CHILDHOOD OBESITY
February 2014 | Volume 10, Number 1

DOI: 10.1089/chi.2013.0133

Active Commuting to Elementary School and Adiposity: An Observational Study

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Abstract

Background: Active commuting to school (ACS; walking or cycling to school) appears promising for decreasing children's obesity risk, although long-term studies are sparse. The aim was to examine whether kindergarten ACS was associated with fifth-grade adiposity.

Methods: This study was a secondary analysis of the Early Childhood Longitudinal Study, Kindergarten ($n = 7938$). Enrollment in kindergarten (1998–1999) was nationally representative of the United States and follow-up occurred in 2004. Kindergarten ACS was the main exposure variable and fifth-grade BMI *z*-score was the main outcome measure. Covariates included (1) neighborhood safety and BMI *z*-score in kindergarten and (2) demographics (*i.e.*, age, gender, race/ethnicity, socioeconomic status, single- vs. two-parent households, region of country, and urbanicity in fifth grade). Three interactions were included: school travel*neighborhood safety; school travel*BMI *z*-score (kindergarten); and school travel*socioeconomic status. Analysis of covariance accounted for the complex sampling design.

Results: Kindergarten ACS was associated with lower BMI *z*-score in fifth grade. The interaction of school travel*neighborhood safety indicated that children from less-safe neighborhoods who did ACS in kindergarten had a lower fifth-grade BMI *z*-score ($p < 0.05$) than their peers who did not do ACS in kindergarten (*i.e.*, in terms of BMI, this difference was $-0.49\ kg/m^2$ for children of average height in less-safe neighborhoods).

Conclusion: Among children from less-safe neighborhoods, kindergarten ACS independently predicted lower BMI *z*-score in fifth grade among a national US cohort. Interventions and policies to increase ACS among young children, especially from unsafe neighborhoods, are warranted and should address parents' safety concerns.

Introduction

Childhood obesity is at record high levels in the United States and worldwide.[1–3] Because physical activity (PA) is inversely related to obesity,[4,5] efforts to prevent childhood obesity include promoting childhood PA. Childhood PA is recommended to help reduce risk factors related to cardiovascular disease,[6,7] type 2 diabetes,[8–10] and multiple cancers.[11–14] Most children in the United States did not meet the recommended 1 hour or more per day of moderate-to-vigorous PA (MVPA) in 2003–2004,[15] which placed them at increased risk for obesity and other chronic diseases.

Children's active commuting to school (ACS; *i.e.*, walking or cycling to school) is a low-cost and sustainable behavior that may broadly increase children's PA.[16,17] In the United States, ACS was once prevalent (48% in 1969), but has declined (13% in 2009).[18] ACS is an important missed opportunity for PA, because most children commute to and from school 5 days per week during the school year. ACS also has broad support among parents,[19] nongovernmental organizations,[19] and multiple federal agencies including the Departments of Health and Human Services and Transportation.[17,20–22] Previous studies have reported associations among ACS, greater PA, and lower adiposity, although most were cross-sectional or short term.[23–26] A systematic review of children's ACS identified only two longitudinal studies.[25] Moreover, no recent studies on US elementary school children have examined the long-term effect of ACS on adiposity. Long-term

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examination is necessary to inform policies to promote ACS, such as the federal Safe Routes to School (SRTS) program.[27] Thus, this study's primary aim was to examine this important question using data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K). The primary hypothesis was that ACS in early childhood would be inversely associated with adiposity in fifth grade, regardless of adiposity in kindergarten. A secondary aim was to examine the potential complex influence of several predictors on children's school travel and adiposity: neighborhood safety; socioeconomic status (SES), and previous BMI *z*-score. All three of these variables were independently associated with ACS and PA or adiposity[18,23,28–31]; thus each was included as an interaction term with school travel. For example, neighborhood safety was positively related to children's PA and ACS and inversely related to risk of obesity.[28,29] However, some children have limited options for traveling to school besides ACS,[18] and for those children, ACS may be an important opportunity for PA if concerns for neighborhood safety limit other forms of physical activity. Thus, it is important to examine the interaction of school travel*neighborhood safety on adiposity.

Methods

The ECLS-K was sponsored by the US Department of Education[32] and designed to provide national data on what influences children's cognitive- and education-related outcomes. Briefly, children were enrolled from kindergarten programs (>1000), both public and private, in the 1998–1999 school year. ECLS-K used a complex, multistage probability sampling design to obtain a nationally representative kindergarten-age sample. This cohort was followed into middle school with periodic assessments as described in detail.[32] Fifth grade was chosen as the endpoint of the present study, to examine changes from early to late elementary school, because children generally live closer and thus are more able to walk or cycle to elementary school. Moreover, middle schools are fewer in number and thus generally have larger geographic catchment areas, making ACS more difficult. The institutional review board of Baylor College of Medicine (Houston, TX) determined this secondary analysis as exempted from review.

Participants

Eligible ECLS-K participants were enrolled during their kindergarten year (1998–1999). Of the 21,357 participants enrolled in the original kindergarten sample, 5214 were excluded by ECLS-K procedures from the fifth-grade data collection.[32] For the fifth-grade data collection, the ECLS-K sampled all children who stayed within their original schools, but subsampled only certain children who moved from their original schools to new schools, which reduced the eligible sample further. As a result of this expected attrition, ECLS-K provided fifth-grade sample weights to account for differing probabilities of selection (exclusions as described above) and to adjust for nonresponse in order for analyses to be representative of the ECLS-K fifth-grade cohort.[32] With the expected attrition, the eligible sample was $n = 12{,}022$.

Outcome Variable

Children's height using a Shorr board and weight using a Seca digital scale (Seca, Hanover, MD) were measured in duplicate by study staff using a standard protocol.[32] Children removed their shoes and heavy clothing before measurements. BMI *z*-score in fifth grade was the main outcome variable and calculated using standardized growth charts for the United States.[33]

Main Exposure

ACS was assessed during the spring kindergarten parent interview, but not during the fifth-grade parent interview, by the following: ''How does [child] usually get to school? Does [he/she]: (1) walk or ride a bike, (2) ride a bus, (3) is [he/she] dropped off by a parent, relative, or adult friend, or (4) is [he/she] dropped off by [his/her] day care provider?'' Though the validity of this question is unknown, similarly worded ACS questions have acceptable validity.[34–36] ACS was defined as the child walking or riding a bike to school, with the remaining modes considered as passive commuting.

Covariates

The following covariates from the fifth-grade data collection were included: demographics (child's age, gender, race/ethnicity, and single- vs. two-parent household); household SES as a composite measure of parents' education, occupation, and incomes[32]; region of the country (Northeast, Midwest, South, and West); and urbanicity (city, suburb/large town, and rural).

Two covariates from the kindergarten data collection were also included: neighborhood safety and kindergarten BMI *z*-score. Parents' perception of neighborhood safety was assessed as follows in kindergarten (and not in fifth grade): (1) safety for children to play outside; (2) presence of garbage/broken glass; (3) drug use/excessive drinking; (4) burglary or robbery; (5) violent crimes (*i.e.*, drive-by-shootings); and (6) vacant houses/buildings. Responses were 0–2, with higher responses as the most safe. These six items were summed (range, 0–12), and higher scores indicated safer neighborhoods. The neighborhood safety items were significantly associated with child physical activity ($p < 0.05$),[37] had acceptable internal reliability (Cronbach's alpha = 0.75),[37] and, similarly, had acceptable internal reliability in the present study (Cronbach's alpha = 0.76). Kindergarten BMI *z*-score was assessed as indicated above and included as a covariate, because early-childhood BMI is an important predictor of later childhood BMI.[30]

Statistical Analysis

Participant characteristics were described by calculating frequencies and percentages. Demographic variables were

Table 1. Participant Characteristics from the US Early Childhood Longitudinal Study, Kindergarten Class of 1998–99

	Active commuters (n=688; 8.5±0.6%)	Passive commuters (n=7250; 91.5±0.6%)	All (n=7938)
	Mean (SE)	Mean (SE)	Mean (SE)
Age, years[a]	11.09 (0.02)	11.13 (0.01)	11.13 (0.01)
Socioeconomic status[a]	−0.35 (0.05)	−0.06 (0.02)	−0.09 (0.02)
Neighborhood safety in kindergarten[a]	10.57 (0.12)	11.15 (0.04)	11.10 (0.04)
K-BMI z-score in kindergarten[a]	1.26 (0.06)	1.17 (0.02)	1.17 (0.02)
BMI z-score in 5th grade	0.76 (0.06)	0.66 (0.02)	0.67 (0.02)
	% (SE)	% (SE)	% (SE)
Gender			
Female	46.01 (2.84)	49.23 (1.07)	48.96 (0.99)
Male	53.99 (2.84)	50.77 (1.07)	51.04 (0.99)
Race/ethnicity[a]			
Non-Hispanic white	38.39 (3.36)	60.51 (1.70)	58.62 (1.69)
Non-Hispanic black	16.46 (2.94)	14.17 (1.13)	14.37 (1.06)
Hispanic	36.18 (3.47)	17.72 (1.32)	19.29 (1.34)
Other	8.98 (1.59)	7.60 (0.86)	7.72 (0.83)
Highest parent education level[a]			
High school or less	44.77 (3.06)	29.82 (1.26)	31.09 (1.24)
Some college or vocational/technical	30.10 (2.50)	35.79 (1.03)	35.30 (1.00)
Bachelor's degree	12.81 (1.86)	18.53 (0.89)	18.04 (0.84)
Graduate degree or higher	12.32 (1.61)	15.87 (0.89)	15.56 (0.84)
Annual household income[a]			
≤$30,000	45.82 (3.13)	32.08 (1.28)	33.25 (1.28)
>$30,000 to ≤$50,000	23.61 (2.31)	21.82 (0.86)	21.98 (0.80)
>$50,000 to ≤$100,000	22.44 (2.53)	31.51 (1.04)	30.73 (1.01)
>$100,000	8.13 (1.26)	14.59 (0.87)	14.04 (0.84)
Family composition[a]			
Two-parent and siblings	68.56 (2.77)	62.39 (1.32)	62.91 (1.26)
Two-parent without siblings	2.82 (0.73)	8.36 (0.56)	7.89 (0.51)
One-parent and siblings	21.71 (2.55)	21.56 (1.23)	21.57 (1.20)
One-parent without siblings	3.92 (0.93)	5.60 (0.53)	5.46 (0.49)
Other	3.00 (1.07)	2.09 (0.33)	2.17 (0.31)
Urbanicity[a]			
Large or mid-size city	50.74 (3.38)	33.63 (1.65)	35.09 (1.65)
Surburban/large town	40.15 (3.18)	42.39 (2.93)	42.20 (2.78)
Small town/rural	9.11 (1.61)	23.98 (2.49)	22.71 (2.34)
Census region of United States[a]			
Northeast	21.98 (2.32)	18.30 (1.33)	18.61 (1.25)
Midwest	22.33 (2.74)	24.89 (1.28)	24.68 (1.21)
South	18.69 (2.26)	35.06 (1.61)	33.67 (1.51)
West	37.00 (2.82)	21.74 (1.11)	23.05 (1.06)

[a]Active versus passive commuters were significantly different at $p < 0.05$ by Student's t-test for continuous variables and Wald's chi-square test for categorical variables.

K, kindergarten; SE, standard error.

compared between included and excluded participants using Student's *t*-test and Wald's chi-square test.

Analysis of covariance (ANCOVA) was used with fifth-grade BMI *z*-score as the dependent variable. ANCOVA was chosen because of the complex survey design of the ECLS-K (survey weights, primary sampling units, and strata), which could be accommodated by SAS 9.2 software (SAS Institute Inc., Cary, NC) and not typically by other analytic methods.[38] Longitudinal sample weights were applied, which accounted for differing nonresponse

Table 2. ANCOVA Predicting BMI z-Score in Fifth-Grade from Kindergarten (K) School Travel Mode from the US Early Childhood Longitudinal Study, Kindergarten Class of 1998–99

	β	95% CI	*p* value
School travel			
Passive commuting	Reference		
Active commuting	−0.59	−1.09, −0.09	0.021
K-BMI z-score	0.69	0.58, 0.80	<0.0001
Age	−0.01	−0.01, 0.001	0.017
Gender			
Female	Reference		
Male	0.05	0.00, 0.09	0.058
Race/ethnicity			
Non-Hispanic white	Reference		
Non-Hispanic black	0.04	−0.06, 0.14	0.443
Hispanic	0.00	−0.07, 0.07	0.991
Other	0.03	−0.03, 0.10	0.300
Socioeconomic status	−0.07	−0.12, −0.03	0.002
Neighborhood safety	−0.02	−0.04, −0.01	0.010
Family composition			
Other	Reference		
Two-parent and siblings	0.00	−0.12, 0.13	0.942
Two-parent without siblings	0.07	−0.09, 0.24	0.381
One-parent and siblings	0.05	−0.07, 0.17	0.425
One-parent without siblings	0.01	−0.13, 0.14	0.910
Urbanicity			
Small town/rural	Reference		
Large or mid-size city	0.01	−0.07, 0.09	0.759
Surburban/large town	0.02	−0.05, 0.09	0.639
Census region			
West	Reference		
Northeast	0.02	−0.06, 0.10	0.616
Midwest	0.01	−0.06, 0.09	0.730
South	0.08	0.00, 0.16	0.058
School travel*K-BMI z-score	0.13	−0.01, 0.28	0.070
School travel*neighborhood safety	0.04	0.002, 0.07	0.039
School travel*socioeconomic status	−0.02	−0.10, 0.05	0.569

ANCOVA, analysis of covariance; CI, confidence interval.

rates and oversampling of selected groups.[32] Covariates were as discussed above. The significance level for all analyses was 0.05.

Results

Of the 12,022 eligible participants in the ECLS-K fifth-grade sample, some were dropped because of missing data for any of the following: (1) fifth-grade longitudinal sample weights, primary sampling unit, or strata ($n=2755$); (2) ACS question ($n=4$); (3) BMI z-score in kindergarten or fifth grade ($n=983$); and (4) any of the covariates specified previously ($n=342$), which yielded a final analytic sample of $n=7938$. Comparisons of included and excluded participant characteristics left out participants with missing sample weights, primary sampling units, or strata ($n=2755$), because those data are necessary to calculate estimates that take into account the cohort's complex design. Compared to the included participants, excluded eligible participants ($n=1330$) were slightly older (11.17 vs. 11.13 years; $p=0.035$), less likely to be from a two-parent household with or without siblings (67.0% vs. 70.8%; $p=0.022$), and more likely to be from the South (50.72% vs. 33.67%; $p<0.0001$). There were no significant differences by ACS, neighborhood safety, gender, race/ethnicity, urbanicity, SES, and BMI z-scores in kindergarten or fifth grade.

The mean child's age [$\pm$standard error (SE)] in fifth grade was 11.13 ± 0.01 years. For the whole sample (Table 1), 49.0 ± 1.0% were female, 58.6 ± 1.7% were non-Hispanic white, 19.3 ± 1.3% were Hispanic, 14.4 ± 1.0% were non-Hispanic black, and 7.7 ± 0.8% were other race/ethnicity. The ACS group had significantly lower age, neighborhood safety scores, and SES scores and had higher BMI z-scores in kindergarten, percentages of racial/ethnic minorities, percentages of two-parent households with siblings, percentages from urban areas, and percentages from the Northeast and West.

Prevalence of ACS in kindergarten was 8.5 ± 0.6%. The ANCOVA model yielded significant main effects for ACS, neighborhood safety, kindergarten BMI z-score, age, SES, and interaction of neighborhood safety and ACS (Table 2). Interaction of neighborhood safety and kindergarten ACS indicated that (1) children from less-safe neighborhoods who did ACS had lower fifth-grade BMI z-scores than their peers who did not do ACS (Fig. 1), and (2) there was no difference in fifth-grade BMI z-scores among children from more-safe neighborhoods. The estimated difference in fifth-grade BMI between active and passive commuters from less-safe neighborhoods was $-0.49\,kg/m^2$ for children of average height. Inverse predictors of fifth-grade BMI z-score included (1) age [$\beta=-0.01$; 95% confidence interval (95% CI), -0.01, -0.001; $p=0.017$] and (2) SES ($\beta=-0.07$; 95% CI, -0.12, -0.03; $p=0.002$). The only positive predictor of fifth-grade BMI z-score was kindergarten BMI z-score ($\beta=0.69$; 95% CI, 0.58, 0.80; $p<0.0001$). Gender, race/ethnicity, single-/two-parent household, region of the country, urbanicity, interaction of ACS and kindergarten BMI z-score, and interaction of ACS and SES were not significant predictors of fifth-grade BMI z-score (all $p>0.05$).

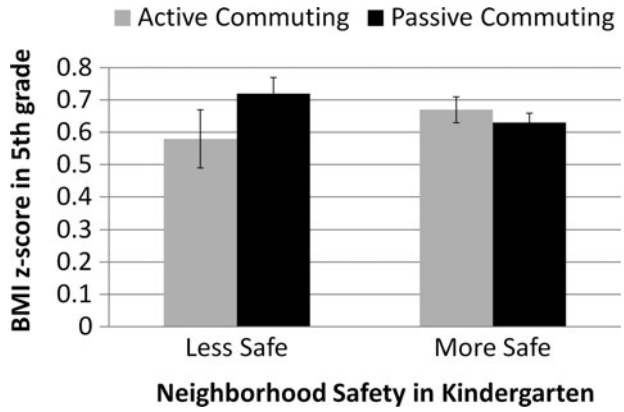

Figure 1. Active commuting to school predicting fifth-grade BMI z-score, stratified by neighborhood safety for the US Early Childhood Longitudinal Study, Kindergarten Class of 1998–99.

Discussion

This US study is one of the largest on children's ACS and examined the long-term association between ACS and adiposity. Overall, children who did ACS in kindergarten had lower BMI z-scores in fifth grade, compared to their peers who were passive commuters to school, regardless of BMI z-score in kindergarten. Neighborhood safety appeared influential to this relationship such that kindergarteners from less-safe neighborhoods who did ACS developed lower fifth-grade BMI z-scores, compared to their passive commuting peers. The estimated mean difference in BMI was $-0.49\,kg/m^2$ for children of average height in less-safe neighborhoods, which is comparable to the change in BMI reported for two meta-analyses of school-based obesity prevention interventions (-0.17 and $-0.62\,kg/m^2$).[39,40] We speculate that ACS was related to lower BMI z-score among children from less-safe neighborhoods because other forms of PA besides ACS were limited in less-safe neighborhoods,[28,41,42] and thus ACS was an important type of PA that decreased children's risk of excess adiposity. This explanation requires confirmation. The present results highlight the need to intervene in early elementary school, especially in less-safe neighborhoods, to prevent obesity, given that the largest increase in BMI percentiles occurs before third grade.[30] The present study's main finding was also consistent with previous cross-sectional studies that also reported inverse associations between ACS and adiposity.[23] For example, ACS among US adolescents was positively associated with MVPA and inversely associated with adiposity.[43] In contrast, some longitudinal studies reported no association between ACS and adiposity. In a US study that collected data in 1990, there was no association between ACS and adiposity from fourth ($n=1083$) to fifth grade ($n=924$).[44]

Similarly, the Trial of Activity for Adolescent Girls study reported no association between ACS and BMI.[45] One US study reported a positive association between ACS and child BMI,[46] although these results have not been replicated. The present study's sample was larger, more nationally representative, included both boys and girls, and followed children from an earlier age and for a longer duration than these previous studies, which may help explain differences in findings.

Higher household SES independently predicted lower BMI *z*-score in fifth grade, controlling for other independent variables. This relationship was expected, because a previous US national study on childhood obesity reported a similar inverse relationship.[31] Additionally, higher age predicted slightly lower BMI *z*-scores in fifth grade, although this relationship was modest and of questionable clinical significance.

Prevalence of ACS in kindergarten in this sample was lower (8.5%), compared with other US national reports. Reasons for the lower rate of ACS were likely a result of (1) the younger age of the sample, because most previous national studies included older school-age children[18,47,48] and (2) the present study asking about ''usual'' ACS, rather than ''any'' ACS (*i.e*., differences in the wording of the exposure question). Regardless, policies to support young children's ACS are needed. The federal SRTS program is the most important policy relevant to children's ACS in the United States. Signed into law in 2005 as part of the federal Safe, Accountable, Flexible, Efficient Transportation Equity Act, the mission of SRTS is to promote safe ACS for elementary and middle school children.[49] Evaluation of the influence of the SRTS program has shown promising results for reducing child pedestrian injuries,[50] improving child pedestrian safety behaviors,[51] and increasing rates of children's ACS and PA.[52–56] Despite the growing evidence of SRTS policy effectiveness, funding for SRTS through the new federal law, Moving Ahead for Progress in the 21st Century, was recently cut by 33–66%, depending on the number of states that opt out of programs.[57] Given that most children need to travel to school, SRTS represents a potential and important population-level approach to provide children with frequent opportunities for PA.[16]

Study Limitations

This secondary analysis has several limitations. First, the validity of the ACS question is unknown, although similar ACS questions had acceptable validity.[34,35] Whereas other analytic methods (*e.g*., propensity score matching) may help reduce bias, these methods cannot take into account the cohort's complex design.[38] ACS was assessed in kindergarten, but not in fifth grade. The contribution of ACS in fifth grade to the primary outcome cannot be evaluated, and the large time interval between kindergarten ACS and fifth-grade BMI *z*-score may be affected by unaccounted confounders. The ECLS-K lacked an objective measure of distance from home to school, or assessment of the built environment, which have been linked to children's ACS.[58–60] There were baseline differences between the active and passive commuting groups, and it is uncertain how these differences may have affected estimates. Regardless, longitudinal cohort and experimental trials are necessary to confirm and more precisely characterize these observational findings and explore associations with other important ACS outcomes.

Conclusion

ACS in kindergarten appears to have a protective effect on later BMI *z*-score among fifth graders from less-safe neighborhoods in the United States, although current rates of ACS are low, compared to previous generations. Policies to promote ACS and prevent obesity are necessary and should include young children, children from less-safe neighborhoods, families of lower SES, and take into account parents' concerns regarding safety.

Acknowledgments

Research reported in this publication was supported by the National Cancer Institute of the National Institutes of Health (NIH) under award numbers K07CA131178 and R01CA163146 and the USDA under Cooperative Agreement 6250-51000-053. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH, other funders, or the authors' affiliated academic institutions.

Author Disclosure Statement

No competing financial interests exist.

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