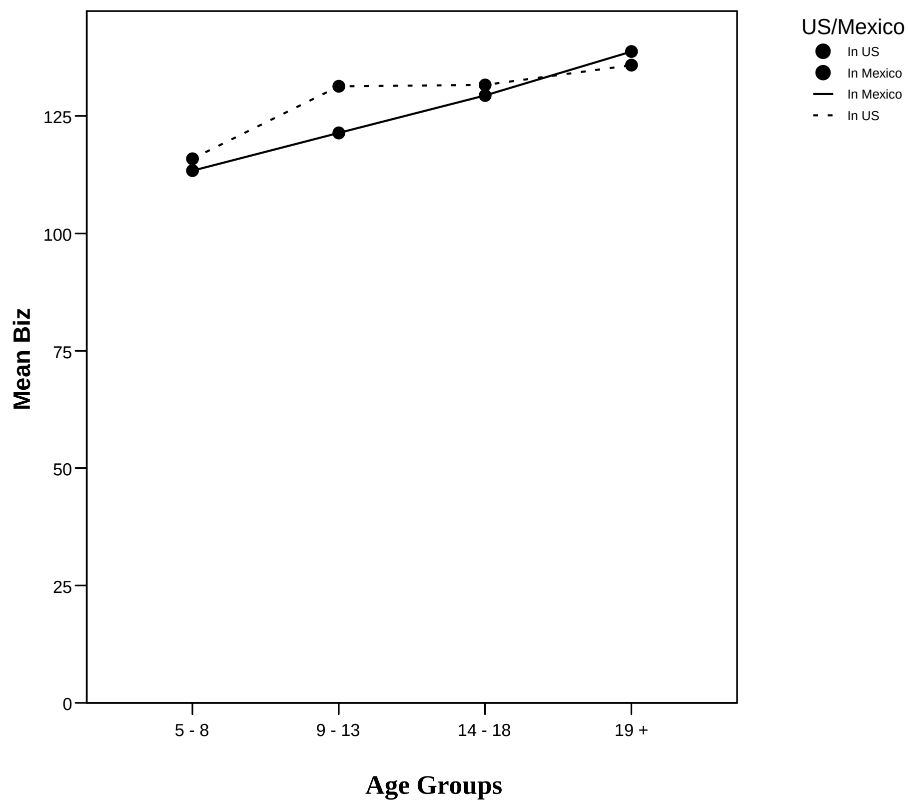

Figure 7: Plot of Mean Maximum Bizygomatic Diameter (Mean Biz in mm)

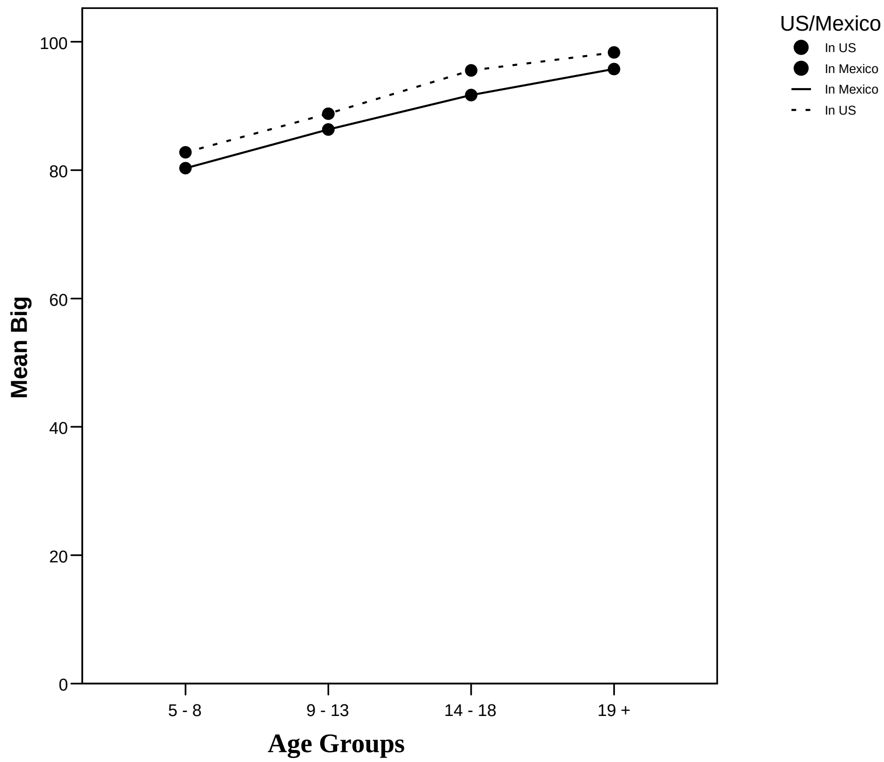

Figure 8: Mean Bigonial Diameter Scores (Mean Big in mm)

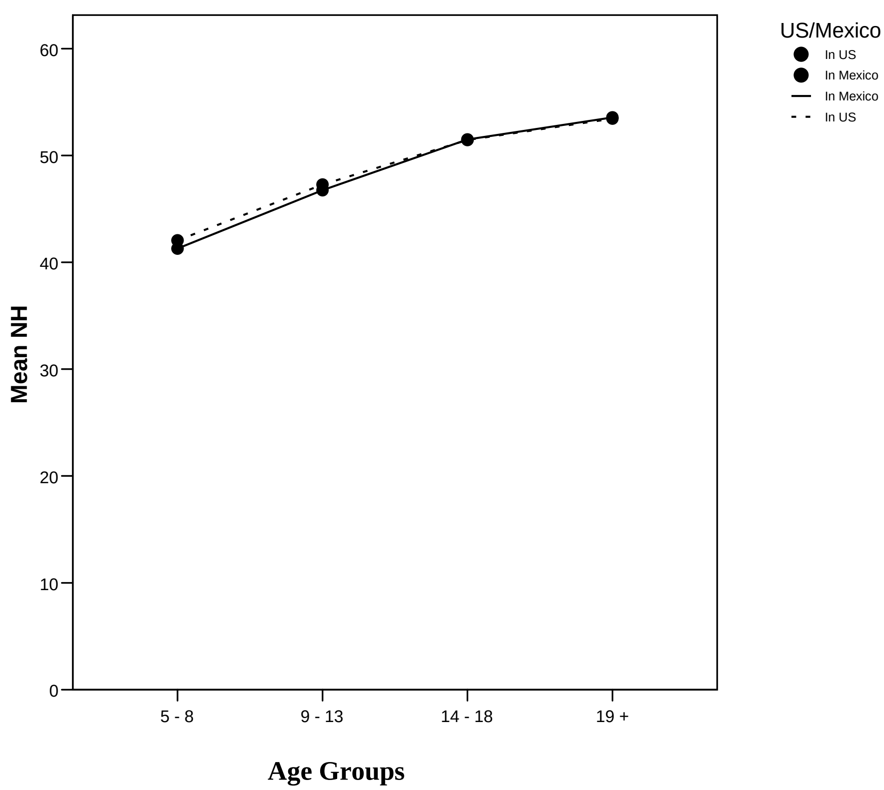

Figure 9: Plot of Mean Nasal Height Scores (Mean NH in mm)

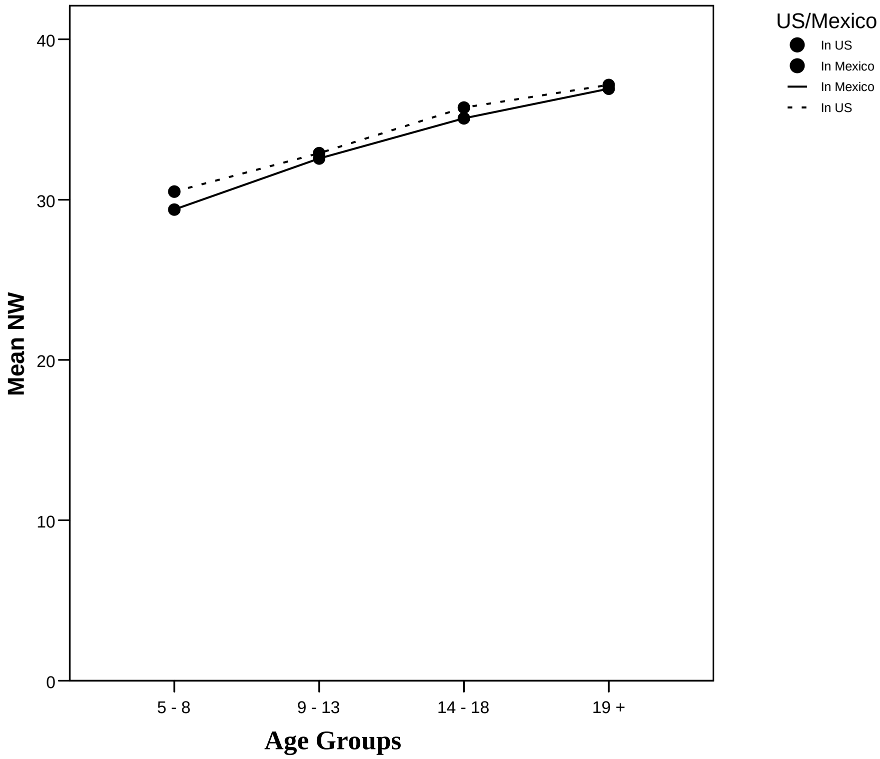

Figure 10: Plot of Mean Nasal Width Scores (Mean NW in mm)

<u>Analysis of Covariance for all Variables Employed (ANCOVA)</u>

An analysis of covariance was performed in order to determine the significant effect, if any, age may have on the distribution of data. Specifically, ANCOVA demonstrates the correlation between age and the anthropometric variable being tested. After controlling for the effects of age, differences between the groups should continue to exist, making it possible to reject the null hypothesis that there is no difference between the two groups. Each dependent variable was analyzed using age as the covariate. Table 12 shows the results of the analysis of covariance on stature. The grouping variable for all results of the covariance analysis for each dependent variable was location (living in the United States or Mexico). With a p-value 0.000 it is clear that age predicts stature. However, when the effect of the covariate is removed, the two groups are not significantly different ($p = 0.223$). The null hypothesis of no difference in stature between groups cannot be rejected.

Table 12: Analysis of Covariance – Stature

Tests of Between-Subjects Effects

Dependent Variable: Zscore(Stature)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	461.858[a]	2	230.929	148.145	.000
Intercept	559.429	1	559.429	358.884	.000
Age	452.282	1	452.282	290.147	.000
USMexico	2.323	1	2.323	1.490	.223
Error	1153.514	740	1.559		
Total	1731.960	743			
Corrected Total	1615.372	742			

a. R Squared = .286 (Adjusted R Squared = .284)

Table 13 shows the results of the analysis of covariance on head length. With a *p*-value of 0.000, it is clear that age predicts head length. However, after the effects of age are removed the two groups are not significantly different ($p = 0.875$). Here, the null hypothesis of no difference in head length between the groups cannot be rejected.

Table 13: Analysis of Covariance – Head Length

Tests of Between-Subjects Effects

Dependent Variable: Zscore(HL)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	98.080[a]	2	49.040	43.200	.000
Intercept	125.112	1	125.112	110.215	.000
Age	97.247	1	97.247	85.667	.000
USMexico	.028	1	.028	.025	.875
Error	837.756	738	1.135		
Total	969.095	741			
Corrected Total	935.836	740			

a. R Squared = .105 (Adjusted R Squared = .102)

The results of the covariance analysis on head width are displayed on Table 14. With *p*-value of 0.000, it is clear that age predicts head width. After the effects of age are removed the two groups are significantly different ($p = 0.001$). The null hypothesis of no difference between groups for head width can be rejected.

Table 14: Analysis of Covariance – Head Width

Tests of Between-Subjects Effects

Dependent Variable: Zscore(HW)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	177.655[a]	2	88.827	126.416	.000
Intercept	267.167	1	267.167	380.224	.000
Age	162.913	1	162.913	231.852	.000
USMexico	8.228	1	8.228	11.710	.001
Error	518.562	738	.703		
Total	871.291	741			
Corrected Total	696.217	740			

a. R Squared = .255 (Adjusted R Squared = .253)

Table 15 displays the results of the covariance analysis on minimum frontal diameter. With a *p*-value of 0.000, it is clear that age predicts minimum frontal diameter. After the effects of age are removed the two groups are significantly different ($p = 0.002$), and the null hypothesis of no difference between the groups can be rejected.

Table 15: Analysis of Covariance – Minimum Frontal Diameter

Tests of Between-Subjects Effects

Dependent Variable: Zscore(MF)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	93.374[a]	2	46.687	43.559	.000
Intercept	112.800	1	112.800	105.242	.000
Age	78.178	1	78.178	72.940	.000
USMexico	10.467	1	10.467	9.765	.002
Error	783.491	731	1.072		
Total	923.250	734			
Corrected Total	876.865	733			

a. R Squared = .106 (Adjusted R Squared = .104)

Table 16 shows the results of the covariance analysis on the menton-crinion dependent variable. With a *p*-value of 0.000, it is clear that age predicts menton-crinion. However, after the effects of age are removed the two groups are not significantly different ($p = 0.873$). Here, the null hypothesis of no difference between the groups cannot be rejected.

Table 16: Analysis of Covariance – Menton-Crinion

Tests of Between-Subjects Effects

Dependent Variable: Zscore(MC)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	122.977[a]	2	61.488	137.354	.000
Intercept	183.087	1	183.087	408.983	.000
Age	122.254	1	122.254	273.093	.000
USMexico	.012	1	.012	.026	.873
Error	309.784	692	.448		
Total	533.176	695			
Corrected Total	432.760	694			

a. R Squared = .284 (Adjusted R Squared = .282)

The results of the covariance analysis on the menton-nasion dependent variable are displayed on Table 17. With a *p*-value of 0.000, it is clear that age predicts menton-nasion. However, after the effects of age are removed the two groups are not significantly different (p = 0.123). Here, the null hypothesis of no difference between the groups cannot be rejected.

Table 17: Analysis of Covariance – Menton- Nasion

Tests of Between-Subjects Effects

Dependent Variable: Zscore(MN)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26.954[a]	2	13.477	10.946	.000
Intercept	35.189	1	35.189	28.580	.000
Age	22.848	1	22.848	18.557	.000
USMexico	2.939	1	2.939	2.387	.123
Error	853.235	693	1.231		
Total	899.751	696			
Corrected Total	880.188	695			

a. R Squared = .031 (Adjusted R Squared = .028)

The results of the covariance analysis on the maximum bizygomatic diameter as a dependent variable are displayed in Table 18. With a *p*-value of 0.005, it is clear that age predicts maximum bizygomatic diameter. However, after the effects of age are removed the two groups are not significantly different ($p = 0.126$) and the null hypothesis of no difference between the groups cannot be rejected.

Table 18: Analysis of Covariance – Maximum Bizygomatic Diameter

Tests of Between-Subjects Effects

Dependent Variable: Zscore(Biz)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.449[a]	2	7.225	5.429	.005
Intercept	18.088	1	18.088	13.591	.000
Age	10.464	1	10.464	7.863	.005
USMexico	3.115	1	3.115	2.340	.126
Error	982.154	738	1.331		
Total	1009.603	741			
Corrected Total	996.603	740			

a. R Squared = .014 (Adjusted R Squared = .012)

Table 19 shows the results of the covariance analysis on bigonial diameter as a dependent variable. With a *p*-value of 0.000, it is clear that age predicts bigonial diameter. After the effects of age are removed the two groups are significantly different ($p = 0.000$). The null hypothesis of no difference between the groups can be rejected.

Table 19: Analysis of Covariance – Bigonial Diameter

Tests of Between-Subjects Effects

Dependent Variable: Zscore(Big)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	315.761[a]	2	157.881	314.110	.000
Intercept	428.108	1	428.108	851.739	.000
Age	269.892	1	269.892	536.963	.000
USMexico	33.315	1	33.315	66.282	.000
Error	357.368	711	.503		
Total	929.124	714			
Corrected Total	673.129	713			

a. R Squared = .469 (Adjusted R Squared = .468)

Table 20 shows the results of the covariance analysis using nose height as the dependent variable. With a *p*-value of 0.000, it is clear that age predicts nose height. However, after the effects of age are removed the two groups are not significantly different (p = 0.260). Here, the null hypothesis of no difference between the groups cannot be rejected.

Table 20: Analysis of Covariance – Nose Height

Tests of Between-Subjects Effects

Dependent Variable: Zscore(NH)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	398.147[a]	2	199.074	374.042	.000
Intercept	585.728	1	585.728	1100.533	.000
Age	393.761	1	393.761	739.843	.000
USMexico	.676	1	.676	1.270	.260
Error	371.491	698	.532		
Total	1075.115	701			
Corrected Total	769.638	700			

a. R Squared = .517 (Adjusted R Squared = .516)

The results of the covariance analysis using nose width as the dependent variable are exhibited in Table 21. With a p-value of 0.000, it is clear that age predicts nose width. After the effects of age are removed the two groups are significantly different (p = 0.008). The null hypothesis of no difference between the groups can be rejected.

Table 21: Analysis of Covariance – Nose Width

Tests of Between-Subjects Effects

Dependent Variable: Zscore(NW)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	251.032[a]	2	125.516	240.465	.000
Intercept	376.791	1	376.791	721.860	.000
Age	236.928	1	236.928	453.908	.000
USMexico	7.478	1	7.478	14.327	.000
Error	364.337	698	.522		
Total	855.492	701			
Corrected Total	615.370	700			

a. R Squared = .408 (Adjusted R Squared = .406)

In summary, head width, minimum frontal diameter, bigonial diameter, and nose width were significant at the alpha level 0.05. It is sufficient to say that when age was controlled for in the comparison between the two groups, the means were still found to have highly significant differences. Therefore, with the bias removed, these anthropometric measurements are significantly different between individuals living in the United States compared to individuals living in Mexico.

RMET Results

An analysis of the multivariate quantitative data using RMET 5.0 is useful for predicting similarity based on group membership using the R matrix and Fst, as well as a Relethford-Blangero analysis. Additionally, genetic distance, potential for genetic drift, and within-group phenotypic variance can be evaluated. This analysis focuses on the results generated by the R Matrix analysis of the eight independent groups based on location (Mexico or the U.S.) and age category (1 to 4).

Table 22 displays the Fst values based on the R matrix showing the amount of among-group variation. The Fst value is fairly low at 0.020803, compared to worldwide Fsts calculated based on genetics (Fst = 0.10 to .11) and craniometrics (Fst = 0.144) (Relethford 1994). This indicates that the amount of among-group variation is fairly low.

Table 22: Fst Values

Fst	Unbiased Fst	Standard Error (se)
0.020803	0.016420	0.002449

The within-group phenotypic variance for all populations from the Relethford-Blangero analysis is displayed on Table 23. Observed, expected and residual values are all shown. About half of the groups show positive residuals (Mexican children aged 9 to 13 (0.101), US children aged 9 to 13 (0.127), US children aged 14 to 18 (0.257), and Mexican adults aged 19 + (0.196)) indicating the likelihood of gene flow or other factors that increase diversity, within the population group. All other age and location groupings show negative residuals, possibly indicative of genetic drift, or other factors that serve to decrease diversity. The mean within-group phenotypic variance is 0.951. Within-group phenotypic variance values are based on the unbiased R matrix.

Table 23: Within-group Phenotypic Variance

Population	R(ii)	Observed	Expected	Residual
Age1Mexico	0.027181	0.645	0.940	-0.295
Age1US	0.029188	0.810	0.938	-0.128
Age2Mexico	0.023192	1.045	0.944	0.101
Age2US	0.010409	1.084	0.957	0.127
Age3Mexico	0.012898	0.798	0.954	-0.156
Age3US	0.005735	1.218	0.961	0.257
Age4Mexico	0.012975	1.150	0.954	0.196
Age4US	0.009785	0.855	0.957	-0.103

Principal coordinates were also calculated by RMET 5.0. Five non-zero eigenvalues were determined based on the groups, and each account for a degree of the variation between groups. The first eigenvalue accounts for 61.8% of the variation, while the second accounts for 18.9% of the variation. Collectively, both account for 80.6% of the total variation between groups. Eigenvector scores are then generated from the scaled square roots of the eigenvalues.

Figure 11 displays the first two eigenvector scores plotted as a genetic distance map. Groups are clearly spaced based on geographical location with no two group comparisons showing strong similarities with regards to distances from each other. This suggests that the differences between the groups are based on geographical location (Principal Coordinate 1) then age (Principal Coordinate 2).

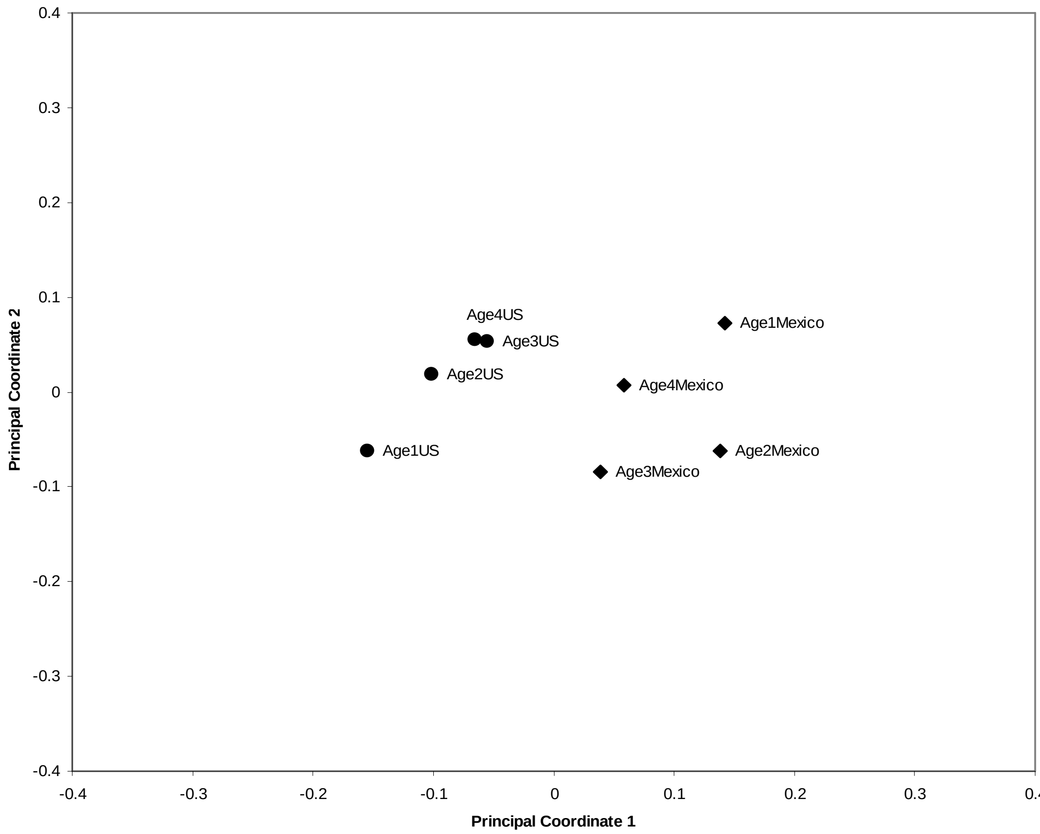

Figure 11: Genetic Distance Map of all Groups

The results of the generated R Matrix scores are displayed in Table 24. Individual groups as well as comparisons of group similarities and differences are available. The standard error for each group and group comparison is also displayed. Morphologically similar population groups are indicated by more positive values (0 >), while less positive values are indicative of a less then average similarity between population groups (0 <). Though all age group comparisons between geographic location show negative R matrix scores, indicating groups that are less similar then average, they are essentially 0. Comparatively, US and Mexican born adults aged 19+ were the most morphologically similar (-0.001036), followed by US and Mexican born children aged 14 to 18 (-0.005325), US and Mexican born children aged 5 to 8 (-0.025941), and US and Mexican born children aged 9 to 13 (-0.014981).

Table 24: R Matrix Results

	Age1Mex	Age2Mex	Age3Mex	Age4Mex	Age1US	Age2US	Age3US	Age4US
Age1Mex	0.027181	0.015352	-0.002781	0.002675	-0.025941	-0.013423	-0.004237	-0.008259
Age2Mex	0.015352	0.023192	0.008252	0.006830	-0.017260	-0.014981	-0.012919	-0.013011
Age3Mex	-0.002781	0.008252	0.012898	0.000196	-0.005480	-0.005228	-0.005325	-0.005956
Age4Mex	0.002675	0.006830	0.000196	0.012975	-0.011865	-0.008371	-0.002545	-0.001036
Age1US	-0.025941	-0.017260	-0.005480	-0.011865	0.029188	0.013425	0.004022	0.003494
Age2US	-0.013423	-0.014981	-0.005228	-0.008371	0.013425	0.010409	0.006982	0.008377
Age3US	-0.004237	-0.012919	-0.005325	-0.002545	0.004022	0.006982	0.005735	0.005799
Age4US	-0.008259	-0.013011	-0.005956	-0.001036	0.003494	0.008377	0.005799	0.009785

A Mahalanobis D^2 matrix was also generated in order to measure biological distances between groups. Based on correlations between variables, different patterns within the data can be identified and analyzed. Pairwise distances are evaluated, with more similar groups having smaller distances and less similar groups having larger distances. The D^2 matrix is displayed on Table 25. US and Mexican adults aged 19 + were the most similar (0.024833) followed by US and Mexican born children aged 14 to 18 (0.029283), US and Mexican born children aged 9 to 13 (0.0635633), and finally US and Mexican born children aged 5 to 8 (0.1082514). The data presented here confirms that presented in the above section of R matrix values.

Table 25: D-Squared Matrix Results

	Age1Mex	Age2Mex	Age3Mex	Age4Mex	Age1US	Age2US	Age3US	Age4US
Age1Mex	0	0.019669	0.045640	0.034807	0.108251	0.064435	0.041390	0.053484
Age2Mex	0.019669	0	0.019584	0.022508	0.086898	0.063563	0.054764	0.058999
Age3Mex	0.045640	0.019584	0	0.025481	0.053046	0.033762	0.029283	0.034594
Age4Mex	0.034807	0.022508	0.025481	0	0.065892	0.040125	0.023799	0.024833
Age1US	0.108251	0.086898	0.053046	0.065892	0	0.012748	0.026878	0.031984
Age2US	0.064435	0.063563	0.033762	0.040125	0.012748	0	0.002180	0.003439
Age3US	0.041390	0.054764	0.029283	0.023799	0.026878	0.002180	0	0.003922
Age4US	0.053484	0.058999	0.034594	0.024833	0.031984	0.003439	0.003922	0

CHAPTER VI. DISCUSSION

The importance of this section is to interpret the results for evidence of plasticity of the human body with regards to environmental factors and evaluate any evidence that may point towards a genetic contribution based on selective migration or gene flow. Based on background information it can be inferred that the overall environment in the U.S. was only marginally improved over that of Mexico; however, key differences in the U.S. environment, including greater access to health care and a less nutritionally restricted diet would may have produced a generation of children with significantly different measurements than their parents. This was definitely the opinion of both Goldstein and Boas when the two performed their analyses on immigrant populations. Both scholars believed that their findings pointed toward evidence in favor of variation between two genetically similar populations based on the effects of a different environment. Goldstein (1943) believed that stature and bigonial diameter showed the most plastic response to the environment, while Boas (1912) reported that the cephalic index were the most plastic. In both cases, variation in growth between two populations was attributed to environment rather then genetics. The results presented here do indicate variation between groups and that the variation is seen most strongly between the youngest age group, teen age group, and between immigrant parents and their US born children. This would indicate a plastic response of the human body based on environmental changes, as seen in the results of the RMET analysis, t-tests some of the results of the ANCOVA analysis, and genetic distance map. Specifically, the amount of time spent in a particular environment has a direct impact on variation in bodily measurements shown when Mexican and US groups were compared.

Independent Samples T-tests

Based on the results and *p*-values put forth in the results, there is at least one variable in each test showing a significant difference between the two groups at the .05 alpha level. The greatest number of significant differences between groups occurred in the tests comparing Mexican immigrant parents to their United States born children. This was followed by the number of significant differences among the comparison between United States born and Mexican born children aged 14 to 18 years, then among the comparison between United States born and Mexican born children aged 5 to 8, then among the comparison between adults living in the United States and those living in Mexico aged 19 +, then finally among the comparison between United States born and Mexican born children aged 9 to 13 years. A general pattern emerges from significant differences among group comparisons. The most significant differences amongst the children being compared occurred between US and Mexican born children in the puberty group (aged 14 to 18). This is indicative of variation in growth based on genetics, as environmental stimuli typically affect children in the younger age groups before the onset of puberty. If children are stunted or slowed at growth due to environmental effects then they will not grow as quickly, or as tall during puberty; however, variation seen at puberty is largely under genetic control. Variation in growth based on environment should be seen increasingly among younger age groups, something that is not seen consistently in the results of the t-test presented here; however, differences between US and Mexican born children aged 5 to 8 mirror those differences seen between children in the 14 to 18 age groups. Significant differences were seen between those two groups in head width, minimum frontal diameter, maximum bizygomatic diameter, bigonial diameter, and nasal width. These measurements are all specific to the cranium. Growth rates are extremely fast during the childhood years between

4 and 6; therefore, an environment has the potential to alter skeletal measurements dramatically during this stage of life compared to the juvenile and adolescent periods, both of which are characterized by slower, and more similar growth rates regardless of environmental situation (Stinson 2000). This appears to be the general pattern exhibited in the t-test results. Cranial measurements show significant differentiation between US and Mexican children aged 5 to 8, then level off in comparisons between children aged 9 to 13, then show the same significant differences in measurements between US and Mexican children aged 14 to 18. Although the lack of indication of significant variation between the juvenile age groups (age 9 to 13) suggests a lack of environmental influence on all anthropometric measurements except bigonial diameter, studies have suggested that the vast majority of adult height differences can be interpreted by looking at growth differences that occurred in early childhood (see Stinson 2000). In addition, growth is fastest in the youngest age category, then levels off during adolescence, then again speeds up during the teen years. As the majority of cranial variables that exhibit significant differences between US and Mexican children aged 5 to 8 are the same as both US and Mexican children aged 14 to 18, US and Mexican adults aged 19 +, and immigrant parents and their US born children compared, then differences in environment appears to be a likely cause for variation.

In the comparison between Mexican immigrants and their United States born children almost all variables show significant differences between the two groups. This is indicative of an extremely plastic response of the human body to the environment within only one generation. As natural selection and biological adaptation typically take years to manifest, the plasticity witnessed in this case cannot be attributed to natural selection. It might also be suggested that the differences between children and their parents came as the result of selective migration, that is Mexican immigrants who came to the U.S. had children who were generally taller then those who stayed in Mexico because they themselves were taller; however, the significant differences in cranial measurements between US and Mexican born children aged 5 to 8 when growth is most affected by environment suggests that there are outside factors at work that are much more influential then genetically predetermined patterns of growth. Selective migration can additionally be assessed by looking at the fourth group comparison between adults aged 19 + living in the United States and those living in Mexico. Stature, head width, and bigonial diameter were the three dimensions which showed a significant difference, while the majority of variables showed no difference between the two groups. The absence of several dimensions showing a significant difference is indicative of two populations who are essentially more similar in measurements then they are different. In addition, in his original sample Goldstein only chose individuals of a particular group – mestizos with primarily Indian characteristics. The homogeneity of the entire sample would also rule out selective migration. These three variables mentioned above were also consistently significant in comparisons between US and Mexican born children aged 14 to 18, and Mexican immigrants and their US born children. In addition, all individuals included in this study were from the same central and northern areas of Mexico. Years of gene flow has worked to increase the amount of genetic variation within groups being compared, while decreases the amount of variation between groups (Relethford 2004); therefore, differences between migrating adult populations compared to native adult populations will be expected to be greater if the populations are more similar, indicating more variation. More variation allows traits to be expressed differently in children genetically, while also being altered in different ways by the effects of an improved environment. While still a possibility, selective migration does not appear to be a likely factor in differences between the offspring of immigrating versus native Mexican adults.

Among the other tests, the comparison of U.S. born to Mexican born children aged 14 to 18 shows the largest number of variables with significant differences between groups. Stature, as well as the majority of head and face measurements, show significant differences between groups at an alpha level of .05. During the normal cycle of growth and development these are typically the ages in which puberty hits in both boys and girls, so if differences were to be made apparent between the two groups then this is the age range that would show those differences most acutely; however, differences in puberty typically manifest themselves due to genetic potential first, followed by differences in growth pre-puberty due to environment. If children are exposed to a better environment while young then the potential for optimal growth will be realized much quicker then children who experience stunting during childhood and reach adult measurements at a much slower pace. Even with the onset of catch up growth, some children who grew up in harsher environments do not reach their full genetic potential for growth then those who grew up in better environments. While comparisons between U.S. born to Mexican born children aged 9 to 13 years result in significant variation between only bigonial diameter, the number of variables that show differences between groups drastically rises during both early childhood and puberty (ages 5 to 8 and 14 to 18). This is indicative of changes based on environment. During early childhood growth rates are typically fast, and more easily influenced by changes in environment that may alter or stunt regular patterns. During adolescence, growth becomes slower, more even and less influenced by environmental factors. While the puberty years are typified by rapid growth, traits are also under the most genetic control, unlike childhood rapid growth; however, growth disruption in childhood can significantly affect complete skeletal maturation that occurs during puberty. Catch up growth, or even lengthened, or late onset puberty, cannot always make up for delayed growth suffered during childhood. In many cases, skeletal maturation is completed before delayed linear growth can fully catch up. While bigonial diameter is the one variable that is consistently significantly different between groups in all group comparisons, it appears as though the majority of cranial measurements are affected by environmental stimuli. The differences in adult populations, as well as the differences in pre-puberty groups with regards to these variables would point towards plasticity of the cranium based on environmental factors.

A number of conclusions are to be gained from the results of the T-tests. Each grouping being compared results in at least one significant difference among variables between groups. Gene flow from outside groups does not appear to be a valid explanation of the apparent differences as the individuals chosen came from a relatively homogenous population from specific areas of Mexico and tended to stay within cultural and geographic boundaries when choosing partners to procreate. Selective migration is not viewed as a likely possibility due to the pattern of significant differences apparent between immigrant parents and their US born children along with the homogeneity of the entire sample, US and Mexican born children aged 5 to 8, and US and Mexican born children aged 14 to 18. The consistency of cranial variables showing significant differences between age groups experiencing the most rapid growth spurts, along with comparisons between immigrant parents and their US born children would point towards an explanation of skeletal variation based on differences in the United States environment compared to that of Mexico. Specifically, the cranium shows the most plasticity based on environmental stimuli.

Plots of Mean Scores for All Variables

The plots of mean scores for all variables were used as a visual examination of the data; however, a number of conclusions can be drawn based on the plots themselves. The majority of variables show clear differences between the U.S. group and the Mexican group populations. Typically, the U.S. group exhibits the larger mean measurements for each category; however, head length is the exception where more then two age categories show larger mean measurements among the Mexican group. Additionally, menton-nasion, maximum bizygomatic diameter, and to some extent both nose height and width show larger measurements among the Mexican group in the adult age category (age 19 +). In all these cases the difference appears minimal with both groups approaching equal measurements. As discussed in the above section, the largest number of significant differences occurs during the puberty years, then decreases in the next age group (age 19 +) where the two adult groups being compared show only three variables with significant differences. This could indicate a number of things; foremost of which is selective migration as was discussed in the above section. The fact that differences exist could lead to a tentative conclusion that any differences at all could be attributed to an immigrating population that differed from the native population that stayed in Mexico. As the majority of adults included in the sample immigrated to the United States as adults when the growth process was already complete, they were not affected by a change in environment as children, still experiencing growth, would have been.

The plots also visually show the biological progression of growth and development with a number of large gaps between groups among variables occurring during puberty years. Specifically the 9 to13 years and 14 to 18 years categories express both the jumps in mean measurement scores as well as large visual differences apparent between the U.S. and Mexican group lines. The progression of growth and development is also apparent with both the youngest and oldest groups showing very similar mean scores with differences primarily occurring during the two middle age categories. This is not consistent with all variables. Some variables, such as head width, menton-crinion, nose height and nose width all show consistently straight and even mean measurement progressions across the ages, but small differences in scores are apparent in most cases.

Analysis of Covariance

The analyses of head width, minimum frontal diameter, bigonial diameter and nose width with age as a covariate for the comparison between the two groups (United States and Mexican sample populations) were significant at the alpha level .05. It is sufficient to say that when age was controlled for in the comparison between the two groups, the means were still found to have highly significant differences. Therefore, with the bias removed, these anthropometric measurements are significantly different between individuals living in the United States compared to individuals living in Mexico. This would point towards an environmental rather then genetic explanation of differences between groups. However, it was assumed based on the t-test results that length of time in the United States does have an affect on anthropometric measurements and optimal growth, especially when comparing immigrants to their United States born children. The lack of significant differences with the t-test may be explained since age is clearly a confounding factor.

RMET Analysis

The analysis generated by RMET 5.0 indicated a number of group differences including among-group variation, overall genetic similarity, and specific differences between individual groupings. The Fst value of 0.020803 is fairly low indicating low among-group variation compared to both Reletheford's (2004) calculations of Fsts for world wide genetics data (0.10 to 0.11), and craniometrics (0.144).

The results of the Relethford-Blangero analysis are indicative of the amount of phenotypic diversity within a population group. While positive residuals suggest more gene flow, negative residuals are typically caused by genetic isolation and drift. The mean within-group phonotypic variance is high at 0.951, denoting a relatively high amount of biological variability within population groups. Specifically, only three groups (Mexican and US children aged 9 to 13 and Mexican adults aged 19 +) showed positive residuals suggesting gene flow or other diversity promoting factor within groups. All other groups displayed negative residuals, suggesting genetic isolation and/or drift within groups. This analysis does confirm the above discussion based on the results of the Independent Samples T-tests performed. Only the older population groups tested showed evidence of genetic dissimilarities, or variation within group which would indicate more isolation and variation from other groups. This is specifically important with regards to the U.S. and Mexican adult groups. The greater variation within the U.S. adult group would suggest more gene flow over a long period of time as variation within groups increases, while variation between groups decreases. It would then make sense that the adult children born in the U.S. showed more variation when compared to their immigrant parents due to the length of time spent in a better environment.

Additional conclusions can be made using the results of the genetic distance map. Generally, the groups are spaced on the map based on geographical location first, then age. There appears to be a pretty clear line between the US sample and the Mexican sample with both location groups spread out on either side of the map respectively. It is apparent from the genetic distance plot that no two age category groups (US and Mexican) are very closely spaced to each other. Each group is fairly separate from its counterpart. The differences are drastic between age groups 5 to 8 and 9 to 13. The data leads to a number of conclusions. The first being that variation in the growth process is attributed to differences in geographical location and the associated environment. Next, variation is affected by the amount of time spent in the United States as indicated by relative spacing of age groups. US born children appear to be different from Mexican born children with at an early age, then are most similar, respectively, as adults. The drastic differences in the younger age groups can most likely be attributed to environmental effects on the rapid growth of young children, then gradually leveling off and becoming slower as skeletal maturation is achieved after puberty. As growth is most affected by the environment prior to puberty, children who experienced stunting or improper growth due to harsher environmental stimuli are shorter than those living in an improved environment before puberty sets in. At the onset of puberty, these children who are shorter do not gain optimal levels of growth, or experience a much later, slower period of catch-up growth later in life. The distance map allows a clear picture to be shown of the effects of puberty with regards to ultimate variation and genetic distance between two groups, while at the same time showing an accurate portrayal of genetic differences before and after the effects of a differing environment are realized. Children exposed to a less advantaged environment compared to children living in improved conditions are smaller and shorter overall. At puberty, they are not able to catch up to the amount of growth their counterparts experience living in a better environment.

The results of the R matrix analysis tend to mirror the results of the Independent Samples T-test with regards to group similarities and differences. Among the four major group comparisons based on age and location, Mexican and US adults aged 19 + were the most morphologically similar populations followed by Mexican and U.S. children aged 14 to 18, Mexican and U.S. children aged 5 to 8, and Mexican and US children aged 9 to 13. This is similar to previous t-test results. As the effects of the environment are increasingly apparent in younger children (before puberty) then greater differences should be seen between the two youngest groups sampled. This appears to be the case. Mexican and US children aged 5 to 8 and 9 to 13 compared were shown to be the least morphologically similar populations. This would indicate variation between the groups suggesting differing environments allowing dissimilar patterns of growth. Overall, the results of the R matrix suggest that children in the 5 to 8 age group in both countries were experiencing differing growth patterns which continues into late childhood (9 to 13 years), although at a much slower pace continuing into adulthood. This is evident in both the t-test scores as well as the comparatively low negative R matrix scores of US and Mexican children aged 14 to 18 that indicates less variation during puberty then early childhood. Since the evidence for strong variation among the younger age groups is convincing, the results of the R matrix analysis would point towards an environmentally inclined model of variation in growth where changes in environment have the effect of altering skeletal growth rather then one in which underlying genetics have played a major role in growth patterns.

The D^2 matrix results confirm the abovementioned R matrix scores and results. US and Mexican born adults aged 19 + were found to be the most similar, followed closely by US and Mexican born children aged 14 to 18, US and Mexican born children aged 9 to 13, and US and Mexican children aged 5 to 8. This is indicative of a pattern of skeletal variation based on environmental differences that affect the rapid growth and development in young children, leading to insufficient catch up growth and balanced maturation and linear growth rates.

Comparison of Results to Goldstein's and Boas's Findings

Goldstein's (1943) results were based on mean scores for each measurement, and comparisons were made across and between two groups: parents and children. Age was not used as a grouping variable, rather individuals were grouped as to whether or not they were a father, mother, son, or daughter. When mean scores were calculated for each variable, Goldstein calculated the average amount each group living in the United States exceeded, or not, those living in Mexico. Fathers in the United States showed an increase in all variables measured over fathers in Mexico with the exception of nose height and nose width. The greatest difference occurred in bigonial diameter, followed by bizygomatic diameter, and menton-nasion. Anthropometric measurements for mothers in the United States compared to mothers in Mexico were all greater except for menton-crinion and menton-nasion. The greatest difference occurred in bigonial diameter, bizygomatic diameter, and head length. In comparison to the data reported in the current study, bigonial diameter also showed the most significant difference between adults in both locations; however, the t-test performed on Mexican and US adults aged 19 + did not show significant differences between populations for bizygomatic diameter, menton-nasion, or head length.

Since Goldstein did not group children into age categories, instead focusing on a large group of individuals 18 years and younger, it is difficult to get the full extent of differences and similarities between the data presented in this thesis and Goldstein's original data; however, some generalities can be made. Sons born in the United States showed an increase in all measurements except nose width. The greatest differences occurred in bigonial diameter, menton-nasion, and stature. Daughters born in the United States also showed an increase in all measurements except menton-crinion and menton-nasion. The largest increases occurred in bigonial diameter, bizygomatic diameter, and stature. These increases are also consistent with significant differences found in the results of the t-tests in this thesis. Bigonial diameter, stature and bizygomatic diameter were almost universally significantly different in between United States and Mexican born children aged 5 to 18. The consistency of bigonial diameter in Goldstein's data as well as the results generated in this paper, would suggest, as stated above, that it is an anthropometric variable under a larger degree of environmental control then others. The same can also be said for stature, although the increases in both this and Goldstein's results were not as profound as that of bigonial diameter.

Goldstein's data was consistent with Boas's with regards to stature increases; however, in comparison to Boas, Goldstein did not find any significant difference in cephalic index between both groupings – children and parents and Mexicans and Mexican-Americans. This is different from Boas, who found significant differences in cranial dimensions between immigrants and their United States born children. This is also a point of differentiation in the data generated in this report. With the exception of bigonial diameter, cranial dimensions did not universally appear to have been significantly different between United States and Mexican born children, although significant differences for head length and width can be seen across all groups. Overall, there are some definite similarities between Goldstein's original findings, especially among cranial measurements and plasticity. It would appear with regards to these measurements, Goldstein's original conclusions are valid; however, other measurements such as stature, were not found to be significantly affected by a different environment, for the most part, by modern statistical analyses.

CHAPTER VII. CONCLUSION

The extensive literature available on environmental and genetic contributions to human growth and development has generally led to a virtual standstill in the hope for any consensus being reached. Analyses of data continue to be performed, calling into question many of the ideas that were once held as fact in anthropological discussions. Today, two sides have emerged with very little middle ground between them. It is impossible for this report to conclusively choose one side or the other without performing additional, and more specific tests; however, when looked at as a sum of all parts it is possible to put forth some tentative conclusions regarding both the statistical validity of Goldstein's original findings and an explanation of the underlying factors at work that may have had the potential to cause certain significant differences in measurements between a population living in the United States to that living in Mexico.

Based on the background information judged in an appropriate historical context, it is clear that populations of individuals living in the United States had certain advantages over those living in Mexico. The opportunity for an improved lifestyle in the form of higher wages, more sanitary and stable living conditions, greater access to health care and less restriction on proper nutrition, as well as extensive social programs set up to help minority and poor groups of people typically made the choice of immigrating to the United States an easy one. While in some areas life in the United States was only a marginal improvement over that in Mexico, overall the conditions and potential for an improved lifestyle was still greater then that in Mexico especially for the legions of immigrants represented the lowest socioeconomic class who moved to Texas. Based on historical information it can be said that overall, life in the United States was an improvement to life in Mexico.

While the background information is appropriate in giving the statistical results a historical context, it is the literature review which allows for further explanation. Based on the extensive studies and research performed on both environmental and genetic factors in determining deviations from normal growth and development, it is clear that both have important influences on the overall measurements of any given population. Growth and development are extremely susceptible to changes in the environment during the childhood to young adult years, but it is ultimately the genetic component that determines the greatest optimal growth. Deviations in growth and development can make themselves felt during periods of environmental stress in childhood in the form of late onset of puberty or a lack of sufficient catch up growth due to prolonged periods of stress; however, it has also been shown that when the stress factors are lifted a child can return to normal growth and express the same genetic potential as those who grew up in a stable environment. It is with this in mind that the ultimate conclusions of this report are interpreted.

The results of the statistical analysis lead to several clear conclusions: head width, minimum frontal diameter, bigonial diameter, and nose width are statistically different between all groups when the affects of age are accounted for, deviations and significant differences among variables when two groups are being compared are consistently present in early childhood (ages 5 to 8), puberty (14 to 18), adult (ages 19 +), and parent – child comparison groups; certain variables are under more environmental control then others (cranial measurements) therefore exhibiting larger or more consistent significant differences between groups; the ages that correspond with early childhood and the onset of puberty show the most statistically significant differences when variables are being compared between the two groups; and almost all variables show significant differences when immigrant parents are compared to their United States born children. Additionally, the United States and Mexican groups show a fairly low degree of variation compared to world wide samples, with more morphological similarity being expressed between United States and Mexican children aged 14 to 18, and adults aged 19 +. The least morphologically similar groups were between United States and Mexican born children aged 5 to 8 and 9 to 13. Finally, results of genetic distance mapping shows that variation in the growth process can be attributed first to geographical location, then to amount of time spent in the United States. While these are all covered in much more detail in the Discussion section of this report, the results mentioned above beg the conclusion that while there is extensive environmental pressure on growth and development of the groups being compared. In light of these conclusions, the working hypothesis put forth in the Introduction section stating that the Mexican immigration population and its subsequent generation of U.S. born children are significantly different from the Mexican native population with regards to the anthropometric measurements investigated is to be accepted.

Regardless, it is difficult to conclusively prove the importance of environmental over genetic factors or vice versa. As stated in the Discussion section, the consistency of certain variables in showing significant differences across groups and age ranges, the significant differences between the majority of variables when immigrant parents are compared to their U.S. born children, the pattern of mean measurements showing larger degrees of differentiation among early childhood and puberty years, and the testimony of an improved lifestyle in the United States over that in Mexico put forth by the background information would ultimately make Goldstein's conclusions on the influence of environmental factors on growth and development appear sound. This is evidenced by the high variation shown between the two youngest groups of children, who are the most susceptible to deviations in growth and development based on environmental stimuli. It is clear from the ANOVA analysis that the United States and Mexican groups are significantly different with regards to certain variables when the age bias is removed; therefore, the suggestion of environmental pressure on all age groups can be concluded. While differences in both the adult and puberty groups may be viewed as genetic, it is most likely a combination of genetics and the failure of sufficient catch up growth, due to deviations of growth throughout childhood, to achieve normal skeletal maturation. In addition, the high degree of significant differentiation between anthropometric measurements of United States born children and their immigrant parents can be attributed to the length of time spent in the United States and its potential to realize the greatest optimum growth potential. Additionally, bigonial diameter (and head width in all but age 9 to 13) is the one consistently significantly different variable in all groups compared. It appears that the mandible is under an extremely high degree of environmental control for the groups sampled in this study.

While this study is a preliminary one with the intent of discovering consistencies and variations among skeletal measurements between two geographically separated groups of people, the possibilities for additional scholarly pursuits and research are boundless. Perhaps by reanalyzing additional data sets on numerous different populations throughout the world some concrete conclusions regarding the role environment versus genetics plays in human growth and development will be drawn; however, for now reanalyzing data such as this is a good way of both reexamining past conclusions while at the same time posing an almost limitless supply of new questions and ideas that might help explain our skeletal biology and its ultimate reaction and physical manifestations to an ever-changing world.

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