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Physical Activity and Asthma Symptoms among New York City Head Start Children

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The coincidence of both an obesity epidemic and an asthma epidemic among children in the United States has suggested that childhood overweight and sedentary lifestyles may be risk factors for asthma development. We therefore conducted a study of those factors among children enrolled in Head Start Centers located in areas of New York City with high asthma hospitalization rates.

Data were gathered from 547 children through an intensive home visit, and physical activity was measured on 463 children using the Actiwatch accelerometer. Data on allergy and asthma symptoms and demographic variables were obtained from parents' responses to a questionnaire and complete data were available from 433 children.

Overall physical activity was highest in warmer months, among boys, among children whose mothers did not work or attend school, and among children of mothers born in the United States. Activity was also positively associated with the number of rooms in the home. The season in which the activity data were collected modified many of the associations between demographic predictor variables and activity levels. Nearly half the children were above the range considered healthy weight. In cross-sectional analyses, before and after control for demographic correlates of physical activity, asthma symptoms were not associated with physical activity in this age group. Comparing the highest quartile of activity to the lowest, the odds ratio for asthma was 0.91 (95% CI = 0.46, 1.80).

However, the novel associations with physical activity that we have observed may be relevant to the obesity epidemic and useful for planning interventions to increase physical activity among preschool children living in cities in the northern United States.

Keywords physical activity, asthma, childhood, Head Start

INTRODUCTION

The United States faces an epidemic of overweight and obesity (1). Among participants in NHANES in 1999–2002, 65% of those over the age of 20 were overweight or obese; 15% of children between the ages of 6 and 19 were at risk of overweight (85th-95th percentile of body mass index for age by sex), and 16% were overweight (>95th percentile) (1). Among children in New York City (2, 3), 40% of The Special Supplement Nutrition Program for Women, Infants and Children (WIC) participants were found to be at risk of overweight or overweight (2). Among New York City elementary school children, 19.4% were at risk of overweight and 23.8% were overweight (4). Among kindergarten children, 25% were at risk of overweight and 23.3% were overweight (4). The most proximal cause of increased body size is an imbalance between energy intake and energy expenditure, which most often occurs through physical activity. However, very little is known about the physical activity patterns of young children in part because their physical activity has been difficult to measure (5, 6).

The epidemic of overweight in children and the concern about its potential adverse effects on health have prompted efforts to incorporate physical activity measures into studies of children's health (7, 8). Platts-Mills et al. have noted that the epidemic of childhood asthma has much in common with the epidemic of childhood overweight (7). They have suggested that both may be related to sedentary lifestyles among children However, little is known about the possible demographic, household, familial, and behavioral determinants of daily physical activity among children, especially the urban minority children who bear more than their share of the burden of asthma. A cross-sectional study of 54 children enrolled in Head Start in Virginia found that asthma symptoms were associated with lower physical activity as measured by accelerometry (8) but could not determine whether inactive children were at higher risk of developing asthma than active children or whether children with asthma were less likely to be active than children without asthma.

Among children enrolled in Head Start programs in New York City neighborhoods with high hospitalization rates for asthma, we have conducted around-the-clock, 6-day monitoring of children's physical activity patterns using accelerometers. Here we report on the correlates and determinants, including asthma and allergy symptoms, of physical activity among these children at 4 years of age.

METHODS

Subjects and Recruitment

Head Start provides preschool education for low-income children and supportive services for their families throughout

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the United States. With encouragement from the New York City Administration for Children's Services, which sponsors 250 Head Start programs, we requested and received permission from 50 Head Start centers in northern Manhattan, the Bronx, and Brooklyn (areas with high pediatric asthma hospitalization rates and reported asthma prevalence ∼15% among children entering public school) to recruit at their sites (9). At the centers, English- and Spanish-speaking interviewers presented the study to groups of parents. From those parents who expressed interest, we obtained informed consent for participation in a cohort study involving annual questionnaires and an annual home visit. The respondents were provided financial compensation for their time and the study was approved by the Institutional Review Board of the Columbia University Medical Center.

A survey instrument was administered to the parent who enrolled the child in the study. The survey included questions about the child's history of wheeze, difficulty in breathing, or doctor-diagnosed asthma; other personal and family medical history; indoor and outdoor activities and environments (places where the child spends time regularly, travel history, etc.); demographic factors, including parents' country/ territory of origin; residential history in New York City; and lifestyle factors, including environmental tobacco exposure of the child and parents' educational attainment and employment. Race and Hispanic subgroup affiliation was determined through questions about the parent's race, Hispanic ethnicity, and birthplace. Based on this information the children were classified as black non-Hispanic, Mexican, Puerto Rican, Dominican, or Other Hispanic.

Definition of Asthma

It is difficult to diagnose asthma reliably in children younger than 6 years of age (10, 11). For the purposes of this analysis, in which the participants were too young to be given a definitive diagnosis, we categorized children as having asthma symptoms based on the parent's report of whether the child had received a physician's diagnosis and their report of asthma- related symptoms. Children were classified on the basis of the following criteria:

1. A history of physician-diagnosed asthma and any wheezing or difficulty in breathing in the past year, or
2. Wheezing or difficulty in breathing ≥3 times in the past year, or
3. Any urgent physician, emergency department, or hospital visit because of wheezing or difficulty in breathing, or
4. The use of any asthma medication in the past year unless the only symptom was cough

Definition of Allergy

Children were categorized as having allergies based on symptoms reported by questionnaire: sneezing or runny nose that is not a cold and respiratory symptoms or rash in response to exposure to specific allergens.

Physical Activity Monitoring

We used the Actiwatch accelerometer (MiniMiter, Bend, Oregon) to monitor physical activity, using a slight variant of the protocol of Firrincieli et al. (8). During home visits

taking place between June 2003 and January 2006, field staff attached the Actiwatch to the child's non-dominant wrist with a hospital band. We programmed the Actiwatch to delay starting the collection of accelerometer data until 11:50 pm on that day (day zero) so that children would have 6 to 12 hours in which to become accustomed to wearing the device before it began recording. The Actiwatch then continued to collect data, using a 1-minute epoch, for 6 complete days. The Actiwatch was retrieved on the seventh day of monitoring, and data from days 1 to 6 were used for analyses. To account for having collected only partial data on the seventh day Firrincieli et al. extrapolated the data for the missing hours. Our protocol differs from theirs in that we dropped the data collected on the seventh day and analyzed only data from 6 days.

As Freedson recommended, we analyzed raw accelerometer count data, rather than estimated energy expenditure data (12). We used mean activity counts as our measure of physical activity, which was defined as the mean per-minute accelerometer count during awake minutes. Awake minutes were identified from the accelerometer data using an algorithm supplied by MiniMitter (8).

Anthropometric Measures

The child's weight and height were measured using a portable Seca electronic scale and a portable height board. Data on height, weight, age, and gender were used to calculate BMI z-score and BMI percentile using the Centers for Disease Control SAS macro (13).

Statistical Analyses

The goal of the analyses was to identify variables associated with physical activity in the children and to determine whether activity was associated with asthma and allergy after control for these factors. Sociodemographic and sedentary behavior variables were chosen for analyses based on a priori hypotheses that they would be associated with children's physical activity or body size. Linear regression analyses were used to assess seasonal variation and to identify demographic and familial characteristics that were predictors of physical activity. Variables that were chosen for analyses included the child's gender, age, and ethnicity; the age of mother; the number of rooms in the home as a measure of the amount of space potentially available to the child; whether the mother spent substantial amounts of time away from the home, as measured by being employed out of the home or attending school; whether the child played video games; and the amount of time the child spent watching television. Hours of television viewing was dichotomized at the median level (>2 hours per day) reported for the overall population of children. Because body size and proportions have been shown to vary by race/ethnicity and by country of origin among Hispanic adults the Hispanic children were further categorized by the country or territory of birth of the child or parents (14–16). Mothers were categorized as born either in the continental United States or elsewhere, including Puerto Rico (17). A model containing all the variables was fit first and then each variable, or in the case of race/ethnicity set of variables, was removed from the model to determine its effects on the beta coefficients of the other variables.

Initial analyses were performed to compare children with and without asthma symptoms in the study population regarding demographic characteristics and behavior, using *t* tests for continuous variables and chi-square tests for categorical variables to evaluate the statistical significance of differences between the two groups. We then developed linear regression models of predictors of mean physical activity counts per minute for the sample overall. Because we hypothesized that the effects of the predictors would depend in part on weather and season, we also conducted separate analyses of children whose physical activity was measured during the summer (May–September) and winter (October–April). We analyzed interactions by including a variable for season and an interaction term for season and the predictor variable in separate models.

We then analyzed the association of asthma symptoms with physical activity before and after control for sociodemographic factors. The children were classified into categories of increasing mean activity counts per minute using quartile cut-points from the over-all data distribution. Logistic regression analyses were used to calculate odds ratios and 95% confidence intervals for the association between increasing activity category and the presence of asthma symptoms.

Results

Among 547 children who received a home visit at baseline, we were able to collect usable physical activity data from 463 children, of whom 442 provided complete data on the sociodemographic and behavioral measures of interest. Of the 442 children with complete data, sufficient data were available from 437 children to classify them as having allergies or asthma. Of these, 40% had neither, 25% had allergies, 9% had asthma, and 26% had both. Sufficient data were available to calculate CDC BMI percentiles for 435 children.

Table 1 presents, in the overall population and in the subpopulations with and without asthma symptoms, the demographic, familial characteristics, and activity data for the 437 children with complete demographic and asthma outcome data. In these univariate comparisons of children with and without asthma symptoms the child's gender, race/ethnicity, the mother's place of birth, watching more than 2 hours of television per day, and the presence of allergy symptoms are associated with asthma status.

In a multivariable linear regression model that included all the children, by far the strongest predictor of mean activity counts was season (Table 2). The counts were higher during summer than winter ($p < 0.001$). Counts were also higher among boys than among girls, and among children whose mother did not work outside the home or attend school than among other children. Among those whose activity was measured during the warm-weather months, boys had higher activity counts than girls, activity counts were positively associated with the number of rooms in the apartment (almost all the children lived in an apartment, rather than a single-family dwelling), and activity counts were higher among children whose mother did not work or attend school as compared to children whose mother attended school or worked outside the home. Among those monitored during the winter months, children of an older mother and children whose mother was born in the continental United States had higher activity counts than children of a younger mother and children of a mother born elsewhere, respectively. Season of monitoring modified the association of the mother's employment or school attendance, the mother's birthplace, and the child's video game playing with the child's physical activity. Playing video games was non-significantly associated with *decreased* activity in the summer and with increased activity in the winter, and the difference in associations by season was

TABLE 1.—Demographic characteristics and physical activity levels of 437 participating children by asthma status.

Continuous variables	Total N = 437		No asthma symptoms N = 282		Asthma symptoms N = 155		
	Mean	SD	Mean	SD	Mean	SD	*p* value
Child's mean physical activity Counts per minute							
	684.5	150.2	683.4	151.8	686.4	147.5	0.85
Child's age in months	50.7	8.0	50.5	8.0	51.0	6.0	0.54
Mother's age in years	30.4	6.1	30.1	6.2	31.0	6.0	0.15
Number of rooms in the home	4.03	0.96	3.87	1.06	4.03	0.96	0.12
Categorical variables	N	%	N	%	N	%	*P* value
Gender							
Female	224	51.3	158	56.0	66	42.6	0.007
Male	213	48.7	124	44.0	89	57.4	
Ethnicity/national origin							
Black/African American	47	10.8	20	7.1	27	17.4	<0.001
Dominican	102	23.3	62	22.0	40	25.8	
Mexican	155	35.5	129	45.7	26	16.8	
Puerto Rican	48	11.0	23	8.2	25	16.1	
Other/mixed Hispanic	80	18.3	45	16.0	35	22.6	
Other/unknown	5	1.1	3	1.1	2	1.3	
Body size							
Underweight	19	4.4	14	5.0	5	3.3	0.2
Healthy weight	226	52.0	154	54.6	72	47.1	
At risk of overweight	94	21.6	54	19.1	40	26.1	
Overweight	96	22.1	60	21.3	36	23.5	
Mother works or attends school	194	44.4	118	41.8	76	49.0	0.150
Mother born in continental US	90	20.6	39	13.8	51	32.9	<0.001
Child watches >2 hours TV/day	230	52.6	136	48.2	94	60.6	0.010
Child plays video games	115	26.3	71	25.2	44	28.4	0.5
Child has allergy symptoms	221	50.6	108	38.3	113	72.9	<0.001

TABLE 2.—Multivariate linear regression of predictors of mean Aactivity, by season.

Predictor	Overall Beta,* p value	Summer Beta,* p value	Winter Beta,* p value	p for interaction with season
Season (May–Sept vs. Oct–April)	87.04, <0.001			
Gender, referent boy	−25.59, 0.05	−61.48, 0.002	−11.91, 0.48	0.13
Age of mother, in years	2.29, 0.04	0.61, 0.71	3.56, 0.01	0.10
Number of rooms in home	16.60, 0.01	26.45, 0.01	9.53, 0.25	0.40
Mother works or attends school	−43.03, 0.001	−80.81, <0.001	−27.07, 0.12	0.03
Born in continental United States	34.80, 0.04	−0.51, 0.98	57.47, 0.01	0.04
>2 hours TV/Day	−17.31, 0.20	−40.35, 0.04	−11.89, 0.50	0.20
Plays video games	−1.69, 0.91	−34.07, 0.12	25.18, 0.22	0.01

*Regression coefficients mutually adjusted for the other variables in the table.

statistically significant. Because race/ethnicity did not predict mean activity counts or confound associations between activity and the other variables, it was not included in the final model.

Mean activity counts per minute were not associated with asthma symptoms before or after control for the sociodemographic and behavioral correlates/predictors of accelerometer measured physical activity identified above, the child's body size, and allergy symptoms. This lack of association was observed in the overall population, in boys and girls separately and in each season of activity monitoring (data not shown). Table 3 presents crude and adjusted odds ratios for the association between increasing quartiles of activity and the presence of asthma symptoms. As in past analyses increasing body size was marginally associated with asthma symptoms [at risk of overweight OR = 1.68 (0.95, 2.95) and overweight OR = 1.65 (0.95, 2.89)], and non-Mexican ethnicity was associated with asthma symptoms [black/African American OR = 4.39 (1.73, 11.14), Puerto Rican OR = 3.57 (1.42, 8.98), Dominican OR = 3.11 (1.58, 6.12), and Other OR = 3.50 (1.74, 7.04)], and female gender was protective [OR = 0.54 (0.34, 0.85)] (18). The univariate associations shown in Table 1 between mother's place of birth and asthma symptoms and extensive television viewing and asthma were not apparent in the multivariate model.

DISCUSSION

Among 4-year-olds in living in New York City neighborhoods where the prevalence of asthma is high, asthma symptoms were not associated with physical activity measured by an accelerometry. Asthma was associated with gender and ethnicity; and marginally with body size. The strongest predictors of physical activity were season, the mother's place of birth, occupation or school status, and the number of rooms in the child's home.

We developed our Actiwatch-based protocol in consultation with Platts-Mills's team, who were assessing physical activity patterns in children enrolled in Head Start in Virginia. Although they did not publish their overall mean Actiwatch results, the activity levels in the two samples appear to be quite similar. Unlike us, they observed an inverse association between physical activity and asthma symptoms, although it did not reach statistical significance (8). One reason why our results differ from theirs may be differences in the prevalence of uncontrolled risk factors for asthma in the two locations that may interact with physical activity; Firrincielli et al. did not control for covariates in their analyses (8). Richmond and New York may differ in climate, which was a very important factor in our data, as well as in the racial/ethnic backgrounds of the study participants. Our sample size was nearly 10 times larger than that of the Richmond study; its findings may reflect statistical variation in a small sample (19). Because much of the wheezing that occurs in children of this age is transient in nature and some of the children who are symptom free at 4 years of age may develop symptoms in the coming years, these cross-sectional analyses do not rule out the possibility that an association between sedentary behavior and asthma may emerge at later ages.

A few other studies have evaluated the association between physical activity and asthma, mainly in children. In NHANES III, reported asthma was non-significantly positively associated with increased television viewing among children 2 to 5 years of age but non-significantly inversely associated with television watching among 6- to 16-year olds (20). Recent analyses of the National Youth Behavior Survey found associations between asthma and body size, but not between asthma and physical activity patterns (21). A study of 9- to 11-year-old children in Taiwan found that children with asthma had lower engagement in vigorous physical activity than children without asthma. Because all these studies, ours included, are cross-sectional in design, they do not shed light on the temporal relationship between asthma symptoms and physical activity or physical activity and body size. We hope to continue to follow the children and to address those questions.

These data also illustrate disparities in physical activity levels in this population that may serve as targets for interventions to increase childhood activity. The strongest predictor of activity counts was the season in which physical activity was monitored. The children were significantly more active in the May–September period than in the October–April

TABLE 3.—Association between physical activity and the presence of asthma symptoms.

Quartile of Mean Activity Counts per minute	Non-asthmatic subjects	Asthmatic subjects	Odds ratio (95% CI)	Adjusted* odds ratio (95% CI)
Quartile 1 (<= 598 counts/minute)	72	38	1	1
Quartile 2 (>598–<= 685 counts/minute)	73	36	0.93 (0.53, 1.63)	0.85 (0.45, 1.63)
Quartile 3 (>685–<= 773.5 counts/minute)	66	43	1.23 (0.71, 2.14)	1.03 (0.54, 1.96)
Quartile 4 (>773.5 counts/minute)	71	38	1.01 (0.58, 1.77)	0.91 (0.46, 1.80)

*Adjusted for minutes awake, season, child's age, mother's age, number of rooms in the home, whether the mother attends school or works, mother's place of birth, the child's race/ethnicity, extensive television viewing, playing video games, the child's body size, and allergy symptoms.

period. In New York City, outdoor temperatures during those two periods are dramatically different. Most people spend more time indoors engaged in sedentary activities during the colder months than during the summer. In addition, season appeared to modify the associations between activity counts and several of the demographic and lifestyle variables. Opportunities for physical activity appear to differ by season, and other factors vary by season in their associations with physical activity. For instance, gender was a strong predictor of activity in the summer months, but the age of the mother was more predictive during winter months. Several other studies have reported lower activity in colder compared with warmer months, but only a few investigators have analyzed interactions between season and other predictors of physical activity (22–25). A finding by DuRant et al. that 3- and 4-year-old children engaged in more physical activity while watching television during colder months than during warmer months (24) is consistent with our results.

Our finding that the number of rooms in the apartment was correlated with physical activity appears to be new. This association may reflect the space available for active play or, because apartment size is often a function of family size, the availability of siblings as playmates. Apartment size is probably not simply a marker of socioeconomic status because Head Start participants represent a relatively narrow range of socioeconomic status conditions, and the analyses controlled for whether the mother worked or attended school. Contrary to our expectations, the association between apartment size and activity counts appeared to be stronger in summer months. We had assumed that indoor space would be a stronger predictor of activity in the colder months, when the children have less access to outdoor spaces. Further analyses including measures of daily indoor and outdoor temperature and humidity are in progress.

The children of mothers who worked or attended school proved to be significantly less active that the children of mothers who did not work or attend school, and this association was significantly stronger among children whose physical activity was monitored during the summer months. Because the independent effects of mothers at school and mothers at work were essentially the same (results not shown), these two categories were combined. Studies of older children have shown that inactivity is higher among children whose mothers work outside the home than among those whose mothers do not (26). However, another study found that among girls having an unemployed mother significantly predicted declines in physical activity over the course of a year (27). Our questionnaire did not ask specifically who takes care of the child while the mother is out of the house, but our data suggest that mothers play a key role in facilitating children's activity. The strong seasonal effect suggests that mothers who do not work or go to school may take their children out to play or on errands more frequently than mothers who work or attend school or the caregivers who are present when the mother is not at home. In the inner-city neighborhoods where most of the families live, it is possible that parents may instruct the caregivers to keep the children indoors for safety reasons.

Several studies of Hispanic children and adults suggest that acculturation to American norms, as measured by place of birth, duration of residence in the United States, and English language usage, predicts increased body size and lower physical activity (28–32). The acculturation paradigm would suggest that the children of US-born mothers would be less active than other children. However, children of US-born (predominantly New York City-born) mothers in our study were *more* active than others, and this difference was almost entirely seasonal, driven by children who were monitored during the winter months. Most of the immigrant mothers had come from Mexico, Central America, or the Caribbean, and they may have been unaccustomed to and poorly equipped to cope with cold weather. Mothers born in New York City probably have greater experience with and have tolerance of outdoor activities during the winter. Hence in New York City, in some domains of health behavior, acculturation may represent a healthful adaptation to the local environment.

A recent meta-analysis of five studies with a total of 618 children found a significant inverse association between media use and activity (33). Our sample size is 75% of the entire sample size included in the meta-analysis and is much larger than any one of the studies included in the analysis (33). We did not find the same association overall, but we did find that in summer months watching more than 2 hours of television a day was associated with lower mean activity measures. Our overall results are similar to those from the EarlyBird study, which found no association between hours of television watching and total physical activity measured by accelerometry, although the EarlyBird study did not assess associations by season (34). Similarly, playing video games was not associated with the physical activity measures overall but was associated with more activity in the winter months and less activity in summer months. Although the within-season associations were not statistically significant, there was a significant interaction between video game playing and season in predicting activity. The data suggest that during winter months, video game playing is not as sedentary as television watching and may entail a slight net gain in activity. We tested the possibility that the Actiwatch might detect wrist movements during game controller use, which might account for associations between video game playing and activity counts. Extensive game play while maintaining a still torso demonstrated that the Actiwatch was not sensitive to the slight wrist movements and flexing of forearm muscles that occurs when using a game controller. However, during normal game play young children have been observed to move their bodies, standing and jumping around, as if trying to influence the on-screen avatar, and such motion may account for our Actiwatch data. The effect of season on the association of video game playing with physical activity probably is due to time substitution; in winter months, video game playing is more active than alternatives, such as watching television, but in summer months video game playing may be less active than alternatives. Our findings are consistent with those of Grund et al., who used indirect calorimetry and 24-hour heart rate monitoring to measure energy expenditure and found no association with television viewing. Our data suggest that television watching and video game playing are not strong predictors of total activity and that it may be important to consider seasonal effects.

Many types of accelerometers are now available for use in studies such as ours. Recent reviews of the literature on accelerometer validation studies concluded that the choice of accelerometer should be driven by logistical concerns

(35–37). Our major concern was that relying on the mother to remove and replace the accelerometer before and after bathing and before and after sleep would yield an unacceptable amount of missing data. We therefore needed an accelerometer that was light, waterproof, and tamper resistant, and the Actiwatch was the only device to meet all these criteria (35). We also wished to generate data compatible with other studies of physical activity and asthma in this age group (8). Only a few studies have addressed the validity of using the Actiwatch to measure physical activity in children. Two studies of children with a mean age of around 10 and 12 years who engaged in structured activities in a room calorimeter found the Actiwatch counts to be highly significantly correlated with energy expenditure (38, 39). Another study of 3- to 4-year-old children engaged in free play in a child-care setting found Actiwatch counts to be significantly correlated with activity measured by direct minute-by-minute observation using the Children's Activity Rating Scale (40). However, a recent study of 4- to 6-year-old children did not observe an association between Actiwatch counts and energy expenditure as measured by doubly labeled water (41). The data presented here suggest that the Actiwatch has construct validity, in that many factors known to be associated with physical activity in children were associated with the Actiwatch counts (42).

There are a number of caveats to be considered with this study. The first is that the data are cross-sectional in nature and so temporal relationships and causality cannot be established. The study also explored a large number of associations between sociodemographic variables, asthma symptoms, and physical activity, raising the possibility that some associations arose by chance alone. Additionally, while the Actiwatch was used as an objective measure of physical activity, the measures of television watching and video game playing relied on parental reports, which may be prone to measurement error and social desirability bias. Likewise the data on asthma symptoms and diagnoses relied on parental reports. Such measurement error is likely to have caused a bias to the null for analyses of main effects and also reduced our power to observe significant interaction effects. Since the study was only of modest sample size any loss of power is a concern.

In conclusion, although asthma symptoms were common among the children we studied, we did not find an association between physical activity and asthma symptoms. However, given that more than 40% of the children were above a weight that is considered healthy, their level of physical activity demands further scrutiny. We have identified some new correlates of activity, including the effect of season on the association of physical activity with the number of rooms in the child's apartment, the mother's place of birth, her roles outside the home, and video game playing. If confirmed, these associations may provide a basis for the development of intervention strategies to promote physical activity in this population.

DECLARATION OF INTEREST

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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