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Relationships among Obesity, Physical Activity and Sedentary Behavior in Young Adolescents with and without Lifetime Asthma

Susan Groth, PhD, WHNP-BC, FAANP,
University of Rochester, 601 Elmwood Ave., Box SON, Rochester, NY 14642, 585-275-8895, Fax: 1-585-273-1270, Susan_Groth@urmc.rochester.edu

Hyekyun Rhee, PhD, PNP, and
University of Rochester

Harriet Kitzman, PhD, RN, FAAN
University of Rochester

Abstract

Objective—To examine the interrelationships among body mass index (BMI), physical activity, sedentary behavior and gender in urban, low-income, primarily African American young adolescents with or without lifetime asthma.

Methods—Data were collected in 2002–2004 from 626 12-year old adolescents who were children of women who participated in the New Mother's Study in Memphis, TN (1990 – 91). Adolescents with and without asthma were compared on BMI, physical activity and sedentary behavior. Multiple linear regression models were used to examine the association of asthma, gender and BMI with physical activity and sedentary behavior.

Results—Complete data were available for 545 adolescents. 11% of adolescents had lifetime asthma. Asthma and gender were associated with high-intensity physical activity ($p < .001$). Adolescents with asthma participated in less physical activity and girls participated less than boys. Gender was associated with sedentary behavior ($p < .001$): boys used personal computer (pc)/ video after school more than girls. Girls with asthma had a higher BMI than girls without asthma ($p = .027$). Boys with asthma were less physically active than boys without asthma ($p < .05$).

Conclusions—Adolescents with asthma are less physically active than those without asthma and girls are less active than boys. Clinicians who provide care for adolescents with asthma are encouraged to assess physical activity/sedentary behavior and provide guidance that promotes active lifestyles. A longitudinal study is needed to shed light on the unique contribution of asthma separated from the effects of overweight/obesity on physical activity and sedentary behaviors.

Correspondence to: Susan Groth.

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Keywords

adolescents; asthma; body mass index; physical activity; sedentary behavior; gender difference

Introduction

Obesity and asthma are serious chronic conditions that have had a rapid parallel increase in prevalence (1). Epidemiological data indicate these two conditions are linked; obese individuals are at greater risk for asthma development, increased severity, symptoms, treatment resistance and reduced quality of life (QOL) than non-obese individuals (2–4). Nearly 20% of obese adolescents have asthma, compared to 14.2% of non-obese adolescents (5). Adolescents suffer greater asthma related morbidity than other age groups (6, 7). Asthma decreases QOL (6), and over 50% of teens with asthma report activity limitations (8, 9).

Adolescents are advised to engage in 60 minutes of physical activity daily, most of which should be moderate-vigorous aerobic, with at least three days/week being vigorous intensity (10). However, in adolescence, physical activity decreases with age, particularly in girls (11, 12). If adolescents are overweight/obese and have asthma, their physical activity could be limited either by asthma (13–15), or their overweight/obesity status (16). Obesity and overweight in adolescents with asthma are associated with increased asthma symptoms (17). Physical activity may reduce asthma symptoms in adolescents with asthma in conjunction with an improvement in aerobic fitness (15, 18).

Sedentary behavior is defined as waking behavior characterized by low energy expenditure, often occurring while sitting or reclining (19). Sedentary behavior has an independent effect on risk of morbidity and mortality, even when there is moderate-vigorous physical activity (19). Literature on the sedentary behavior of adolescents with asthma is minimal, although it has been noted that adolescents with asthma spent more time using a computer for non-schoolwork activities than those without asthma, even when they were similar in terms of physical activity (20). Sedentary behaviors, such as television viewing, have been associated with an increased risk for asthma symptoms (17).

The limited number of studies specific to adolescents, or that separate adolescents from children, are inconsistent as to whether the physical activity levels of adolescents with asthma differ from those without asthma (14, 15, 20–23). Treating adolescents as a unique group is necessary because it appears that the association of vigorous physical activity with asthma is different in adolescents than in children. For example, Mitchell et al. (17) reported that vigorous physical activity had a positive association with asthma symptoms in adolescents, but not in children.

Obesity and asthma frequently co-occur in adolescents and both may have a negative influence on their physical activity and sedentary behavior levels. The purpose of this analysis was to examine the interrelationships among body mass index (BMI), physical activity, sedentary behavior and gender in urban, low-income, primarily African American young adolescents with or without lifetime asthma. The following hypotheses were tested:

(1) adolescents with asthma would be less physically active and more sedentary than adolescents without asthma, (2) adolescents with asthma would have a higher BMI than those without asthma, and (3) asthma, BMI and gender would be associated with physical activity levels and sedentary behavior.

Methods

Design and Sample

This study was based on data collected in 2002–2004 from 626 12-year old adolescents who were the children of women who participated in the New Mother's Study in Memphis, TN in 1990 – 91. The original study tested the efficacy of a home visiting model that is now known as the Nurse-Family Partnership. Healthy pregnant women with no previous live births enrolled in the randomized controlled trial if they were no more than 28 weeks pregnant and had 2 of the 3 following risk factors: unmarried, less than high school education, and unemployed. Participants have been followed over the past 20 years for periodic interviews (24, 25). Data analyzed in this study were collected from the participating mothers and their children 12 years after the initial trial. The study was approved by the Institutional Review Board affiliated with the investigators.

Measures

Body mass index—BMI (kg/m^2) was calculated based on measured heights and weights at the 12-year data collection time point. BMI was used as a continuous variable and BMI percentile categories. BMI-for-age percentiles were derived using age and the Center for Disease Control and Prevention (CDC)-for-age growth charts for girls and boys to subdivide the sample into BMI categories (26). The BMI percentile categories for adolescents are: underweight ($<5^{th}$ percentile); normal weight ($\geq 5^{th}$ percentile and $< 85^{th}$ percentile); overweight ($\geq 85^{th}$ percentile and $< 95^{th}$ percentile); and obesity ($\geq 95^{th}$ percentile) (27). BMI percentile categories were further collapsed to underweight/normal weight and overweight/obese categories.

Asthma—Asthma in this analysis is maternal report of lifetime asthma (ever been diagnosed by a care provider) for the child collected at the time the child was approximately 12 years of age. Throughout the remainder of this paper asthma indicates lifetime asthma.

Physical activity and sedentary behavior were collected via a questionnaire from the adolescent participants. There were three questions related to exercise and two questions related to sedentary behavior. For physical activity these were: (1) number of days in the past week they participated in physical activity for at least 20 minutes that made them sweat and breathe hard (e.g. basketball, soccer, running, fast dancing), considered high-intensity exercise; (2) number of days in the past week they participated in physical activity for at least 30 minutes that did not make them sweat or breathe hard (e.g. fast walking, slow bicycling, pushing a lawnmower), considered low-intensity exercise; (3) number of days in the past week they participated in strengthening/toning exercise (e.g. push-ups, sit-ups, weight lifting). For sedentary behavior these were: (1) number of hours/day they watched

TV or videos on school days after school; and (2) number of hours/day they used a personal computer (pc) or played video games on school days after school.

Data Analyses

Preliminary evaluation of data involved examination of distributions, medians, means and standard deviations for continuous variables and frequency distributions of categorical variables. Student's t-tests were used to compare adolescents with asthma vs. those without asthma on BMI, high- and low- intensity physical activity, strength-toning exercise, and # hours/day they watched TV or used pc/videogames on school days after school. The sample was stratified by gender to identify subgroup mean differences. Multiple linear regression models were used to examine the effects of asthma, gender, age, and BMI on physical activity and sedentary behavior. All analyses were done using SPSS (20.0). Given that the sample consisted of more than one racial group with black being the primary group (95%), we repeated the analyses without the white adolescents (n = 26) and results remained unchanged. Therefore our report is based on the entire group.

Results

Sample characteristics

Adolescents ranged in age from 12–15 years at the time of data collection. Data for all variables used in these analyses were available for 545 of the 626 adolescents included in the original study. The most commonly missing variable was BMI at 12 years (n = 79). Therefore, 545 adolescents were included for all analyses. Of these, 61 (11%) were reported by their parent to ever have had physician-diagnosed asthma by the time the child was roughly 12-years of age (See Table 1). More boys had asthma (15% of boys and 7% of girls). BMI classification; <1% were underweight, 54% were normal weight, 20% were overweight and 26% were obese. A higher percentage of adolescents with asthma (34%) were in the obese category than adolescents without asthma (24%). All physical activity data were positively skewed with the exception of high intensity physical activity which had a slight negative skew. Median days/week of participation in physical activity for the entire sample ranged from 2–4 and median hours/day of TV or pc/video use were 2 and 0.25 respectively.

Adolescents with asthma had significantly fewer # days/week of both high- and low-intensity physical exercise (Table 2). When stratified by gender, boys with asthma had significantly fewer # days/week of both high- and low-intensity physical exercise than boys without asthma, but this relationship was not significant for girls. Sedentary behavior did not differ overall between adolescents with and without asthma.

Body mass index did not differ between adolescents with and without asthma ($t = -0.48$, $p = 0.6$) (See Table 2). When considered separately for each gender, BMI was similar for boys with and without asthma ($p = 0.6$). For girls, there was a significant difference in mean BMI ($p = .027$), which was higher for the girls with asthma compared to those without asthma.

Asthma and gender were associated with the number of days/week of high-intensity physical activity ($p < .001$) (See Table 3). Controlling for BMI and age, adolescents with asthma were

less physically active at the high intensity level than those without asthma, and girls were less active than boys regardless of asthma status. In terms of low- intensity physical activity, adolescents with asthma participated to a lesser extent than adolescents without asthma. There were no interactions in these two models. There were no significant associations between asthma, BMI, age or gender and strengthening activities or watching TV after school. Gender was associated with the number of hours/day using pc or video games on school days after school. Controlling for BMI, age, and asthma the boys spent more time/day using the pc or video games than the girls. There were no interactions in this model.

Discussion

We examined BMI, physical activity and sedentary behavior in a sample of urban boys and girls with and without lifetime asthma in early adolescence. Comparisons of adolescents with asthma to those without asthma indicated that overall, adolescents with asthma engaged in less high- and low-intensity exercise/week than adolescents without asthma. Furthermore, these differences in exercise were specific to the boys. The pc/video use on school days after school for the entire sample of adolescents was similar irrespective of asthma status. We found that asthma and gender were associated with high-intensity exercise; adolescents with asthma participated less in both high- and low- intensity physical activity, and girls participated less than boys. Gender was significantly associated with sedentary behavior (pc/video use) and the boys used the pc/video games more than the girls.

Overall, adolescents in this sample reported a median of 4 days/week of high-intensity exercise, which does not meet the recommendation of daily physical activity but may meet the recommendation of at least three days of vigorous physical activity per week. Boys with asthma had less high- and low- intensity physical activity, than boys without asthma. This finding is consistent with previous studies (14, 15) that reported boys with asthma as less physically active. In general, adolescents with asthma have been found to be less physically active than those without asthma (14, 15). On the other hand, others have found that teens with asthma reported comparable degree of activity (16, 20, 22, 23) or higher levels of activity (23) than children without asthma. The mixed findings may have been due to lack of attention to potential gender differences as none of these studies examined girls and boys separately.

The reported amount of time spent participating in pc/video use ranged from 0–6 hours in our sample, with only 3% spending more than 3-hours/day doing so. These numbers are lower than reported for a national sample in which 41% of high school students played video/computer games or used a computer for something other than school work for 3-hours or more on an average school day (28). The same report indicated that there had been a significant linear increase from 22%–41% between 2003 and 2013. The explanation for our results could be due to under reporting of use, possibly due to social desirability. Alternatively, it may be that these subjects had limited access to pc/video games given their urban, low-income status in the early 2000’s.

Although no differences in BMI were found between adolescents with asthma and those without asthma for the entire sample, statistically higher average BMI was found in girls with asthma than their counterparts without asthma. This finding is similar to that of Willeboordse et al. (29) who found higher BMIs in girls with asthma than girls without asthma in a sample of Dutch adolescents but this finding was not substantiated in boys. Similarly, in a Taiwanese sample, development of asthma was associated with BMI in girls only (30). Conversely, in another Taiwanese sample, the risk of suspected asthma (not diagnosed asthma) was higher only in overweight boys (31). Jones et al. (20) reported that significantly more adolescents with asthma were overweight compared to those without asthma, but did not separate the sample by gender. The mixed findings might have been due to differences in asthma classification, approaches to analysis, participant age, and population differences.

Sedentary behavior was not different overall between adolescents with and without asthma. The finding of no overall differences in sedentary behavior is similar to an earlier study (14). Conversely, Jones et al. (20) reported that adolescents with asthma had a significantly higher use of computers outside of schoolwork on a daily basis. A third study reported Korean adolescents with asthma to be less sedentary (23). Differences between studies could be due to differences in measures of sedentary behavior, the populations being studied or BMI categories (e.g., normal vs. overweight/obese).

Asthma was associated with physical activity levels for these urban adolescents, while BMI was not. Findings reported in the literature are conflicted on whether it is asthma or overweight/obesity that influences such behaviors (13–16). Arguments that favor obesity as the culprit suggest that physiologic mechanical effects, decreased lung volume due to obesity and/or deconditioning due to a sedentary lifestyle lead to an ever decreasing activity (32). Alternatively, our findings and others (14, 15) indicating asthma as the factor negatively influencing physical activity may suggest symptom perception (e.g. breathlessness), lack of self-efficacy, or negative beliefs about asthma as a potential cause of limited physical activity in adolescents. Further study is needed to explore potential mechanisms explaining asthma and limited physical activity in adolescents.

Our findings showed that the interrelationships among lifetime asthma, BMI, physical activity and sedentary behavior differed for early adolescents depending on gender, and therefore, boys and girls should be examined separately. The majority of studies specific to adolescents controlled for gender, thus neglecting potential gender differences. At an age where puberty may or may not have taken place, and given the known differences that boys have the higher rate of asthma pre-puberty and girls post puberty (33), it is conceivable that true gender differences exist in the effects of asthma on both physical activity and sedentary behaviors. Determining true gender differences for this age group could have implications for the types of interventions targeting physical activity and sedentary behavior in teens with asthma. If further research substantiates that boys with asthma are more likely to have lower physical activity levels than those without asthma, clinicians should monitor the activity levels of boys in this age range and encourage them to be more active on a regular basis.

Findings also suggest that adolescents with a history of asthma were less physically active at the high-intensity exercise level compared to adolescents without asthma. Therefore, interventions addressing knowledge gaps on asthma and physical activity and improving skills for symptom control and an active lifestyle could be effective to counteract decreasing physical activity in adolescents. Clinicians should consider providing individualized advice and assistance to reduce sedentary behavior while promoting an active lifestyle.

Our sample in early adolescence was somewhat active regardless of asthma status, although not as active as the recommendations from the US Office of Disease Prevention and Health Promotion (10). Interventions to increase physical activity, and decrease sedentary behavior in adolescents, whether they have asthma or not, are needed because as they become older activity is likely to become less optimal than in early adolescence. It is important for young adolescents with asthma to be physically active and less sedentary because physical activity could improve asthma symptoms and reduce risk for overweight, while sedentary behavior increases the risk of cardio-metabolic disease and all-cause mortality (34).

Of the adolescents in this sample, only 11% were reported to have lifetime asthma, which is lower than would be expected given the inner city population. Given that the sample is primarily black, low income, or ever told they have asthma, we would expect the prevalence to be approximately 17% (35). Prevalence of current asthma in adolescents is 10.9% per the CDC statistics in 2010 (35), which is more consistent with our number. One explanation could be under reporting of asthma as the measure is self-reported. Using school based surveillance, it has been found that approximately 5% of adolescents living in urban areas have a likelihood of undiagnosed asthma (36), thus a number of these subjects may have had asthma but not been diagnosed.

There are several limitations to this study that should be recognized. The sample was primarily low-income, inner city black adolescents therefore generalizing our findings to different sociodemographic groups of adolescents is not warranted. Furthermore, data from the early 2000’s may be considered somewhat dated, underscoring the need for replication with a contemporary sample of adolescents. Body mass index was used as the measure of body composition which may not accurately reflect adiposity (37). The data for this study are cross-sectional and thus no causal inferences can be made. In addition, our data were limited in that lifetime asthma is not representative of current asthma and no information on asthma severity or levels of symptom control were available. We were unable to examine differing degrees of physical activity/sedentary behavior on levels of symptom control. The physical activity, sedentary behavior, and asthma status data were based on self-report, thus subject to social desirability or recollection bias.

Conclusion

The current study suggests that adolescents with asthma are less physically active than adolescents without asthma and that boys are more physically active than girls. Also, our findings suggest that overweight/obesity does not independently contribute to the lower physical activity levels of adolescents with asthma. Clinicians who provide care for adolescents with asthma are encouraged to assess physical activity and sedentary behavior

levels and provide guidance that promotes an active lifestyle. Future research should continue to examine to the unique contribution of asthma separated from the effects of overweight/obesity on physical activity and sedentary behaviors in longitudinal studies and develop specific interventions that incorporate physical activity and sedentary behaviors to avoid high rates of morbidity and mortality into adulthood.

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Table 1

Characteristics of Adolescents With and Without Lifetime Asthma (N = 545) *

	All	Lifetime asthma	Without asthma
	N = 545	**N = 61**	**N = 484**
Age, mean, (SD), y	12.9 (0.4)	12.8 (0.3)	12.9 (0.4)
Race			
Black	519 (95)	59 (97)	460 (95)
White	26 (5)	2 (3)	24 (5)
Gender			
Female	280 (51)	20 (33)	260 (54)
Male	265 (49)	41 (67)	224 (46)
†BMI (kg/m^2) by category			
Underweight (< 5th percentile)	1 (< 1)		1 (<1)
Normal weight (≥5th percentile < 85th percentile)	294 (54)	32 (53)	262 (54)
Overweight (≥ 85th percentile < 95th percentile)	111 (20)	8 (13)	103 (21)
Obese (≥ 95th percentile)	139 (26)	21 (34)	118 (24)
BMI kg/m^2, mean, (SD)	23.2 (5.4)	23.5 (5.6)	23.1(5.4)
High-intensity exercise (# days/week), median	4	3	4
Low-intensity exercise (# days/week), median	2	1	2
Strength/tone exercise (# days/week), median	3	2	3
# hours/day watch TV school days, Median	2	1.5	2
# hours/day pc/video school days	0.25	0.25	0.25

*Data are given as number and percentage unless otherwise noted

†BMI indicates body mass index

Table 2

Comparison of Adolescents With and Without Asthma *

Outcome	Asthma	Non-asthma	95% CI for mean difference	p-value
Year 12 BMI	23.50 (5.6)	23.1 (5.4)	−1.81, 1.10	0.63
• Girls	26.5 (6.5)	23.7 (5.4)	−5.3, −0.33	**0.03**
• Boys	22.1(4.4)	22.5 (5.5)	−1.31,2.25	0.60
# Days in past week of high-intensity exercise	3.44(2.1)	4.0(2.1)	0.09, 1.21	**0.02**
• Girls	3.1 (1.8)	3.7 (2.0)	−0.37, 1.5	0.24
• Boys	3.5 (2.2)	4.4 (2.1)	0.21, 1.65	**0.01**
# Days in past week of low-intensity exercise	2.20(2.2)	2.9 (2.3)	0.13, 1.34	**0.02**
• Girls	2.35 (2.1)	2.9 (2.2)	−0.45, 1.6	0.28
• Boys	2.1 (2.2)	3 (2.3)	0.06, 1.61	**0.04**
# Days in past week of strengthen/toning exercise	3.05 (2.5)	3 (2.5)	−0.68, 0.63	0.95
• Girls	2.9 (2.5)	2.9 (2.5)	−1.2, 1.1	0.96
• Boys	3.1 (2.5)	3.2 (2.40	−0.74, 0.9	0.84
School days # hours/day use pc or watch video games	0.53 (0.7)	0.6 (0.8)	−0.18, 0.24	0.77
• Girls	0.4 (0.6)	0.4 (0.6)	−0.29, 0.28	0.96
• Boys	0.6 (0.7)	0.7 (0.9)	−0.15, 0.46	0.31
School days # hours/day watch TV	1.99 (1.3)	2 (1.4)	−0.36, 0.38	0.95
• Girls	1.9 (1.4)	2.1 (1.4)	−0.38, 0.91	0.42
• Boys	2.1 (1.3)	1.9 (1.4)	−0.64, 0.27	0.42

* Data are given as mean, standard deviation (SD).

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Table 3

Associations of BMI, Lifetime Asthma, Gender, and Age with Physical Activity and Sedentary Behavior

Outcome variable	Step	Predictor variable	B	t for within step predictors	R^2 change for step	Cumulative R^2	F change for step
High-intensity exercise	1	Age, y	−0.18	−1.03			
		BMI *	0.16	0.89	.001	.001	.34
	2	Asthma †	−0.81	−2.83	.010	.011	5.18[a]
	3	Gender ‡	−0.72	−3.92	.03	.039	15.35[b]
Low - intensity exercise	1	Age	0.27	1.42			
		BMI	−0.30	−1.54	0.009	0.009	2.34
	2	Asthma	0.31	−2.26	0.01	0.019	5.42[a]
	3	Gender	0.20	0.31	0.00	0.019	.009
Strength/tone exercise	1	Age	0.1	0.48			
		BMI	0.04	0.16	0.001	0.001	0.16
	2	Asthma	−0.03	−0.9	0.0	0.001	0.01
	3	Gender	−0.32	−1.47	0.004	0.005	2.15
#hours/day watch TV on school days	1	Age	0.12	1.01			
		BMI	−0.01	−0.09	0.002	0.002	0.42
	2	Asthma	0.05	0.24	0.0	0.002	0.0
	3	Gender	0.19	1.54	0.004	0.006	2.38
# hours/day pc/video on school days	1	Age	−0.02	−0.23			
		BMI	0.11	1.69	0.002	0.002	0.65
	2	Asthma	−0.09	−0.89	0.0	0.003	0.05
	3	Gender	−0.32	−4.82	0.04	0.04	23.18[b]

[a] $p < .05$,

[b] $p < .001$

* BMI indicate body mass index categorized as underweight/normal weight and overweight/obese; underweight/normal weight is the reference category

† Asthma indicates lifetime asthma yes/no; no is the reference category

‡ Gender; male is the reference category