PRINCIPLES AND PRACTICE OF CLINICAL RESEARCH
A Global Journal of Clinical Research

Association Between Physical Activity Intensity and Allergies in Children: Insights from NHANES 2005-2006

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Abstract

Background: *Allergies are among the most prevalent global health conditions, affecting a growing proportion of children each year and imposing a significant burden on healthcare systems and families. The etiology of allergies involves complex interactions between genetic, socioeconomic, and environmental factors, with potential contributions from modifiable factors like physical activity. This study examined whether higher frequency and intensity of physical activity are associated with reduced allergy diagnoses in children.*

Methods: *This study analyzed data from the National Health and Nutrition Examination Survey (NHANES) 2005-2006 dataset. The sample included 2,196 children aged 2–11 years. Univariable and multivariable logistic regression models were performed to assess the association between the frequency of physical activity and allergy diagnosis.*

Results: *Among the 2,196 children analyzed, 19.85% (436) had been diagnosed with allergies. The median frequency of vigorous physical activity was 7 times per week. Adjusted logistic regression analyses showed no significant association between physical activity frequency and allergy diagnosis (adjusted OR: 0.998, 95% CI: 0.971–1.026, p = 0.915). Higher frequencies of physical activity had a tendency to be associated with a reduction in allergy diagnosis (adjusted analysis, OR: 0.72, 95% CI: 0.45–1.16, p = 0.18), although this finding was also not statistically significant.*

Conclusion: *These findings suggest that while physical activity does not significantly impact allergy diagnoses in children, higher frequencies of activity may have a protective effect. Further research with larger sample sizes and specifically designed cohorts is needed to explore the impact of frequencies of physical activity and additional modifiable factors on allergy diagnoses.*

Introduction

Allergic conditions are some of the most common diseases worldwide and are represented by many different diagnoses, such as food allergies, atopic dermatitis, asthma, and chronic rhinitis (Pinart et al., 2016). In the pediatric healthcare field, the prevalence of allergies has become increasingly higher in recent decades. In 2021, 27.2% of children in the US were reported to have at least one type of allergy (Mazur et al., 2022; Zablotsky et al., 2021). According to the 2019 Global Burden of Disease study, the USA had the highest incidence of childhood asthma among 204 analyzed countries (Lv et al., 2016). Atopic diseases and hypersensitivity disorders impose a significant burden on children and their parents, requiring frequent medical visits and lifestyle adjustments. Mothers of children with food allergies often report higher anxiety levels and reduced health-related quality of life (Protudjer et al., 2020). Additionally, children

*Corresponding author: Rafael.Pinto-2024@ppcr.org
Received: November 1, 2024 **Accepted:** December 25, 2024
Published: January 26, 2025
Editor: Felipe Fregni
Reviewers: Juan Godinez, Angela Ferreira
Keywords: child, exercise, hypersensitivity, allergens, environmental exposure
DOI: https://doi.org/10.21801/ppcrj.2024.103.8

with food allergies face distress, bullying, harassment, and challenges transitioning into adolescence. The increase in allergic conditions also poses a considerable socioeconomic burden on healthcare worldwide. Allergic rhinitis accounts for over half the consultations for respiratory issues, which is the fifth most frequent reason for doctor consultations in the USA (St. Sauver et al., 2013).

The etiology of allergic diseases is complex and not fully understood, though multiple risk factors are well-documented, for example, genetic predisposition, socioeconomic influences, and environmental exposures (Pinart et al., 2016). Epigenetic mechanisms are thought to play a significant role, with allergen interactions capable of triggering immune responses that range from mild to severe symptoms (House of Parliament United Kingdom, 2014). Family history, race, sex, BMI, and exposure to passive smoking are additional known contributors to allergy risk (Zablotsky et al., 2021; Saadeh, 2014, 2013; Huang, 1999; Von Mutius, 2001). Recognizing these factors, especially modifiable ones, is essential for designing prevention strategies that may help mitigate the growing burden of allergies.

Physical activity (PA) is widely recognized for its positive effects on mental and physical health in adults and children. Numerous studies highlight the benefits of physical activity for children and adolescents, associating it with enhanced cognitive or motor development and lower cholesterol levels, depression rates, and metabolic disorders (Janssen & LeBlanc, 2010; Carson et al., 2017). Regular exercise has been associated with reduced inflammatory cytokines and increased Th-1 immunologic response, resulting in decreased allergic reactions (Del Giacco et al., 2012). A recent systematic review and meta-analysis has shown evidence that physical activity reduces systemic inflammatory markers and enhances immune regulation, thus ameliorating symptoms in conditions like asthma, which shares inflammatory mechanisms with other allergies. (Eichenberger et al.,2013) However, it is important to note that excessive physical activity can lead to momentary immunosuppression and increased inflammation. This phenomenon highlights the relationship between exercise intensity and immune function. (Gleeson M et al., 2011)

Building on the above-mentioned facts, we hypothesize that children who exercise more frequently show a reduced likelihood of the development of allergies. We conducted an analysis of the National Health and Nutrition Examination Surveys (NHANES) 2005-2006 dataset using a logistic regression model while adjusting for known confounders to evaluate the association between frequent and intense physical activity or strenuous playtime and allergies in children.

Materials and Methods

Study Design

This cross-sectional study used data from the NHANES 2005-2006 dataset, a United States survey conducted by the National Institute of Allergy and Infectious Diseases (NIAID) and the National Institute of Environmental Health Sciences (NIEHS). Sampling is performed through a complex, multistage probability design. Certain population subgroups are oversampled to improve the reliability and precision of health status estimates in these groups. The dataset includes a representative sample of the civilian, non-institutionalized population aged 1 to 74 years and can be found at https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2005. Variables cover demographics, lifestyle, household characteristics, health status, and social factors, with a validated questionnaire on physical activity (National Center for Health Statistics, 2005). From 10,348 participants, 3,081 (29.8%) were aged 12 or younger, forming the basis for our analysis. All participants signed a written informed consent for the survey, which is publicly accessible. Therefore, no ethical approval was required. This research was reported following the STROBE checklist (von Elm et al., 2008).

Study Population

We selected a study sample of children aged 2 to 11, as only participants with complete information on both physical activity and allergy status were included in the analysis, yielding a sample of 2,196 children.

Exposure

The exposure of interest was physical activity (PA), specifically vigorous play or exercise. Exposure levels were determined using the NHANES survey question: 'Number of times per week you play or exercise hard.' This variable was chosen because it was the only one that reported physical activity for children aged 2–11 years. Responses were proxy-reported by their parents or legal representatives. This approach ensured that the exposure measurement reflected observable behaviors in young children. The variable was operationalized as a continuous measure, representing the number of times per week that the child engaged in vigorous activity.

The physical activity frequency was categorized

into three different categories: less than 7 times per week (low), 7 times per week (intermediate), and more than 7 times per week (high). The reason for this stratification was that the original data from exercise frequencies ranged from zero to 77 times, with 21 subjects in the 99th percentile considered outliers that impacted the data analysis.

Outcomes

The outcome was determined as the presence of allergies. Therefore, we chose the variable of whether the participant was ever told by a doctor they have allergies as our primary outcome variable. This concerns a binary variable with 'yes' or 'no' as options. If the participant or proxy responded "yes," the child was classified as having allergies. Detailed descriptions of the variables used in this analysis can be found on the NHANES website.

Covariates

Covariates and their reported allergic associations were selected a priori based on a comprehensive review of the literature and their known or plausible associations with both physical activity and allergy development. Covariates of data that were available in the NHANES 2005-2006 database were included in the model. These concerned the categories of age, sex, ethnicity, and annual family income. Children in the youngest age group, from 0 to 5, are less likely to suffer from seasonal allergies compared to older children, respectively, age groups 6 to 11 and 12 to 17) (Zablotsky, 2021). The same authors describe that boys are more likely to have seasonal allergies than girls (20.0% vs. 17.7%) (Zablotsky, 2021). Concerning ethnic descent, non-Hispanic Black (21.3%) and non-Hispanic White (20.4%) children are shown to have higher rates of seasonal allergies than Hispanic (15.3%) and non-Hispanic Asian (11.0%) children (Zablotsky, 2021). Concluding, low household income has been recognized as a risk factor for doctor-diagnosed asthma and eczema, which are often comorbid with allergies (Kojima, 2022).

Statistical Analysis

Baseline characteristics of the study population were described using frequencies for categorical variables and mean with standard deviations for continuous variables. For missing data below 5%, a complete-case analysis approach was planned to be employed.

A logistic regression was used due to the categorical binary outcome and ability to adjust for covariates. Both unadjusted and multivariable models were run. Odds Ratios (OR) and 95% confidence intervals (95% CIs) were reported. Statistical significance was set at $p < 0.05$. All analyses were conducted using StataNow/BE version 18.5 (StataCorp, College Station, TX, USA).

Results

Baseline Characteristics

The baseline characteristics of the participants are described in Table 1. The analysis included 2,196 children from the NHANES 2005-2006 dataset, of whom 19.85% (n = 436) had been told by a doctor that they had allergies. The median frequency of vigorous physical activity was reported as 7 times per week, with an interquartile range (IQR) of 4 to 7. Missing data was minimal, accounting for less than 0.5% of the total children sample.

Statistical Analysis

The univariable analysis showed no significant association between physical activity (PA) and exercise. Similarly, comparisons across different exercise frequency categories revealed no effect on allergies. Compared to the baseline (low frequency), children exercising seven times per week had an odds ratio (OR) of 0.90 (95% CI: 0.72–1.12, p = 0.34), while those exercising more than seven times weekly had an OR of 0.76 (95% CI: 0.48–1.20, p = 0.24), see also Table 2. Multivariable logistic regression also yielded non-significant results, even after adjusting for covariates such as age, gender, annual family income, and ethnicity. In this adjusted model, which can be found in Table 3, neither intermediate nor high frequencies of physical activity significantly affected the likelihood of an allergy diagnosis (Intermediate: OR: 0.91, 95% CI: 0.72–1.26, p = 0.41; High: OR: 0.72, 95% CI: 0.45–1.16, p = 0.18). Stata codes and further details on the covariable unadjusted analysis can be found in Appendix 1, and the covariable analysis in Appendix 2.

The model's goodness-of-fit test yielded a non-significant result (p = 0.51), indicating an adequate fit to the data.

Discussion

Globally increasing cases of allergies affect children and lead to increased mortality and morbidity as well as a significant burden for the healthcare system. Allergies, specifically respiratory allergies, also have significant public health implications and require effective management strategies. (Christensen, 2023) On the other hand, physical activity (PA) is

Characteristic	Overall (n = 2,196)	Been told by a doctor that has allergies (n = 436)	Not been told by a doctor that has allergies (n= 1,749)
Age (years, mean ± SD)	6.0 ± 3.0	6.6 ± 2.9	5.9 ± 3.0
2–5 years	3.3 ± 1.2	3.5 ± 1.2	3.3 ± 1.2
6–11 years	8.5 ± 1.7	8.5 ± 1.7	8.5 ± 1.7
Gender (n, %)			
Male	1,078 (49.1)	230 (52.8)	842 (48.1)
Female	1,118 (50.9)	206 (47.3)	907 (51.9)
Race/Ethnicity (n, %)			
Mexican American	753 (34.3)	97 (22.3)	652 (37.3)
Other Hispanic	91 (4.1)	15 (3.4)	75 (4.3)
Non-Hispanic White	582 (26.5)	134 (30.7)	445 (25.4)
Non-Hispanic Black	626 (28.5)	163 (37.4)	461 (26.4)
Other Race (including multi-racial)	144 (6.6)	27 (6.2)	116 (6.6)
Annual Family Income range in USD (n, %)			
Under $20,000	563 (25.6)	89 (20.4)	472 (27.0)
$20,000 and over	1,568 (71.4)	338 (77.5)	1,221 (69.8)
Inconclusive	65 (3.0)	9 (2.1)	56 (3.2)

Table 1: *Study summary.*

Covariate	Odds Ratio	95% Confidence Interval	p-value
Times a child plays in a week			
7 Times a week	0.90	0.72 - 1.12	0.335
More than 7 times a week	0.75	0.48 - 1.20	0.236

Table 2: *Patient and arm characteristics.*

Covariate	Odds Ratio	95% Confidence Interval	p-value
Age	1.08	1.04 - 1.12	< 0.005
Gender	1.17	0.94 - 1.46	0.145
Ethnicity			
Other Hispanic	1.58	0.86 - 2.89	0.138
Non-Hispanic White	1.90	1.41 - 2.55	0.138
Non-Hispanic Black	2.30	1.73 - 3.05	< 0.005
Other Race - Including Multi-Racial	1.51	0.94 - 2.43	0.089
Annual Family Income	1.40	1.08 - 1.83	0.013

Table 3: *Study outcome.*

associated with many health benefits, such as promoting favorable immune system changes, reducing pro-inflammatory cytokines, and shifting toward a Th-1 profile, potentially alleviating allergic inflammation. (Howard, 2022) Also, functional indicators of lung function, such as forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), peak expiratory flow (PEF), and maximal voluntary ventilation (MVV) in children, may be improved with PA. (Qian et al., 2023) Regular physical activity such as walking, cycling, running, playing ball, or swimming has the potential to improve exercise capacity, bronchial hyperresponsiveness, and lung function and reduces serum proinflammatory cytokines (among others, interleukin-4 and -6 and monocyte chemoattractant protein. (Hofmeister, 2016)

Combining these two facts, we aimed to investigate the association between physical activity and allergies while adjusting for several known confounding factors. To reach our goal, we decided to perform an analysis of the NHANES 2005-2006 database, which consists of a large cohort including children from as early as the age of 2. It also includes data concerning physical activity frequency and allergies in the subgroup of children.

Our findings suggest that vigorous physical activity in children did not significantly impact the diagnosis of allergies in children, although higher weekly frequencies had a protective tendency in allergy diagnosis. This holds true even after controlling for important demographic factors. These results are consistent with previous research. Eijkemans et al. (2019) also reported no direct correlation between physical activity and allergic conditions like asthma. Similarly, a systematic review by Lobelo et al. (2020) links sedentary behavior to respiratory health risks but not directly to physical activity. For specific atopic conditions, like allergic rhinitis, Vlaski et al. (2008) found no significant impact from physical activity, likely due to allergen exposure being the primary immune trigger rather than PA.

Strengths and Limitations

The strength of our database analysis is mainly the size of the NHANES 2005-2006 database. It includes 2,196 children under the age of 12 years, meaning that the findings of our study could be generalized, at least to an extent, to the general pediatric population.

This type of database analysis also has some limitations. First, the NHANES 2005-2006 database was not primarily intended to investigate our current question. Being a cross-sectional database, it cannot establish causality; the use of transverse data allowed us to solely investigate a possible correlation. Additionally, in connection to the nature of the database, the majority of physical activity measurements in the NHANES database were documented for individuals over 12 years and adults. The parameter 'times per week of hard play or exercise' was the single documented parameter for participants younger than 12 years old, and it was available for use in our research question. Unfortunately, this parameter did not include any further details on intensity, type, and/or duration of exercise, which we also consider a considerable limitation. Our dependent variable aimed to determine the presence of allergies. The most appropriate variable in the NHANES database was "ever been told by a doctor to have allergies." 'There was no medical confirmation, which indicates an increased risk of bias. For example, participants or proxies might not have understood the diagnosis set by the doctor correctly, or they might have interchanged terms like 'allergy,' 'asthma,' 'intolerance,' and 'sensitivity.' Another substantial limitation is the inability to adjust for all confounders since they were not collected in the NHANES 2005-2006 dataset. Important confounders for allergy development were not available, including genetic predisposition, family history of allergies, pets at home, exposure to indoor allergens, exposure to pollen, industrial areas, geographic location (e.g., city, suburb, village, or countryside), exposure to tobacco smoke, family history, genetic predisposition and dietary details (e.g., maternal diet, breastfeeding and diet in childhood). To conclude, the NHANES 2005-2006 database was collected through self-reported questionnaires, which were completed by parents or guardians of children. At this point, there is a risk of introducing (recall) bias in the responses and possibly leading to an overestimation in the total number of analyses conducted.

Conclusion

The NHANES 2005–2006 database analysis suggests no association between physical activity and allergies. However, there might be a tendency for lower allergy prevalence in children who engage in more frequent vigorous physical exercise. These findings highlight a research gap that warrants further exploration in future studies.

Acknowledgement

The authors would like to thank following Teaching Assistants for their support and guidance in creating this manuscript: Walid Omer, Michelle Quarti Machado da Rosa, Ibrahim Ali Khalil Ahmad, Salim Hamood Hamdan Al-Busaidi, Sabrina Uchiyama, Francesca Buffone, Ruth Elizabeth Chávez Nomberto,

Ana Luisa Peralta, Guilherme Jose Machado Lacerda, Vinicius Trindade Gomes da Silva, Aisha Aladab, Penelope Parra, Sheethal Kalmadka, Gustavo Mucci, Katia Roque, Ashley Alanna Barrios Ruiz, Aline Marcadenti de Oliveira, Sauradeep Mitra, Angie Altagracia Pichardo Arias, Jose Antonio Bustos Cabrera, Ana Paula Jun Tsuneto Kose, Kaique Filardi.

Supplementary Materials

Appendix 1: Covariate Unadjusted Analysis
Appendix 2: Covariate Analysis

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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