Influence of Physical Activity and Diet on Aggregation of Body Mass Index in Mexican-American and Anglo Families

THOMAS L. PATTERSON, PH.D., JAMES F. SALLIS, PH.D., ROBERT M. KAPLAN, PH.D., PHILIP R. NADER, M.D.

ABSTRACT: It is often stated that human obesity is determined by both genetic and environmental factors. However, few studies have simultaneously considered both factors. To clarify inconsistent findings, we studied the aggregation of ponderosity while controlling for the effects of caloric intake and caloric expenditure through physical activity among 95 Anglo and 111 Mexican-American families. Body mass index (Kg/m²) was used as an index of relative obesity. Our results suggest that environmental factors play little role in modulating familial similarities of BMI. Mexican-Americans had significantly higher BMI's than their Anglo counterparts.

Most reviewers have concluded that obesity is associated with a number of chronic medical disorders in both children (1) and adults (2), although there is some dissent (3). Extensive research suggests that the etiology of obesity is complex, and that there are at least three major factors that affect the storage of fat in obesity; caloric intake, caloric output, and genetic predisposition. All three factors have been considered by different investigators.

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While it is known that obesity is strongly associated with
family factors, the relative contributions of genetic and environmen-
tal factors remain largely unknown. In one study, the importance of
family influences in the development of obesity was highlighted. These
findings suggest that variations in family structure and environment
within families have significant implications for the development of
obesity. Studies by researchers have demonstrated that children and adults
who are overweight or obese have different characteristics in their
eating and physical activity patterns compared to their peers.

In addition to genetic influences, environmental factors, such as the
social and cultural environment, play a significant role in the develop-
ment of obesity. One study found that children who regularly eat
outside the home have a higher risk of obesity. Another study suggested
that children who are exposed to high levels of screen time are more
likely to be obese. Despite these findings, the relationship between
environmental factors and obesity remains complex and poorly under-
stood.

In conclusion, obesity is a multifactorial problem that is influenced
by both genetic and environmental factors. Further research is needed to
better understand the role of each factor in the development of obesity
and to develop effective strategies for prevention and treatment.
tal influences are unclear, and studies have not often addressed these issues simultaneously. The purpose of the present paper is to, first, investigate the aggregation of obesity, as measured by body mass index (BMI; Kg/m$^2$), in Anglo and Mexican-American families. The second purpose of the paper is to determine how the correlations are affected by adjustments for two potential environmental influences on body mass index; caloric intake and expenditure. Specifically we hypothesize that adjusting for these environmental factors will result in improved familial correlations. If our data do not support this hypothesis, we will conclude that the environment is not so important in determining obesity.

METHODS

Subjects

The data reported here were gathered as part of a cardiovascular risk reduction program known as the San Diego Family Health Project (24). Families of 5th- and 6th-grade children were recruited from elementary schools in the San Diego Unified School District. Census tract data were used to identify schools with large numbers of Mexican-American or Anglo families of lower to middle socioeconomic status (SES). Ninety-five Anglo families (58 fathers, 87 mothers, 60 male offspring, 54 female offspring) and 111 Mexican-American families (42 fathers, 102 mothers, 65 male offspring, 78 female offspring) participated in the study. The Mexican-American group included many immigrants along with native born participants.

Tables 1 and 2 show the age distribution for these groups. In addition, the tables show means and standard deviations for body mass index, total number of calories consumed, and Kcals expended during exercise. The Hollingshead (25) two factor index of social position indicated that Anglo participants were predominantly middle class ($\bar{X} = 2.15$), while the Mexican-American families were of lower social status ($\bar{X} = 3.73$).

Individuals were excluded from participation in the study if there was some indication of high blood pressure (defined in adults as taking BP medications or, either a mean of three BP
### By Family Status for Anglo Families

#### Means and Standard Deviations for All Measures

<table>
<thead>
<tr>
<th>Expenditure (kg/wk/month)</th>
<th>Calorie Intake (kJ/day)</th>
<th>Calorie Expenditure (kJ/day)</th>
<th>Total Calorie (kJ/day)</th>
<th>Body Mass Index</th>
<th>Expenditure (kg/m²)</th>
<th>Calorie Intake (kJ)</th>
<th>Calorie Expenditure (kJ)</th>
<th>Total Calorie (kJ)</th>
<th>Body Mass Index</th>
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### By Family Status for Mexican-American Families

#### Means and Standard Deviations for All Measures

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<tr>
<th>Expenditure (kg/wk/month)</th>
<th>Calorie Intake (kJ/day)</th>
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<th>Body Mass Index</th>
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determinations of 150 systolic or 95 diastolic; in children either reading above the 95 percentile for that age), pre-existing cardiovascular disease, total cholesterol above the 95th percentile for that age and sex, or some chronic illness that would prohibit an individual from participating in the exercise/diet program promoted in the intervention (24). Families who volunteered to participate in the study were very similar to nonparticipating families from the same schools who completed brief surveys (26).

**Procedures**

Subjects reported to the measurement center between 7:00 and 11:30 a.m. following a 12-hour fast. Weight was measured without shoes or heavy objects in pockets. Height was obtained using a secured height anthropometer. The quetelet body mass index (Kg/m\(^2\)) was used as a measure of obesity.

Collection of nutritional intake data was accomplished using a 24-hour dietary recall interview. The 24-hour dietary interview was conducted using standardized techniques and food models. Nutrition assessors were trained using Nutrition Coordinating Center procedures plus modifications to improve accuracy of children's reports (27). Results were coded and analyzed for 27 nutrients at the Nutrition Coordinating Center at the University of Minnesota (28). For this study we used Kilocalories divided by the subjects' weight. This adjustment for weight yields a value that can be thought of as a measure of "gluttony," or lack thereof.

The number of kilocalories expended during exercise was calculated from the 7-day Physical Activity Recall (PAR). The reliability and validity of the standardized PAR interview are discussed in a number of publications (29-31). The PAR interviewer determines which portion of each of the previous seven days subjects engaged in moderate, hard, and very hard intensity activities. Kilocalories of energy expenditure per kilogram of body weight per day (KKD) were calculated following the procedures of Blair (29).

Six correlations were computed for BMI using SPSS-X programs: spouse pairs, fathers with older children, fathers with younger children, mothers with older children, mothers with younger children and sibling pairs. Partial correlation methods
American-BMI's to determine if there were significant ethnic changes as a result of adjustmen.
change in energy expenditure were made. There were no significant correlation coefficients after adjustmen for caloric intake and
The left bars of the correlations in Figure 1 show partic

The results for Mexican-American families are shown in the

The results were non-significant. A little correlation. All other comparisons between pairs
Young child correlation was significantly lower than the mother-
Young child correlation was significantly lower than the father-

For Anglo's, BMI's were significantly correlated for the father-

RESULTS

American and Anglo families were analyzed separately.
Figure 1  Intra-family correlations of body mass in Anglo and Mexican-American families. The left (unpatterned) bar of each pair is the zero order correlation and the right (patterned) bar is the partial correlation after adjusting for subject’s caloric input and output. (FA-1 is father with younger child; FA-2 is father with older child; MO-1 is mother with younger child; MO-2 is mother with older child).
findings from other populations with these limitations in mind. Utilizing self-reported BMI, it is informative to compare the group of subjects utilized in different studies. Thresh et al. (92) reported skeletal thickness, while many of the other studies utilized different measures of ponderosity. For example, these studies utilized correlations of ponderosity, while many of which were summarized by Kärnä et al. (94) reported samples agree with existing literature. A number of studies, the magnitude of the correlations that we observed in our sample are non-environmental.

that, based on these data, the most important influences on body mass are non-environmental. Our study took a different approach, that of genetic influence. Our study took a different approach, that of genetic influence. In general, these studies suggest that genetic influence overwhelms the potential environmental influence directly (13, 52, 22, 33). In this study, these studies suggest that genetic influence on the obesity trait is important in determining the results of these studies. The results of these studies are mixed (52, 22, 33). In this study, these studies suggest that genetic influence on the obesity trait is important in determining the results of these studies. The results of these studies are mixed (52, 22, 33).

Most previous studies investigating the relative contributions of heredity and environment have compared genetically related or unrelated individuals with non-related individuals using data from twin or adoption studies. The results of these studies are mixed (52, 22, 33). In this study, these studies suggest that genetic influence on the obesity trait is important in determining the results of these studies. The results of these studies are mixed (52, 22, 33).

Our data suggest that the pattern of family aggregation of BMI, when compared to their Anglo counterparts, and older children (16.1 ± 4.9 vs. 17.2 ± 2.1, p < 0.05). Younger children (1.2 ± 0.2 vs. 1.4 ± 0.2, p < 0.05). Differences. In Mexican-American families, weight-related

DISCUSSION

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Table 3
Comparison of 12 Previously Reported Studies of Ponderosity Measures and the Present Study of Anglo and Mexican-American Samples

<table>
<thead>
<tr>
<th></th>
<th>Spouse Pair</th>
<th>Father offspring 1*</th>
<th>Father offspring 2</th>
<th>Mother offspring 1</th>
<th>Mother offspring 2</th>
<th>Sibling Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous Studies</td>
<td></td>
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</tr>
<tr>
<td>Range</td>
<td>-.01-.23</td>
<td>-.06-.56</td>
<td>.00-.48</td>
<td>.01-.62</td>
<td>-.11-.40</td>
<td>.15-.38</td>
</tr>
<tr>
<td>Median r</td>
<td>.12</td>
<td>.26</td>
<td>.18</td>
<td>.24</td>
<td>.24</td>
<td>.26</td>
</tr>
<tr>
<td>Present Study</td>
<td></td>
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<tr>
<td>Anglo</td>
<td>.05</td>
<td>.43</td>
<td>.27</td>
<td>.07</td>
<td>.22</td>
<td>.21</td>
</tr>
<tr>
<td>Mexican-American</td>
<td>.25</td>
<td>.22</td>
<td>.10</td>
<td>.38</td>
<td>.30</td>
<td>.35</td>
</tr>
</tbody>
</table>

*Offspring are reported in various studies divided by sex, age or mixed samples.

Table 3 summarizes the finding from 12 previously published works. As can be seen, the magnitudes of correlations that we observed were within the range of previous studies. The range of values in those studies reveals that there is great variability in the findings to date. However examination of the median values of these works indicates that when genetically related individuals are compared correlations tended to be in the .20 range, while the median spouse correlation was .12.

A curious anomaly in our study was the relatively high zero order correlation between Mexican-American spouses and lack of effect of adjustment for environmental factors. Since spouses are genetically unrelated, we would expect that of all the relationships observed, this one would be most subject to environmental influence. In a previous study of blood pressure aggregation in this population (36), we also found higher correlations among Mexican-American spouse pairs. Both body mass index and blood pressure must be determined to some degree by genetic make-up. This suggests that assortative mating or similar health habits contribute to the observed similarities. Yet, in
Discrepancies in findings in both the twin/adoptive studies and in the recent intake/origin studies point to the possibility that in the obese individuals such as high blood pressure others studied by Weisner et al. (1978) and Hunt et al. (1972) have also used the same approach to study obesity. We believe that obesity reflects on a genetic and environmental structure which influence the etiology of obesity. It is necessary to study obese individuals in a more detailed way and that in order to understand the obese children and adults obesity. The subjects we studied were not selected on the basis of random characteristics.

This appears to be an area that merits further study. Our findings contradict the results of previous studies, that Mexican-American women have lower IQ scores than Anglo counterparts. Our findings are in agreement with Stern's (37-39) findings that Mexican-American women were less intelligent and had a higher BMI. The only exception was among women whose mothers were born in lower income groups. The results of the regression analysis were significant for the prevalence of obesity from the average nutrient intake. We also found that in our sample, Mexican-American women were less likely to have obesity than Anglo counterparts. Our findings are consistent with previous studies which showed that obesity may be associated with lower socioeconomic status and lifestyle factors. Thus, some correlates of obesity may be influenced by socioeconomic factors such as education, income, and diet. We should be aware that our sample may not be representative of the general population.
cluded that the heritability of obesity was "quite low, only 11%," while family environment accounted for between 32 and 39 percent of the observed variation in obesity. In contrast Brook et al. (5) compared monozygotic and dizygotic twins and concluded that the overall contributions of non-genetic familial effects on skinfold thickness was small. The findings of the current study were more in agreement with Brook et al. (5).

Study limitations must be addressed. It is possible that there is some selection bias in our sample since fewer fathers volunteered to participate than mothers. While this is not a random sample, in a previous analysis we found few significant differences between families who volunteered to participate in the study and those who did not (26). Since the study is cross-sectional, it is possible that obese and non-obese individuals may have similar caloric intake or expenditure at a single point in time, whereas differences may be more likely to emerge when data are collected over time. However we did study children from two different age groups and found similar results. Nevertheless, it is possible that had we collected data on very young children over time, controlling for environmental influences might have changed the strength of association between family members’ BMI. Additionally, the reader is cautioned that food intake (and perhaps exercise) may not be a purely environmental factor. That is, food intake may itself have a genetic component. The measures of diet and physical activity were based on recall of behavior over a short time period. Measurement error would tend to reduce the apparent contribution of these environmental variables.

Our findings should provide more fuel for the debate over the relative contributions of genetic versus environmental factors in the determination of obesity. These results indicate that environmental factors such as caloric intake and physical activity are more important in the similarities of fathers and their children's level of obesity, but they have small impacts on the aggregation of mothers' and their children's obesity in both Anglo and Mexican-American groups. Mexican-American mothers and Anglo fathers showed the strongest concordance of obesity with their children. These cross cultural differences should be explored further.


The effects of family relationships, age, body weight, and diet on blood pressure and the 24-hour urinary excretion of sodium, potassium, and creatinine in men, women, and children of randomly selected families.  


