

Teens and Greens: The Effect of Vegetable-Based Smoothies on Adolescent Health and School Performance

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ABSTRACT

Background: Children who eat breakfast are more likely to meet nutritional needs and perform better in school and on tests, yet many skip breakfast and do not meet their RDI for vegetable intake.

Purpose: Introduce vegetables to high school students at breakfast by giving a variety of fresh produce and high-powered blenders to make healthy, palatable smoothies.

Design: Pre-post design 43 students from a local high school volunteered for a 3-month pilot study. An RD met and encouraged students daily to make their own smoothie, ideally with 2 C veggies. Outcome measures were body composition, lipids and change in nutrient intake. Qualitative data were obtained at baseline and end of study via surveys regarding students' views of health, focus and performance in school.

Results: Of the 43 students, 20 completed. Waist circumference decreased by 3% on average; plasma HDL increased in 14 students, TC dropped 9% in 7 students. Energy improved in 13 students. Ten percent had better grades. Afternoon lethargy dropped from 35% to 22%. Change in nutrient profiles of smoothies: Total kcal decreased from 293 to 247; veg servings increased from 1.75 to 2.25; CHO decreased from 58 to 40.5g; protein intake increased 1g, fat increased from 6 to 8.5 g and no change in fiber intake.

Conclusion: A daily vegetable-based smoothie improved energy levels, focus, waist circumference and body image in participating high school students.

KEYWORDS

Blast, green smoothies, carbohydrates, total cholesterol, high density lipids (HDL) cholesterol, NutriBullet, waist circumference

BACKGROUND

Research has shown that children who eat a healthy breakfast have improved cognitive function, reduced absenteeism, and better mood(3). When adolescents incorporate breakfast into their daily lives, they also have a decreased risk for becoming overweight and obese, which is a precursor for multiple chronic lifestyle diseases. (7)

Unfortunately, most US adolescents are more likely to consume empty calories from processed foods such as sugared-cereals, pop tarts and chips. These foods have been shown to contribute around 40% of daily calories, which can negatively affect the overall quality of their diets (3). Additionally, this same age group fails to meet federal guidelines recommending 2 ½ to 6 ½ cups of fruits and vegetables each day. (3). The stats don't improve much within the adult population. The Behavioral Risk Factor Surveillance System (BRFSS) found that only 32.6% of adults consumed fruit two or more times per day and 27.2% ate vegetables three or more times per day. These results show that the adult population still has a far way to go in order to meet recommended guidelines for fruit and vegetable intake. (4)

A 2003-2006 NHANES U.S. national survey found that adolescents age 14-18 are lacking key vitamins and minerals in their diets. 58% of adolescent boys and 90% of adolescent girls are not meeting their daily recommended intake of calcium, which is crucial for attaining peak bone mass during development. Potassium can help lower blood pressure, reduce salt sensitivity and minimize the risk of kidney stones. Only 3% of American adolescent meet the adequate intake for potassium. Adequate levels of vitamin C, facilitate iron absorb and can help prevent iron deficiency. Adolescents had lower serum vitamin C levels than their younger peers aged 6-11 and adolescent girls had lower levels than adolescent boys. 80% of children age 2-18 do not consume adequate folate without including fortified foods in their diet. When fortified foods were added, this amount went down to 5%. Folic acid helps with the production and maintenance of new cells and is important for growth periods. (5)

In addition, results from a four-year longitudinal national health study "The Next Generation Health Study Report," a nationally-representative longitudinal study focusing on key health behaviors and health status of older adolescents as they transition into young adulthood, found that only 26% of students who attended a local high school ate breakfast compared to the national average of 43%. This high school was the perfect place to initiate a healthy eating study.

Since children spend about 60% of their time at school, more than they spend at home with

their families, making healthy dietary changes at school may be the best time to impact daily habits. Routines developed during teenage years may also be carried into adulthood.

Thus, presenting nutritional education along with hands-on opportunity to create healthy breakfast choices was tested in a group of high school students. By providing a “Blast station” to schools, children had access to fresh fruits and vegetables daily with the intent to have them develop a palate for healthy foods and reprogram their taste buds to enjoy fruits and veggies. This aligns with the LAUSD Wellness Policy to increase student access to a healthy breakfast and encourages students to choose a balanced and nutritious meal. California Ed Code 51210.4 requires nutrition education curricula to be research-based and focused on pupils’ eating behavior. Therefore this program is aligned with the goals of LAUSD and the California Department of Education.

METHODS

Subjects

Forty-three healthy, high school students, age 13-18 with the average age of 15, in a first period health class, volunteered to participate in this pilot study. Of the 43 students 53% were Hispanic, 16% were Caucasian, 26% were African American with an even distribution of male and female. Written parental consent was obtained for all participants and those who reported severe allergies were excluded from the study.

Study Design

NutriBullet created a variety of recipes incorporating veggies and fruits using their NutriBullet blenders, these are called Blasts. Students were required to make 1 Blast per day over the 5 day school week and fill out a daily questionnaire to indicate which recipe they followed and a weekly qualitative questionnaire.

Anthropometric data were collected from all participants by certified nurses at the beginning and end of the study. Non-fasting baseline cholesterol and non-fasting HDL cholesterol were taken using a CardioCheck PA. Waist circumference was measured in compliance with the guidelines outlined by the Heart Foundation (6) using a standard quilting tape measures and BMI calculated. Height and weight, were taken using a Health O Meter Weight Tracking Scale and lean body mass was obtained by using the Body Logic, Body Fat Analyzer.

Diet

Over the course of 90 days, fruits and vegetables were prepped and placed in plastic containers and made available to students by setting up the “Blast Bar”. Serving utensils and measuring cups were placed in food bowls, preparing their Blasts by following recipes. Food stores were replenished and students were coached to load cups properly. Students selected a recipe, filled their cups, retrieved a blade and went to the Blast bar to blend their ingredients. Before they began Blasting, they filled out a sheet of paper with the recipe they chose to use or the recipe they created for their Blast for the day.

For this 3 month study, recipes were designed to increase nutrient dense vegetables and decrease fruit with each proceeding month as outlined in Table 1.

Table 1. Nutrient Profile of Monthly Blasts

	Month 1	Month 2	Month 3
Fruit Serving	1.5-2	1	1-1.5
Vegetable Serving	1.5	1.5-2	2-2.5
Nut Serving	-	.25	.25
Grain Serving	-	.25	-
Seed Serving	.3	.3	.3
Protein (grams)	7-10	8-9	9-10
Carbohydrate (grams)	55-60	35-57	27-45
Fat (grams)	4-8	6-8	5-12.5
Fiber (grams)	7-15	7-11	7-11
Calories	286-300	243-298	245-249

Month 1: The students were allowed to choose their own recipe and were encouraged to use vegetables, but not required.

Month 2: Students were required to follow one of the two recipes, if they did not want to follow them, they were not allowed to make a Blast that day.

Month 3: Students were encouraged to choose one of the two recipes but were allowed to make their own as long as they used half vegetables in their Blasts.

Questionnaire

Participants were given an initial questionnaire to assess eating habits, fruit and vegetable intake, perceived energy levels, performance in school and health related goals at baseline and at program completion.

Students were also given weekly qualitative questionnaires to track changes in sleeping and eating habits, energy levels, attendance and attitude towards to program and were reviewed each week. Students struggling with the program met with a registered dietitian to tailor Blasts they would enjoy while still remaining within program guidelines.

Statistical Analysis

Data were collected from a sample of 20 students at two time points (initial and final). For all test, a p-value ≤ 0.05 was considered significant. Data were analyzed using SAS statistical software (Version 9.3).

Lab data were analyzed with Wilcoxon Ranked Sum tests (non-parametric equivalent to the parametric Paired t-Test) to discover significant differences between average initial and average final lab values. The data are displayed as means with standard deviation.

Wellness assessment data were analyzed using Chi-Square tests for independence among variables with more than two levels and 2 Sample Proportion test for independence among variables with two or less levels. The wellness assessment results were analyzed to find significant differences between initial and final distributions. Data are displayed as raw counts.

RESULTS

Of the 43 students who started the study, 21 completed. Drop-outs were due to changes in class schedule, school transfers and inability to make it to scheduled testing days.

In preliminary data collected from the 43 students who started the program, 40% did not eat breakfast, 6% ate fruit for breakfast and 0% reported having any vegetables for breakfast, but 35% of students reported eating vegetables a couple of times per week. Of the 21 students who completed the study, 95% reported eating breakfast and of that 73% reported having a Blast for breakfast.

The students who completed the study made an average of 13 Blasts per month out of 20, a 65% completion rate.

Anthropometric data are shown in Table 2 and blood chemistries are shown in Table 3. Statistically significant changes were measured in waist circumference with a p-value of <0.0230.

Nutrient profiles changes in smoothies: Total kcal decreased from 293 at the first month to 247 at the end of the third month; veg servings increased from 1.75 to 2.25; CHO decreased from 58 to 40.5g; protein intake increased 1g, fat increased from 6 to 8.5 g and no change in fiber intake.

Figure 1-5 compared student's perceptions of themselves and their behavior and habits before and after the program. Perceived energy levels showed a statistically significant change with a p-value of <0.0001. Although there was no statistical significance in body image perception, 38% of students reported feeling better about their weight status at the completion of the program. Figure 6-8 looked at perceived dietary intake patterns. A statistical significance was measured with an increase in dark leafy green, p-value of 0.0093, and berries, p-value of 0.0033, consumption over the three month period.

Table 2. Anthropometric Data at Baseline and Final

Body Composition	PRE (Baseline)	POST (3 months)
***Waist circumference (inches)	***33 ± 5.68	***32 ± 5.89
Body weight (lbs)	154.9 ± 38.64	153.4 ± 37.3
BMI (kg/ht squared)	26.7 ± 5.65	26.3 ± 5.73
Body fat percentage (%)	29.2 ± 9.56	28.2 ± 10.56

*** Indicates statistical significance, p-value: 0.0230

Table 3. Pre and Post Blood Cholesterol Levels

Blood Values	PRE (Baseline)	POST (3 months)
Total cholesterol (non-fasting, mg/dL)	163.87 ± 41.4	161 ± 38.4
HDL cholesterol (non-fasting, mg/dL)	41 ± 12.9	43.9 ± 14.69

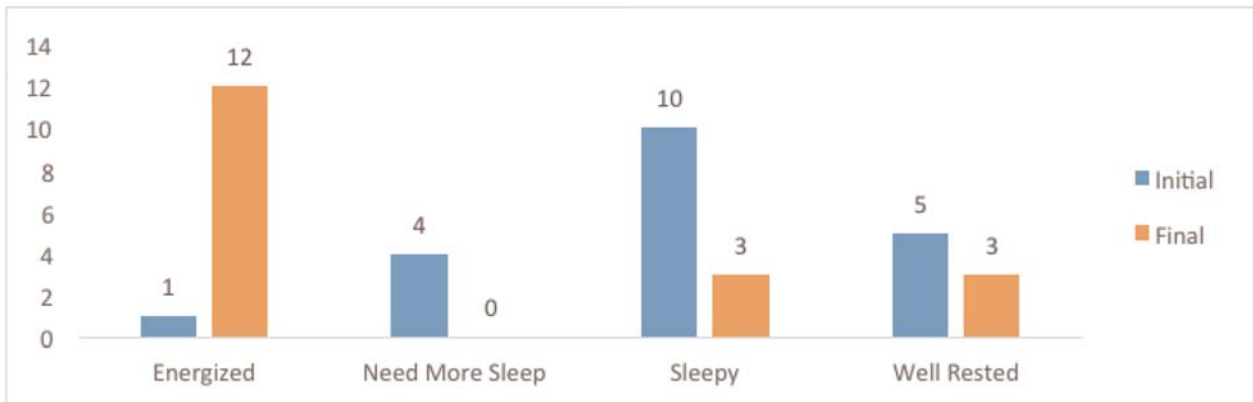


Figure 1 How do you feel when you wake up in the morning?

***Overall p-value: <0.0001, Energized p-value: <0.0001

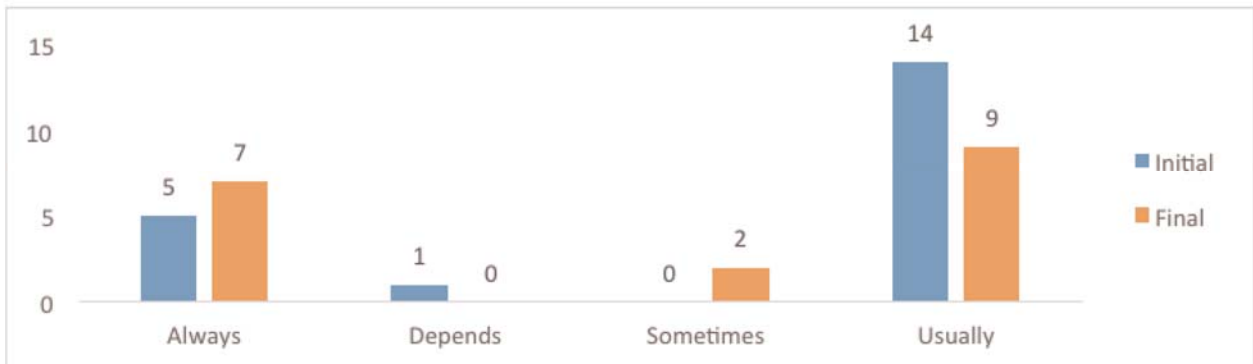


Figure 2. Would you describe yourself as a good student?

No significant difference between initial and final answers

**ALWAYS - I love to get high scores YES

**USUALLY - School is a priority MOSTLY

**DEPENDS - if the subject interests me OCCASIONALLY

**SOMETIMES - School is not my priority NO

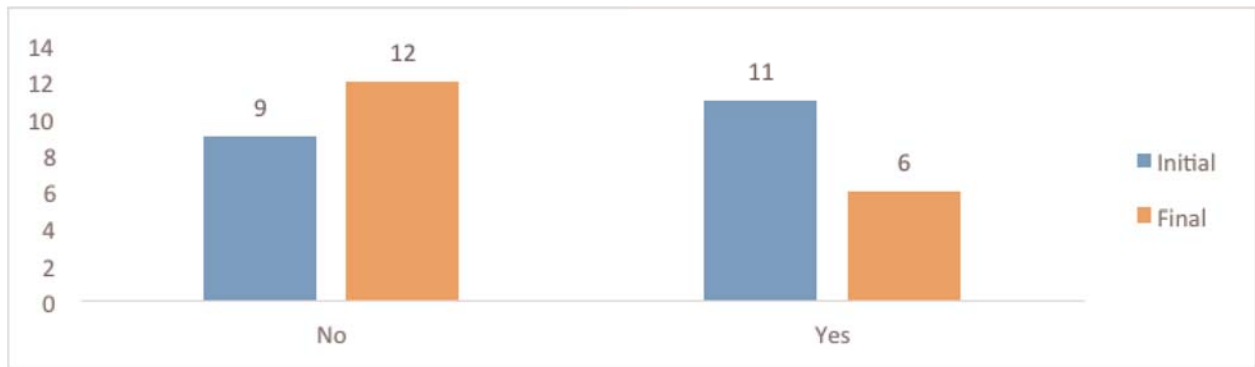


Figure 3. Is it difficult to concentrate on school work?
No significant difference between initial and final answers

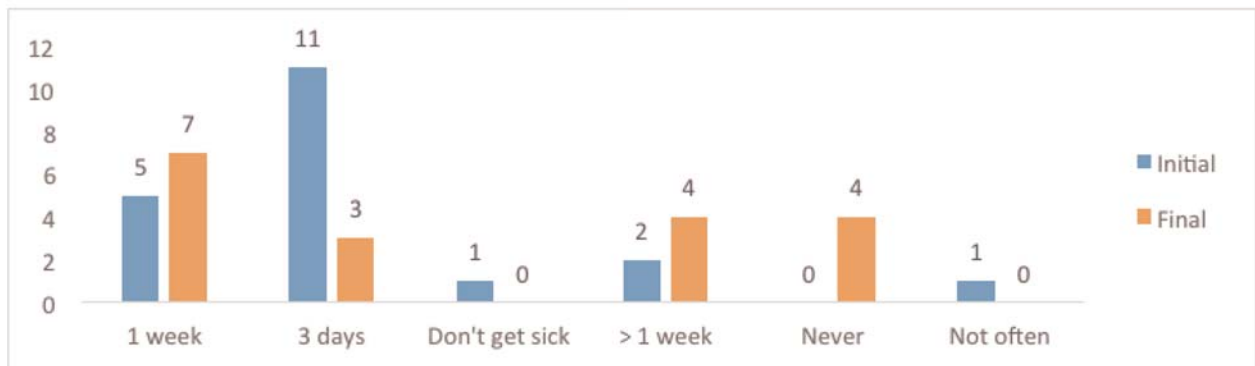


Figure 4. How frequently do you get sick and miss school?
Data from baseline to end of study, p-value 0.0424; 3 days p-value 0.0072, never p-value: 0.0129

***COMBINE DATA: > 3 or more days (1 week, > 1week)
AND ≤ 3 days (3 days, Dont get sick, never, not often)



Figure 5. Are you comfortable at your current weight?

No significant differences.
No, want to gain weight
No, want to lose weight
Yes

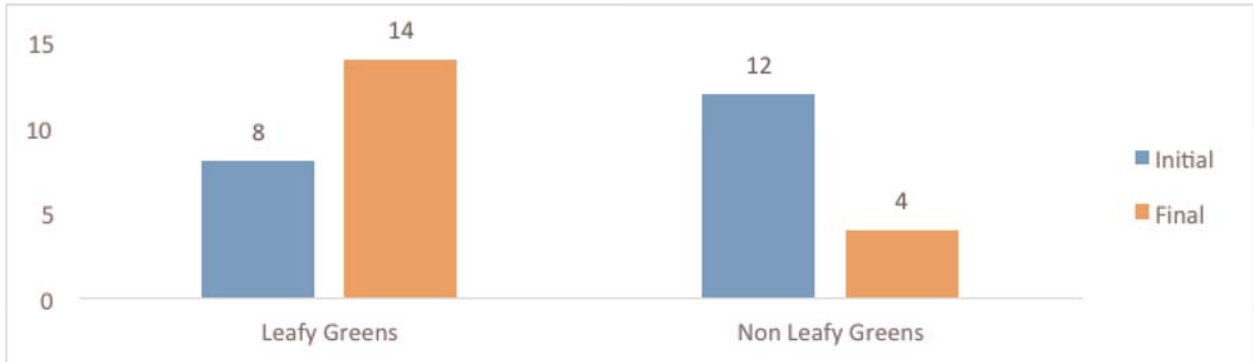


Figure 6. List vegetables you typically eat
Overall p-value: 0.0018
Leafy Greens p-value: 0.0093
Non Leafy Greens p-value: 0.0093

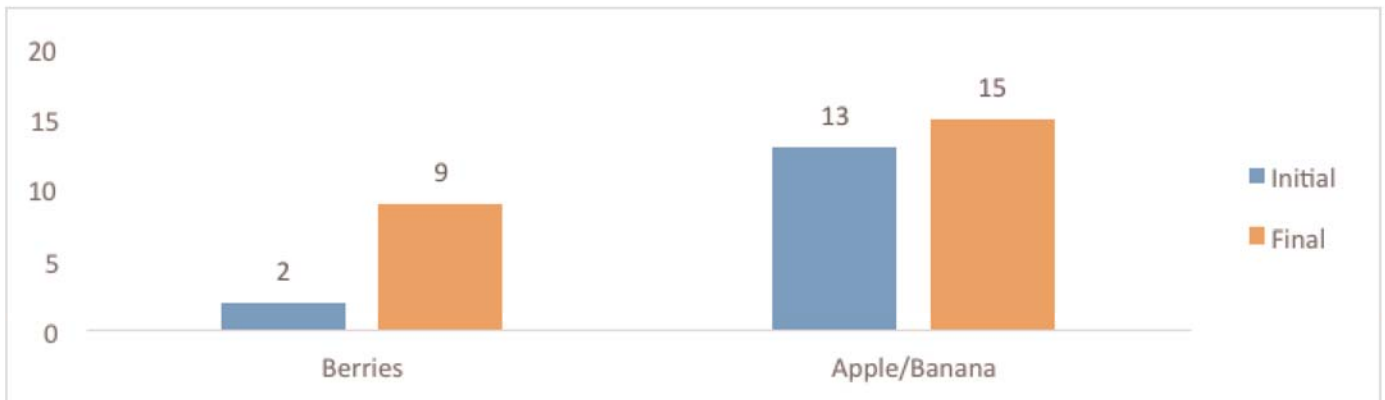


Figure 7. List fruits you typically eat .
Berries p-value: 0.0033
Apple/Banana p-value: 0.1000

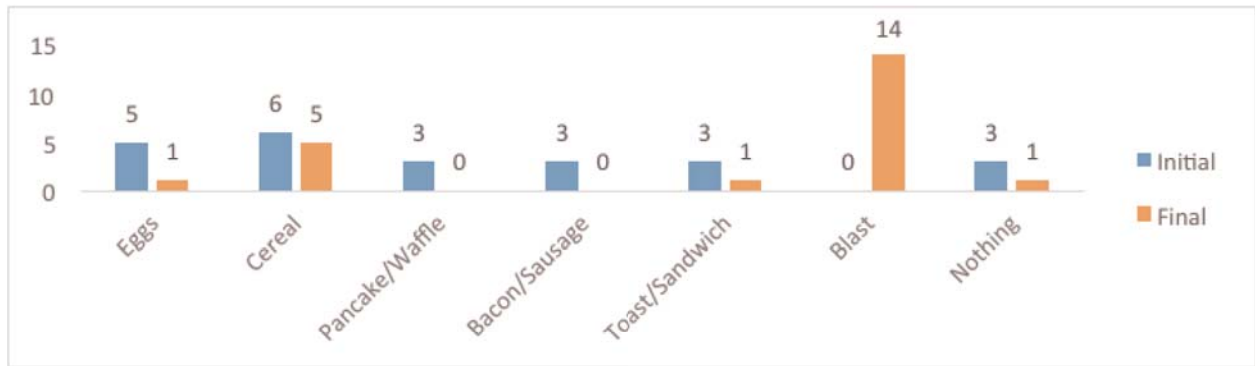


Figure 8. What do you normally eat for breakfast?

Blast p-value: <0.0001

DISCUSSION

Starting with 46 students and ending with 21, provided a small sample population. Many of the students had to be reminded to complete questionnaires which may have skewed final data for average number of Blasts per month which only showed 65% compliance. Putting a simple tracking method in place would account for less error.

Statistically significant decreases in waist circumference were measured in students. Waist size measures visceral fat, which if elevated above normal levels, is associated with an increase in inflammatory markers circulating in the bloodstream and can affect insulin resistance. The bodies inability to properly regulate insulin can lead to diabetes, obesity, heart disease and a vast array of chronic lifestyle diseases. (2) A reduction in waist size decreases the risk of developing chronic lifestyle diseases into adulthood.

Measurable changes were observed in vegetable intake shown in Figure 6. As dark leafy green vegetable increased, students reported incorporating less starchy vegetables in their diets like potatoes, corn and peas. Instead, they were including more nutrient dense vegetables like greens, broccoli and zucchini. As students health improved, they became more conscious eaters and were more intune with consuming foods to nourish their bodies. When students were nourished, their attention and focus improved, see Figure 3. They also reported taking less sick days at the end of the program, see Figure 4. The Journal of School Health observed similar changes when students were on school breakfast programs which improved academic performance, cognitive function and attendance (8). This further proves that providing nutrition at breakfast time has a positive impact on students' overall health and performance.

With an increasing prevalence of obesity (1), it is not surprising that many teens are reporting an interest in weight loss. When initially surveyed, 14 students reported not feeling comfortable at their current weight and wanting to lose weight. At the end of the program, this number decreased from 14 to 4 students, see Figure 5. Improved eating habits lead to an improved perception of self which opened up the floor to discuss health at home. As parents noticed changes in their children whether it was weight or an improved attitude about themselves, this

set the stage for health oriented discussion to take place at home. The education process was seamlessly moved from the classroom into the home and parents began modifying habits as well.

This study is the starting point to show that students are willing to increase fruit and vegetable intake when given the right tools and opportunities. The potential impact of including a green smoothie on the health of an adolescent, were limited by our small size, but seeing changes in waist circumference, attitude and blood chemistries are reason to try and implement this system into more schools and conduct further well-designed studies. Further investigation in the area of self perception and self worth associated with fruit and vegetable intake may additionally show positive results.

Other Co-founding Variables

Students were not put on any diet plan and were only given the green Blasts / smoothies at school. They were encouraged to Blast at home but were not required to follow any specific plan outside of the classroom.

CONCLUSION

By including a balanced breakfast with whole foods, students not only reported feeling better but also had the anthropometric data to support the healthy changes that were taking place.

Significant decreases in waist circumference were measured, which can reduce the risk of chronic lifestyle disease later in life.

Results from the lifestyle questionnaire also showed statistical significance in reported energy levels and improved concentration while in school. By increasing nutrient dense foods in their diets, like dark leafy greens, berries, nuts and seeds, the students were feeling noticeable changes.

With only a 90-day program, the students were able to experience and feel first hand healthy dietary changes not only in school, but throughout their day-to-day lives.

After the program concluded, students continued to be healthy advocates for lifestyle changes through diet as evidence by their participation in a local community run benefiting LA school systems, harvesting food for the Blast Bar in the LAUSD garden, and continuing to run the Blast Bar after the program was completed.

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