

Effects of a School-Based Intervention on BMI z-Scores and Fitness Parameters in Mississippi Delta Children

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Abstract

Background and Objectives: Although Mississippi is making modest progress in childhood obesity prevention and reduction; most of the recent benefits are seen in white children. The purpose of Eating good and moving like we should (EGMLWS), a school-based intervention was to create a successful program to prevent and reduce childhood obesity in the Mississippi Delta, among mostly African American students.

Methods: The program worked with third grades in 7 schools. It provided curricula, started school gardens, and school menu consultation. BMI s-scores were calculated and Fitnessgram parameters were measured, including 20-m progressive aerobic cardiovascular endurance run (PACER) and back-saver sit-and-reach (BSSR). Demographic and beginning heights and weights were analyzed using descriptive statistics. Pre- and post-intervention BMI z-scores and Fitnessgram scores for each school were compared using paired t-test.

Results: Mean BMI z-scores were significantly lowered in 2 schools, not changed in 4 schools and increased in 2, although all schools had individuals with decreased BMI z-scores. PACER scores increased in 5 of 7 schools while sit-and-reach left and right scores increased in 5 and 6 of the 7 schools, respectively. All schools improved in at least one PACER measure, and 3 schools improved across all measures.

Conclusions: After one school year in EGMLWS, north MS Delta third graders improved in both the PACER and sit-and-reach components of Fitnessgram assessment. BMI z-scores were lowered in 2 schools and remained the same in 4 schools. Also, BMI-z-scores did not rise over all schools and there was some lowering of BMI z-scores in every school, which was encouragement that school-based interventions can favorably impact BMI and fitness in primarily African American populations.

Keywords: School-Based Intervention, Exercise, Pediatrics, Obesity, Physical Activity, Fitnessgram Assessment

1. Background

While obesity rates have decreased in children aged 2 to 5 years from 13.9% in 2003 - 2004 to 9.4% in 2013 - 2014, they have remained stable for children aged 6 to 11 years at around 17% since 2007 - 2008, and increased for adolescents aged 12 to 19 years from 10.5% in 1993 - 1994 to 20.6% in 2013 - 2014 (1-3). In Mississippi, the prevalence of overweight and obesity for all K-12 students was 41.8% as compared to 40.9% in 2011 (4), and Mississippi annually spends over \$925 million in health-care costs directly related to obesity (5, 6). Because of this concern and economic cost, Mississippi has been the focus of several researchers and/or practitioners who are interested in childhood obesity treatment and prevention. Based on the last statewide survey (7), there are approximately 32 childhood obesity interventions occurring in Mississippi. In 2007, the Mississippi legislature passed the Mississippi healthy students Act (8), a comprehensive bill requiring all schools to administer a focused and multi-pronged approach to student health (9).

Despite limitations, these efforts appear to have yielded modest progress. In 2012, evaluators of the Mississippi healthy students Act observed that obesity rates stabilized in Mississippi public school children as a whole (10). In 2014, those same observers reported significant decreases for white students in combined overweight and obesity rates: from 40.6% in 2005 to 38.8% in 2013 ($P = 0.0007$) (4). However, once the population-level statistics are disaggregated, they show that from 2005 to 2011, obesity in white male and female, and African-American male children remained constant but obesity in African-American females increased every year (9). In 2013, obesity rates among all black students was significantly higher (11).

Like many other states, Mississippi faces competing priorities addressing health and academic challenges in the schools (12). An emphasis on academic achievement and test scores by policy makers (13) as well as shrinking resources (14) has forced many school districts to cut back on physical education and recess at the same time that some

researchers suggest that physical education may improve academic performance (13).

The obesity epidemic is a complex problem with many overlapping interdependencies (15), making reversal difficult without simultaneously promoting change in the environments where the overweight and obese are living and working (14,16). School-based nutrition interventions have shown positive effects on body mass index (BMI) values in elementary children, but with mixed results (17-20), and few interventions have been conducted with African American children (21). This lack of information can make it hard to design interventions for areas with a high percentage of African-Americans, like in Mississippi and the Mississippi Delta.

In a literature review of all pre-school and school-based obesity prevention or treatment interventions, Robinson et al. (21) found only 17 studies published between January 1980 and March 2013 that targeted populations that were more than 80% African American. The authors stressed that there are still deficits in understanding what must be done to address the disparities that contribute to obesity in this population (21).

2. Objectives

The purpose of the eating good and moving like we should (EGMLWS), a school-based nutrition intervention, was to create a successful healthy eating program to prevent and reduce childhood obesity in the MS Delta, a region with adult obesity rates of 38.9%, higher than any other region in Mississippi. Program objectives were to decrease or maintain BMI and improve fitness levels of third graders by providing nutrition and physical activity lesson plans to teachers, starting school gardens, and working with school nutrition directors/managers to make school lunch menus healthier and more appealing.

3. Methods

3.1. Subjects

EGMLWS was designed as a primary prevention program, as described by Williamson et al. (22) for the Louisiana health study, in that all children were equally exposed to the intervention, conducted over the course of the 2013 - 14 school year. In the spring of 2013, superintendents of all school districts ($n = 16$) in the northern half of the Mississippi Delta region were emailed a brief description of the EGMLWS project along with a request for an appointment to meet with the projects staff (a health education specialist, a registered dietitian, and university faculty) During the meetings, the project team explained the

intervention and brainstormed with the superintendents on how it could be implemented in their school districts. A total of 7 schools in 6 school districts agreed to participate in the program. All were located in rural counties, had more than 90% of their students eligible for free or reduced school lunch, and had student populations that were more than 80% African American (23). Also, in all the schools, the students went to physical education classes 2 times per week. A total of 533 third grade students, from the 7 elementary schools (one in each of 5 school districts and 2 in one school district) participated in the program. The research protocol and activities were approved by the University of Mississippi institutional review board and (when existing) the review boards of the school districts involved.

3.2. Procedure

The 7 participating schools agreed to all components of the intervention: 1) a 15-minute nutrition education class once per week, 2) two, 5-minute classroom physical activity sessions per day, 3) the start-up of a school garden, 4) implementation of physical education lesson plans by physical education teachers, 5) the development of a teacher fitness room, 6) a review of school breakfast and lunch menus by the project's registered dietitian, and 7) collection of heights and weights and Fitnessgram (24) data at the beginning and ending of the school year.

Nutrition education lesson plans were developed from ChooseMyPlate.gov (25) and the resources on the Mississippi department of education's office of healthy school's website (26). EGMLWS also worked collaboratively with teachers to develop 5-minute physical activity sessions that could be performed in the classroom, and recommended that the activities be performed twice per day. Forty-three percent ($n = 9$) of the teachers reported conducting the sessions once per day, 24% ($n = 5$) reported conducting the sessions twice per day, and 28% ($n = 6$) reported conducting sessions at least 3 times per week. The EGMLWS staff also provided lesson plans to the physical education instructors to structure exercises to develop age appropriate skills in accordance with the Mississippi department of education's office of Healthy schools' Mississippi 2013 - 14 physical education framework (27). All 7 physical education teachers (one per school) used the EGMLWS lesson plans once per week.

To promote a wellness mindset in teachers and school staff, "fitness rooms" for their use were created. Each school provided some space which was outfitted with a treadmill, stationary exercise bike, three sizes of hand weights, and resistance bands. Teachers received a short lesson on exercise safety and how to use the equipment and were encouraged to set their own fitness goals.

The EGMLWS registered dietitian reviewed all the schools' breakfast and lunch cycle menus. Although most of the menus already conformed to the USDA Meal Pattern requirements (28), the registered dietitian worked with the child nutrition program directors to decrease excess calories and/or increase acceptability of the food.

3.3. Measures

Heights and weights of the children and Fitnessgram parameters (the 20-m Progressive aerobic cardiovascular endurance run (PACER) and back-saver sit-and-reach (BSSR) (29) Fitnessgram assessment) were measured during the first full month (September) and the last full month (May) of the school year. Heights were measured using a portable wall-mounted measuring tape (white stature meter height measure measuring tape 200 cm/2M). Weights of the children, in light clothing and without shoes, were measured to the nearest 0.1 pound with a portable digital scale (Tanita HD-384 Digital Scale).

PACER is a multistage shuttle run designed to measure aerobic capacity (30). The objective is to run as long as possible while keeping a specified pace. The other fitness measure, BSSR is similar to the traditional sit-and-reach test, except that the measurement is performed on one side at a time (29). Members of the EGMLWS research team worked with school staff to collect the data.

To assess use of the fitness rooms, sign-in sheets were provided for teachers. Also, an electronic survey was created using an online format, and an email with a link to the brief survey was sent to the school's teachers and staff, who were asked about their awareness, use, and opinion of the fitness room.

3.4. Statistical Analysis

Demographic and beginning heights and weights were analyzed using descriptive statistics. Body mass index (BMI) is an index of body mass divided by the square of height expressed as kg/m² and in those individuals between 2 and 20 years of age, height and therefore weight often change rapidly (31). Therefore, an alternative measure, BMI z-scores, which are relative weights adjusted for child's age and gender expressed as deviations from the mean for a given age and gender in standard deviations may be used (32, 33), and was calculated.

The ages of the children, to the nearest quarter year, were collected. This and pre- and post-intervention heights and weight were used to calculate age and gender-specific BMI z-scores according to the guidelines provided by the centers for disease control and prevention (34). Pre- and post-intervention BMI z-scores and pre- and post-intervention Fitnessgram component scores (PACER and

BSSR) for each school were compared using paired t-test. Paired t-tests with an alpha of 0.05 were also used to determine any category changes from pre- to post-intervention. BSSR scores were compared to the Fitnessgram performance standards (24). There are no set PACER performance standards for children younger than 10 years of age.

4. Results

Demographic information is presented in Table 1. The subject population was almost evenly divided with regards to gender, but not with regards to race. Mean height for males was lower than for females, but weights for males were significantly greater than for girls.

Mean BMI z-scores significantly decreased in 2 schools, did not significantly change in 4 schools and significantly increased in 2, although both schools had individuals with decreased BMI z-scores (Table 2). The highest percentage of participants with decreased BMIs predictably occurred in the schools that showed a significant decrease (92.1% in School 7 and 71.9% in School 6). The next highest percentages of participants with lowered BMI z-scores were in two schools in which overall BMIs did not change (58.9% in School 2 and 57.6% in School 3). BMI z-scores increased in both school 4 and school 5. School 4 had the lowest percentage of students with decreased BMI (21.9%).

Across all schools, the pre-intervention mean BMI z-score was 0.922 (± 1.229) compared to 0.916 (± 1.187) following intervention. While numerically different, there was no statistical difference between the paired BMI z-scores.

As shown in Figure 1 when pre-intervention BMIs were sorted according to age- and gender-specific percentiles, no males were underweight (below the 5th percentile), 45.48% were in the normal range between the 5th and 85th percentiles, 20.74% were overweight, (between the 85th and 95th percentiles, and 33.78% were classified as obese (above the 95th percentile). No significant differences were seen between pre- and post-intervention BMI z-scores in any of the groups except for obese females, whose BMI z-scores significantly increased. However, post intervention, the numbers of children in each group shifted to 1.00%, 50.17%, 16.05%, 32.78%; underweight, normal, overweight, and obese, respectively. Pre-intervention, 0.76% of the girls were underweight, 51.14% were normal weight, 17.42% were overweight, and 30.68% were obese. Post intervention, 1.52% of the girls were underweight, 53.79% were normal weight, 17.80% were overweight, and 26.89% were obese.

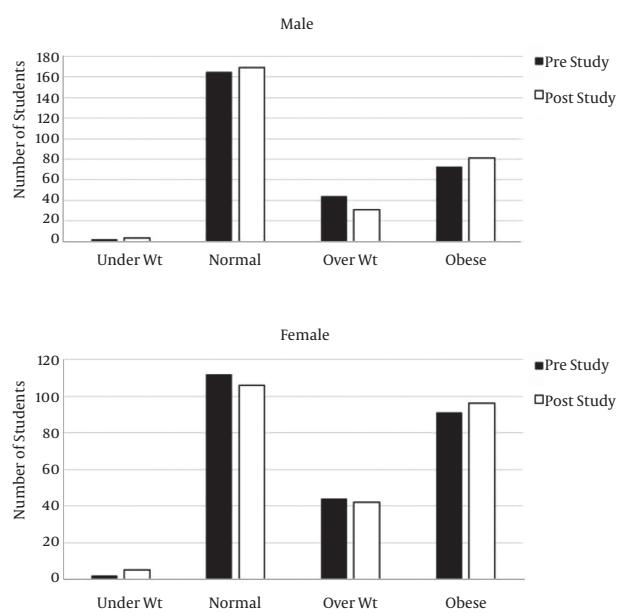
PACER scores increased in 5 of the 7 schools, while sit-and-reach left and sit-and reach-right scores increased in 4 of the 7 and 5 of the 7 schools, respectively (Table 3). All schools improved at least one Fitnessgram measure, and

Table 1. Baseline Demographic Characteristics of Participants^a

Variable	Overall Sample (n = 533)
Age, y	8.4 ± 0.4
Gender	
Males (n = 284)	53.28
Females (n = 249)	46.72
Ethnicity	
White	11.21
Black	82.13
Hispanic	6.66
Height, inches	
Total (n = 533)	54.05 ± 3.06
Minimum - Maximum	45.13 to 65.00
Males (n = 284)	53.94 ± 2.85
Females (n = 249)	54.19 ± 3.28
Weight, lbs	
Total	83.80 ± 25.68
Minimum - Maximum	45.8 to 197.40
Males	81.90 ± 23.69 ^b
Females	54.19 ± 3.28 ^b
BMI/BMI z-scores	
Total	
BMI	0.977 ± 1.229
BMI z-scores	0.922 ± 1.229
Minimum - Maximum	
BMI	-8.384 to 3.406
BMI z-scores	-8.384 to 3.406
Males	
BMI	19.58 ± 4.62
BMI z-scores	0.922 ± 1.297
Females	
BMI	20.49 ± 4.80
BMI z-scores	1.040 ± 1.146

^aValues are expressed as mean SD or (%).^bSignificant difference P < 0.01.

3 schools improved across all measures. The one school (School 7) that showed decreased BMI improved across all fitness parameters. Three of the 4 schools with unchanged BMI improved across all fitness parameters, and one improved for only sit-and-reach right. The two schools that showed the largest increase in Fitnessgram scores also had the greatest teacher compliance with all 4 of the teachers

**Figure 1.** Pre- vs. Post- Percentages of Participants by BMI Weight Percentile

conducting the sessions at least once per day.

Prior to the intervention, 28.01% and 16.49% of the participants did not meet the minimum age- and gender-specific fitness standard for flexibility (sit-and-reach left and right, respectively). Post intervention this percentage decreased to 26.63% for sit-and-reach left and 15.98% for sit-and-reach right. When compared by gender, 35.23% and 24.16% of the males did not meet the minimum standard for flexibility (sit-and-reach left and right, respectively), but post-intervention, the percentages decreased to 34.23% and 21.48% respectively. For females, 21.97% did not meet the minimum standard for sit-and-reach left, but this number decreased to 9.09% after the intervention. For sit-and-reach-right, however, the number of females who did not meet the minimum standard increased from 9.09% to 10.98%.

A total of 77 out of a possible 134 school staff responded to the email survey for a response rate of 57.5%. Forty-nine (63%) respondents knew there was a fitness room in their school, 22 (44%) of those respondents (16.42% of the total 134) had used the fitness room, and 16 (75%) of those said it met or exceeded their expectations.

5. Discussion

The purpose of EGMLWS was to create a successful multi-component school-based nutrition and physical activity program to prevent and reduce childhood obesity in

Table 2. T-Values from Paired T-Test for Pre vs Post BMI Z-Scores, Average BMI Z-Score Differences, Number of Students with Decreased BMI Z-Scores, and Percentage of BMI Z-Scores that Decreased for Each School and Total Sample

School	T Value	P Value	Average Difference in Pre vs Post BMI z-Scores	Number of Decreased BMI z-Scores	Percentages of BMI z-Scores that Decreased
School 1 (n = 29)	1.08	0.288	0.072	13	44.8
School 2 (n = 56)	1.69	0.097	0.049	33	58.9
School 3 (n = 66)	1.18	0.244	0.043	38	57.6
School 4 (n = 32)	-3.61**	0.001	-0.182	7	21.9
School 5 (n = 279)	-2.98*	0.003	-0.042	113	40.5
School 6 (n = 32)	2.76*	0.010	0.110	23	71.9
School 7 (n = 39)	3.72**	0.001	0.311	33	92.1
Total sample (n = 533)	0.32	0.748	0.004	257	48.2

Table 3. Results of Paired T-Test Comparing Pre- and Post- Fitnessgram Measurement for Each School

PACER					
School	Pre Mean \pm SD	Post Mean \pm SD	t	P Value	
1	12.38 \pm 4.43	12.76 \pm 5.91	-1.57	0.064	
2	9.00 \pm 6.28	13.05 \pm 9.82	-5.03	< 0.001	
3	11.53 \pm 7.35	15.30 \pm 7.47	-5.83	< 0.001	
4	12.45 \pm 5.64	3.21 \pm 5.95	-0.72	0.237	
5	11.66 \pm 8.26	14.38 \pm 8.13	-5.45	< 0.001	
6	6.46 \pm 3.34	9.77 \pm 3.97	-9.00	< 0.001	
7	9.67 \pm 5.36	13.95 \pm 6.07	-10.60	< 0.001	
Sit-and-reach left					
1	9.55 \pm 2.43	9.62 \pm 2.21	-0.21	0.418	
2	8.46 \pm 2.48	9.31 \pm 2.49	-3.87	< 0.001	
3	9.21 \pm 2.17	10.77 \pm 2.49	-7.00	< 0.001	
4	9.03 \pm 2.24	9.88 \pm 1.82	-3.29	0.001	
5	8.65 \pm 6.41	9.35 \pm 6.29	-1.43	0.076	
6	10.59 \pm 2.20	13.87 \pm 3.00	-8.44	< 0.001	
7	9.08 \pm 2.33	12.44 \pm 3.14	>-10.81	< 0.001	
Sit-and-reach right					
1	9.10 \pm 2.23	9.59 \pm 2.20	-1.70	0.050	
2	8.83 \pm 2.47	9.47 \pm 2.39	-2.52	0.007	
3	9.33 \pm 2.06	11.17 \pm 2.58	-7.64	< 0.001	
4	9.06 \pm 2.14	9.94 \pm 2.11	2.53	0.008	
5	8.35 \pm 2.34	9.15 \pm 2.13	-8.04	< 0.001	
6	10.41 \pm 2.17	14.00 \pm 2.64	-9.99	< 0.001	
7	8.71 \pm 2.32	12.62 \pm 3.13	-11.80	< 0.001	

the Mississippi Delta. The results reported here describe

the program's effectiveness in decreasing the BMIs and im-

proving the fitness levels of the participants.

BMI z-scores decreased in 2 of the 7 schools, did not change in 3 schools, and increased in 2 schools. All the schools, however, had students with some decrease in BMI z-scores with the percentages ranging from 21.9 % to 92.1%. The percentages of obese participants decreased for both boys (33.78% pre-intervention to 32.78% post-intervention) and girls (30.68% pre-intervention to 26.89% post-intervention). While suggesting some effectiveness these results also support the findings of Safron et al. (18) who revealed that only one-third of intervention trials (per systematic review) reported significant changes, and suggested that the lack of larger effects may be due to the fact that most children in a population-based intervention are of normal BMI and that a floor effect may exist. Sbruzzi et al. (35) found similar results and posited that educational interventions performed for longer than 12 months were associated with reduction in BMI. Since the present study was conducted for one school year (10 months), intervention duration may have been a confounding factor.

Pre-intervention fitness was not robust: 28.01% of the participants (34.23% of the boys and 21.97% of the girls) and 16.49% (24.16% of the boys and 9.09% of the girls) of did not meet the minimum age-and gender-specific fitness standard for flexibility (sit-and-reach left and right, respectively). This supports the findings of Ling et al. (36) who reported in an assessment of rural school-children that at baseline only 1.6% of the girls and 1.1% of the boys met physical activity recommendations, and Ling et al. (37) who determined that 36% of rural third-graders could not meet minimum performance standards for sit-and-reach. The low level of pre-intervention physical performance in all three of these studies is evidence for the need for more research on improving physical activity performance in children. The mean school scores for PACER for the third-graders in this study ranged from 6.46 ± 3.34 to 12.45 ± 5.64 pre-intervention to 9.77 ± 3.97 to 15.30 ± 7.47 post-intervention. As stated, there are no minimum standards set for aerobic capacity (PACER) for 8 or 9-year-olds. Although a comparison of these PACER scores to the minimum performance standard for 10-year-olds (37.3) may not be a valid comparison, 559 (96.06%) did not meet the minimum standard for 10-year-olds. The fact that less than 1% of the participants in this study could meet this standard does point towards a low cardiovascular capacity in the other 99% of participants (37). With the continued reporting of minimal physical activity performance, and the correlation of PACER scores to health parameters (37), waist circumference (38), and academic performance (39), perhaps the time has come to research and set minimal performance standards for PACER for children under 10 years of age.

The elevation of PACER scores in 5 of the 7 schools, sit-and-reach left in 5 of 7 schools, and sit-and reach-right in 6 of the 7 schools suggested that the intervention significantly improved physical fitness of participants in all schools. These results are consistent with the findings of Bezold et al. (40) (increased sit-and-reach scores), Naylor et al. (19) (increased PACER scores but not sit-and reach), and Uys et al. (41) who found improvement in running speed tests for boys but not girls but did not find improvement in sit-and-reach scores for either gender.

While the teachers and staff who reported using the fitness room stated it met or exceeded expectations, only 16.42% of the teachers visited them. More research is needed on providing exercise opportunities for teachers and comparing their fitness levels to their students' attitudes about physical activity. Dedicated marketing of the fitness rooms may have increased usage and satisfaction.

5.1. Limitations

Although the results of our study add to the literature by showing improvements in physical fitness and lowering or maintaining of BMI z-scores in schools that are more than 80% African Americans, there were several limitations. First the lack of a control group of schools renders the results less reliable than those from a randomized controlled trial. As with Sacchetti et al. (42) geographical distances may have interfered with the amount of programming delivered by the program. Ages of the children were only recorded to the nearest quarter of the year; so calculated BMI z-scores were not as accurate as if we had collected birthdates, probably reducing the impact of the intervention on BMI. Waist circumference and percent body fat data were also not collected, again probably reducing impact of the intervention. Because national age-and gender-specific standards for PACER are not available for children less than 10 years of age, we were unable to determine how many children met the minimum cardiovascular Fitnessgram standards.

5.2. Conclusions

Although the prevention of childhood obesity is challenging, especially in areas with fewer resources, multi-faceted interventions can make an impact, especially in fitness levels. After one school year in the EGMLWS program, north Mississippi Delta third graders improved in both the PACER and the sit-and-reach components of the Fitnessgram assessment. Also, although BMI z-scores were lowered in only 2 schools, they stayed the same in 4 schools. This, with the fact that BMI-z-scores did not raise over all schools and that there was some lowering of BMI z-scores every school is encouragement that school-based interventions can favorably impact BMI and fitness in primarily

African American populations. Multifaceted school-based interventions show promise in the prevention of childhood obesity, but more research is needed to identify the components that are most successful in impacting behavior change.

Implication for health policy makers/practice/research/medical education: findings from this study suggest that nutrition physical activity education can be effective in the prevention of childhood obesity and has expanded the database for the use of these interventions in primarily African American populations. EGAMILWS has succeeded in providing access to low cost, self-sustaining nutrition and physical activity education and programming to remote schools in Mississippi. This is a difficult challenge that rural areas everywhere face as part of the urban/rural divide. Eating Good is a model of how to bridge this gap.

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Footnotes

Authors' Contribution: Study concept and design: the study was developed and designed by Kathy B. Knight and Charlotte Oakley; acquisition of data: Lacy M. Dodd and Janie W. Cole collected the data; analysis and interpretation of data: Kathy B. Knight analyzed the data; drafting of the manuscript: Dr. Kathy B. Knight drafted the manuscript; critical revision of the manuscript for important intellectual content: all Authors helped revise the manuscript; statistical analysis: Dr. Kathy B. Knight performed the statistical analysis; administrative, technical, and material support: All authors contributed this support; study supervision: Drs. Kathy B. Knight and Oakley helped supervise the study.

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