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Correlational and Predictive Analysis of Obesity on Student Achievement Using HISD FITNESSGRAM® Results, 2008–2009.

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The prevalence of childhood obesity has increased dramatically in the United States over the past decade. Childhood obesity is of particular concern since this condition can lead to overweight adults and increase the risk of other chronic diseases in adulthood, including coronary heart disease, stroke, type 2 diabetes, and some cancers (Gerberding, 2009; Ogden, Carrol, and Flegal, 2008). The National Health and Nutrition Examination Survey (NHANES) data provide evidence that youth in all age groups are impacted by obesity. Specifically, NHANES (2003 – 2006) found the prevalence of overweight youth was 12.4 percent for 2-5 year olds, 17 percent for 6-11 year olds, and 17.6 percent for 12-19 year olds. These rates reflect increases of 7.4, 10.5, and 12.6 percentage points, respectively, from the 1976 to 1980 subgroups who participated in NHANES. This study is based on the assumption that health is correlated with academic achievement (Basch, 2010; Byrd, 2007; Grissom, 2005); and that efforts to combat obesity are reflected in school health and physical education programs. Coordinated physical activity programs "can benefit aspects of cognition" and positively impact educational outcomes (CDC, 2010; Basch, 2010, p. 41).

Data and Methods

Texas state law requires high-quality, evidence-based health and physical education (P.E.) for all public school students as well as a system that monitors the impact of P.E. on youth. Accordingly, Texas instituted the *FITNESSGRAM®*. The *FITNESSGRAM®* was developed by the Cooper Institute to assess children's fitness levels. The assessment includes the body mass index (BMI), which is recognized by the Centers for Disease Control and Prevention (CDC) as a measure of childhood obesity. The Progressive Aerobic Cardiovascular Endurance Run (PACER) and 1 mile run are also components of the *FITNESSGRAM®*, and were utilized as additional measures in the study.

Study Sample

The study sample consisted of 54,060 third through twelfth-grade HISD students who participated in the *FITNESSGRAM®* assessment during the 2008–2009 academic year. Outliers consisting of student weights <40 lbs and >300 lbs were excluded from the analysis. **Table 1** shows that 59.6% of the student sample was Hispanic, 26.5% African American, 9.7% White, and 4.0% were Asian.

Table 1: HISD *FITNESSGRAM®* Sample, 2008–09

	n (54,060)	**%**
Gender		
Male	27,123	50.2
Female	26,937	49.8
Ethnicity		
American Indian	40	.1
Asian	2,186	4.0
African American	14,342	26.5
Hispanic	32,234	59.6
White	5,258	9.7
Econ. Disadvantaged		
Yes	41,910	77.5
No	12,150	22.5
At Risk		
Yes	30,221	56.6
No	23,218	43.4
Special Education		
Yes	4,673	8.8
No	48,483	91.2

Further, the majority of the study sample was economically disadvantaged (77.5%). Nearly 60% of the sample was at risk, and 8.8% of the sample was designated as special education program participants. The sample was fairly representative of the HISD student population at large.

Study Variables

Health-related Measures

The *FITNESSGRAM®* incorporates a variety of health-related physical fitness tests that assess aerobic capacity; muscular strength, muscular endurance, and flexibility; along with body composition. The BMI, Progressive Aerobic Cardiovascular Endurance Run (PACER), and 1 mile run are among the variables extracted from the assessment to analyze in this study. For children, BMI is used to screen for obesity, overweight, healthy weight, or underweight (U.S. Department of Health and Human Services, Institute of Health, Centers for Disease Control (CDC) and Prevention). The CDC adds that to determine whether excess fat is a problem for a child, a health care provider should perform additional assessments, such as skinfold thickness measurements, evaluations of diet, physical activity, and family history.

BMI category definitions can be found in **Table 2**. The BMI was calculated by multiplying the child's weight in pounds by 703 and dividing by the square of the child's composite height in inches. Height and weight were included in the *FITNESSGRAM®* database. The BMI is a continuous variable, thus summary statistics were computed for height (M=60.31, Std.=5.49) and weight (M=117.8, Std.=40.54). The findings are depicted in **Table 3**.

The Progressive Aerobic Cardiovascular Endurance Run (PACER) is the recommended test for aerobic capacity in the *FITNESSGRAM®* assessment battery. The PACER test consists of running a 20-meter shuttle course with 1-minute paced stages at an initial running speed of 8.5 kilometers per hour (km/h) with an increasing speed of 0.5 km/h. Table 3 shows Pacer Laps results for the study sample (M=21.99, Std. =16.59). One Mile Run data are also included in Table 3. The 1 mile run data were converted to minutes from two separate data fields of minutes and seconds, yielding M=12.59, Std.=4.38 for the study sample.

Table 2: BMI Category Definitions*

Underweight	<18.5
Normal weight	18.5-24.9
Overweight	22.31-<30
Obesity	30 or greater

*Depart,ment of Health and Human Services, Institute of Health

Table 3: Descriptive Statistics on Health Measures, 2008-2009

Health Factors	N	Mean	Std.
Height (in.)	53,631	60.31	5.49
Weight (lbs)	54,060	117.8	40.54
BMI	53,627	22.31	6.52
Pacer Laps	33,702	21.99	16.59
1 Mile Run	17,186	12.59	4.38

Note: Missing data or no values were recoded as 'system missing'.

Academic Measures

Stanford Achievement Test Series Tenth Edition (Stanford 10) administered in spring 2009 was used to assess student achievement in reading, language, mathematics, and science for the *FITNESSGRAM®* sample. Descriptive statistics included the mean and standard deviation by grade level using the Normal Curve Equivalent (NCE) scores. Group mean NCEs on Stanford 10 of ≥ 65.6 were classified as above average, between 34.4 and 64.9 were average, and ≤ 34.4 were considered below average (Stanford 10 Manual, 2009). In addition, logistic regression was performed using Stanford 10 reading and math results, resulting in categorization of students' performance to 'above average' and 'not above average'. Stanford 10 cut point for 'above average' performance was ≥65.6 NCEs.

What was the academic performance of the HISD *FITNESSGRAM®* student sample, 2008–2009?

The spring 2009 Stanford 10 results were used to measure the academic performance of HISD students administered the *FITNESSGRAM®* in 2008–2009. The results are presented by ethnicity, grade level, and subtest. Asian student outcomes are depicted in **Table 4**. It is evident that reading and language performance of the Asian student sample was above average at 4th, 6th-7th, and 9th-11th grades. (The sample sizes were less than 5 students at 8th and 12th grades, so the results are not shown). The outcomes at all grade levels in mathematics,

Table 4. Spring 2009 Stanford Test Results for the *FITNESSGRAM®* Asian Student Sample by Grade and Subtest

	Reading			Math			Language			Science		
Grade	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**
3	315	61.4	19.3	316	71.0*	18.1	315	64.2	20.0	315	66.4*	20.3
4	294	65.4*	20.2	294	72.2*	17.8	294	69.2*	19.8	294	64.6	19.8
5	268	64.8	22.7	268	72.5*	19.8	267	65.0	19.9	267	72.0*	21.6
6	242	67.5*	20.3	242	74.4*	18.1	242	68.5*	19.7	242	70.5*	17.5
7	266	69.6*	20.5	266	77.7*	17.8	265	69.0*	18.9	266	75.4*	17.7
8	†	-	-	†	-	-	†	-	-	†	-	-
9	204	72.5*	21.6	203	79.6*	15.4	204	70.0*	17.6	204	76.4*	17.4
10	188	71.2*	19.7	186	80.0*	18.2	186	68.4*	18.9	187	74.0*	17.8
11	192	73.3*	22.7	193	80.2*	17.7	191	68.5*	19.2	193	73.1*	17.6
12	†	-	-	†	-	-	†	-	-	†	-	-

Note: † sample size less than 5
* Above Average NCEs

and at all but 4th grade in science reflected above average NCEs on Stanford 10.

Test results for African American students (**Table 5)** in the sample reflect mean NCEs that fell within the average range at the 3rd-11th grade levels in reading, mathematics, language, and science. Hispanic students demonstrated comparable results as African American students relative to the range of scores that were considered average on Stanford 10 subtests **(Table 6).**

Comparatively, mean NCEs at each grade level in science were above average for White students (**Table 7**). Reading results were also above average at 5th-11th grades for White students. Relative to mathematics performance, 3rd and 6th graders were the only student groups that did not attain above average mean scores on the test. At the same time, 4th, 7th and 9th-11th-grade White students achieved above average scores in language.

Is there an association between BMI and academic achievement?

The association between BMI and achievement was measured using the Pearson Product-Moment correlation coefficient. The results are reported by subject and grade level. Preliminary analysis was performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity.

Table 8 shows statistically significant negative correlations between BMI and reading, math, language, and science scores for the Asian subgroup. Overall, the correlation between language scores and BMI were highly statistically significant for Asian students [$r=-.106$, $n=2184$, $p<.01$]. While a negative association between BMI and test scores were also observed for African American students, the relationship was stronger in math and language, as indicated by high statistical significance [$r=-.028$, n = 14, 175, $p<.01$] and [$r = -.041$, n = 141, 175, $p<.01$], respectively.

Table 5: Spring 2009 Stanford Test Results for the BMI African American Student Sample by Grade and Subtest

	Reading			Math			Language			Science		
Grade	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**
3	2257	42.5	17.0	2265	46.7	19.4	2261	43.4	18.0	2257	44.4	18.9
4	2206	44.4	18.0	2202	47.6	18.7	2205	49.3	18.9	2205	44.5	17.7
5	2133	47.0	18.3	2129	47.8	17.5	2128	47.5	17.7	2126	53.3	20.4
6	1678	42.8	18.5	1676	44.8	16.3	1676	44.6	19.3	1676	45.9	18.7
7	1578	44.6	20.1	1575	45.6	18.2	1577	45.1	19.3	1571	50.9	19.1
8	1605	43.0	18.3	1601	46.1	17.6	1600	44.5	17.1	1597	49.5	17.6
9	1186	47.4	20.6	1174	51.8	16.7	1188	46.6	18.9	1181	48.4	19.2
10	916	46.0	19.0	916	46.9	19.1	919	42.7	17.1	919	44.6	17.0
11	668	50.1	18.4	669	48.1	17.1	669	49.4	16.2	672	47.9	16.0
12	†	-	-	†	-	-	†	-	-	†	-	-

† sample size less than 5

The findings also revealed negative associations between BMI and tests scores in all areas for Hispanic and White students (**Table 9**). Overall, the results were highly statistically significant at p<.01. Further, for Hispanic and White students, the overall association was strongest in language [r =-.061, n = 31,976, p<.01] and [r=-.112, n=5,253, p<.01], respectively.

Table 6: Spring 2009 Stanford Test Results for the BMI Hispanic Student Sample by Grade and Subtest

	Reading			Math			Language			Science		
Grade	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**
3	3204	44.0	16.8	3211	51.1	18.8	3206	46.4	17.7	3199	49.1	18.7
4	4219	45.0	17.1	4220	53.0	17.8	4215	51.0	18.5	4215	48.0	17.6
5	5666	43.8	17.4	5668	51.9	16.5	5665	45.5	17.2	5662	53.3	19.1
6	4568	41.0	16.1	4565	48.3	15.3	4558	43.7	17.0	4565	48.5	16.9
7	4294	42.9	18.0	4286	48.3	17.3	4284	44.3	17.6	4282	51.8	17.8
8	4423	43.4	17.5	4426	49.7	17.1	4413	43.4	15.9	4409	51.8	17.2
9	2368	46.0	20.7	2366	56.0	16.3	2368	47.6	18.5	2368	51.2	19.0
10	1938	46.8	18.0	1944	51.1	17.0	1943	43.7	17.0	1948	49.4	17.0
11	1344	51.8	18.2	1351	51.7	16.4	1347	49.4	17.0	1348	50.7	16.4
12	8	48.9	15.7	9	49.4	14.1	10	40.6	10.8	10	48.4	20.4

Table 7: Spring 2009 Stanford Test Results for the BMI White Student Sample by Grade and Subtest

	Reading			Math			Language			Science		
Grade	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**	**N**	**Mean**	**Std. devia.**
3	777	62.5	19.2	777	65.1	19.8	773	62.0	19.8	772	69.2*	19.6
4	682	64.6	19.4	685	66.8*	18.8	685	65.9*	19.3	683	68.0*	18.7
5	689	66.5*	19.5	686	65.6*	18.1	685	63.4	18.3	684	75.1*	18.0
6	505	66.0*	18.2	505	64.0	18.3	504	64.7	18.7	503	69.4*	17.6
7	626	70.1*	19.1	626	68.7*	18.1	627	66.9*	18.0	625	73.3*	16.5
8	592	69.0*	18.7	592	69.5*	19.5	591	63.2	16.6	590	70.7*	15.5
9	478	73.6*	20.1	480	72.7*	17.5	479	70.0*	17.4	480	74.3*	18.3
10	476	73.8*	16.0	477	73.5*	17.0	477	67.7*	15.5	478	74.1*	16.0
11	398	74.1*	17.1	398	72.0*	18.1	400	69.4*	15.2	400	71.3*	16.0
12	†	-	-	†	-	-	†	-	-	†	-	-

†sample size less than 5
*Above average NCEs

Table 8: Pearson Product-Moment Correlations of BMI and 2009 Stanford 10 Scores by Grade Level for Asian and African American Students

	Asian				African American			
	BMI							
Grade	**Reading**	**Math**	**Language**	**Science**	**Reading**	**Math**	**Language**	**Science**
3	-.100	-.066	-.059	-.125*	-.001	-.015	.001	.031
4	-.075	-.090	-.128*	-.017	-.012	-.020	-.034	.002
5	-.080*	-.077	-.092	-.143*	-.035	-.032	-.077**	.062**
6	-.129*	-.189**	-.191**	-.122	-.023	-.039	-.003	-.015
7	-.085	-.054	-.061	-.010	-.013	-.025	-.045	-.024
8	†	†	†	†	-.046	-.039	-.034	-.038
9	-.092	-.210**	-.155*	-.164*	-.025	-.067*	-.043	-.054
10	-.151*	-.094	-.221**	-.100	-.068*	-.080*	-.047	-.072*
11	-.078	-.073	-.134	-.068	-.003	-.024	-.068	-.045
12	†	†	†	†	†	†	†	†
Total	-.050*	-.051*	-.106**	-.046*	-.008	-.028**	-.041**	-.011

*p<.05
**p<.01
†sample size less than 5

Are there correlations among test scores and covariates?

Table 10 provides Pearson product-moment correlations for reading and math scores and *FITNESSGRAM®* variables (BMI, pacer laps, 1 mile run). The data show that as reading scores increase, BMI decreases ($r=-.072$, $p<.01$). The strongest correlation with BMI among the variables was math scores ($r=-.088$, $p<.01$). The associations between reading and math scores were highly statistically significant ($p<.01$) for all *FITNESSGRAM®* variables, except 1 mile run with math, which was statistically significant ($p<.05$). The correlations between the variables reflected very weak relationships. Moreover, while this was a high level of statistical significance, the results could be due to the large sample sizes.

What were covariate predictors of students' reading and math performance?

Logistic regression was conducted to assess the impact of a number of predictor variables on above average and not above average performance in reading and math of the student *FITNESSGRAM®* sample (**Table 11**). The dependent variables, reading and math scores, were recoded to reflect the Stanford 10 cut point for above performance (≥65.6 NCEs). The model contained seven independent variables: BMI, economic status, ethnicity (White vs. non White), grade level (elementary vs. middle/high) gender, pacer laps, and 1 mile run.

Table 9: Pearson Product-Moment Correlations of BMI and 2009 Stanford 10 Scores by Grade Level for Hispanic and White Students

	Hispanic				**White**			
	BMI				**BMI**			
Grade	**Reading**	**Math**	**Language**	**Science**	**Reading**	**Math**	**Language**	**Science**
3	-.066**	-.055**	-.080**	-.051**	-.077*	-.085*	-.103*	-.072*
4	-.051*	-.073**	-.083**	-.041**	-.139**	-.108**	-.172**	-.121**
5	-.030*	-.050**	-.066**	-.040**	-.135**	-.156**	-.126**	-.098*
6	-.026	-.043**	-.041**	-.003	-.165**	-.226**	-.142**	-.160**
7	-.033*	-.030	-.042**	-.012	-.160**	-.203	-.190**	-.172**
8	-.052*	-.075**	-.057**	-116**	-.117**	-.209**	-.170**	-.116**
9	-.050*	-.090**	-.072**	-.071**	-.110*	-.126**	-.192**	-.085
10	-.008	-.063**	-.009	-.008	-.098*	-.127**	-.149**	-.103*
11	-.028	-.046	-.027	-.024	-.209*	-.198**	-.242**	-.118*
12	-.728*	-.537	-.556	-.090	†	†	†	†
Total	-.028**	-.050**	-.061**	-.020**	-.059**	-.103**	-.112**	-.078**

*p<.05
**p<.01
†sample size less than 5

Table 10: Pearson Product-Moment Correlations for 2009 Stanford 10 Reading and Math Scores and Covariates

	1	**2**	**3**	**4**	**5**
Read (1)	1.00				
Math (2)	.531**	1.00			
BMI (3)	-.072**	-.088**	1.00		
Pacer laps (4)	-.095**	.107**	-.220**	1.00	
1 Mile run (5)	.033**	-.009*	.110**	-.032**	1.00

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the .05 level (2-tailed)

Table 11: Logistic Regression Predicting Likelihood of Scoring Above Average in Reading on Stanford 10, 2009

							95% C.I. for EXP(B)	
	B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**Lower**	**Upper**
BMI	-.019	.003	30.342	1	.000	.982	.975	.988
Economic Status	-1.454	.036	1628.734	1	.000	.234	.218	.251
Ethnicity (White vs. Non White)	1.289	.048	735.464	1	.000	3.630	3.307	3.985
Grade Level (Elem. vs. Middle/High)	-.009	.035	.071	1	.789	.991	.924	1.062
Gender	-.234	.033	50.588	1	.000	.791	.742	.844
1 Mile Run	-.005	.007	.447	1	.504	.995	.982	1.009
Pacer Laps	.008	.001	76.652	1	.000	1.008	1.006	1.010
Constant	-.204	.091	4.968	1	.026	.816		

For reading, the full model containing all predictors was statistically significant, χ^2 (8, N = 33,943) = 4536.532, p < .001, indicating that the model was able to distinguish between respondents who scored above average and not above average in reading. The model as a whole explained between 12.5% (Cox and Snell R square) and 21.1% (Nagelkerke R squared) of the variance in reading scores, and correctly identified 83.4% of the cases. In the model, estimates of odds ratios are given in terms of the increase of one unit change of the independent variable. As shown in Table 11, five of the seven independent variables made a statistically significant contribution to the model (BMI, economic status, ethnicity, gender, and pacer laps). The strongest predictor of reading scores was ethnic classification, recording an odds ratio of 3.630. This indicated that students who scored above average in reading were nearly 4 times more likely to be White than non White. The data also show that BMI is a significant predictor of reading. The odds ratio (OR) for BMI and reading indicates students scoring above average in reading were more likely to have a lower BMI (OR = .982). Further, pacer laps were also among the significant predictor of reading scores. The study revealed the odds of scoring above average in reading are 1.008 times more for students completing more pacer laps (OR = 1.008). Moreover, females and elementary students were more likely to score above average in reading than males and middle/high school students, respectively (OR =.791 and OR = .991).

Logistic regression was also conducted to determine the impact of the same independent variables on math scores (**Table 12**). The full model containing all predictors was statistically significant, χ^2 (8, N = 33,943) = 3252.410, p < .001, indicating that the model was able to distinguish between respondents who scored above average and not above average in math. The model as a whole explained between 9.1% (Cox and Snell R square) and 13.6% (Nagelkerke R squared) of the variance in math scores, and correctly identified 62.8% of the cases.

Table 12 reveals that six of the seven independent variables made a statistically significant contribution to the model. The strongest predictor of above average math scores compared to not above average math scores was ethnicity, recording an odds ratio of 2.653. Specifically, students who scored above average in math were about 2.7 times more likely to be White than non White. The data also show that BMI is a significant predictor of math performance. The odds ratio for BMI and math was .979, denoting that above average math scores were more likely for students with lower BMIs. Further, pacer laps was also among the strong predictors of math scores. The odds of a student scoring above average in math was 1.009 times more likely for students who recorded more pacer laps. Additional findings indicated females and elementary students more likely to perform above average in math than males and middle/high school students, respectively (OR = 1.031 and OR = .756).

Table 12: Logistic Regression Predicting Likelihood of Scoring Above Average in Math on Stanford 10, 2009

							95% C.I. for EXP(B)	
Variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**Lower**	**Upper**
BMI	-.021	.003	59.358	1	.000	.979	.973	.984
Economic Status	-1.029	.033	987.210	1	.000	.357	.335	.381
Ethnicity (White vs. Non White)	.976	.046	447.905	1	.000	2.653	2.424	2.904
Grade Level (Elem. vs. Middle/High)	-.279	.030	88.471	1	.000	.756	.713	.802
Gender	.030	.027	1.233	1	.267	1.031	.977	1.087
1 Mile Run	-.019	.006	9.566	1	.002	.981	.969	.993
Pacer Laps Run	.009	.001	139.830	1	.000	1.009	1.008	1.011

Discussion

Childhood obesity is considered a serious public health concern due to the rising incidence of obesity among children and its many adverse health effects (Gerberding, 2009; Ogden, Carrol, and Flegal, 2008). Obesity is often the result of an improper balance between energy/calories consumed (poor diet) and energy expended (physical inactivity) (U.S. Department of Health and Human Services, 2010). Previous research has supported the relationship between student achievement and obesity (Basch, 2010; Byrd, 2007; Grissom, 2005) by documenting how fitness and school-based physical activity programs, including physical education, positively influence educational outcomes (Basch, 2010).

"Physically active, fit youth are more likely to have better grades and test scores than their inactive counterparts" (Trost and van der Mars, 2009, p. 62). This point is evident based on the study findings. Specifically, higher scores in reading, math, language, and science among Asian, African American, Hispanic, and White students were found to be significantly correlated with lower BMIs. Moreover, students with above average math and reading scores were more likely not to experience obesity. These results are relevant since brain research documents "cognitive development occurs in tandem" with physical activity (CDC, 2010, p. 13).

It is critical that school districts build sustainable and effective physical education programs by implementing population-based strategies and interventions. This is, particularly, critical since "decreasing time in physical education does not significantly improve academic performance" (Trost and van der Mars, 2009, p. 62). Strategies practiced by school districts should address environmental factors that incorporate "increasing the consumption of fruits and vegetables, increasing physical activity, reducing the consumption of sugar sweetened beverages, and reducing calorie dense-nutrient poor food intake" in order to improve student health and decrease the incidence of obesity *(Gerberding, 2008)*. Future research is warranted to investigate trends in BMI and achievement and to assess the impact of specific programs toward reducing obesity rates among student groups.

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