



The Effect of a Five-Day Educational Program for Children with Asthma on Airway Inflammation: a Two-Year Study

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Introduction

Camp Wheez is a five-day camp experience, currently in its 41st year, offering free asthma educational program for children at “high risk” for asthma exacerbation during the upcoming Fall Season. A formal, age appropriate curriculum was provided by GSK Asthma Quest 2013 to develop early education in a medically-supervised environment. Education was provided by community volunteer physicians, nurses and respiratory therapists. Special guests provided entertainment and activities for the campers. The families and parents attended an asthma workshop t the end of the week. Asthmatic children are at “high risk” for fall exacerbations due to the fall viral season, fall allergen exposure and failure to take anti-inflammatory medications during the summer months.^{1,2,3} Previous studies have demonstrated the effectiveness of camp education^{4,5} in reducing exacerbations on asthmatic children, 90% of whom have an allergic component and polysensitization resulting in TH2-driven bronchial inflammation.⁶ Fractional exhaled nitric oxide (FeNO) is frequently increased in some inflammatory processes such as allergic asthma⁷ and has been used as a metric to evaluate TH2 allergic inflammation. We measured FeNO in all campers at Camp Wheez 2018 and 2019 to evaluate the effectiveness of a five-day educational program on airway inflammation.

Methods and Materials

Ninety-seven children with mild, moderate and severe asthma were enrolled in Camp Wheez in Santa Barbara, CA August 2018 and 2019. Of these 97, 24 children were repeat campers. Written informed consent for was obtained for each participant. All children were counseled on the use of controller medication, home peak flow monitoring, early signs of asthma, and identification and avoidance of asthma triggers. Baseline FeNO determinations on day one were not discussed nor interpreted for the campers. Follow-up FeNO determinations on day five were revealed to the families if airway inflammation was significant, as these children were at risk for asthma exacerbation. The portable NIOX VERO was used by 2 trained healthcare professionals for non-invasive, quantitative, simple and safe measurement of nitric oxide in human breath. FeNO was measured with age-appropriate incentive visualization using the cartoon character with a 6 or 10 second breath analysis. Children were monitored for Fall exacerbations. Non-parametric one-tailed Wilcoxon signed-rank test was used to measure difference scores between FENO measurements on day one and five. Results were reported using the Z value. Significance level at $p < 0.05$.

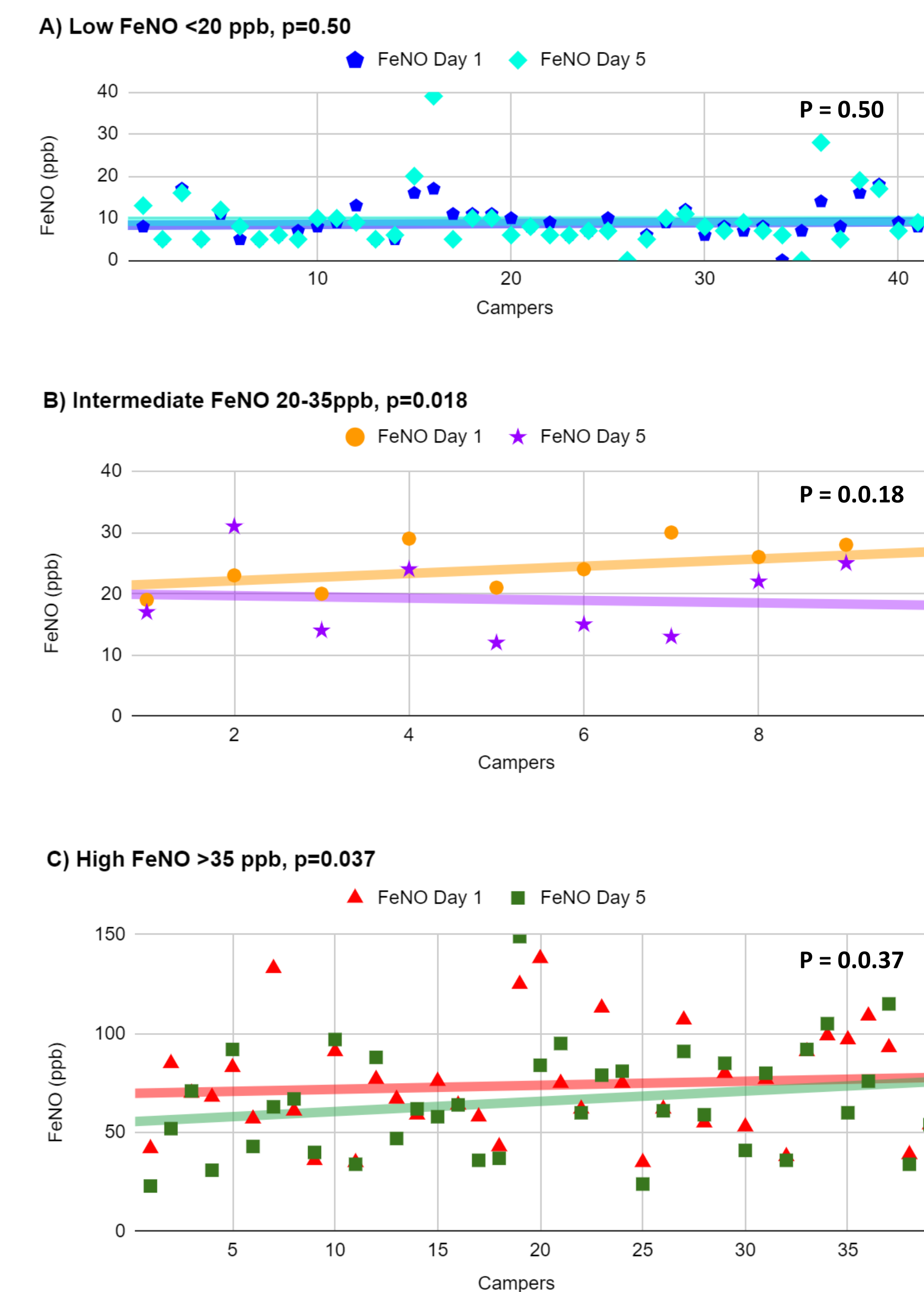
Results

A total of 97 campers between the two years of Camp Wheez were enrolled. Average age was 8.5 years (6-17 years). Six children were excluded due to absence or inability to complete FeNO. Campers were stratified by baseline FeNO levels into low (<20ppb), intermediate (20-35ppb), and high (>35ppb) groups.⁸ Mean baseline FeNO for all campers was 38.3 ppb with a 10% improvement to 34.6 ppb by day 5 ($z = -1.9$, $p = 0.027$, **Table 1**). Both the intermediate and high baseline FeNO campers showed statistically significant decreases from their baseline FeNO day 1 to day 5. Intermediate FeNO campers had a 22% improvement from 24.2 to 19ppb ($z = -2.1$, $p = 0.018$) and high FeNO campers had an 11% improvement from 73.9 to 65.8ppb for the high group ($z = -1.8$, $p = 0.037$). No difference was observed in campers with low FeNo (<20 ppb). The magnitude of improvement was greater than the magnitude of those unimproved ($p = .05$ by two tailed test.) One child in the high FeNO group required a hospitalization in the fall of 2018.

Table 1. Baseline characteristics and Day 1 and Day 5 mean FeNO measurements

Baseline FeNO levels	Campers n (%)	Mean Age (years)	Mean FeNO Day 1 (ppb)	Mean FeNO Day 5 (ppb)	FeNO Δ	% Change	p-value	Z value
All campers	97†	8.5	38.3	34.6	↓ 3.7	↓ 10	0.027*	-1.9
Low (<20 ppb)	42 (43.3)	8.2	8.8	9.4	↑ 0.6	↑ 6.8	0.50	-0.01
Intermediate (20-35 ppb)	10 (10.3)	8.9	24.2	19	↓ 5.2	↓ 22	0.018*	-2.1
High (>35ppb)	39 (40.2)	8.8	73.9	65.8	↓ 8.1	↓ 11	0.037*	-1.8

Figure 1. Day 1 and Day 5 mean FeNO measurements: A) low FeNO group, B) intermediate FeNO group, C) high FeNO group



Discussion

Pulmonary function testing in children greater than 5 years of age has traditionally relied on spirometry with FEV1 response to short-acting bronchodilators. The American Thoracic Society criterion for diagnosing asthma is a 12% and 200ml improvement in FEV1 after bronchodilator.⁹ We chose the FeNO incentive single-breath test in order to define children at risk due to TH2 airway inflammation. One hundred and eighty-eight determinations were done during days one and five of Camp Wheez for the following reasons:

1. Simplicity of testing, using a pediatric 6 or 10-second incentive breath test. The incentive utilized “Flying person cartoon” (only one camper was unable to complete the test).
2. Accuracy of testing duplication and reliability in diagnosing Th2 allergic inflammation.
3. Standardization of norms with less than 20 ppb as low, 20-35 ppb as intermediate and high-risk defined as greater than 35 ppm (our highest result was 138 in a child who was not taking controller ICS as recommended).

This study demonstrated the utility of FeNO determinations at a summer day camp to help define pediatric asthmatic patients at risk for asthma exacerbations. However, it has been difficult to define high-risk pediatric patients according to the NIH guidelines. Although all attendees received the same asthma education in a supportive environment, at no time did any of the individual campers receive personal coaching based on their his/her FeNO levels. The parents of the high FeNO group were notified after follow-up determinations on day five to advise asthma follow-up and adherence of their child’s controller inhalers. Our results showed a statistically significant improvement at the conclusion of education with a 10% reduction in FeNO ($p = 0.027$) in all campers, specifically those with intermediate or high baseline FeNO.

Conclusions

Clinical experience has shown that many asthmatic children are taken off their asthma controller medications during the summer months and are thereby susceptible to undiagnosed airway inflammation. Families mistakenly assume that in asymptomatic children, “asthma takes a vacation during the summer.” While this may be true due to fewer circulating viruses in the summer, ongoing inflammation occurs during asymptomatic periods.⁹ We demonstrated a significant improvement in airway inflammation as evidenced by FeNO reduction in at-risk campers through the use of short-term education. Our long-term goal was to follow these campers throughout the fall asthma season in order to prevent asthma exacerbations.

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