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# Exercise and Substance Use Among American Youth, 1991–2009

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## Abstract

**Background—**The National Institute on Drug Abuse has called for increased research into the use of physical activity in substance abuse prevention, specifically research into physical activity type and context.

**Purpose—**This paper examines the relationships between (1) secondary school student substance use and (2) exercise in general and school athletic team participation, and examines such relationships over time.

**Methods—**Nationally representative cross-sectional samples of 8th, 10th, and 12th grade students were surveyed each year from 1991 to 2009. Substance use measures included past 2-week binge drinking and past 30-day alcohol, cigarette, smokeless tobacco, marijuana, and steroid use. Analyses were conducted during 2009–2010.

**Results—**Across grades, higher levels of exercise associated with lower levels of alcohol, cigarette, and marijuana use. Higher levels of athletic team participation associated with higher levels of smokeless tobacco use and lower levels of cigarette and marijuana use across grades and to higher levels of high school alcohol and steroid use. Exercise helped suppress the undesired relationship between team participation and alcohol use; exercise and athletic team participation worked synergistically in lowering cigarette and marijuana use. Observed relationships were generally stable across time.

**Conclusions—**There appear to be substantive differences between exercise and team sport participation in relation to adolescent substance use. These findings from cross-sectional data suggest that interventions to improve levels of general physical activity should be evaluated to determine if they help delay or reduce substance use among youth in general as well as among student athletes.

## Introduction

The costs of tobacco, illicit drug, and alcohol abuse are staggering;[1–4] improved prevention methods are needed. Support for exercise in preventing substance use is well-grounded in theory and neurobiology.[5–14] However, the National Institute on Drug Abuse has identified important knowledge gaps in the relationship between physical activity and substance use including "…type, amount, context (including access), and persistence of physical activity.



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…"[15] The current study focuses on relationships between physical activity type and adolescent substance use.

Adolescence is a key developmental stage for prevention; most substance initiation occurs at ages <18 years.[16,17] Early onset associates with heavier, problematic substance use;[18] delaying onset results in substantially less lifetime use and dependence.[19,20] Effective strategies to increase physical activity among adolescents do exist.[21,22] Thus, utilizing physical activity in substance use prevention among adolescents is promising if relationships between adolescent physical activity and substance use can be further explored.[15]

Youth substance use and poor exercise are interrelated.[23,24] However, studies indicate no single relationship between adolescent exercise and substance use. Alcohol has associated positively to exercise in some studies,[25–29] negatively in others,[30,31] and has been unassociated in others.[32,33] For cigarettes, exercise primarily associates with lower levels of use;[25,34,35] however, some studies have shown no or inconsistent findings.[36,37] Relationships between exercise and illegal drug use are generally negative,[25,30,38,39] but positive with smokeless tobacco.[25,35,39]

Such inconsistencies may associate with how exercise is defined. Team or competitive sport participation associates positively with alcohol for adolescents overall,[25,28,29] or men/boys only.[26] Among highly athletic youth and young adults (aged 16–24 years), team sports associated with higher levels of alcohol use than non-team-based sports.[40] In contrast, exercise frequency and intensity has associated with lowered prevalence of being drunk and driving after drinking.[30] Both team sports and exercise frequency and intensity associate with decreased cigarette and illicit drug use.[25,30,39] Hypotheses associated with team sports participation and adolescent substance use include both protective and risk-related factors.[41] Knowledge of differences in how adolescent substance use associates with physical activity based on type of exercise could strengthen available approaches to reduce or delay adolescent substance use as well as identify at-risk populations.

Two studies have compared adolescent substance use based on interacting team sport participation and exercise level/frequency: Rainey and colleagues used 1991 and 1993 high school South Carolina data;[28] Kulig and colleagues used nationally representative 1999 high school data.[38] Rainey found highly active athletes more likely to use alcohol than low-activity and sedentary nonathletes. Kulig found that lower levels of cigarette use was seen among physically active female sports team members compared with nonactive women who are not members of sports teams. Neither study included middle school students nor did they examine if findings held over time.

The current study: (1) examines relationships between general exercising and school athletic team participation and substance use among U.S. middle and high school students from 1991 to 2009; (2) explores interactions between exercise and team participation; and (3) investigates relationship stability over time. Hypotheses are that (1) higher levels of exercise will associate with lower levels of alcohol, cigarette and marijuana use and will have mixed relationships with smokeless tobacco and steroid use; (2) higher levels of athletic team participation will associate with higher levels of alcohol, smokeless tobacco, and steroid use but lower levels of cigarette and marijuana use; (3) results will be similar across grades; and (4) results will be stable across time.

## Methods

Analyses utilize Monitoring the Future (MTF) study data; detailed methodology is available elsewhere.[17] MTF annually surveys nationally representative cross-sectional samples of approximately 45,000 8$^{th}$, 10$^{th}$, and 12$^{th}$ grade students in the coterminous U.S.. Informed

consent was obtained; the University of Michigan Behavioral Sciences IRB approved the study. Classroom surveys were administered by study personnel. From 1991 to 2009, student response rates averaged 90%, 87%, and 83% for 8th, 10th, and 12th grades, respectively. Absenteeism was the primary reason for missing data; less than 1% of students refused participation.

### Measures

**Substance use—**Students self-reported recent substance use (recent use was used to lessen endogeneity among substance use, exercise and athletic team participation). Past 30-day alcohol, marijuana, and steroid use (1=0 occasions, 2=1–2, 3=3–5, 4=6–9, 5=10–19, 6=20–39, 7=40 or more occasions). Binge drinking (having 5 or more drinks in a row) in the past 2 weeks (1=none, 2=once, 3=twice, 4=3–5 times, 5=6–9 times, 6=10 or more times). Past 30-day smoking (1=not at all, 2= <1 cigarette per day, 3=1–5 cigarettes per day, 4=about ½ pack per day, 5=about 1 pack per day, 6=about 1 ½ packs per day, 7=2 packs or more per day). Past 30-day smokeless tobacco use (1=not at all, 2=once or twice, 3=once or twice per week, 4=3–5 times per week, 5=about once a day, 6=more than once a day).

**Exercise participation—**General exercise participation (hereafter referred to as exercise): "How often do you…actively participate in sports, athletics or exercising"? (1=never, 2=a few times a year, 3=once or twice a month, 4=at least once a week, 5=almost every day). Athletic team participation: "To what extent have you participated in the following school activities during this school year?… athletic teams" (1=not at all, 2=slight, 3=moderate, 4=considerable, 5=great).

**Control variables—**Self-reported race/ethnicity, parental education, and gender were used as demographic controls; multivariate models included dummy year variables. Race/ethnicity was coded as African-American, Hispanic, white, or Other. Parental education was a 5-point ordinal variable representing student-reported parental educational attainment and was a proxy for family SES. These measures have been shown to be key predictors of adolescent substance use and physical activity.[17,42,43]

### Statistical Analysis

Weighted sample sizes for cases without missing data on control variables or exercise and athletic team participation were 289,503 for middle school (8th graders) and 363,708 for high school (10th and 12th grade combined). Data were weighted to adjust for differential probability of school and student selection. Analyses were conducted during 2009–2010 and corrected for clustered sampling design effects using SAS v.9.2 surveymeans and surveyreg procedures. Analyses are presented separately for middle and high school (clear differences emerged between 8th and 10th/12th grades; overall findings did not differ between 10th and 12th grades). Multivariate models were first run with all years combined and then separately for four time periods: 1991–1995, 1996–2000, 2001–2005, and 2006–2009. Year groupings allowed for concise result presentation while still capturing overall substance use trends.[17]

## Results

Mean exercise participation was 4.09 in middle school and 3.94 in high school. Mean athletic team participation was 3.14 for middle school and 2.85 for high school. Among middle school students, the Pearson correlation between these two measures was 0.51 ($p<.001$); among high school students, the correlation was 0.57 ($p<.001$). Thus, while overlapping, the terms each retain a unique measure of the exercise spectrum. Including both terms in analytic models showed variance inflation factors of 1.51 or less, well below levels indicating multicollinearity.[44] Descriptive data can be found in Table 1.

Table 2 shows trends in substance use, exercise, and athletic team participation. The two physical activity measures showed minor changes over time; substance use exhibited previously documented significant shifts.[17]

## Associations from Bivariate Models and After Adding Controls

Table 3 presents bivariate model results and nonstandardized and standardized estimates from models controlling for sociodemographics. Given the large sample, results are considered significant only with probabilities less than or equal to .001. Middle school bivariate models showed exercise associated negatively with alcohol, cigarette, and marijuana use; positively to steroid use; and was unassociated with smokeless tobacco use. Relationships remained unchanged after adding control variables. Among high school students, exercise showed no significant bivariate relationship with alcohol use; significant negative relationships were observed for cigarette and marijuana use; positive relationships were found for smokeless tobacco and steroids. Adding controls to high school models resulted in the negative relationships between exercise and alcohol to reach significance and removing significance for smokeless tobacco. Standardized estimates indicated the largest exercise effect was found for cigarettes (a 1 SD increase in exercise resulted in a 0.10 SD use decrease for middle school and a 0.16 SD use decrease for high school) followed by marijuana (with a 1 SD increase associated with a 0.07 SD use decrease for middle school and 0.10 SD use decrease for high school).

Athletic team participation showed significant negative relationships with alcohol, cigarette and marijuana use and positive relationships for smokeless tobacco and steroid use in bivariate middle school models. With controls, significance dropped for past 30-day alcohol use. For high school students, bivariate models showed higher athletic team participation associated with significantly more alcohol, smokeless tobacco and steroid use but significantly less cigarette and marijuana use. Adding controls did not change these relationships. Standardized estimates showed that effect sizes for team sports participation were strongest for cigarette use for both middle and high school students, followed by marijuana.

## Additive and Interactive Relationships

Table 4 provides results of multivariate additive (exercise and athletic team participation entered simultaneously) or interactive (measures entered simultaneously with interaction term) models for all years combined. The additive model examines the direct effect of changes in exercise on substance use holding team sports participation constant and vice versa. In contrast, the interaction model examines the possibility that the relationship between exercise and substance use changes as a function of team sports participation and vice versa. All continuous measures were mean-centered; the interaction term was created by multiplying the mean-centered exercise and team sports measures. If the interactive model was not significant, only the additive model is shown. Because all years were combined in Table 4 models, results were considered significant only with probabilities less than or equal to .001. Table 5 presents results for models run by year groupings with probabilities less than or equal to .05 shown.

**Past 30-day alcohol use—**Exercise remained significantly associated with lower past 30-day alcohol use for middle school students; athletic team participation continued to show no significant relationship. Exercise was significantly and negatively associated with high school alcohol use; athletic team participation was positively associated. The significant high school interaction term indicated that exercise helped suppress the positive relationship between athletic team participation and alcohol use. These findings were generally stable across time (see Table 5). The predicted means for high school alcohol use from additive

and interactive models showed that alcohol use remained virtually constant across all levels of team participation with almost daily exercise. However, as exercise dropped, the slope of alcohol use rose dramatically as team participation rose.

**Binge drinking—**Significant negative relationships continued to be observed between exercise and binge drinking among middle school students. However, athletic team participation was no longer significant; no significant interaction was observed. High school results showed exercise continued to have a negative relationship, while athletic team participation continued to be positively associated. The significant interaction term indicated exercise helped suppress the positive relationship between athletic team participation and binge drinking. Observed results for middle school were stable across time. Among high school students, significant interactions were observed during 1991–1995 and 2006–2009 only.

**Cigarette smoking—**Exercise and athletic team participation continued to associate significantly and negatively to cigarette smoking with no interaction effects among middle school students. Similar results were observed for high school students; however, the interactive model indicated that the two forms of physical activity worked synergistically to decrease cigarette smoking. Relationships were stable across time.

**Smokeless tobacco—**In contrast to Table 3 results, both middle and high school additive models showed exercise associated with lower levels of smokeless tobacco use. Examination of results over time, however, showed that this was the case for only 1996–2005 for middle school students. Athletic team participation continued to be associated with higher levels of use; no interaction effects were observed (findings were stable over time).

**Marijuana use—**Higher levels of exercise and athletic team participation associated with lower levels of middle school marijuana use with no significant interactions. For high school students, exercise and athletic team participation remained independently and significantly associated with lower levels of marijuana use; the significant interaction term indicated the two types of physical activity worked together as was observed for cigarette use. Findings were very stable over time.

**Steroid use—**Models showed no relationships between steroid use and either exercise or athletic team participation for middle school students. Among high school students, athletic team participation continued to associate with higher levels of steroid use in the additive model with no observed interaction effects (this remained consistent over time).

## Discussion

This paper examined relationships among substance use, exercise and athletic team participation among U.S. middle and high school youth from 1991 to 2009. Exercise is associated with lower prevalence of middle and high school use of several substances. In contrast, school athletic team participation had mixed results with substance use. Results were generally stable across time.

### Athletic Team Participation

Higher levels of athletic team participation associated with higher levels of smokeless tobacco use but lower levels of cigarette and marijuana use for both middle and high school, and higher levels of high school alcohol and steroid use. Students who frequently participate in school-based athletic teams report more use of some substances. While athletic team participation is hypothesized to be protective against substance use via higher levels of adult

supervision, reduction in free time, and age/gender separation,[45] it also involves factors associated with increased substance use that are not strongly associated with general exercise participation.[41] Athletic team participant substance use has been associated with higher levels of conformity, perceived norms, and personality characteristics of competitiveness, extroversion, and risk-taking. Youth with delinquent histories may tend to drop out of school athletics, leaving a group with comparatively higher level of conformity,[46] which may involve a higher likelihood to conform to perceived substance use norms.

Alcohol consumption is closely tied to U.S. sports with similarities between sports fan and beer drinker demographics, alcohol industry advertising and sponsorship of athletic events, and athlete alcohol consumption.[47] Perceived social norms consistently associate with young adult alcohol use.[48,49] College athletes' own alcohol consumption has been predicted significantly better by perceptions of athlete use than general student population use.[50] Most U.S. schools have written substance use policies;[51,52] many have clear violation consequences for student athletes.[53]

Certainly, U.S. federal policy prohibits marijuana use. Students with higher levels of conformity (athletes) may be more likely to adhere to such policies (especially if consequences include being barred from sports participation). However, policies may be effective only with reliable enforcement, and effectiveness may be limited to substances perceived to be unaccepted by athletic peers and the larger sporting world. In the current analyses, as athletic team participation (and exercise) rose the use of marijuana and cigarettes dropped. Among high school students, however, athletic team participation was associated with higher levels of alcohol use. Given the illegality of marijuana, and the increasing recognition and acceptance of the dangers of cigarette use, such results make sense based on conformity. Regarding alcohol, however, not only is there a strong social connection with sport, but research also indicates perceived leniency on the part of policy enforcers such as coaches may be associated with higher levels of college student use.[54] Secondary school alcohol prevention efforts may be improved by enlisting the active involvement and support of coaches and other adult role models who frequently interact with student athletes.

Smokeless tobacco is strongly associated with sport, especially baseball. Tobacco companies frequently gave free samples to athletes and teams,[55–57] and famous athletes were employed as product spokespeople.[55] Experimentation and use of smokeless tobacco has been shown to be high among both high school and rookie baseball players.[58,59] Participation in organized sports in general—not just baseball—has been shown to predict youth smokeless tobacco use.[35,60] While youth smokeless tobacco use has decreased substantially since 1991,[17] the current study shows that athletic team participation remains associated with its use.

## Exercise

Among daily exercising youth, a higher level of team sport participation was not associated with alcohol use, and predicted means of cigarette and marijuana use were lowest for highly physically active athletic team participants. Thus, among both non–team athletes and athletic team participants, higher levels of actual physical exercise had a desired negative relationship with substance use. Such findings may reflect exercise-associated improved brain cognition and executive function, as well as endorphin and neurotransmitter release discussed in the Introduction.

The current analyses indicate general exercise associates with lower levels of alcohol, cigarette, and marijuana use. These results were stable over time even with shifting

substance use trends. Efforts to incorporate physical activity into prevention programming should focus on developing interventions that result in adolescents increasing enjoyment of and involvement in exercise for general reasons. Such efforts may help delay or reduce substance use among not only the general youth population, but also high school student athletes. If successful, such efforts may also then result in lower levels of use and abuse of substances as youth transition to young adulthood and beyond.

### Middle School, High School, and Substance Use

Why should the positive relationship between athletic team participation and alcohol use be limited to high school? And why should significant interactions between athletic team participation and exercise be limited to high school for alcohol, cigarettes, and marijuana? Substance use is less frequent in middle than high school; however, prevalence rates are still high enough to detect relationships (for example, an average of over 20% of 8$^{th}$ graders reported past 30-day alcohol use from 1991 to 2008).[17] Further, the data show that more middle school youth participate in athletic teams than high school youth; thus, low participation rates cannot account for observed differences. The population participating in athletic teams throughout the high school years may exhibit qualitatively different motivations and personality characteristics associated with higher levels of alcohol use. Research confirms substantial attrition in almost all team sports as students move from middle school to completion of high school.[61] Part of such attrition may be attributable to a higher level of competition; by the senior year, student sport participation is limited to the most skilled and likely most competitive,[61] a characteristic associated with increased alcohol consumption.[62]

### Limitations

These findings should be considered within their limitations. Available physical activity and substance use measures were single-item self-report measures. The single-item general exercise measure did not incorporate exercise intensity or duration, and the single-item team sports participation item did not account for participation in team sports outside of school environments or differences in type of team sport. Some school districts do not offer school-based team sports; youth who were involved in non-school-based athletic teams may have been excluded. Further, research has indicated significant differences in substance use rates by type of team sport.[40,63,64] The data are cross-sectional and thus cannot be used to draw causal conclusions. However, as noted previously, 30-day substance use was chosen as the time frame to minimize endogeneity. Such limitations notwithstanding, this study's use of a representative national sample and consistent measures over time contribute substantially to understanding the relationships between adolescent physical activity and substance use.

## Conclusion

The current study supports the possible preventive effects of physical exercise on adolescent substance use and indicates important differences exist between general exercise and team sports participation. Frequent exercise appears to associate strongly with lowered levels of adolescent alcohol, tobacco, and marijuana use for the general student population and school athletic team participants.

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## Table 1

Sample Descriptives for Middle School (8th Grade) and High School (10th and 12th grades), 1991–2009

| | Range | Middle school M (SE) | High school M (SE) |
|---|---|---|---|
| **Weighted *n*[a]** | | 289,503 | 363,708 |
| **Substance use outcomes** | | | |
| Alcohol: # of occasions in past 30 days | 1–7 | 1.38 (0.005) | 1.80 (0.007) |
| Binge drinking: # of occasions in past 2 weeks | 1–6 | 1.21 (0.003) | 1.49 (0.005) |
| Cigarette smoking: Average # of cigarettes per day in past 30 days | 1–7 | 1.25 (0.004) | 1.46 (0.006) |
| Smokeless tobacco: use in past 30 days | 1–6 | 1.11 (0.004) | 1.18 (0.005) |
| Marijuana: # of occasions in past 30 days | 1–7 | 1.17 (0.004) | 1.45 (0.005) |
| Steroids: # of occasions in past 30 days | 1–7 | 1.01 (0.000) | 1.02 (0.001) |
| **Independent predictors** | | | |
| Participation in sports, athletics, or exercising | 1–5 | 4.09 (0.007) | 3.94 (0.006) |
| Extent of participation in school athletic teams | 1–5 | 3.14 (0.013) | 2.85 (0.009) |
| **Control variables** | | | |
| Male | 0, 1 | 0.48 (0.001) | 0.49 (0.002) |
| Race/ethnicity | | | |
| African-American | | 0.13 (0.006) | 0.12 (0.004) |
| Hispanic | | 0.11 (0.005) | 0.11 (0.004) |
| White | | 0.60 (0.007) | 0.67 (0.006) |
| Other/missing data | | 0.15 (0.003) | 0.11 (0.002) |
| Parental education indicator | 1–5 | 3.14 (0.015) | 3.12 (0.013) |

[a]Including cases with no missing data for either control variables, and requiring valid data for at least one of the independent predictors.

## Table 2

Trends in exercise, athletic team participation, and substance use among secondary school students, 1991–2009; M (SE)

| | 1991–1995 | 1996–2000 | 2001–2005 | 2006–2009 |
|---|---|---|---|---|
| Middle school | | | | |
| Exercise | 4.09 (0.014) | 4.08 (0.013) | 4.08 (0.014) | 4.12 (0.015) |
| Athletic team participation | 3.12 (0.026) | 3.15 (0.023) | 3.17 (0.026) | 3.09 (0.028) |
| Alcohol use | 1.44 (0.008) | 1.43 (0.008) | 1.33* (0.008) | 1.27* (0.008) |
| Binge drinking | 1.23 (0.006) | 1.25 (0.006) | 1.19* (0.006) | 1.16* (0.006) |
| Cigarette use | 1.31 (0.007) | 1.33 (0.008) | 1.18* (0.006) | 1.13* (0.005) |
| Smokeless tobacco use | 1.15 (0.009) | 1.11* (0.006) | 1.08* (0.006) | 1.08* (0.005) |
| Marijuana use | 1.12 (0.006) | 1.23* (0.008) | 1.18* (0.007) | 1.14 (0.006) |
| Steroid use | 1.01 (0.001) | 1.01 (0.001) | 1.01 (0.001) | 1.01 (0.001) |
| High school | | | | |
| Exercise | 3.97 (0.011) | 3.93 (0.011) | 3.91* (0.012) | 3.96 (0.013) |
| Athletic team participation | 2.84 (0.017) | 2.86 (0.016) | 2.86 (0.017) | 2.87 (0.020) |
| Alcohol use | 1.86 (0.013) | 1.88 (0.013) | 1.76* (0.012) | 1.66* (0.012) |
| Binge drinking | 1.49 (0.009) | 1.55* (0.010) | 1.48 (0.009) | 1.42* (0.009) |
| Cigarette use | 1.54 (0.010) | 1.62* (0.011) | 1.38* (0.008) | 1.28* (0.007) |
| Smokeless tobacco use | 1.25 (0.011) | 1.17* (0.010) | 1.14* (0.008) | 1.15* (0.006) |
| Marijuana use | 1.32 (0.009) | 1.56* (0.010) | 1.50* (0.010) | 1.42* (0.010) |
| Steroid use | 1.01 (0.001) | 1.02* (0.001) | 1.02* (0.001) | 1.02 (0.001) |

*Notes*: All substance use outcomes other than binge drinking represent reported use over the past 30 days. For binge drinking, the measure represents the reported number of occasions over the past 2 weeks. Middle school = $8^{th}$ grade; high school = $10^{th}$ and $12^{th}$ grades combined. Exercise refers to exercise in general, indicating reported level of participation in sports, athletics, or exercising. Athletic team participation indicates the extent of participating in school athletic teams.

* $p \leq 0.001$ in comparison with 1991–1995.

**Table 3**

Secondary school student substance use, exercise and athletic team participation: bivariate and multivariate models

| Outcome[a] | | | Exercise[c] | | | | | Athletic team participation[d] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| School | *n* (weighted) | Bivariate[e] | | Multivariate[f] | | | Bivariate | | Multivariate | | |
| Level[b] | | b[g] | p | b | B[h] | p | b | p | b | B | p |
| Alcohol use | | | | | | | | | | | |
| Middle school | 112,950 | −0.0235 | * | −0.0165 | −0.0235 | * | −0.0105 | * | −0.0054 | −0.0106 | |
| High school | 198,754 | −0.0056 | | −0.0102 | −0.0109 | * | 0.0087 | * | 0.0108 | 0.0152 | * |
| Binge drinking | | | | | | | | | | | |
| Middle school | 111,446 | −0.0254 | * | −0.0187 | −0.0331 | * | −0.0107 | * | −0.0058 | −0.0141 | * |
| High school | 196,087 | −0.0049 | | −0.0098 | −0.0125 | * | 0.0137 | * | 0.0138 | 0.0232 | * |
| Cigarette use | | | | | | | | | | | |
| Middle school | 118,005 | −0.0635 | * | −0.0572 | −0.0963 | * | −0.0395 | * | −0.0349 | −0.0812 | * |
| High school | 204,292 | −0.1216 | * | −0.1202 | −0.1573 | * | −0.0849 | * | −0.0793 | −0.1364 | * |
| Smokeless tobacco use | | | | | | | | | | | |
| Middle school | 118,840 | 0.0022 | | −0.0021 | −0.0046 | | 0.0073 | * | 0.0064 | 0.0192 | * |
| High school | 135,480 | 0.0109 | * | −0.0034 | −0.0058 | | 0.0195 | * | 0.0130 | 0.0295 | * |
| Marijuana use | | | | | | | | | | | |
| Middle school | 118,303 | −0.0424 | * | −0.0388 | −0.0665 | * | −0.0279 | * | −0.0251 | −0.0594 | * |
| High school | 203,732 | −0.0769 | * | −0.0833 | −0.0906 | * | −0.0587 | * | −0.0625 | −0.0893 | * |
| Steroid use | | | | | | | | | | | |
| Middle school | 119,555 | 0.0014 | * | 0.0012 | 0.0076 | * | 0.0013 | * | 0.0013 | 0.0120 | * |
| High school | 202,104 | 0.0025 | * | 0.0017 | 0.0093 | * | 0.0029 | * | 0.0026 | 0.0181 | * |

[a] All substance use outcomes other than binge drinking represent reported use over the past 30 days. For binge drinking, the measure represents the reported number of occasions over the past 2 weeks.

[b] Middle school = 8th grade; high school = 10th and 12th grades combined.

[c] Exercise in general, indicating reported level of participation in sports, athletics, or exercising.

[d] Athletic team participation, indicating the extent of participating in school athletic teams.

[e] Bivariate relationships for each main predictors (exercise, athletic team participation) and specified substance use outcome separately.

[f] Models included each main predictor separately as well as controls for gender, race/ethnicity, average parental education, and year (high school models also controlled for grade).

[g] Nonstandardized regression parameter estimates.

[h] Standardized regression parameter estimates (M=0; SD=1).

[*] $p \leq 0.001$

**Table 4**

Secondary school student substance use, exercise and athletic team participation: additive and interactive multivariate models 1991–2009

| Outcome[a] | School Level[b] | *n*(wtd) | Exercise[c] | | Athletic Team Participation[d] | | Interaction[e] | |
|---|---|---|---|---|---|---|---|---|
| | | | b[f] | p | b | p | b | p |
| Alcohol use | | | | | | | | |
| | Middle school | 112,950 | −0.0195 | * | 0.0013 | | | |
| | High school | 198,754 | −0.0321 | * | 0.0253 | * | −0.0150 | * |
| Binge drinking | | | | | | | | |
| | Middle school | 111,446 | −0.0243 | * | 0.0026 | | | |
| | High school | 196,087 | −0.0290 | * | 0.0266 | * | −0.0106 | * |
| Cigarette use | | | | | | | | |
| | Middle school | 118,005 | −0.0433 | * | −0.0197 | * | | |
| | High school | 204,292 | −0.1071 | * | −0.0343 | * | −0.0137 | * |
| Smokeless tobacco use | | | | | | | | |
| | Middle school | 118,840 | −0.0080 | * | 0.0091 | * | | |
| | High school | 135,480 | −0.0169 | * | 0.0200 | * | | |
| Marijuana use | | | | | | | | |
| | Middle school | 118,303 | −0.0309 | * | −0.0144 | * | | |
| | High school | 203,732 | −0.0728 | * | −0.0313 | * | −0.0165 | * |
| Steroid use | | | | | | | | |
| | Middle school | 119,555 | 0.0007 | | 0.0011 | | | |
| | High school | 202,104 | −0.0006 | | 0.0028 | * | | |

*Notes*: All models included both predictors simultaneously and also controlled for gender, race/ethnicity, average parental education, and year (high school models also controlled for grade). All continuous outcomes and predictors were mean-centered prior to analysis. If the model included an interaction term for exercise and athletic team participation that was significant, results for the interaction model are shown. If the interaction term was not significant, results from the additive model are reported.

[a] All substance use outcomes other than binge drinking represent reported use over the past 30 days. For binge drinking, the measure represents the reported number of occasions over the past 2 weeks.

[b] Middle school = 8$^{th}$ grade; high school = 10$^{th}$ and 12$^{th}$ grades combined

[c] Exercise in general, indicating reported level of participation in sports, athletics, or exercising

[d] Athletic team participation, indicating the extent of participating in school athletic teams

[e] Exercise x athletic team participation (both variables mean-centered prior to creating the interaction)

[f] Nonstandardized regression parameter estimates

* p≤.001

**Table 5**

Trends over time in secondary school student substance use, exercise and athletic team participation: additive and interactive multivariate models

| Outcome[a] | School Level[b] | N(wtd) | Year Grouping[c] | Exercise[d] | | Athletic Team Participation[e] | | Interaction[f] | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | b[g] | p | b | p | b | p |
| Alcohol use | | | | | | | | | |
| | MS | 30,076 | '91–'95 | −0.0137 | | 0.0013 | | | |
| | | 29,640 | '96–'00 | −0.0248 | *** | −0.0024 | | | |
| | | 29,790 | '01–'05 | −0.0237 | *** | 0.0034 | | | |
| | | 23,444 | '06–'09 | −0.0151 | * | 0.0031 | | | |
| | HS | 53,617 | '91–'95 | −0.0397 | *** | 0.0260 | *** | −0.0162 | *** |
| | | 50,303 | '96–'00 | −0.0377 | *** | 0.0213 | *** | −0.0114 | * |
| | | 51,886 | '01–'05 | −0.0231 | ** | 0.0234 | *** | −0.0119 | ** |
| | | 42,948 | '06–'09 | −0.0274 | ** | 0.0295 | *** | −0.0224 | *** |
| Binge drinking | | | | | | | | | |
| | MS | 29,828 | '91–'95 | −0.0212 | *** | 0.0007 | | | |
| | | 29,281 | '96–'00 | −0.0291 | *** | 0.0001 | | | |
| | | 29,302 | '01–'05 | −0.0252 | *** | 0.0055 | | | |
| | | 23,035 | '06–'09 | −0.0211 | *** | 0.0038 | | | |
| | HS | 53,164 | '91–'95 | −0.0354 | *** | 0.0282 | *** | −0.0127 | ** |
| | | 49,625 | '96–'00 | −0.0348 | *** | 0.0251 | *** | −0.0065 | |
| | | 51,086 | '01–'05 | −0.0182 | ** | 0.0206 | *** | −0.0073 | |
| | | 42,212 | '06–'09 | −0.0278 | *** | 0.0314 | *** | −0.0174 | *** |
| Cigarette use | | | | | | | | | |
| | MS | 31,662 | '91–'95 | −0.0436 | *** | −0.0237 | *** | | |
| | | 30,996 | '96–'00 | −0.0590 | *** | −0.0242 | *** | | |
| | | 31,004 | '01–'05 | −0.0359 | *** | −0.0193 | *** | | |
| | | 24,343 | '06–'09 | −0.0333 | *** | −0.0104 | *** | | |
| | HS | 55,194 | '91–'95 | −0.1228 | *** | −0.0496 | *** | −0.0113 | ** |
| | | 51,731 | '96–'00 | −0.1352 | *** | −0.0413 | *** | −0.0176 | *** |
| | | 53,270 | '01–'05 | −0.0897 | *** | −0.0263 | *** | −0.0119 | *** |

| Outcome[a] | School Level[b] | N(wtd) | Year Grouping[c] | Exercise[d] | | Athletic Team Participation[e] | | Interaction[f] | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | b[g] | p | b | p | b | p |
| | | 44,096 | '06–'09 | −0.0763 | *** | −0.0194 | *** | −0.0125 | *** |
| Smokeless tobacco use | | | | | | | | | |
| | MS | 31,886 | '91–'95 | −0.0083 | | 0.0115 | *** | | |
| | | 31,218 | '96–'00 | −0.0084 | * | 0.0061 | * | | |
| | | 31,160 | '01–'05 | −0.0109 | ** | 0.0100 | ** | | |
| | | 24,576 | '06–'09 | −0.0045 | | 0.0072 | ** | | |
| | HS | 32,618 | '91–'95 | −0.0156 | ** | 0.0251 | *** | | |
| | | 31,153 | '96–'00 | −0.0238 | *** | 0.0227 | *** | | |
| | | 35,115 | '01–'05 | −0.0139 | *** | 0.0165 | *** | | |
| | | 36,595 | '06–'09 | −0.0141 | *** | 0.0146 | *** | | |
| Marijuana use | | | | | | | | | |
| | MS | 31,802 | '91–'95 | −0.0222 | *** | −0.0118 | *** | | |
| | | 31,026 | '96–'00 | −0.0458 | *** | −0.0205 | *** | | |
| | | 31,002 | '01–'05 | −0.0304 | *** | −0.0162 | *** | | |
| | | 24,473 | '06–'09 | −0.0228 | *** | −0.0079 | * | | |
| | HS | 55,240 | '91–'95 | −0.0599 | *** | −0.0256 | *** | −0.0121 | *** |
| | | 51,534 | '96–'00 | −0.0913 | *** | −0.0419 | *** | −0.0134 | ** |
| | | 53,040 | '01–'05 | −0.0690 | *** | −0.0339 | *** | −0.0208 | *** |
| | | 43,918 | '06–'09 | −0.0707 | *** | −0.0229 | *** | −0.0201 | *** |
| Steroid use | | | | | | | | | |
| | MS | 32,023 | '91–'95 | −0.0004 | | 0.0012 | | | |
| | | 31,419 | '96–'00 | 0.0021 | | 0.0000 | | | |
| | | 31,363 | '01–'05 | 0.0009 | | 0.0009 | | | |
| | | 24,750 | '06–'09 | 0.0003 | | 0.0024 | * | | |
| | HS | 54,781 | '91–'95 | −0.0006 | | 0.0019 | ** | | |
| | | 50,981 | '96–'00 | 0.0006 | | 0.0032 | ** | | |
| | | 52,607 | '01–'05 | −0.0010 | | 0.0036 | *** | | |
| | | 43,735 | '06–'09 | −0.0018 | | 0.0027 | ** | | |

*Notes*: All models included both predictors simultaneously and also controlled for gender, race/ethnicity, average parental education, and year (high school models also controlled for grade). All continuous outcomes and predictors were mean-centered prior to analysis.

[a] All substance use outcomes other than binge drinking represent reported use over the past 30 days. For binge drinking, the measure represents the reported number of occasions over the past 2 weeks.

[b] MS= Middle school (8th grade); HS=High school (grades 10 and 12 combined).

[c] Separate models run for each year grouping.

[d] Exercise in general, indicating reported level of participation in sports, athletics, or exercising

[e] Athletic team participation, indicating the extent of participating in school athletic teams

[f] Exercise x athletic team participation (both variables mean-centered prior to creating the interaction)

[g] Nonstandardized regression parameter estimates

* $p<0.05$;

** $p<0.01$;

*** $p\leq0.001$