The Availability of Local-Area Commercial Physical Activity–Related Facilities and Physical Activity Among Adolescents

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Background: A significant number of American youth do not participate in sufficient levels of physical activity.

Methods: This article reports the association between the availability of commercial physical activity–related facilities and self-reported physical activity behavior among United States adolescents. Geographic identifiers at the ZIP-code level were used to combine repeated cross-sections of individual-level data on 8th-, 10th-, and 12th-grade adolescents from the Monitoring the Future (MTF) Survey with external commercial physical activity–related facility outlet density measures obtained from business lists from Dun and Bradstreet for the years 1997 through 2003. The estimation samples based on questions from different survey forms included a total of 195,702 observations on which information on physical activity (sports, athletics, or exercise) was available and 58,876 observations on which information on vigorous exercise behavior was available.

Results: The results showed a statistically significant but very small association between local-area per capita availability of commercial physical activity–related facilities and physical activity behavior among U.S. adolescents. An additional local-area facility per 10,000 capita was associated with only a 0.22 percentage point increase in frequent vigorous exercise among the full sample of adolescents. By gender and grade level, the study found significant associations among female and older students: increasing availability from a low (1 facility) to a high (8 facilities) number of local-area facilities was associated with a 6.6% and 9.0% increase in frequent physical activity and frequent vigorous exercise among 12th-grade girls, respectively, and a 6.4% increase in frequent vigorous exercise among 12th-grade boys.

Conclusions: Improving the availability of commercial physical activity–related opportunities among underserved populations may help to increase activity levels among older adolescents and girls.

(Am J Prev Med 2007;33(4S):S292–S300) © 2007 American Journal of Preventive Medicine

Introduction

The positive health benefits associated with regular physical activity include reduced risk of obesity, coronary heart disease, diabetes, colon cancer, hip fractures, and high blood pressure.[1,2] Despite this evidence, a significant proportion of American youths do not participate in sufficient levels of physical activity. Data from the 2005 Youth Risk Behavior Survey[3] showed that 31.3% of high school students had not participated in sufficient vigorous physical activity (at least 20 minutes on 3 or more of the past 7 days) and/or had not participated in sufficient moderate physical activity (at least 30 minutes on 5 or more of the past 7 days). These data also showed that 9.6% of students participated in no vigorous or moderate exercise during the past 7 days. Further, the data revealed significant differences in the prevalence of having participated in an insufficient amount of physical activity by gender, race, and ethnicity and by grade level: higher among female (38.5%) versus male (24.2%) students; higher among black (38.0%) than Hispanic (30.6%) and white (29.8%) students; and higher among 11th- (32.6%) and 12th- (38.2%) grade than 9th- (26.5%) and 10th- (29.5%) grade students.[3] The Centers for Disease Control and Prevention (CDC) found that in 2002, based on the Youth Media Cam-

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0749-3797/07/$–see front matter
doi:10.1016/j.amepre.2007.07.002

paign Longitudinal Survey (YMCLS), among children aged 9–13, 38.5% participated in organized sports, and 77.4% participated in freetime physical activity where substantial differences by race and parental income and education levels were found in the participation rates of organized sports.[4]

Examining trends in physical activity among 8th, 10th, and 12th graders, Johnston and O'Malley[5] found that over time there has been a steady decrease in both exercise levels (for 10th and 12th graders) and participation in sports/athletics among all three age groups, with the exception of 8th-grade girls who showed no decline. Results also showed that, in general, boys reported higher rates of exercise than girls. Lower than the rates for the 10th graders, the nearly every day or more vigorous exercise rates for 12th-grade boys and girls were reported to be 42% and 26%, respectively, in 2002, down from 50% and 33%, respectively, in 1979.[5]

Therefore, it is not surprising that physical activity and fitness are key areas of the *Healthy People 2010* initiative.[6] In addressing the importance of contextual influences in their support of physical activity and healthy food choices, the Surgeon General's 2001 Report called for research to "determine the root causes, behaviors, and social and ecological factors leading to obesity and how such forces vary by race and ethnicity, gender, and socioeconomic status."[6] Promoting regular physical activity and creating an environment that supports this behavior is essential to reducing the obesity epidemic and establishing healthy behaviors that youth can carry into adulthood.

An increasing body of behavioral physical activity research has examined associations between local area environmental factors and physical activity among children and adolescents.[7] Outdoor play/sports areas and parks[8–12] have been associated with higher levels of children's and adolescents' physical activity. Participation in community sports[13] and use of a community recreation center[14] have been found to be significant predictors of higher levels of moderate and vigorous physical activity among children and suggest that local-area facility access was important. Several recent studies have found that greater access to commercial physical activity–related facilities was positively associated with higher levels of physical activity among youths.[11,15–17] A limited number of these studies[8,15,17] have included objective rather than perceived measures of local-area recreational infrastructure.

Data also suggest that barriers to physical activity vary significantly by race and socioeconomic status (SES). Based on the YMCLS, parents of non-Hispanic black children and parents with lower income and education levels perceived significantly higher barriers that included transportation problems, lack of opportunities to participate in physical activity, expense, and concerns about neighborhood safety.[4] Studies based on objective measures of available local-area physical activity–related commercial and public outdoor settings have found less availability in minority and low-SES communities.[17–20]

The research presented in this article examined the association between the availability of commercial physical activity–related facilities and self-reported physical activity behaviors among United States adolescents in 8th, 10th, and 12th grades. The study used geographic identifiers at the ZIP-code level to combine repeated cross-sections of individual-level data on adolescents from the Monitoring the Future (MTF) Survey with external commercial physical activity–related facility outlet density measures obtained from business lists from Dun and Bradstreet (D&B)for the years 1997 through 2003. Multivariate regression analyses that controlled for individual, family, and neighborhood covariates were undertaken to examine the associations among the availability of commercial physical activity–related facilities and (1) frequent physical activity and (2) frequent vigorous exercise.

Methods

Conceptual Framework

This study draws on economic and ecologic theories to examine the importance of external factors associated with youth physical activity. Economic models are based on the assumption that individuals make behavioral decisions that maximize their utility (happiness) based on a set of personal preferences and subject to constraints.[21] Individual behaviors (i.e., physical activity behaviors) are affected by tastes and are constrained by income and the total cost of goods. The total cost refers to both the monetary cost (price) and other costs such as those related to access. For example, close proximal access will reduce transportation costs associated with a given behavior. Ecologic models also highlight access and availability as important environmental factors that underlie physical activity behaviors.[22,23] The importance of policy interventions based on ecologic models to promote physical activity has been clearly articulated in several studies.[22,23] Sallis et al.[23] discussed the importance of physical environmental factors as essential elements of an ecologic model of physical activity. Underlying this is the premise that physical activities take place in specific physical environments (behavior settings) that are likely to influence the amount and type of activity. Behavior settings were defined as the physical and social contexts in which behaviors occur (e.g., sports fields, gyms, health clubs, and bicycle trails). While the range of external factors associated with physical activity is extensive, this study focuses on the importance of commercial physical activity–related facilities.

Data

Repeated cross-sections of individual-level national data for 8th-, 10th-, and 12th-grade students from the MTF surveys were combined with external data on commercial physical activity–related facility outlets obtained from business lists developed by D&B. The physical activity–related outlet den-

sity measures were matched to the individual-level data at the school ZIP-code level for the years 1997 through 2003.

MTF Survey Data

The MTF study, conducted by the University of Michigan's Institute for Social Research (ISR) and funded by the National Institute on Drug Abuse, began in 1975; using national samples of high school seniors in the coterminous U.S., it is the nation's longest running survey of youth substance use and abuse. Since 1991 the MTF surveys also have included 45,000 to 50,000 8th- and 10th-grade students annually. Located in approximately 420 schools, these students/schools were selected annually for the MTF survey based on a three-stage sampling procedure.[24] Stage 1 involved geographic area selection. Stage 2 involved the selection of one or more schools in each area based on establishing the probability for inclusion proportionate to the size of the respective grade to be sampled. Stage 3 focused on the selection of students within each selected grade. Within each school, up to 350 students per grade were selected for the study. For those schools with a smaller student body for the respective grade, all students were selected. If a school had more than 350 students, a random sample of classrooms or other random method was used to choose the final sample.

Questionnaires were administered by an ISR representative in classrooms during normal class periods whenever possible. Students were informed of the importance of accurate responses and assured that their confidentiality would be protected. Neither parents nor the school was informed of individual student responses, but schools were provided with the overall survey results for their respective schools. In the MTF study 8th and 10th graders were administered four different forms and 12th graders six different forms of the questionnaire. This occurred in an ordered sequence, to ensure virtually identical subsamples for each form. Approximately one third of the questions on each form were

Table 1. Summary statistics: Outcomes, commercial physical activity–related facilities and control variables

	Frequent physical activity sample	Frequent vigorous exercise sample
Frequent physical activity (%)	73.48	—
Frequent vigorous exercise (%)	—	64.94
Total physical activity-related facilities (per 10,000 capita)	3.7574 (2.8775)	3.8289 (2.9419)
Per capita income (in 10,000s)	2.1929 (0.9663)	2.2173 (0.9808)
Male (%)	48.25	47.32
Age	14.9896 (1.4804)	15.1810 (1.5548)
Grade (%)		
8th grade	44.46	39.71
10th grade	42.73	42.14
12th grade	12.81	18.15
Race (%)		
White	67.96	70.40
Black	11.51	10.30
Hispanic	10.54	9.58
Other race	9.99	9.72
Father's education (%)		
Father less than high school	13.73	13.24
Father completed high school	29.94	29.27
Father college or more	56.33	57.49
Mother's education (%)		
Mother less than high school	11.51	10.88
Mother completed high school	28.71	28.32
Mother college or more	59.78	60.80
Live with both parents (%)	78.50	79.09
Live in rural area (%)	22.74	23.24
Student's weekly real income (in 100s)	0.2570 (0.2857)	0.2716 (0.2886)
Weekly hours worked by student	5.0521 (8.2874)	5.6822 (8.6717)
Mother's work status (%)		
Mother did not work	17.30	17.07
Mother worked part-time	18.72	18.98
Mother worked full-time	63.98	63.95
Year indicators (%)		
Year 1997	15.27	14.84
Year 1998	15.26	15.07
Year 1999	13.80	13.99
Year 2000	13.80	13.56
Year 2001	13.85	13.78
Year 2002	13.37	13.63
Year 2003	14.65	15.13
Number of observations	195,702	58,876

Notes: Standard deviations are shown in parentheses for nondummy variables. Statistics are weighted using the sampling selection weights.

common to all 10 forms; these included the demographic variables and questions about substance use. Questions related to physical activity behavior were all form-specific and were included on only a subset of forms.

For the 7 years of data from 1997 through 2003 for 8th-, 10th-, and 12th-grade students, 195,702 observations with information on physical activity (sports, athletics, or exercise) and 58,876 observations with information on vigorous exercise behavior and nonmissing information on all of our control variables were available. As noted above, the reason for the differing sample sizes was that in order to collect as much varied information as possible on adolescent attitudes, beliefs, and behaviors, MTF consisted of multiple forms that included both core and form-specific questions. Many of the questions on physical activity were form-specific and often were not on the same form.

Physical activity outcome measures. Two self-reported measures available in the MTF surveys were used to study physical activity. The first measure was based on the following question: How often do you do actively participate in sports, athletics, or exercise? Responses were based on a 5-point scale that included: never, a few times a year, once or twice a month, at least once a week, and almost every day. Based on these answers, a dichotomous indicator was created for frequent participation in physical activity equal to unity if the student answered at least weekly or almost every day and equal to zero otherwise. The second measure was based on the question: How often do you exercise vigorously (jogging, swimming, calisthenics, or any other active sports)? Students' responses included the following possible categories: never, seldom, sometimes, most days, nearly every day, and every day. Based on these answers, a dichotomous indicator was created for frequent vigorous exercise equal to unity if the student answered most days, nearly every day, or every day and equal to zero otherwise. Table 1 shows that 73.5% of students participated in physical activity (sports, athletics, or exercise) at least weekly and that 64.9% frequently participated in vigorous exercise.

Control measures. Basic demographic measures available in the MTF student surveys were controlled, including: gender; grade; race/ethnicity; highest level of schooling completed by father; highest level of schooling completed by mother; rural/urban area neighborhood designation; total student income (earned and unearned, such as allowance) in real (consumer price index base $82–$84) dollars; weekly hours of work by the student; and mother's work status (did not work, worked

Table 2. Marginal effects of availability of physical activity–related facilities on frequent physical activity (N=195,702)

	Model 1	Model 2	Model 3
Total physical activity-related facilities (per 10,000 capita)	0.0010 (0.0007)	0.0023*** (0.0007)	—
Per capita income	0.0175*** (0.0023)	—	—
Male	0.0925*** (0.0034)	0.0926*** (0.0034)	0.0926*** (0.0034)
Grade (Referent category: 8th grade)			
10th grade	−0.0445*** (0.0042)	−0.0439*** (0.0044)	−0.0440*** (0.0044)
12th grade	−0.0711*** (0.0056)	−0.0705*** (0.0057)	−0.0699 (0.0057)
Race (Referent category: White)			
Black	−0.0301*** (0.0047)	−0.0360*** (0.0049)	−0.0394*** (0.0048)
Hispanic	−0.0433*** (0.0061)	−0.0480*** (0.0063)	−0.0510*** (0.0064)
Other race	−0.0576*** (0.0051)	−0.0570*** (0.0051)	−0.0581*** (0.0051)
Father's education (Referent category: Father completed high school)			
Father less than high school	−0.0492*** (0.0044)	−0.0498*** (0.0044)	−0.0503*** (0.0045)
Father college or more	0.0498*** (0.0029)	0.0542*** (0.0029)	0.0547*** (0.0029)
Mother's education (Referent category: Mother completed high school)			
Mother less than high school	−0.0508*** (0.0048)	−0.0523*** (0.0049)	−0.0531*** (0.0049)
Mother college or more	0.0476*** (0.0030)	0.0505*** (0.0030)	0.0509*** (0.0030)
Live with both parents	0.0436*** (0.0030)	0.0447*** (0.0030)	0.0448*** (0.0030)
Live in rural areas	−0.0100*** (0.0038)	−0.0169*** (0.0039)	−0.0177*** (0.0038)
Student's weekly real income	0.0423*** (0.0059)	0.0432*** (0.0060)	0.0431*** (0.0060)
Weekly hours worked by student	−0.0026*** (0.0002)	−0.0026*** (0.0022)	−0.0026*** (0.0002)
Mother's work status (Referent category: Mother did not work)			
Mother worked part-time	0.0240*** (0.0038)	0.0235*** (0.0038)	0.0238*** (0.0038)
Mother worked full-time	0.0294*** (0.0033)	0.0276*** (0.0034)	0.0276*** (0.0034)
Year indicators (Referent category: Year 1997)			
Year 1998	−0.0179*** (0.0055)	−0.0190*** (0.0055)	−0.0189*** (0.0055)
Year 1999	−0.0069 (0.0062)	−0.0074 (0.0063)	−0.0072 (0.0063)
Year 2000	−0.0069 (0.0063)	−0.0073 (0.0064)	−0.0068 (0.0064)
Year 2001	−0.0135** (0.0061)	−0.0154** (0.0063)	−0.0138** (0.0062)
Year 2002	−0.0164*** (0.0063)	−0.0179*** (0.0063)	−0.0155** (0.0063)
Year 2003	−0.0146** (0.0059)	−0.0155*** (0.0060)	−0.0139** (0.0060)

Notes: Standard errors are robust and clustered at the school zip code level and are shown in parentheses. Models 1 and 2 provide estimates with and without controlling for neighborhood per capita income, respectively. Model 3 provides estimates with only the demographic covariates. The symbols *, **, and *** represent statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

part-time, or worked full-time). Neighborhood wealth effects were controlled for by including a measure of mean per capita income at the ZIP-code level from the Census 2000.[25,26] Table 1 presents the summary statistics for all of the control variables.

Physical Activity–Related Outlet Density Measure

Data on physical activity–related outlets were obtained from a business list developed by D&B.[27] The data were obtained through D&B MarketPlace software, which allowed a sorting of the data by ZIP code and Standard Industry Classification (SIC) codes. The database allowed for SIC code searches at varying levels of outlet detail/specificity. A measure of physical activity–related facilities was developed based on a list of facilities drawn from 100 different 8-digit SIC codes. These business SIC codes included facilities such as physical fitness facilities, membership sports and recreation clubs, public golf courses, ice rinks, swimming pools, dance studios, sports and athletic instruction (i.e. gymnastics), tennis courts, and the YMCA. All businesses in the D&B database had a primary SIC code but may have had multiple nonprimary SIC codes assigned to it depending on the combination of services/products offered. The search was not limited to "primary" SIC codes because certain facilities such as a YMCA may offer physical activity facilities but may, for example, have primary SIC codes related to social services. All duplications were eliminated prior to consolidating the list of total physical activity–related facilities. The total number of facility outlets were summed across ZIP codes and divided by ZIP-code population times 10,000 to develop a measure of commercial physical activity–related facility availability per 10,000 capita. Table 1 shows that ZIP codes had, on average, 3.8 physical activity–related facilities per 10,000 capita.

Estimation Framework

Following the conceptual framework and variable definitions as outlined above, empirical models examined the importance of commercial physical activity–related facility availability for two measures of adolescent physical activity behavior. Separate models were used to examine the associations between the availability of physical activity–related facilities and frequent physical activity (sports, athletics, or exercise) and frequent vigorous exercise outcomes. Separate models were estimated by grade and gender.

Specifically, the following specification was estimated:

$$PA_{ist} = \beta_0 + \beta_1 PAD_{st} + \beta_2 I_{st} + \beta_3 X_{ist} + \varepsilon_{ist} \quad (1)$$

Table 3. Marginal effects of availability of physical activity–related facilities on frequent vigorous exercise (N=58,876)

	Model 1	Model 2	Model 3
Total physical activity-related facilities (per 10,000 capita)	0.0022** (0.0010)	0.0026** (0.0010)	—
Per capita income	0.0064** (0.0028)	—	—
Male	0.1166*** (0.0049)	0.1166*** (0.0049)	0.1166*** (0.0049)
Grade (Referent category: 8th grade)			
10th grade	−0.0828*** (0.0065)	−0.0827*** (0.0065)	−0.0828*** (0.0065)
12th grade	−0.2005*** (0.0089)	−0.2005*** (0.0089)	−0.1998*** (0.0089)
Race (Referent category: White)			
Black	−0.0507*** (0.0091)	−0.0528*** (0.0092)	−0.0564*** (0.0091)
Hispanic	−0.0087 (0.0094)	−0.0103 (0.0094)	−0.0137 (0.0094)
Other race	−0.0332*** (0.0084)	−0.0327*** (0.0084)	−0.0338*** (0.0084)
Father's education (Referent category: Father completed high school)			
Father less than high school	−0.0480*** (0.0084)	−0.0482*** (0.0084)	−0.0490*** (0.0084)
Father college or more	0.0610*** (0.0057)	0.0627*** (0.0056)	0.0632*** (0.0057)
Mother's education (Referent category: Mother completed high school)			
Mother less than high school	−0.0371*** (0.0087)	−0.0377*** (0.0087)	−0.0384*** (0.0087)
Mother college or more	0.0274*** (0.0055)	0.0286*** (0.0055)	0.0289*** (0.0055)
Live with both parents	0.0544*** (0.0059)	0.0549*** (0.0059)	0.0551*** (0.0059)
Live in rural areas	0.0098 (0.0061)	0.0071 (0.0061)	0.0062 (0.0060)
Student's weekly real income	0.0578*** (0.0111)	0.0584*** (0.0111)	0.0581*** (0.0111)
Weekly hours worked by student	−0.0033*** (0.0004)	−0.0033*** (0.0004)	−0.0033*** (0.0004)
Mother's work status (Referent category: Mother did not work)			
Mother worked part-time	0.0123 (0.0078)	0.0120 (0.0078)	0.0125 (0.0078)
Mother worked full-time	0.0115* (0.0066)	0.0106 (0.0067)	0.0108 (0.0067)
Year indicators (Referent category: Year 1997)			
Year 1998	0.0020 (0.0093)	0.0016 (0.0093)	0.0017 (0.0093)
Year 1999	−0.0026 (0.0095)	−0.0028 (0.0095)	−0.0026 (0.0096)
Year 2000	−0.0171* (0.0099)	−0.0171* (0.0099)	−0.0167* (0.0099)
Year 2001	−0.0110 (0.0099)	−0.0116 (0.0099)	−0.0099 (0.0099)
Year 2002	−0.0128 (0.0097)	−0.0134 (0.0097)	−0.0106 (0.0097)
Year 2003	−0.0101 (0.0095)	−0.0105 (0.0095)	−0.0088 (0.0095)

Notes: Standard errors are robust and clustered at the school zip code level and are shown in parentheses. The symbols *, **, and *** represent statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Models 1 and 2 provide estimates with and without controlling for neighborhood per capita income, respectively. Model 3 provides estimates with only the demographic variates.

where PA_{ist} defined our dichotomous frequent physical activity behavior outcome variable for individual i, living in area s at time t. PAD_{is} defined the per 10,000 capita density of commercial physical activity–related facility outlets available in geographic area s and time t, I_{st} was per capita income in area s and time t, and, X_{ist} was a vector of individual characteristics and time dummy variables and ε_{ist} was a disturbance term. Marginal effects were reported from maximum likelihood probit models for our physical activity binary outcome measures. All models were estimated using Stata version 9.2. Weights were used to adjust for differential probabilities of student selection, and standard errors were adjusted using a Huber–White covariance matrix estimate that was robust to clustering at the ZIP-code level and heteroskedasticity of unknown form.[28]

Results

Tables 2 and 3 present the marginal effects of the probit estimation results on the association between the availability of commercial physical activity–related facilities per 10,000 capita and self-reported frequent participation in physical activity and vigorous exercise among adolescents. Models 1 and 2 provide estimates with and without controlling for neighborhood per capita income, respectively. Model 3 provides estimates with only the demographic covariates. Examining first the results presented in Table 2 for frequent physical activity (sports, athletics, or exercise) participation, the results show that the availability of commercial physical activity–related facilities, had a statistically significant positive but small association with the likelihood of frequent physical activity (Model 2). However, as shown in Model 1 this effect fell substantially in magnitude (from 0.0023 to 0.0010) and lost statistical significance once neighborhood per capita income was controlled for in Model 1.

The results from Model 1 show that the estimated effect of the availability of commercial physical activity–related facilities was significantly associated with frequent vigorous exercise among adolescents (Table 3). Comparing the results from Model 2 to Model 1, the magnitude of the effect dropped slightly (from 0.0026 to 0.0022) once neighborhood per capita income levels were accounted for, and it remained statistically significant. The presence of one additional physical activity–related facility per 10,000 capita was statistically significantly associated with just over one fifth of a percentage point increase in frequent vigorous exercise. The present study found smaller associations between facility availability and adolescent physical activity than those reported in a similar previous study.[17]

Tables 4 and 5 present the estimated association of the availability of commercial physical activity–related facilities and adolescent physical activity measures by gender for the full sample and by gender for each grade. These tables also provide predicted probabilities of frequent physical activity simulated for increasing

Table 4. Effects of physical activity-related facilities on frequent physical activity: by gender and by grade

	Female				Male			
	All grades (N=101,693)	**8th grade (N=44,807)**	**10th grade (N=44,028)**	**12th grade (N=12,858)**	**All grades (N=94,009)**	**8th grade (N=41,795)**	**10th grade (N=40,291)**	**12th grade (N=11,923)**
Mean rate of frequent physical activity (%)	68.73	72.32	67.18	61.47	78.57	80.91	76.92	75.94
Marginal effects of total physical activity-related facilities on frequent physical activity	0.0020** (0.0009)	0.0006 (0.0016)	0.0016 (0.0013)	0.0057*** (0.0017)	−0.0002 (0.0008)	−0.0001 (0.0013)	−0.0006 (0.0011)	0.0012 (0.0013)
Number of physical activity–related facilities	Predicted probabilities of frequent physical activity with increasing numbers of facilities (%)							
1	69.12	73.16	67.55	60.23	79.19	81.54	77.63	76.06
4	69.71	73.35	68.04	61.94	79.13	81.52	77.43	76.42
8	70.48	73.61	68.69	64.19	79.05	81.49	77.18	76.89

Note: Marginal effects and predicted probabilities are based on regression estimates that include all control covariates shown in Model 1 of Table 2. The symbols *, **, and *** represent statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Standard errors are robust and clustered at the school ZIP-code level and are shown in parentheses.

Table 5. Effects of physical activity-related facilities on frequent vigorous exercise: by gender and by grade

	Female				Male			
	All grades (N=31,315)	**8th grade (N=12,260)**	**10th grade (N=13,503)**	**12th grade (N=5,552)**	**All grades (N=27,561)**	**8th grade (N=10,891)**	**10th grade (N=11,714)**	**12th grade (N=4,956)**
Mean rate of frequent vigorous exercise (%)	59.27	68.13	57.42	44.10	71.25	76.92	71.54	58.90
Marginal effects of total physical activity-related facilities on frequent vigorous exercise	0.0029** (0.0013)	0.0017 (0.0024)	0.0024 (0.0019)	0.0055** (0.0025)	0.0014 (0.0012)	0.0018 (0.0018)	−0.0008 (0.0021)	0.0052** (0.0022)
Number of physical activity-related facilities	Predicted probabilities of frequent vigorous exercise with increasing numbers of facilities (%)							
1	58.87	68.24	56.97	42.21	71.37	76.81	71.76	57.34
4	59.75	68.75	57.69	43.84	71.79	77.34	71.52	58.92
8	60.92	69.41	58.65	46.03	72.34	78.05	71.20	61.01

Note: Marginal effects and predicted probabilities are based on regression estimates that include all control covariates shown in Model 1 of Table 3. The symbols *, **, and *** represent statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

numbers of available facilities. For the full-sample of all grade levels, the tables show that greater numbers of local-area commercial physical activity–related facilities were statistically significantly associated with both physical activity outcome measures for girls but not for boys. The presence of an additional local-area commercial physical activity–related facility was associated with a 0.20 and 0.29 percentage point increase, respectively, in frequent physical activity and frequent vigorous exercise among female adolescents. A previous study that examined separate models by gender also found significant associations between commercial recreation facilities and physical activity levels for adolescent girls but not boys.[15]

Examining the associations by gender across grades, the results showed no significant associations for either gender among 8th- and 10th-grade students. Statistically significant effects were found for both activity measures among 12th-grade girls and for the frequent vigorous exercise among 12th-grade boys. The simulation results showed that increasing availability from a low (1 facility) to a high (8 facilities) number of local-area facilities was associated with a 6.6% and 9.0% increase in frequent physical activity and frequent vigorous exercise among 12th-grade girls, respectively, and a 6.4% increase in frequent vigorous exercise among 12th-grade boys.

Turning to the neighborhood SES control covariate, the results from Model 1, presented in Tables 2 and 3, show that living in a neighborhood with higher per capita income was associated with a greater probability of both frequent physical activity and vigorous exercise. Accounting for the availability of total physical activity–related facilities and all other control variables, a $10,000 increase in per capita income was associated with a 1.75 percentage point increase in frequent physical activity and a 0.64 percentage point increase in frequent vigorous exercise.

In terms of individual- and household-level covariates, regression results from Model 1 in Tables 2 and 3 showed that male students were statistically significantly more likely to frequently engage in both types of physical activity. Students of minority races were statistically significantly less likely to frequently participate in sports, although Hispanic teens did not differ significantly from their white counterparts in their likelihood of frequent vigorous exercise. Compared to middle school students, adolescents in 10th and 12th grade were substantially less likely to exercise vigorously (by 20 percentage points among 12th-grade students), though students in higher grades did not differ as much in terms of their general physical activity participation. Students with parents who had less than a high school education were less likely to participate frequently in both physical activity behaviors, whereas students with college-educated parents had significantly higher participation rates, with a large percentage

point spread in participation across these parental characteristics. Further, living in a household with both parents present increased the likelihood of frequent participation in physical activity by about 4–5 percentage points. Higher student income was associated with an increased probability of both types of physical activity, but holding income constant, greater hours of work were associated with a slightly lower probability of both types of activity. Students with mothers who worked part- or full-time versus not working were more likely to participate in physical activity more frequently but mothers' work status was only weakly statistically significantly associated with the probability of frequent vigorous exercise. Living in a rural area reduced physical activity rates slightly, but was not associated with vigorous exercise behavior. After controlling for all of the covariates, the time dummies showed that a statistically significant downward time trend still remained for frequent physical activity but not for frequent vigorous exercise among the adolescent sample.

Discussion

The results from the present study showed a statistically significant but small association between local-area per capita availability of commercial physical activity–related facilities and frequent vigorous exercise among U.S. adolescents. An additional local-area facility per 10,000 capita was associated with only a 0.22 percentage point increase in frequent vigorous exercise among the full sample of adolescents.

Results by gender, however, showed that the availability of physical activity–related facilities had a statistically significant positive association with both frequent physical activity and frequent vigorous exercise among girls, but was not significantly associated with either of the two physical activity behavior outcomes among boys. By gender and grade levels, increasing the number of available commercial physical activity–related facilities from 1 to 8 was associated with an increased likelihood of frequent physical activity by 6.6% and an increased likelihood of frequent vigorous exercise by 9.0% among 12th-grade girls and a 6.4% increase in the likelihood of frequent vigorous exercise among 12th-grade boys.

In all models, the estimated associations between the availability of commercial physical activity–related facilities and physical activity behaviors were substantially reduced once local-area per capita income was controlled for. These results implied that much of the correlation between the availability of commercial physical activity facilities and adolescent physical activity behaviors is attributable to lower density of these outlets in low-income neighborhoods. Higher neighborhood per capita income was associated with a greater frequency of physical activity and vigorous exercise.

This study was subject to several limitations. First, the physical activity–related outlet facility data were linked to the individual-level data by the student's school ZIP code. While this may be a good proxy for the student's home ZIP code at lower grade levels (in this case grade 8), high schools were likely to draw their student population from beyond its own ZIP code. The extent to which neighboring ZIP codes are similar will help to mitigate this potential source of error. Second, the study was subject to measurement error due to potential inaccuracies in the commercial outlet density data. Third, the physical activity behavior measures were self-reported. However, the validity of the MTF physical activity data is enhanced by preliminary analyses that suggest that a reasonable level of agreement exists between the school principals' responses about the rates of sports participation by students and how students in the same schools respond about their own level of participation in school athletics.[29] Fourth, while parental education was controlled, no information on household income was available. In addition, existing literature suggested that other family/household factors such as parental physical activity behavior (role modeling) were important determinants of children's physical activity behavior.[30–32] Fifth, the study did not control for school-level physical education (PE) and intramural sports opportunities. Cawley et al.[33] found that increased PE time increased both the weekly number of days of 20 minutes of moderate to vigorous exercise and strength building, but with a very small positive effect. However, they also found that more PE time resulted in a substitution away from light physical activity. Sixth, the availability of parks and other outdoor public facilities, which as noted earlier has been shown to be correlated with children's physical activity, were not accounted for. Finally, facility user cost was not addressed. Access barriers relate to both availability and cost. Future studies that could link local-area price data for physical activity opportunities would contribute immensely to this debate.

Despite these limitations, the results from this study revealed statistically significant, albeit very small, associations between the availability of commercial physical activity–related facilities and physical activity levels among a national sample of U.S. adolescents. The results suggested that improved availability was likely to be more important for female and older students whose rates of physical activity tend to be lower than their respective male and younger counterparts.

However, given the small magnitude of incremental effects of commercial facility outlet density on physical activity behavior, any efforts to promote additional neighborhood facilities should be concentrated in areas with disparate availability to substantially improve the extent of availability. Also, increased availability of proximal commercial facilities within the neighborhood is likely to be particularly important for low-SES

populations given that they are less likely to have private means of transportation[34] to reach facilities outside of their immediate community. Improving availability among underserved minority and low-SES populations may help to increase activity levels and reduce health disparities.

We gratefully acknowledge research support from the Robert Wood Johnson Foundation through Bridging the Gap for the ImpacTeen and Youth, Education, and Society studies. Monitoring the Future data were collected under a grant from the National Institute on Drug Abuse. We thank Yanjun Bao and Donka Mirtcheva at the University of Illinois and Deborah Kloska at the University of Michigan for their excellent research assistance.

No financial disclosures were reported by the authors of this paper.

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