THE EFFECT OF ENVIRONMENTAL FACTORS AND SOCIOECONOMIC STATUS ON BODY MASS INDEX, AND PHYSICAL ACTIVITY IN A SAMPLE OF ADOLESCENTS FROM AUSTIN, TEXAS

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ABSTRACT

THE EFFECT OF ENVIRONMENTAL FACTORS AND SOCIOECONOMIC STATUS ON BODY MASS INDEX, AND PHYSICAL ACTIVITY IN A SAMPLE OF ADOLESCENTS FROM AUSTIN, TEXAS

by

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May 2012

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Obesity, a chronic multifactorial disease has become highly prevalent in the United States in the past few decades, and the incidence is predicted to continue to increase. The purpose of this study was to investigate the associations among the walkability characteristics of neighborhoods, as measured using the Neighborhood Environmental Walkability Scale (NEWS) survey, with physical activity and body mass index (BMI) in a sample of adolescents from Lyndon Baines Johnson High School of Austin, Texas. Packets for participants and their parent/guardian were sent home and completed. Height and weight were obtained to calculate BMI. Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS). Several factors were correlated with the adolescents' BMI, including the parent's perceptions of neighborhood aesthetics, the students' perception of pedestrian and automobile traffic safety in their neighborhood, and distance to hike/bike trails and recreation facilities. Neighborhood walkability appeared to be moderately related to

adolescents’ BMI.

Chapter I: Introduction

Obesity, a chronic multifactorial disease has become highly prevalent in the United States in the past few decades, and the incidence is predicted to continue to increase. Health care professionals have attempted to treat for obesity but most treatments fail. However, they continue to research, in hopes of finding solutions that are more effective. Failure to address this problem in both adults and children can lead to a host of psychosocial and physical consequences. The pediatric component, which was a quickly rising problem with limited research, is very relevant in the overall spectrum of obesity. With a high incidence of this prevailing disease, children and adolescents have begun to face medical complications that are novel to their age category, such as type 2 diabetes, cardiovascular disease, and certain cancers (26). The causes of the increase in the rate of pediatric obesity are unclear. Social ecological modeling is sometimes used to explain the multitude of influences on health conditions such as obesity. While obesity results from caloric imbalance, this imbalance is influenced by many factors that affect physical activity (PA) and/or dietary intake (26), which are integral players in the etiology of obesity.

Environmental factors that induce negative behaviors such as decreased physical activity and poor nutrition are imperative when researching pediatric obesity. While the build of an environment can affect these two components, individuals' socioeconomic status may determine their environment. Availability of particular activities and food outlets are just two of the many opportunities the environment has to influence its community's health. Strategies that change the environment rather than the individual may be very effective in hindering the rise in the incidence of pediatric obesity. To the researchers knowledge, there has been very little previous research on the influence of neighborhood characteristics on body size and physical activity patterns in children and adolescents.

<u>Purpose of the Study</u>

The purpose of this study is to investigate the associations among the walkability characteristics of neighborhoods through the Neighborhood Environmental Walkability Scale (NEWS) survey with physical activity and BMI in a sample of adolescents from Lyndon Baines Johnson High School of Austin Texas.

<u>Hypotheses</u>

It is hypothesized that:

1. There will be a negative correlation between BMI and physical activity rating in students.

2. There will be significant correlations between BMI and the various items describing the walkability of the students' neighborhoods.
3. There will be a positive correlation between BMI and distance to recreational facilities.
4. There will be a positive correlation between BMI and distance to hike/bike trails.
5. There will be a positive correlation between BMI and distance to the nearest grocery stores.
6. There will be a significant correlation between the student's responses on each item of the NEWS survey with their parents' responses on those same items of the NEWS survey.
7. There will be a significant relationship between the neighborhood walkability variables and the students' Fitnessgram® classification as within the Heathy Fitness Zone (HFZ) for BMI.

Delimitations

1. This study is delimited to measures of BMI and Fitnessgram® classification as within the Heathy Fitness Zone (HFZ) for BMI only as an index of health-related fitness.
2. This study is delimited to students enrolled at L.B.J. High School in Austin, Texas.

Operational Definitions

1. Body Mass Index: BMI is a number that is calculated from a person's weight in kilograms divided by their height in square meters, and offers a reliable estimate of body fatness for most people. BMI is used to screen for weight categories that may lead to health problems.
2. Walkability: Walkability is described as the extent to which a neighborhood supports and encourages walking.
3. Socio-economic Status: SES is the position of an individual on a socio-economic scale that is measured using education, income, type of occupation, and place of residence.
4. Moderate-to-Vigorous Physical Activity (MVPA): Vigorous activities are actions than can only reasonably be done in short spurts and are measured as a seven or eight on a scale from zero to ten, while moderate physical activity can be sustained for a longer period of time and is usually a five or six on a scale of zero to ten.
5. Pediatric Obesity: For a child, obesity will be defined as a body mass index at or above the 95th percentile for the 2000 CDC sex-specific BMI-for-age growth chart.

Chapter II: Review of Literature

Obesity is a multifactorial disease that is caused by a caloric imbalance resulting from behavioral, genetic and environmental factors (27). The product of the imbalance is excessive weight gain, leading to a host of consequences. Fully understanding the severity of this prevailing disease begins with identifying how it is defined. Body Mass Index is a number calculated from a person's weight in kilograms divided by height in meters squared. BMI provides a reliable indicator of body fatness for most people and is used to screen for body size categories that may lead to health problems (27). A person's BMI helps to determine the risks of associated diseases seen in both pediatric and adult obese patients.

For children aged 2-19, BMI is then plotted on the 2000 CDC sex-specific BMI-for-age growth charts. Once the child's BMI is placed into a percentile group, they can then be characterized. Children are considered underweight if their BMI is under the 5th percentile. They are deemed to have a healthy weight if BMI is between the 5th and 85th percentile and overweight between the 85th and 95th percentile. If a child has a BMI at or above the 95^{th} percentile, the child is considered obese. According to a recent Nation Health and Nutrition Examination Survey (NHANES) study, 11.9% of children and adolescents were at or above the 97th percentile. Between 2007 and 2008, it was determined that 23 million children, or 31.7% were either overweight or obese (26). It is very critical that reducing the incidence of this disease become priority because the consequences could be devastating to the population.

The Fitnessgram youth fitness program is a comprehensive health-related fitness test that is widely used in school-based physical education programs across the country (47). Fitnessgram provides teachers with a battery of valid field-based fitness assessments to facilitate effective physical education programming. An advantage of the Fitnessgram program is the use of criterion-referenced standards that reflect how fit children need to be to receive health benefits (47). Fitnessgram also provides software for test data entry and storage that allows teachers to create personalized reports that provide information about the child's level of health-related fitness and suggestions for improving the child's fitness profile (47).

For assessing body composition, Fitnessgram offers teachers the choice of a two-site skinfold test, or body mass index. The two-site skinfold test allows teachers to estimate each child's level of percent fat from established equations and appropriate criterion standards for assessing appropriate body composition (47). As an alternative to skinfold analysis, Fitnessgram also offers the option of assessing body size by calculation of body mass index from measures of height and weight. The criterion standards for body mass index classify the body size for each student according to gender and age into one of four categories: Lean, for students who have a much lower than normal body mass index; Healthy

Fitness Zone (HFZ), for students who are within the healthy range for body size; Needs Improvement (NI) Some Risk, for students whose body mass index is moderately above the HFZ standard; and Needs Improvement (NI) High Risk, for students whose body mass index is well above the HFZ standard (47). The Fitnessgram HFZ standard was derived from research identifying the level of body mass index that optimally reduces a child's likelihood for developing metabolic syndrone. The Fitnessgram HFZ standard is considered the most appropriate criterion for assessing body size in children (47).

Several factors are associated with the frequency of both adult and pediatric obesity and all must be taken into consideration when discussing its etiology. While the gene pool does not change dramatically, epigenetic modification can happen. The interaction between particular genetic markers and the environment is a large contributor to the development of obesity.

Factors of pediatric obesity include, but are not limited to, nutrition (19,24), lack of physical activity (10,11,19), sedentary behavior (11,24), socioeconomic status (13,14), and comorbidities.

According to David Ludwig, there are potentially four overlapping phases of the child obesity epidemic. The first phase was characterized as the time at which the increase in incidence of obesity was not considered dangerous because the children were still healthy. The second phase, which we are currently in, is the emergence of weight related problems. Phase three consists of the medical consequences of obesity leading to life-threatening diseases and premature death. The final phase is simply even more acceleration of the obesity incidence (20). Therefore, it is paramount that researchers search for treatments or prevention strategies be researched and put in place to avoid this trend from continuing.

Interventions

A variety of methods have been employed by researchers to treat this vast epidemic, such as weight loss programs, community and school projects, nutritional counseling, and behavioral modifications. Outside of the home, there are treatments that can be used to reduce the prevalence of pediatric obesity. Interventions for obesity should differ significantly depending on the individual's current health situation. The main goal for most of the various treatments is to reduce the body weight and then to reevaluate for either additional weight loss or maintenance strategies. Interventions to decrease the prevalence obesity have ranged from four weeks to as long as eight years (39). Before optimal interventions or treatments can be chosen, there are some individual circumstances that need to be taken into account. Certain interventions can be more beneficial to boys than girls in terms of increasing overall PA levels and time spent in moderate to vigorous physical activity (MVPA), which is a level of intensity shown to provide health benefits (11). These differences include changes in PA levels and nutrition, competence, and BMI changes. (11) Knowing the different reactions according to gender can be beneficial to choosing the correct intervention. Parenting characteristics may also help explain the variability of treatment adherence and success in some interventions (13).

Heinberg et al. (13) concluded that parent involvement is statistically significantly related to weight loss and to clinically significant weight loss, which they considered to be a weight loss of at least two kilograms within the 12-week period. Parent involvement was higher in those who lost weight as compared with those who did not (13). Knowing the effects of gender differences and parent involvement are imperative when designing an intervention for pediatric obesity.

Many benefits resulting from various interventions for obesity have been noted. Although there were no significant changes in weight, eight weeks of aerobic cycle training improves cardiopulmonary function and ventilatory efficiency in overweight children as compared with participants in an overweight control group who maintained their sedentary lifestyles (16). This improvement may assist in increasing PA, which will eventually result weight loss. Also, treatment groups with 2 weeks of day camp that included nutrition and physical activity building have shown a decreased BMI and improved glucoreguation in children after a year (34). While many treatments reveal positive results, decades of research have suggested that targeted behavioral interventions are not sustainable after program activities have ceased (15).

Nutritional counseling is commonly the initial intervention treatment in the majority of the cases (2). This type of treatment is usually coupled with exercise prescriptions to assist in weight loss. Nutritional counseling typically informs children of correct portion sizes, meal patterns, and avoidance of fast foods. These treatments need to be integrated with the introduction of table foods.

Although it is difficult to influence certain eating habits while the rest of the environment does the opposite, it is imperative that parents serve as role models.

The common design for many of the programs do well in restricting the negative health effects of sedentary lifestyle but they fail to provide long-term results to their short-term interventions (39). Many economic and environmental limitations to long-term physical activity in children both during and following interventions have been observed (39). These include work schedules, membership costs, and PA equipment. School systems frequently face budget cuts that reduce nonacademic programs and physical education classes (39). Though short-term interventions have proven successful in reducing obesity, there are many factors that may inhibit long-term results. Finding the best strategy for preventing or treating pediatric and adult obesity is a complicated problem that is still left to be uncovered.

Theories

It is imperative that changes take place in order for the present trend in pediatric obesity to be reversed. Drastic steps must be taken to combat childhood obesity. Unless measures are taken to remedy this epidemic, we will soon see the first generation of children who have shorter life spans than their parents (8). The environmental factors that contribute to the development of pediatric obesity are not the same for every neighborhood and certain characteristics of neighborhood environments are linked to BMI and obesity risk

(49). These include higher intersection density, walkability, and retail food options.

There are two common theories that attempt to explain the effect of neighborhood environments on lifestyle. The first theory is the Deprivation Amplification Theory. This theory proposes that in areas where people are poorer, and have less personal resources, local facilities that may enable healthier lifestyles are substandard (22,41). This difference, in turn, leads to diet and physical activity inequalities of varied neighborhoods. The second philosophy is the Social Cognitive Theory. This theory proposes that individuals' social environments, such as modeling of behavior, access or barriers to resources, reinforcement of behavior, and social norms for behaviors influence their participation in behaviors that promote or harm health (3). The retroactive approach to childhood obesity has proven unsuccessful and altering these factors through prevention should be more of a focus.

Physical Activity

Decreased physical activity has become prominent in children all over the United States and there are countless reasons that this has come about. Individuals' reliance on technology is just one of the many explanations (7,24). The use of cars, escalators, and elevators has prevailed over that of walking and taking the stairs. Increased television watching, video games, and computer games show that reliance on technology for entertainment has overcome other sources of entertainment (7,24). This has in turn increased the prevalence of a sedentary lifestyle. In a two-year study, Mota et al. (24) examined the prospective relationship between baseline television viewing and body mass index (BMI) and cardiorespiratory fitness (CRF). Though obesity and CRF were assessed indirectly, results showed that television viewing predicts lower fitness but not higher BMI (24). With lower cardiorespiratory fitness, moderate to vigorous physical activity can be more difficult to tolerate, decreasing the amount of PA children are willing to partake in. Furthermore, increased television time translates into a greater consumption of second helpings, snacks and beverages (7). A variety of demographic, individual, social, and environmental factors contribute to physical activity levels. In a child's environment, availability of recreation facilities, bicycle or pedestrian trail access points and neighborhood walkability are factors that may have more affects on physical activity than communities may care to acknowledge.

Neighborhoods play a role in the amount of physical activity that children engage in. The amount of PA outside of school makes up the remaining amount of PA needed for children to meet the recommended daily amounts. Adolescents living in neighborhoods characterized by mixed-use, pedestrian-oriented retail development, connected streets, and relatively high residential density were more physically active than those living in less walkable neighborhoods (17).

Recreation facilities act as an avenue for children to engage in multiple activities ranging from sports to leisure. The placement of these recreation facilities could be an environmental factor that influences physical activity levels. In a cross-sectional qualitative study, Ries et al. (32) used interviews with adolescents and direct observation of recreational facilities to determine the influence of environmental factors on recreational facility use for physical activity by African-American adolescents. The immediacy of a recreation center to the home was shown to be a major factor in determining which facilities children use. Transportation limitations create a preference for facilities that are in walking distance (32). Facilities closer to the home are more likely to be utilized by children.

The number of recreation facilities throughout a neighborhood may also determine their use by the community. McCormack et al. (23) studied the relationship between recreational destination use and physical activity behavior in a sample of physically active individuals. Through interviews, surveys, and self-reports, the study found that there was an increase in the likelihood of using a local free destination for each additional local free facility. When examining facilities that charged for memberships, the association was equivalent (22). McCormack et al. (23) also reported that the use of recreational opportunities increased the probability of achieving adequate levels of moderate to vigorous physical activity (22). It has been well documented that the quantity of facilities in a community increased the use of these facilities, which in turn, increased the levels of physical activity. However, contradictory findings have been published. Kilgerman et al. (17) studied the association of recreation environment variables with physical activity and body mass index in adolescents. They concluded that recreation variables, such as walkability, number of parks and schools, and availability of recreational facilities, were not related to physical activity and that

BMI was not explained by environmental variables (17). However, the conclusions of this study might be questioned due to limitations.

Like recreation facilities, bicycle and pedestrian trails provide another way for children, as well as adults to be physically active. Patnode et al. (29) evaluated the associations of selected demographic, individual, social, and environmental factors with moderate-to-vigorous physical activity (MVPA) in a sample of children and adolescents. They used ActiGraph accelerometers and the Geographic Information Systems (GIS) software package, ArcGIS, version 9.2 to measure MVPA and the physical neighborhood environment, respectively. Using the ArcGIS, various street network distances were measured. In their sample, distance to the nearest gym was highly correlated with both distance to the nearest trail access point and distance to the nearest recreation facility. The more available recreation facilities, the more available gyms and trail access points were (29).

Encouraging the community to be physically active is imperative to increasing health. Factors that promote use of bicycles and their trails differ for many individuals. In a telephone interview, Rissel et al. (33) found that having ridden a bicycle in the past year was associated with younger age, being male, having access to a bicycle, and living close to destinations of interest (33). These interviews also showed that 65% desired to ride more often than they currently did. Having children between the ages of 5-18 years, having used local bicycle paths, and opinion of ease of cycling, were all factors that the interviewees associated with wanting to ride bikes more (33). The availability of bicycle paths, as well as other factors, supports bicycle riding. Neighborhoods that lack access to bicycles and pedestrian trails may be less likely to engage or even want to engage in these sorts of physical activities. On the other hand, adding bicycle and pedestrian trails to neighborhoods that lack them, may encourage physical activity amongst the communities.

Encouraging individuals to become physically active in their community not only takes the availability of recreational areas, but also the assurance of a safe area. The walkability of a neighborhood is the extent to which appropriate and conductive walking environments are offered. To examine the associations of neighborhood walkability with physical activity in adolescents, Kilgerman et al. (17) used ActiGraph and GIS software to measure physical activity and walkability, respectively. The authors defined a walkable neighborhood as a mixed-use, pedestrian-oriented retail development, with adjoining streets and a moderately high residential density. The results of the study indicated that adolescents living in more walkable neighborhoods were more physically active (17).

Instead of ActiGraph, researchers can also use pedometer step counts as a measure of physical activity. Along with use of the NEWS survey, Sigmundová et al. (40) found that pleasant environments were positively correlated with daily step counts for both genders in the sample (40). Furthermore, a positive correlation was also established for males between better residencies (more family homes rather then apartment blocks) in a neighborhood and daily step counts (40). Physical activity increases when the neighborhood provides opportunities for walking. Neighborhood environment has been found to be associated with physical activity, as well as obesity prevalence (40). Saelens et al. (36) evaluated neighborhood environment surveys, physical activity, and weight status of individuals in neighborhoods with different walkabilities. High-walkability neighborhood residents reported spending 70 minutes more walking for errands and during breaks at work or school per week than low-walkability neighborhood residents (36).

The built environment of a neighborhood can influence the amount of physical activity that the community engages in. Access to recreation facilities or bike/ pedestrian trails are associated with increased physical activity, which in turn, decrease obesity prevalence. The walkability of a neighborhood not only directly provides opportunities for physical activity through avenues such as sidewalks, but also a community in which recreational activities are deemed safe. Acknowledging these environmental formations may help to produce a solution that boosts physical activity, while declining the prevalence of obesity.

Nutrition

Nutrition is another major factor that influences obesity. Insufficient consumption of fruits and vegetables is a behavioral habit that many have adapted, reducing nutrient uptake (4,9). Rather than eating these healthier foods, consumption of energy dense foods are preferred. When energy intake exceeds that of what is needed, fat begins to accumulate. Not only has there been an increase in the uptake of energy dense foods, but also in the portion sizes. Fast food meal sizes are amplified, while the variety and availability of these low-cost, energy dense foods increases. An increase in the consumption of meals from the various fast food restaurants is the result of many issues such as less family meals, which increases the consumption of both pre-prepared convenience meals, and sugar-sweetened beverages like soft drinks and juices. Lim et al. (19) investigated the association between the consumption of sugar-sweetened beverages and obesity in a cohort of low-income African-American preschool children. Between baseline and follow-up (2 years), the prevalence of obesity almost doubled (19). Also, baseline consumption of soda and all sugar-sweetened beverages are positively associated with children's BMI z-scores (10). The build of a neighborhood not only has effects on physical activity, but nutrition as well. Grocery stores differ in their availability of healthy foods, and the prices of those healthy foods differ as well, relative to the neighborhood (1,4). The environment they live in may influence an individual's nutritional quality.

The availability of nutritious foods such as fresh fruits and vegetables give individuals more of an option when preparing meals. It also makes it easier for families to prepare food rather than eating out. These options may have a great deal of benefits. The lower the ratio of fast-food restaurants and convenience stores to grocery stores and produce vendors near a home, the lower the odds of being obese (42). With healthier foods as the meal option, energy intake decreases, decreasing the prevalence of obesity (4). African-American neighborhoods have been shown to have less supermarkets and the availability of fresh fruits and vegetables is also lower when compared to other neighborhoods (4). Fewer super markets may be a sizeable factor in the increased prevalence of obesity among this ethnicity. Significant correlations have also been observed between the occurrences of healthy grocery stores and reduced BMI/obesity risk in low-income neighborhoods (48).

Individuals may also perceive food availability differently. To determine what African-American and Hispanic parents perceived as the availability of food in their neighborhoods and the factors that influenced their food choices, Sealy conducted three focus groups, choosing three questions to guide these focus groups. Two of the three groups had on average, lower incomes and confirmed that there were limited opportunities to purchase healthy foods in low-income neighborhoods and also felt taken advantage of or discriminated against because of this. On the other hand, the group with the higher income average felt that their healthy food availability was favorable (37). Individuals sometimes notice the differences and may become frustrated with the lack of availability of quality foods by grocery stores, while others are satisfied with their options. The neighborhoods in which they live determine their perceptions of the grocery stores.

The cost of food is one of the most influential determinants of individuals' food purchases. Consumer demand for foods is determined primarily by its cost (6). When shopping, saving money is always a plus. Lean meats, whole grains, and fresh fruits and vegetables are considered to be the healthy diet, but foods with added sugars and fats are much more affordable (18). In comparison to standard food items, Krukowski et al. (18) found that their healthy versions had significantly greater prices (18). This difference in prices may encourage buyers to purchase the less healthy version of the food in order to save money.

Prices of healthy foods may also vary by neighborhood. Dun et al. (19) used the 2000 U.S. Census Summary Files to examine the variability in cost for healthy foods and demographic and economic characteristics in neighborhoods of a large rural region in Texas (9). When holding median income constant, stores in neighborhoods with higher percentages of Black residents paid more for fresh fruits and vegetables (9). With the store paying more for fresh fruits and vegetables, consumers will almost always have to pay more as well. In contrast, Ard et al. (1) reported practically no effects on fruit and vegetable prices of the percentage of the population that was African American (1). Though contradicting findings have been observed, each community is different and individuals should focus on their communities to see if the above findings are similar so that they can then take action.

Socioeconomic Status

Socioeconomic status (SES) is a variable that combines income, education, and occupation and has been correlated with a variety of social health outcomes (5). The SES of a neighborhood may determine the built environment that influences physical activity and nutrition. Grocery stores, recreation centers, and hike/bike trails are just a few of the characteristics that differ amongst numerous neighborhoods. How these neighborhoods vary may be an integral part to unfolding one of the many factors to pediatric obesity.

One clear indicator for early development of childhood obesity is parental BMI because the caregiver's BMI is a significant predictor (19). Genetic, environmental, and parental behavioral influences are different aspects that the parents or caregivers convey to the child. The home environment is a common research focus when dealing with pediatric obesity. MacFarlane et al. (21) examined home food environments of adolescents and how they differed among socioeconomic status by surveying students and parents about meal environments, eating rules and home food availability (21). It was determined that low socioeconomic adolescents had a home environment that was less supportive of healthy eating when compared to those of high socioeconomic status. Adolescents of a low SES also reported that unhealthy foods were always or usually available, while adolescents of a high SES reported fresh fruits and vegetables were always or usually available (21). Socioeconomic status may determine the eating behaviors of a household but differentiating whether these behaviors stem from the family rules or the neighborhood food environment is a challenge.

Primary caregivers' education is a factor of SES that has also been measured. Nuru-Jeter et al. (25) studied the socioeconomic predictors of heath and development in children. Even though the results showed that the child's physical health was superior with each additional year of parental education, the most significant associations were seen when comparing to the degree attained. They found that a 4-year college and graduate degree were associated with increasingly better physical health (25).

SES is also a probable covariate of any association between residential environments and obesity (42). Adolescents with lower individual and area-level SES have higher BMI than adolescents with higher SES but could not determine a causal association (44). Gordon-Larsen et al. (12) contend that decreased physical activity may be the result of structurally linked economic factors, such as the neighborhood, which for lower socioeconomic groups, in most cases, are built with less and inferior recreational areas. The availability of the facilities also presents a problem when considering the longer distances it takes to get to physical activity areas (12).

These associations between SES and physical activity have been shown to be similar when researching nutritional factors as well. Wang et al. (45) used an observational method to determine whether socioeconomic and nutritional physical characteristics of the neighborhood were associated with body mass index. After age, gender, ethnicity, individual SES, physical activity, smoking, and knowledge of nutrition were controlled for, it was shown that those who lived in a low socioeconomic neighborhood had higher BMI when compared to those living in a high socioeconomic neighborhood (45). Eliminating other possible factors creates even more reason for individuals to believe that the built environment influences the prevalence of obesity.

There are also some studies that have reported opposing results. Contrary to the aforementioned deprivation amplification hypothesis, individuals living in the most deprived neighborhoods actually have shorter distances to grocery stores than do those living in the least deprived areas (41). There are many other environmental factors that have been shown to differ by neighborhood that could be a possible explanation for the variance of BMI (17,42).

Summary and Conclusions

PA and nutrition both play a key role in the problem of overweight and obesity because they can influence bodily constitution in different ways (7). The external influences of obesity are various combinations of environmental, behavioral, and social factors, all which can be altered with work. The etiology of pediatric obesity is very complicated and in the majority of cases, multifactorial. In addition to genetics, external factors are crucial in understanding the cause of this viscous epidemic. While children encounter many influences growing up, their school and community environments can either support or hinder obesity prevention behaviors (2). An effective strategy for decreasing the prevalence of obesity may be improving food environments of all socioeconomic neighborhoods (42). Zick et al. (49) believe that increasing food options, especially in low-income neighborhoods could be effective in reducing individuals' obesity risks (49). Making recreational areas more available to children can influence increased physical activity. Also, enhancing the walkability of low-income neighborhoods may be enough action to enable children to reach recommended physical activity levels. Researchers should focus on modifying the built environment to impact these public health challenges. In order to find which environmental factors effect the incidence of pediatric obesity, researchers should investigate the different characteristics of neighborhoods and how they correlate to children's' BMI and PA.

Chapter III: Methods

Participants

Participants for this study were 8 male and 22 female volunteers, ages 11-18 years, recruited from Lyndon Baines Johnson High School (LBJ) in Austin, Texas. This school was chosen because it not only houses LBJ high school, but also The Liberal Arts & Science Academy of Austin, which contains many students from all over Austin in different socioeconomic statuses and neighborhoods. The methods and procedures of this study were reviewed and approved by the internal review board at Texas State University – San Marcos, and informed consent was obtained from each student and his/her parent or guardian.

Measures

Demographic variables of the students' gender, age, and race/ethnicity were gathered through a self-reported student survey. Parents reported their address, income, and highest level of education in a self-reported parent/guardian survey. The school's athletic trainer took height and weight at the school using direct reading. BMI was calculated by dividing the average of two weight readings (kg) by the average of two height readings (m) squared (29). Using the calculated BMI, the students were classified as either within the Healthy Fitness Zone (Within HFZ) or above the Healthy Fitness Zone (Above HFZ) according to the latest Fitnessgram® criterion standards for BMI (47).

Physical Activity was measured using a 3-day Physical Activity Report (3DPAR). The 3DPAR has been proven a valid measure when compared to accelerometry (28).

Availability of Recreation Facilities, Hike & Bike Trails, and Fresh Fruits and Vegetables was calculated using with the Geographic Information Systems (GIS) software package, ArcGIS, version 9.2 (Environmental Systems Research Institute, Redlands CA) Kilgerman, (29,41,42). Road distances were used rather than straight-line distances in order to assure accurate travel time.

Perceived neighborhood safety and walking infrastructure quality was tested using the Neighborhood Environment Walkability Scales (NEWS) which indicate high test-retest reliabilities among adults from neighborhoods with differing levels of "walkability" (36,40).

The NEWS survey assesses different aspects of the environment by splitting the questions into nine separate items (A-I). Section A evaluates walking distances to the nearest stores and other public places in the neighborhoods the subjects live. Previous research has reported averages between 2.8 and 3.5 (36). The results from this study were lower at 2.4. Section B covers walking distances to recreation places. Section C attains a score for the types of homes in the subjects' neighborhoods. With an average of 76.0 for item C, this study's results were on the lower end of previous research that reported an average between 194.4 and 203.2. Section D determines perceptions of access to services in the neighborhoods, such as stores, transit stops, and barriers. This sample had a lower mean (2.8) than that of previous research (2.8-3.0) (36). Item E asks details on the streets in the neighborhoods, while item F asks about the sidewalks and places to walk. Averages of this sample’s responses to both items E and F were lower than previous research (36). Section G is on neighborhood surroundings; the physical appearance of the neighborhood. Item H assesses the neighborhood safety and Item I assesses crime safety. The difference between items H and I is that item H questions the build of the neighborhood (i.e. Lighting at night & crosswalks) and speed limits, while item I focuses on the crime rate and the apprehensiveness of being outside in the neighborhood. Items H and I had lower means in this sample (2.4 and 2.2 respectively), as compared to previous research in which Item H averaged between 2.7 and 3.1, while item I had a mean of 3.1 (36). The sample’s average in this study suggests that the build of their neighborhoods are less safe than that of previous studies.

Procedures

The sample was recruited from Physical Education classes at LBJ High School. At the beginning of each Physical Education class, the students were introduce to the research project and asked to participate for extra credit in the class. Each item of the packet was explained in detail and at the end of the period. The students were able to pick up a packet on the way out of class. Each student was be given a packet that contained both the parent and student survey, as well as the consent form. They were also be given a deadline to turn the packets back into their Physical Education teacher. With the address, the availability of recreation facilities, hike/bike trails, and fresh fruits and vegetables was calculated using the GIS software. After the consent forms were returned, the school's athletic trainer took the participants' height and weight so that the BMI could be calculated.

Design and Analysis

The dependent variables in this study were BMI and physical activity (3DPAR). Each subject was also identified according to the most recent Fitnessgram® criterion standards for BMI as either "within HFZ" or "above HFZ." The Within HFZ category also includes those students classified as "lean." The Above HFZ category includes those students who are classified as "Needs Improvement – Slight Risk" and also those students who are classified as "Needs Improvement – High Risk." The independent variables in this study are the demographic characteristics of the students and their parents. These include: each item (A through I) on the NEWS survey describing the walkability of the neighborhood, distance to a recreation facility, distance to a walk/bike trail, and distance to the nearest grocery store.

The relationship between BMI and the independent variables were determined by Pearson Product-Moment correlation. Tests of significance were conducted through simple regression analysis. Differences in the relationships for male and female students were determined through tests of homogeneity of intercept and slope. Mean BMI was calculated for each level of neighborhood walkability, and for each level of parent education. Comparison across levels was made through one-way Analysis of Variance. The relationship between the independent variables and the probability of being classified as within the Fitnessgram® Healthy Fitness Zone for BMI was determined from a logistic regression model. Odds ratios were calculated for each significant predictor in the logistic model. Receiver Operating Characteristic (ROC) analysis was also conducted for each significant predictor in the logistic model. All statistical tests were conducted with an alpha level of .05.

Chapter IV: Results

The sample included eight boys and twenty-two girls. The descriptive characteristics of the sample are reported in Table 1. 150 surveys were distributed but only 30 were returned. Distances in Table 1 are recorded in miles. Multivariate Analysis of Variance (MANOVA) indicated no gender differences in age, body mass index (BMI), physical activity rating (3DPAR), distance to a recreation facility, distance to a hike-and-bike trail, or distance to a grocery store (Wilk's Lambda = 0.69, $F(6,22) = 1.62$, $p = .19$).

Table 1: Descriptive Characteristics of the Sample (m$\pm$sd)

Variable	Boys	Girls	Total
n	8	22	30
Age (years)	15.1 $\pm$ 1.4	15.8 $\pm$ 1.7	15.6 $\pm$ 1.6
BMI	21.4 $\pm$ 5.9	23.4 $\pm$ 3.5	22.9 $\pm$ 4.3
3DPAR	2.8 $\pm$ 2.6	4.0 $\pm$ 2.2	3.7 $\pm$ 2.3
Distance to Rec.	2.4 $\pm$ 1.3	5.9 $\pm$ 5.9	5.1 $\pm$ 5.4
Distance to Trail	9.4 $\pm$ 3.2	12.4 $\pm$ 6.0	11.7 $\pm$ 5.6
Distance to Groc.	2.4 $\pm$ 1.4	1.8 $\pm$ 1.0	1.9 $\pm$ 1.1

No gender differences, $p \geq .05$, for each of these variables

Table 2 reports the parents' responses to the NEWS survey according to the gender of the student. MANOVA indicated no gender differences in the parents' responses to any of the individual NEWS items (Wilk's Lambda = 0.63, $F(9,20) = 1.29$, $p = .30$).

Table 2: Parent NEWS Responses (m±sd)

Variable	Boys	Girls	Total
n	8	22	30
Land-use mix- diversity	2.4 ± 0.9	2.4 ± 0.8	2.4 ± 0.8
Neighborhood Recreation Facilities	2.8 ± 0.9	2.7 ± 0.8	2.7 ± 0.8
Residential density	83.8 ± 44.4	73.2 ± 30.9	76.0 ± 34.5
Land-use mix- access	2.8 ± 0.5	2.8 ± 0.5	2.8 ± 0.5
Street connectivity	2.5 ± 0.7	2.8 ± 0.5	2.7 ± 0.6
Walking/cycling facilities	3.1 ± 0.4	2.5 ± 0.9	2.7 ± 0.8
Neighborhood aesthetics	3.1 ± 0.6	3.0 ± 0.8	3.0 ± 0.8
Pedestrian and automobile traffic safety	2.3 ± 0.4	2.4 ± 0.6	2.4 ± 0.6
Crime safety	2.3 ± 0.8	2.2 ± 0.9	2.2 ± 0.9

No gender differences, $p \geq .05$, for each of these variables

Table 3 reports the students' responses to the NEWS survey according to gender. MANOVA indicated no gender differences in the students' responses to any of the individual NEWS items (Wilk's Lambda = 0.73, F(9,20) = 0.81, p = .61). The sample included 10 students of African-American heritage, 10 students of Hispanic heritage, and 10 students classified as White, non-Hispanic. MANOVA indicated no racial differences in age, BMI, PAR, or any of the distance variables, (Wilk's Lambda = 0.69, F(12,42) = 1.34, p = .20), the 3DPARents' responses to the NEWS survey, (Wilk's Lambda = 0.31, F(18,38) = 1.66, p = .09), or the students' responses to the NEWS survey, (Wilk's Lambda = 0.33, F(18,38) = 1.58, p = .11).

Table 3: Student NEWS Responses (m±sd)

Variable	Boys	Girls	Total
n	8	22	30
Land-use mix-diversity	2.1 ± 0.8	2.3 ± 0.9	2.2 ± 0.8
Neighborhood Recreation Facilities	2.7 ± 0.8	2.8 ± 0.8	2.8 ± 0.8
Residential density	80.5 ± 43.5	76.8 ± 28.3	77.8 ± 32.2
Land-use mix-access	2.9 ± 0.4	2.7 ± 0.6	2.7 ± 0.6
Street connectivity	2.8 ± 0.5	3.0 ± 0.5	2.9 ± 0.5
Walking/cycling facilities	2.8 ± 0.5	2.6 ± 1.0	2.7 ± 0.9
Neighborhood aesthetics	2.8 ± 1.0	2.7 ± 0.7	2.8 ± 0.8
Pedestrian and automobile traffic safety	2.0 ± 0.5	2.2 ± 0.5	2.2 ± 0.5
Crime safety	1.5 ± 0.5	2.0 ± 0.9	1.8 ± 0.9

No gender differences, $p > .05$, for each of these variables

Table 4 reports the Pearson Product-Moment correlations between BMI, 3DPAR, the distance variables, and the parents' responses to the NEWS survey. No significant correlations were observed between 3DPAR and any other variable. BMI was significantly correlated with distance to a recreation facility (r =

.45, p = .01), distance to a hike-and-bike trail (r = .53, p = .003), and the parents' NEWS item G (r = -.41, p = .02).

Table 4: Correlations with BMI and 3DPAR

Variable		BMI	3DPAR
3DPAR		0.23	
Dist. to Rec.	*	0.45	0.06
Dist. to Trail	*	0.53	0.09
Dist. to Groc.		0.28	0.01
Land-use mix-diversity		-0.21	0.05
Neighborhood Recreation Facilities		-0.21	0.06
Residential density		0.24	-0.17
Land-use mix-access		-0.36	0.14
Street connectivity		-0.01	0.09
Walking/cycling facilities		0.22	0.14
Neighborhood aesthetics	*	-0.41	-0.04
Pedestrian and automobile traffic safety		0.32	0.08
Crime safety		0.26	-0.33

p < .05

Table 5 reports the Pearson Product-Moment correlations between BMI, 3DPAR, and the students' responses to the NEWS survey. No significant correlations were observed between 3DPAR and any other variable. BMI was significantly correlated with the students' NEWS item H ($r = .38$, $p = .04$). BMI was not significantly correlated with distance to a grocery store or any other parent or student NEWS items.

Table 5: Correlations with Student NEWS

Variable		BMI	3DPAR
Land-use mix-diversity		0.17	0.12
Neighborhood Recreation Facilities		0.16	0.24
Residential density		0.26	0.07
Land-use mix-access		-0.32	-0.16
Street connectivity		0.01	-0.24
Walking/cycling facilities		0.31	0.20
Neighborhood aesthetics		-0.15	0.02
Pedestrian and automobile traffic safety	*	0.38	0.20
Crime safety		0.19	-0.07

$p < .05$

The correlations between each of the corresponding parents' and students' NEWS items were: Item A, $r = .53$, $p = .003$; Item B, $r = .44$, $p = .02$; Item C, $r = .76$, $p < .001$; Item D, $r = .76$, $p < .001$; Item E, $r = .38$, $p = .04$; Item F, $r = .62$, $p < .001$; Item G, $r = .68$, $p < .001$; Item H, $r = .58$, $p < .001$; and Item I, $r = .56$, $p = .001$. For each NEWS item, the parents' and students' responses were significantly correlated.

Each student's BMI was compared to the new Fitnessgram® standards for the Healthy Fitness Zone (HFZ) for their respective gender and age group. Students classified as "Within HFZ" include values within the HFZ and Very Lean ranges. Students classified as "Above HFZ" include values within the Needs Improvement - Some Risk and Needs Improvement - High Risk ranges. Table 6 compares the age, BMI, 3DPAR, and distance values for the students classified as Within HFZ and Above HFZ. The only significant differences between the two groups was observed for BMI, $t(28) = 6.7$, $p < .001$, and the distance to a hike-and-bike trail, $t(27) = 2.8$, $p = .005$.

Table 6: Comparison based on the HFZ for BMI (m$\pm$sd)

Variable	Within HFZ	Above HFZ	Total
n	17	13	30
Age (years)	15.9 $\pm$ 1.2	15.3 $\pm$ 2.0	15.6 $\pm$ 1.6
BMI *	20.0 $\pm$ 2.4	26.6 $\pm$ 3.0	22.9 $\pm$ 4.3
3DPAR	3.4 $\pm$ 1.6	4.0 $\pm$ 3.0	3.7 $\pm$ 2.3
Dist. to Rec.	3.7 $\pm$ 2.7	7.0 $\pm$ 7.6	5.1 $\pm$ 5.4
Dist. to Trail *	9.5 $\pm$ 2.9	14.8 $\pm$ 7.0	11.7 $\pm$ 5.6
Dist. to Groc.	1.74 $\pm$ 1.0	2.2 $\pm$ 1.2	1.9 $\pm$ 1.1

$p < .05$

Table 7 compares the parents' NEWS responses for the students classified as Within HFZ and Above HFZ. The only significant differences between the two groups was observed for parents' NEWS Item H, $t(28) = 1.9$, $p = .04$, and parents' NEWS Item I, $t(28) = 2.3$, $p = .02$.

Table 7: Parent NEWS Responses based on HFZ for BMI (m±sd)

Variable		Within HFZ	Above HFZ	Total
n		17	13	30
Land-use mix-diversity		2.4 ± 0.8	2.5 ± 0.9	2.4 ± 0.8
Neighborhood Recreation Facilities		2.6 ± 0.7	2.9 ± 1.0	2.7 ± 0.8
Residential density		71.9 ± 30.9	81.4 ± 39.3	76.0 ± 34.5
Land-use mix-access		2.8 ± 0.6	2.8 ± 0.5	2.8 ± 0.5
Street connectivity		2.7 ± 0.7	2.8 ± 0.5	2.7 ± 0.6
Walking/cycling facilities		2.5 ± 0.9	2.9 ± 0.7	2.7 ± 0.8
Neighborhood aesthetics		3.2 ± 0.6	2.8 ± 0.9	3.0 ± 0.8
Pedestrian and automobile traffic safety	*	2.2 ± 0.5	2.6 ± 0.6	2.4 ± 0.6
Crime safety	*	1.9 ± 0.7	2.6 ± 0.9	2.2 ± 0.9

$p < .05$

Table 8 compares the students' NEWS responses for the students classified as Within HFZ and Above HFZ. The only significant difference between the two groups was observed for students' NEWS Item H, $t(28) = 2.0$, $p = .03$.

The relationship between each variable and the probability of being classified as Within the HFZ standard was determined by logistic regression analysis. Two variables were significantly related to being classified as Within the HFZ. These were the distance to a hike-and-bike trail, Chi-square(1) = 8.95, p = .003, and the parents' NEWS response for Item I, Chi-square(1) = 4.94, p = .026.

Table 8: Student NEWS Responses based on HFZ for BMI (m±sd)

Variable	Within HFZ	Above HFZ	Total
n	17	13	30
Land-use mix-diversity	2.1 ± 0.8	2.4 ± 0.9	2.2 ± 0.8
Neighborhood Recreation Facilities	2.6 ± 0.7	3.0 ± 0.8	2.8 ± 0.8
Residential density	76.6 ± 32.1	79.4 ± 33.6	77.8 ± 32.2
Land-use mix- access	2.8 ± 0.6	2.6 ± 0.5	2.7 ± 0.6
Street connectivity	2.9 ± 0.5	2.9 ± 0.5	2.9 ± 0.5
Walking/cycling facilities	2.4 ± 1.0	2.9 ± 0.7	2.7 ± 0.9
Neighborhood aesthetics	2.7 ± 0.8	2.8 ± 0.7	2.8 ± 0.8
Pedestrian and automobile traffic safety *	2.0 ± 0.4	2.4 ± 0.6	2.2 ± 0.5
Crime safety	1.6 ± 0.7	2.1 ± 1.0	1.8 ± 0.9

$p < .05$

The odds ratios for the related variables indicate the nature of the relationship with the HFZ standard for BMI. For the Parents' NEWS Item I, lower scores indicate better crime safety. The odds ratio for Parents' NEWS Item I is .35, indicating a 65% decrease in the likelihood of achieving the HFZ standard for BMI for every one unit increase in Parents' NEWS Item I response. Receiver Operating Characteristic (ROC) analysis indicated an area under the curve (AUC) of 72%. A cut-off score of 2.67 for the Parents' NEWS Item I provides the highest correct classification for achieving the HFZ standard for BMI (73.3%, with 61.5% sensitivity and 82.4% specificity). Students with a Parents' NEWS Item I response of 2.67 or less have a significantly greater probability of being classified within the HFZ standard for BMI than those with a Parents' NEWS Item I response greater than 2.67. Figure 1 demonstrates the ROC curve for Parents' NEWS Item I.

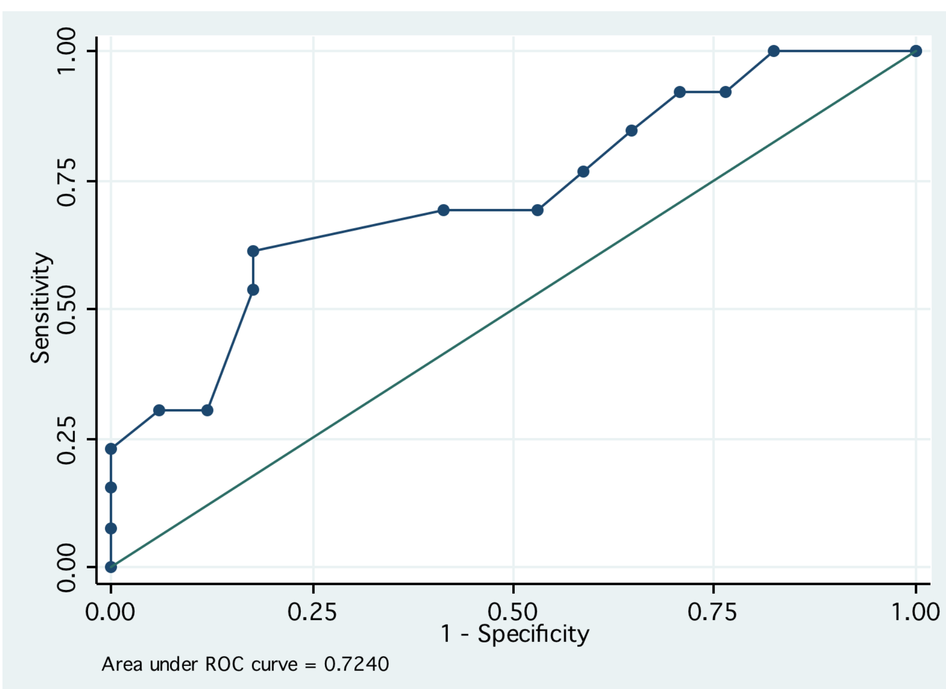

Figure 1: Receiver Operating Characteristic Analysis for Parents' NEWS Item I

For the distance to a hike-and-bike trail, lower values indicate closer proximity. The odds ratio for distance to a hike-and-bike trail is .71, indicating a 29% decrease in the likelihood of achieving the HFZ standard for BMI for every one-mile increase in distance to a hike-and-bike trail. Receiver Operating Characteristic (ROC) analysis indicated an area under the curve (AUC) of 77%. A cut-off score of 12.1 miles for the distance to a hike-and-bike trail provides the highest correct classification for achieving the HFZ standard for BMI (75.9%, with 58.3% sensitivity and 88.2% specificity). Students living less than 12.1 miles from a hike-and-bike trail have a significantly greater probability of being classified within the HFZ standard for BMI than those living more than 12.1 miles from a hike-and-bike trail. Figure 2 demonstrates the ROC curve for the distance to a hike-and-bike trail.

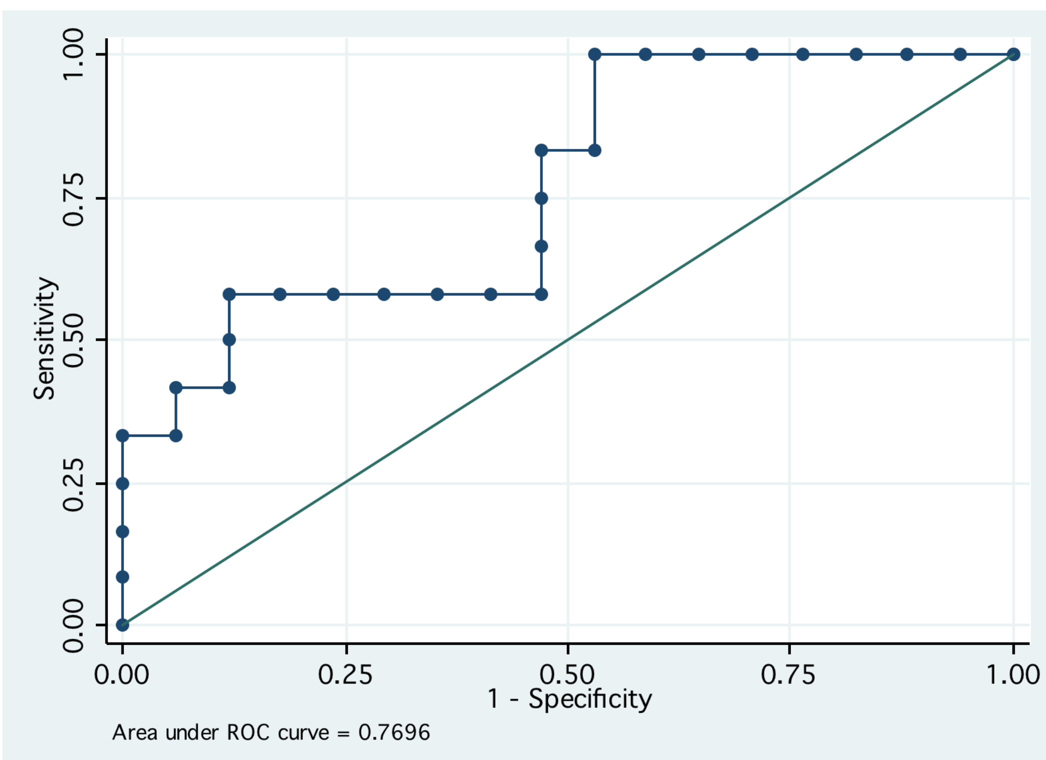

Figure 2: Receiver Operating Characteristic Analysis for distance to a hike-and-bike trail

Chapter V: Discussion

This study found no significant gender or racial differences for BMI, 3DPAR, any of the distances, or NEWS items. Distance to a recreation facility, distance to a hike/bike trail, Parents' NEWS Item G (Neighborhood aesthetics), and Students' NEWS Item H (Pedestrian and automobile traffic safety) were significantly correlated with BMI. No variables were correlated with 3DPAR. Logistic regression analysis indicated that Distance to a hike-and-bike trail and Parents' NEWS Item I were significantly related to the probability of the students' achievement of the Healthy Fitness Zone (HFZ) standards for BMI. Receiver Operating Characteristic analysis indicated that a distance of 12.1miles from a hike/bike trail and a Parent's NEWS Item I score of 2.67 are the optimal cut-off points for identifying the students most likely to achieve the HFZ standards for BMI.

The Neighborhood Environmental Walkability Scale-Youth (NEWS-Y) Survey is a 67-question instrument that was designed based on previous research suggesting that perceptions of neighborhood design features are correlated with physical activity (35). NEWS-Y is a pediatric population appropriate version of the original 98-question instrument. Parents of younger children or adolescents themselves can complete the youth version of the NEWS survey. This version has acceptable test-retest reliability for adolescents, parents of adolescents, and parents of children (35). Intraclass Correlation Coefficients (ICC) range was 0.56 to 0.87 (35). Construct validity has been reported for all three groups (35). ICC range for adolescents was 0.56 to 0.87, parents of adolescents were between 0.61 and 0.78, and parents of children were between 0.56 and 0.87 (35). Also, the items are significantly correlated with youth PA (35). Previous research has indicated high test-retest reliability among adults from neighborhoods with differing levels of "walkability" (ICC range= 0.58-0.80) (36). Items that measured residential density (r=0.63), walking/cycling facilities (r=0.58), and street connectivity (r=0.63), have been shown to have lower but still acceptable reliability. This may be because of item difficulty because judgments differ on distances and lengths of particular areas. (36). The results of this study indicate that each of the NEWS-Y surveys completed by the parents were significantly correlated to their corresponding NEWS-Y surveys completed by the students, suggesting that parents and their children have similar perceptions of their neighborhood. This indicates that this survey is generalizable across different age groups. The NEWS survey has been used in previous research to examine neighborhood environments, and their correlation with PA (17,29,36,40). This study suggests that parents and adolescents have similar perceptions of their neighborhoods, even though none of the NEWS items were related to physical activity.

Item G of the parent survey was significantly correlated to their corresponding child's BMI. As stated above, Item G assesses the neighborhood surroundings. Words used to describe the characteristics of the neighborhood in this section include, nice, interesting, natural, and beautiful. The parent mean for Item G was 3.0, and previous research has reported averages between 2.8 and 3.0 (36). The parent's perception on the appearance of the neighborhood was significantly correlated with their child's BMI. There are many reasons for this relationship. Neighborhood associations play a large role in the appearance of their environment. The presence of a neighborhood association may be affected by the socioeconomic status of the neighborhood. Also, yard work must be done in order to keep a pleasant view in front of the homes, which may mean that neighbors are often outside in their yard. This could, in turn make the parents feel more comfortable letting their children outside, knowing that an adult is near by outside. Student responses for item G were significantly correlated to the parents' responses but not to BMI.

Item H of the student survey was also significantly correlated to their BMI. This item of the survey covers the neighborhood safety. Neighborhood safety includes the amount of traffic, speed limits, and lighting at night. It also covers visibility of pedestrians/bikers, cross walks, and exhaust fumes. Therefore, the student's perception of the neighborhood safety was significantly correlated with their BMI. Parents' responses to item H were not related to BMI. This could be because the children are more likely to pay attention to these characteristics, while playing outside or riding in the car. Parents may not be as aware of the neighborhood safety because while driving, they are paying attention to the road rather than the safety characteristics.

Item I of the parent survey was significantly related to the student's achievement of healthy fitness zone standards for BMI. Item I assesses crime safety of the neighborhood. The crime rate and parents' worries were addressed in this section. Parents may be very aware of crime in their neighborhood (ie watching news or reading the paper), and feel reluctant to send children outside.

No other items of both the parent and student NEWS surveys were significantly correlated to BMI. These items mainly focused on walking distances (times) and characteristics of the neighborhood within walking distances. Accessibility of automobile transportation could be an explanation as to why these items do not correlate to BMI. Individuals can easily drive to stores and facilities in other neighborhoods, reducing the impact of distance. Also, these items could have been less clear or required more thought than items G,H, or I. The walking distances to various facilities may be an issue that is rarely contemplated or known.

The correlations between BMI and the NEWS items G (parent), H (student), and I (parent) were significant, but not high. There are obviously other factors that affect body size and physical activity that were not measured in this study. Even if a neighborhood is not very walkable, that does not mean that some people do not get other forms of exercise that affect their body size and PA. Also, just because a neighborhood is walkable, does not mean that everyone in that neighborhood is walking or physically active.

Previous research has shown that the NEWS survey items are related to fitness behaviors. Similar to the results found in this study, pleasant environments (Item G) was significantly positively correlated to daily step counts for both genders in adults (40). Sigmundova (40) also found that for males, better residencies (Item C) were significantly positively correlated with their step counts. Adult residents of high walkability neighborhoods had lower obesity prevalence (adjusted for individual demographics) than did residents of low walkability neighborhoods (36). The environment or neighborhood has an effect on BMI indirectly through physical activity or other behaviors. These activities include but are not limited to eating habits, sedentary behaviors, social behaviors, and drug and alcohol use. Neither parental BMI nor 3DPAR were measured in this study, so whether the neighborhood walkability was related to parental body size or physical activity can only be speculated.

Based on the address of each student, distances were calculated between the students' home and the closest recreation facilities, hike/bike trails, and grocery stores. This study confirms that the availability of recreational destinations is moderately associated with body size. Distance to a recreation facility and distance to a hike/bike trail were moderately yet significantly correlated to BMI. No NEWS items or distances were related to physical activity.

Previous studies have shown that the presence of at least one healthy grocery option in low-income neighborhoods is associated with a reduction in BMI/obesity risk relative to no food outlets (49). Also, the lower the ratio of fast-food restaurants and convenience stores to grocery stores and produce vendors near individual’s homes, the lower the odds of being obese (42). Contrary to the deprivation amplification theory, it has been shown that residents of the most deprived neighborhoods have shorter travels times to grocery stores than residents of the least deprived communities (41). Availability of healthier foods in low-income neighborhoods has presented an obstacle to good health (18, 37). Distance to a grocery store was not related to either BMI or PA in this study. An explanation for this result could be that most families have cars and the opportunity to ultimately grocery shop at any store near or far. Also, many parents may grocery shop near their jobs after getting off of work, which would explain why the distance a grocery store is from their home is not correlated to their child’s BMI or PA.

This study found no correlation between BMI and 3DPARs. Also, PA in this study was not related to any other variable. The range of average PA values was between 2.7 and 4.5, which coincides s previously reported average 3.6 blocks of MVPA per day over three days (28). This PA measure has been shown to be a valid instrument for assessing overall, vigorous, and moderate to vigorous physical activity in adolescent girls (r=0.27-0.46) (28). However, self-report measures have their limitations. It may be difficult for children to accurately recall their physical activity from three previous days. Also, there is no way to be sure that the student is being truthful when completing the survey. Another possible explanation for the lack of correlation could be difficulty or confusion completing the survey. The instructions for the 3DPAR ask the students to record the number that corresponds with the activity done. This may have been a challenge for some. 3DPARs and step counting (pedometers) both are used to measure but have a great deal of differences. An advantage of step counting with a pedometer is that the subject does not have to recall the data. It shows the researcher the amount of steps that the subject has taken. A disadvantage would definitely be that the pedometer des not show the level of intensity that the subject engaged in. While the 3DPAR differentiates between levels of intensity, it cannot be certain if the subjects' perceptions and realities of PA intensity are correct. Some research has also suggested that increased walkability is positively correlated with moderate to vigorous physical activity (MVPA) (29), and PA (36).

Another measure for PA is accelerometry. Previous studies have used the data from accelerometers to validate 3DPARs (28). Accelerometers are designed to detect activity by measuring vertical acceleration. Similar to the pedometers, this measure is able to give the researcher the data without the subject having to recall any past PA.

Accelerometer measures and pedometer counts may have been related to BMI in this study, had they been used because students would not have had to recall their activity from three previous days. It is hard to determine the exact reason that the 3DPARs were not correlated to any variables but there are many possible explanations, such as item difficulty, and non-compliance. A second measure of PA with this population might have provided a clearer explanation.

The data in this study found no significant differences in BMI or PA across races. Previous studies have reported significant differences in BMI by race.

Hispanic boys had significantly higher odds of having high BMI at all 3 BMI cut point compared with non-Hispanic white boys (26). Also, Non-Hispanic black girls were significantly more likely than non-Hispanic white girls to have high BMI at all 3 BMI cut points (26). Sample size may have been a limitation in finding differences in racial groups in this study.

There were only sixteen parents that disclosed their income and income was unrelated to any other variable. Therefore, there were an inadequate number of responses for income to make any conclusions about income. In this study, income was used as an indicator for socioeconomic status. Previous studies have reported various correlations to SES. Distance to various types of food stores is associated with neighborhood SES (45). Also, the home food environment of low SES adolescents is less supportive of healthy eating than those of high SEP adolescents (21). Stalsberg and Pedersen (43) showed that adolescents with higher SES are more physically active than those with lower SES (43). Adolescents with lower individual and area-level SES had higher BMI then adolescents with higher SES (44). It is unclear whether the non-responses represented no income (unemployment) or just reluctance to provide that information.

Future studies should focus on the most optimal procedures for ensuring compliance from both the children and their parents. A larger sample for comparing gender, age, and racial differences and SES might be helpful to account for additional variation in BMI. Future research needs to consider such variables as income, dietary habits, caloric intake, and grocery shopping behaviors. An individual's income may determine the type neighborhood they can afford to live in and the characteristics of neighborhoods are linked to BMI and obesity risk (49). Dietary habits and caloric intake has increased and contributed to the rise in the prevalence of pediatric obesity (2). Measuring these variables would represent the intake side of the energy balance. Individual's grocery shopping behaviors may effect their dietary habits and in turn, their caloric intake. Also, various and multiple measures for PA could assist in better understanding and analyzing the sample's PA. Measures of aerobic fitness, as well as body composition (% fat), could increase the researcher's knowledge on each individual's PA and energy expenditure.

Only a few NEWS items and distances were significantly correlated with BMI in this sample; however, the results ~~in~~ of this study indicate that some neighborhood environmental characteristics are small yet significant factors in explaining the variability in BMI among adolescents. Previous research also appears to support these results, which provide valuable information about the influence of particular neighborhood characteristics. This study found that the parent's perceptions of neighborhood aesthetics were significantly correlated to their child's BMI. Also, the students' perception of pedestrian and automobile traffic safety in their neighborhood was significantly correlated to BMI. Distance to hike/bike trails and recreation facilities was also significantly correlated to BMI. This information and similar studies are imperative for cities and building companies to consider when revamping in old neighborhoods or starting fresh in new areas. Neighborhood walkability appears to be moderately related to adolescents' BMI. Although neighborhood walkability may only count for a small to modest percentage of the factors affecting body size that might lead to obesity, changing the environment may be a possible solution to decreasing the incidence of this devastating disease.

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