Fitness; Emotional Health

Vigorous Physical Activity, Mental Health, Perceived Stress, and Socializing Among College Students

Nicole A. VanKim, MPH; Toben F. Nelson, ScD

Abstract

Purpose. *To examine cross-sectional associations between vigorous physical activity, mental health, perceived stress, and socializing among 4-year college students.*

Design. *A national cross-sectional sample of 4-year colleges in the United States.*

Setting. *Ninety-four 4-year colleges in the United States.*

Subjects. *A total of 14,804 undergraduate students.*

Measures. *Self-report vigorous physical activity, perceived stress (measured using the Cohen Perceived Stress Scale), mental health (measured using the SF-36), and socializing (assessed using self-report number of friends and hours spent socializing).*

Analysis. *Logistic regression models accounting for clustering within schools were estimated to examine the association between vigorous physical activity, mental health, perceived stress, and socializing. Adjusted models included high school vigorous physical activity and sociodemographic characteristics.*

Results. *Students who met vigorous physical activity recommendations were less likely to report poor mental health (adjusted odds ratio [OR]: .79; 95% confidence interval [CI]: .69, .90) and perceived stress (adjusted OR: .75; 95% CI: .67, .83) than students who did not meet recommendations. In addition, socializing partially mediated the relationship between vigorous physical activity, mental health, and perceived stress; however, race and sex did not moderate the relationship.*

Conclusion. *Interventions aiming to improve mental well-being of college students should also consider promoting physical activity. At least some of the positive benefits of physical activity may arise from social interactions. (Am J Health Promot 2013;28[1]:7–15.)*

Key Words: Mental Health, Physical Activity, College Students, Socializing, Prevention Research. Manuscript format: research; Research purpose: modeling/relationship testing; Study design: nonexperimental; Outcome measure: cognitive, behavioral; Setting: national; Health focus: physical activity, intellectual health, social health, stress management; Strategy: skill building/behavior change; Target population age: adults; Target population circumstances: education

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BACKGROUND

The transition from adolescence into young adulthood represents a unique developmental period that can have a significant effect on the adaptation and maintenance of health behaviors.[1] Research has shown a substantial decrease in physical activity (PA) during the transition from adolescence into adulthood.[2–6] This behavioral change is of particular importance because lack of PA is one of the top three modifiable risk factors of chronic disease and premature death.[7] Thus, a major public health challenge is maintaining higher PA from adolescence into adulthood.[8] Although there is an overall decline in PA with age in general, certain subgroups, such as females and certain racial/ethnic groups, are less likely to engage in PA.[4,6,9,10] These groups may experience worse health outcomes because of insufficient PA.

Approximately a third of young adults (ages 18–24 years) in the United States attend college, representing a critical mass of the young adult population.[11] In addition to decreased PA, the transition to college can be academically and socially stressful for students.[12] In a study assessing cardiovascular health among college students, nearly 60% of participants reported high or very high stress.[13] Increases in reported stress could be attributed to the set of academic and social stressors within the college setting, such as examinations, interpersonal relationships, and the transition to living independently.[12] Relatedly, college can also be a period of increased risk for poor mental health

and depression.[14,15] A nationally representative study of college students found that 4.8% reported symptoms of poor mental health and depression,[14] and a study of adolescents and young adults (ages 15–24 years) from the National Comorbidity Survey found that 5.8% met *Diagnostic and Statistical Manual of Mental Disorders* (Third Edition Revised) criteria for major depression and 2.1% met criteria for minor depression in the past 30 days.[15] Recent national data from the Behavioral Risk Factor Surveillance System indicates that compared to other adult age groups, young adults (ages 18–24) have the highest prevalence of depressive symptoms that do not meet the criteria for major depression.[16] The ability to cope with the stressors associated with the college environment is important for maintaining both mental and physical health.

Existing evidence examining the relationship between PA and mental health has suggested that increased PA is associated with better mental health outcomes, such as mood, self-esteem, and anxiety.[17–20] Some studies have shown that PA reduces stress, anxiety, and depression among adults[21,22]; however, few studies have examined the influence of PA on stress or mental health among college students. A study by Nguyen-Michel and colleagues examined college students in three settings (private university, state university, and community college) and found a moderate inverse association between PA and perceived hassles in daily life, but no association with perceived stress.[23] Another study of college students found that vigorous PA was inversely associated with "feeling downhearted and blue."[24] One of the weaknesses of existing research on the relationship between PA and mental health has been the lack of concurrently collected data to facilitate adjustment for covariates such as social interactions.[25] There is little evidence to explain how much, if any, of the positive benefits of PA are due to socializing. Among young adults attending college, for whom literature is lacking, socializing may be a particularly salient variable in understanding the relationship between PA and mental health.

The purpose of this study is to examine the association of vigorous PA with mental health, perceived stress, and socializing in a national sample of 4-year college students. Based on previous research, we hypothesized that meeting vigorous PA recommendations is associated with better mental health and lower perceived stress. We further hypothesized that socializing will partially mediate the relationships between vigorous PA and mental health and between vigorous PA and perceived stress. Additionally, we hypothesized that race and sex will moderate the relationship between vigorous PA and mental health as well as between vigorous PA and perceived stress.

METHODS

Design and Sample

The participants in the current study were drawn from the Harvard School of Public Health Study of College Health Behaviors, a national sample of undergraduate students attending 4-year colleges in the United States conducted in 2004. Of the schools surveyed (N = 94) most participated in previous surveys of the Harvard School of Public Health College Alcohol Study (CAS).[26] The CAS schools were selected from a list of accredited universities provided by the American Council on Education, using probability sampling proportionate to size. More specifically, two-stage sampling was used, where colleges were selected proportionate to enrollment size, then students were randomly selected within the colleges. Twenty-eight colleges involved in the 2001 CAS survey were invited to participate in the 2004 survey but did not provide a random sample of students and their addresses within the time requirements of the study or were participating in other similar surveys. Three colleges were added to the sample based on their willingness to pay the incremental cost of collecting their data.

Administrators at each college provided a list of the names and postal and e-mail addresses of 750 randomly selected full-time undergraduate students enrolled during the 2003–04 school year. Colleges with fewer than 750 full-time undergraduates provided a list of all students. The survey questionnaire asked students to report on various health risk and protective behaviors and personal characteristics. The survey was conducted by a survey research center using a Web-based survey administered between February and May of 2004. Students were mailed a postcard notifying them that they were selected to participate in the study and to expect to be contacted by e-mail. E-mail invitations containing a direct, confidential Web link were sent to the address provided by the school registrar. Students were sent up to three reminder e-mails to encourage their participation. The survey site was closed around spring break to avoid responses that reflected behavior during spring vacation. Students who completed the survey or returned a response card were entered into a drawing for cash prizes up to $1500. Responses to the survey were voluntary, anonymous, and confidential, and on this basis, the study was approved with exempt review status by the Harvard School of Public Health's Human Subjects Committee. The overall response rate was 28% and ranged from 4.9% to 61.1% at the college level. These response rates are consistent with previous Internet-based studies and studies of the college population.[27,28]

Measures

Vigorous PA was assessed using the following question from the Youth Risk Behavior Survey[29]: "Think back over the past 7 days. On how many days did you exercise or participate in PA for at least 20 minutes that made you sweat or breathe hard, such as basketball, soccer, running, swimming laps, bicycling, or similar aerobic activities?" A similarly phrased question was used to assess vigorous PA during the respondents' last year of high school. Response choices ranged from 0 days to 7 days in whole days. For analysis, vigorous PA was dichotomized using 3 days per week as a cut point for both college and high school and consistent with recommended levels of vigorous PA.[30] Previous research has shown that vigorous PA may be more precisely measured than moderate PA.[31]

Mental health was assessed using the five-item mental health scale from the

Table 1
Vigorous PA Among Male and Female College Students Using Unweighted Sample Sizes and Weighted Proportions, N = 14,706†

			Met Vigorous PA Recommendations in College			
			Male		Female	
	Male, No.	Female, No.	%	OR (95% CI)‡	%	OR (95% CI)‡
Overall	5427	9279	54.4	1.00	48.9	0.82 (0.70, 0.89)*
High school vigorous PA						
Did not meet recommendations	1534	3193	36.8	1.00	36.4	1.00
Met recommendations	3893	6086	61.0	2.64 (2.27, 3.07)*	55.5	2.14 (1.91, 2.40)*
Age						
18–20	2986	5475	55.8	1.00	50.5	1.00
21–23	1910	3080	54.6	0.96 (0.86, 1.07)	48.0	0.92 (0.83, 1.01)
24+	531	724	41.3	0.57 (0.45, 0.71)*	42.2	0.78 (0.63, 0.98)*
Year in college						
Freshman	1405	2417	57.0	1.00	51.6	1.00
Sophomore	1269	2225	54.6	0.90 (0.79, 1.03)	48.8	0.88 (0.77, 1.02)
Junior	1290	2232	53.0	0.86 (0.73, 1.02)	48.0	0.86 (0.76, 0.98)*
Senior	1093	1952	53.8	0.89 (0.75, 1.04)	48.8	0.90 (0.75, 1.08)
Fifth year	370	453	47.3	0.70 (0.54, 0.90)*	41.6	0.70 (0.56, 0.89)*
Race						
White	4355	7240	55.0	1.00	52.0	1.00
African-American	200	483	57.5	1.12 (0.78, 1.61)	37.3	0.58 (0.45, 0.74)*
Asian	461	771	49.3	0.81 (0.67, 0.99)*	32.8	0.44 (0.37, 0.53)*
Other	411	785	51.6	0.87 (0.70, 1.12)	48.6	0.90 (0.74, 1.11)
Ethnicity						
Non-Hispanic	5032	8591	54.3	1.00	49.2	1.00
Hispanic	395	688	52.8	0.90 (0.71, 1.15)	46.5	0.96 (0.80, 1.15)
SEP (attended college)						
Both parents	2320	3602	57.3	1.00	53.2	1.00
Only one parent	1418	2520	52.7	0.85 (0.72, 1.00)	48.3	0.85 (0.76, 0.96)*
Neither parent	1689	3157	51.2	0.81 (0.69, 0.94)*	45.0	0.77 (0.68, 0.87)*
Weight status						
Underweight	106	453	24.5	0.28 (0.17, 0.46)*	34.3	0.51 (0.41, 0.64)*
Normal	3005	6567	54.0	1.00	50.8	1.00
Overweight	1642	1504	59.1	1.24 (1.10, 1.40)	50.4	1.00 (0.88, 1.14)
Obesity	499	469	50.5	0.89 (0.72 1.11)	43.2	0.76 (0.63, 0.93)*
Class II obesity	175	286	37.3	0.53 (0.39, 0.71)*	33.7	0.52 (0.40, 0.68)*
Mental health						
Good (41–100)	4987	8193	54.9	1.00	49.9	1.00
Poor (0–40)	440	1086	46.2	0.73 (0.56, 0.96)*	42.3	0.75 (0.66, 0.86)*
Perceived stress						
Low (0–8)	4722	7474	55.6	1.00	50.5	1.00
High (9–16)	705	1805	44.7	0.66 (0.56, 0.79)*	43.0	0.75 (0.66, 0.85)*
Socializing						
High (2+ h and 5+ friends)	2541	3762	60.5	1.00	55.0	1.00
Low (≤2 h or <5 friends)	2886	5517	48.5	0.62 (0.5, 0.69)*	44.8	0.69 (0.63, 0.76)*

† PA indicates physical activity; OR, odds ratio; CI, confidence interval; and SEP, socioeconomic position.
‡ Adjusted for response rate.
* Statistically significant at $p < 0.05$.

Table 2
Mental Health and Perceived Stress Among Male and Female College Students Using Unweighted Sample Sizes and Weighted Proportions, N = 14,706†

			Poor Mental Health				Perceived Stress			
			Male		Female		Male		Female	
	Male, No.	Female, No.	%	OR (95% CI)‡	%	OR (95% CI)‡	%	OR (95% CI)‡	%	OR (95% CI)‡
Overall	5427	9279	8.3	1.00	11.7	1.45 (1.28, 1.64)*	13.0	1.00	19.5	1.61 (1.47, 1.76)*
High school vigorous PA										
Did not meet recommendations	1534	3193	11.2	1.00	12.4	1.00	17.3	1.00	20.2	1.00
Met recommendations	3893	6086	7.1	0.62 (0.50, 0.76)	11.3	0.90 (0.79, 1.03)	11.3	0.61 (0.51, 0.97)	19.1	0.94 (0.84, 1.05)
Age										
18–20	2986	5475	7.9	1.00	11.7	1.00	13.9	1.00	20.6	1.00
21–23	1910	3080	8.3	1.05 (0.83, 1.33)	10.9	0.91 (0.78, 1.06)	11.7	0.82 (0.69, 0.98)*	17.9	0.84 (0.72, 0.98)*
24+	531	724	10.4	1.33 (0.88, 2.01)	14.6	1.23 (0.96, 1.57)	12.6	0.86 (0.61, 1.21)	18.3	0.84 (0.67, 1.06)
Year in college										
Freshman	1405	2417	7.7	1.00	11.9	1.00	13.3	1.00	21.5	1.00
Sophomore	1269	2225	7.2	0.94 (0.70, 1.25)	11.8	0.99 (0.83, 1.18)	14.5	1.10 (0.88, 1.38)	20.8	0.96 (0.84, 1.09)
Junior	1290	2232	9.4	1.23 (0.99, 1.54)	12.2	1.02 (0.83, 1.25)	13.7	1.03 (0.83, 1.27)	19.2	0.87 (0.75, 1.01)
Senior	1093	1952	7.8	1.01 (0.70, 1.46)	10.4	0.85 (0.68, 1.06)	9.8	0.70 (0.54, 0.91)*	16.2	0.71 (0.59, 0.85)*
Fifth year	370	453	11.1	1.49 (0.90, 2.47)	12.6	1.03 (0.76, 1.41)	13.2	0.96 (0.59, 1.55)	18.4	0.81 (0.63, 1.05)
Race										
White	4355	7240	8.0	1.00	10.7	1.00	12.1	1.00	18.6	1.00
African-American	200	483	4.9	0.58 (0.29, 1.18)	13.3	1.24 (0.91, 1.70)	14.1	1.18 (0.81, 1.70)	22.3	1.25 (0.99, 1.58)
Asian	461	771	10.5	1.35 (0.95, 1.92)	16.8	1.72 (1.39, 2.12)*	17.0	1.52 (1.20, 1.92)*	25.0	1.48 (1.18, 1.86)*
Other	411	785	9.8	1.25 (0.82, 1.89)	12.7	1.19 (0.95, 1.49)	15.3	1.28 (0.97, 1.68)	19.5	1.07 (0.87, 1.31)
Ethnicity										
Non-Hispanic	5032	8591	8.2	1.00	11.7	1.00	12.9	1.00	19.8	1.00
Hispanic	395	688	8.5	1.03 (0.70, 1.53)	11.5	0.96 (0.75, 1.23)	14.7	1.14 (0.85, 1.53)	16.4	0.80 (0.62, 1.01)
SEP (attended college)										
Both parents	2320	3602	7.7	1.00	10.3	1.00	11.5	1.00	18.6	1.00
Only one parent	1418	2520	8.1	1.04 (0.76, 1.42)	11.7	1.15 (0.96, 1.28)	14.2	1.25 (0.98, 1.59)	19.6	1.06 (0.92, 1.22)
Neither parent	1689	3157	9.2	1.19 (0.92, 1.56)	13.1	1.29 (1.10, 1.51)	14.0	1.22 (0.98, 1.51)	20.4	1.10 (0.92, 1.29)
Weight status										
Underweight	106	453	16.1	2.19 (1.18, 4.06)*	11.3	1.06 (0.71, 1.58)	25.2	2.44 (1.44, 4.12)*	16.3	0.86 (0.64, 1.16)
Normal	3005	6567	8.0	1.00	10.8	1.00	12.1	1.00	18.4	1.00
Overweight	1642	1504	8.0	0.99 (0.81, 1.21)	12.8	1.21 (1.01, 1.44)*	13.0	1.07 (0.91, 1.27)	20.7	1.16 (1.00, 1.34)*
Obesity	499	469	8.8	1.10 (0.73, 1.64)	14.9	1.43 (1.09, 1.88)*	14.5	1.21 (0.94, 1.56)	25.0	1.47 (1.13, 1.92)*

Table 2, Continued

			Poor Mental Health				Perceived Stress			
			Male		Female		Male		Female	
	Male, No.	Female, No.	%	OR (95% CI)‡	%	OR (95% CI)‡	%	OR (95% CI)‡	%	OR (95% CI)‡
Class II obesity	175	286	9.3	1.17 (0.65, 2.09)	20.7	2.11 (1.55, 2.89)*	17.1	1.46 (0.95, 2.24)	33.8	2.26 (1.72, 2.95)*
Mental health										
Good (41–100)	4987	8193					8.7	1.00	13.1	1.00
Poor (0–40)	440	1086					61.4	16.82 (13.44, 21.05)*	68.0	14.03 (12.08, 16.30)*
Perceived stress										
Low (0–8)	4722	7474	3.7	1.00	4.6	1.00				
High (9–16)	705	1805	39.0	16.73 (13.40, 20.88)*	40.6	14.02 (12.05, 16.31)*				
Socializing										
High (2+ h and 5+ friends)	2541	3762	4.2	1.00	7.7	1.00	8.4	1.00	15.3	1.00
Low (≤2 h or <5 friends)	2886	5517	11.9	3.04 (2.39, 3.86)*	14.4	1.99 (1.71, 2.31)*	17.1	2.24 (1.81, 2.77)*	22.4	1.60 (1.41, 1.82)*

† PA indicates physical activity; OR, odds ratio; CI, confidence interval; and SEP, socioeconomic position.
‡ Adjusted for response rate.
* Statistically significant at $p < 0.05$.

Short Form–36 (SF-36) health scale.[32] This scale has been shown to be valid in assessing mental health.[33] The questions are as follows: "How much of the time during the past 30 days. . .? (A) have you been a nervous person? (B) have you felt so down in the dumps that nothing could cheer you up? (C) have you felt calm and peaceful? (D) have you felt downhearted and blue? (E) have you been a happy person?" Response choices for each item included "all of the time," "most of the time," "a good bit of the time," "some of the time," "a little of the time," and "none of the time." The two items reflecting positive affect (C and E) were reverse coded and responses were coded to a 100-point scale using the instructions for the SF-36.[32] Scores between 0 and 40 may indicate clinically and socially relevant poor mental health[14]; thus, for analysis, mental health was dichotomized and a score between 0 and 40 was categorized as "poor mental health" and a score between 41 and 100 was "good mental health."

A shortened four-item version of the Cohen Perceived Stress Scale (PSS) was used to assess perceived stress.[34] The scale included these questions: "In the past 30 days, how often have you felt. . .? (A) that you were unable to control important things in your life? (B) confident about your ability to handle your personal problems? (C) that things were going your way? (D) difficulties were piling up so high that you could not overcome them?" Response categories for each item included "never," "almost never," "sometimes," "fairly often," and "very often." Items B and C were reverse coded and the responses were summed consistent with instructions for scoring the PSS.[34] Responses were dichotomized using the 75th percentile as the cutoff, resulting in a group of students with scores from 0 to 8 and another group with scores from 9 to 16. For ease of interpretation, students with scores from 0 to 8 were referred to as "low perceived stress" and students with scores from 9 to 16 as "perceived stress." Mental health and perceived stress scores on a continuous scale were highly correlated in this sample of students (Pearson $R = .71$, $p < .001$).

Sex response choices included male and female. Student age was assessed as current age in years using the following categories: 18, 19, 20, 21, 22, 23, 24, and 25 and older. For analysis, age was grouped into three categories: 18 to 20, 21 to 23, and 24 and older. Body mass index (BMI) was calculated using self-reported height and weight and reported in five weight status categories: underweight, BMI <18.5; normal weight, 18.5 ≤ BMI < 25; overweight, 25 ≤ BMI < 30; class I obese, 30 ≤ BMI < 35; and class II obese, 35 ≤ BMI.[35] Respondents selected one of the following race options: white, black/African-American, Asian/Pacific Islander, Native American Indian/Native Alaskan, and other. Because of small sample sizes, Native American Indian/Native Alaskan and other race categories were combined. A separate question was used to assess Hispanic or Spanish origin. Socioeconomic position (SEP) was assessed using measures of parental educational attainment for each parent. Responses were used to create an SEP variable with the following categories: both parents attended college, only one parent attended college, and neither parent attended college. Year in school was defined as freshman, sophomore, junior, senior,

fifth-year undergraduate or beyond, and graduate students.

Two questions were used to assess socializing among students. One question assessed the number of close friends and was dichotomized to five or more friends and fewer than five friends. The second question assessed the amount of time spent socializing and was dichotomized to 2 or more h/d and less than 2 h/d. In order to facilitate interpretation of the contribution of socialization in the models, the number of friends and time spent socializing were combined into a single, dichotomous socializing variable where students who reported five or more friends and 2 or more h/d socializing were coded as high socializing and all others were coded as low socializing.

Analysis

Graduate students (n = 42) were excluded from analysis. Missing data for all variables included in models were excluded from analysis (n = 1552). The final analytic sample size was n = 14,706. All analyses were weighted by sex, age (under 21 years vs. 21 and older), and race (white vs. nonwhite) using the known demographic makeup of each school as reported in *Barron's Profiles of American Colleges*[36] and by the U.S. Department of Education. Statistical analyses were conducted using SAS version 9.2 (SAS Institute, Cary, North Carolina, 2008). To test our first hypothesis, logistic regression models were estimated using the generalized estimating equations[37,38] approach (PROC GENMOD) to model the association of vigorous PA with mental health and stress and to account for the clustering of students within colleges. There was a significant association between response rate and level of PA at a given college (Pearson $R = .28$, $p = .01$). As a result, response rate was included in all models to help account for any response bias, although this procedure did not significantly alter the findings. Odds ratios (ORs) and 95% confidence intervals (CIs) are presented.

In order to test our second hypothesis, we used the test for mediation methods proposed by Baron and Kenny.[39] Thus, we fit three regression models for each outcome (i.e., mental health and perceived stress): (1) vigorous PA in college predicts socializing (the mediator), (2) vigorous PA predicts the outcome, and (3) socializing and vigorous PA predict the outcome. All regression analyses used in the test for mediation were adjusted for response rate, vigorous PA in high school, sex, age, weight status, race, ethnicity, SEP, and year in school.

Finally, for our third hypothesis, we included the following interaction terms in both vigorous PA and mental health and vigorous PA and perceived stress models: (1) vigorous PA in college and sex and (2) vigorous PA in college and race.

RESULTS

Demographic characteristics of respondents, minimally adjusted ORs, and 95% CIs are presented in Table 1 using weighted proportions and unweighted sample sizes for vigorous PA in college. Table 2 presents demographic characteristics, minimally adjusted ORs, and 95% CIs as well as weighted proportions and unweighted sample sizes for mental health and perceived stress stratified by gender. Minimally adjusted models included only response rate as a covariate. Overall, the majority of respondents were female, between 18 and 20 years old, normal weight (i.e., 18.5 $kg/m^2 \leq$ BMI < 25 kg/m^2), and white, and reported good mental health and low perceived stress. Compared to males, females were less likely to meet vigorous PA recommendations in college (OR [95% CI]: .82 [.70, .89]), and more likely to report poor mental health (OR [95% CI]: 1.45 [1.28, 1.64]) and perceived stress (OR [95% CI]: 1.61 [1.47, 1.76]). Among both males and females, those who met vigorous PA recommendations in high school were more likely to meet vigorous PA recommendations in college (OR [95% CI]: males: 2.64 [2.27, 3.07]; females: 2.14 [1.91, 2.40]). Socializing was significantly associated with meeting vigorous PA recommendations in college, with students reporting low socializing having lower odds of meeting vigorous PA recommendations than those who reported high socializing among males and females (OR [95% CI]: males: .62 [.50, .69]; females: .69 [.63, .76]). In addition, low socializing was associated with higher odds of poor mental health and higher odds of perceived stress among both males and females. Students who met vigorous PA recommendations in college were less likely to report poor mental health (OR [95% CI]: males: .73 [.56, .96]; females: .75 [.66, .86]) and perceived stress (OR [95% CI]: males: .66 [.56, .79]; females: .75 [.66, .85]).

Two adjusted models, building on the minimally adjusted models, examining the association between meeting vigorous PA recommendations in college, poor mental health, and perceived stress are presented in Table 3. Students who met vigorous PA recommendations in college were less likely to report poor mental health (adjusted OR [95% CI]: .79 [.69, .90]) and perceived stress (adjusted OR [95% CI]: .75 [.67, .83]), after adjusting for response rate, meeting vigorous PA recommendations in high school, sex, age, weight status, race, ethnicity, SEP, and year in school. In an additional model, socializing was added as a covariate to the previous model. Adding socializing did not substantially alter the observed relationship between vigorous PA and poor mental health (adjusted OR [95% CI]: .83 [.72, .96]) or perceived stress (adjusted OR [95% CI]: .77 [.69, .87]) although low socializing was significantly associated with poor mental health (adjusted OR [95% CI]: 2.23 [1.94, 2.56]) and perceived stress (adjusted OR [95% CI]: 1.77 [1.58, 1.99]) and confounded the relationships (i.e., attenuated the estimates for vigorous PA, mental health, and perceived stress by at least 10%).

In all models presented in Table 3, female students, Asian students, and students with class II obesity had significantly higher odds of poor mental health and perceived stress than male students, white students, and normal-weight students, respectively. In addition, compared to normal-weight students, overweight and class 1 obese students had significantly higher odds of perceived stress.

The unstandardized estimates and standard errors generated for the mediation analyses are presented in Table 4. We calculated z-scores for each of the models using Sobel's test of partial mediation.[39] A z-score of 4.28

Table 3
Associations Between (1) Vigorous PA* and Mental Health and (2) Vigorous PA and Perceived Stress, N = 14,706*

	Poor Mental Health		Perceived Stress	
	Adjusted OR (95% CI)†	Adjusted OR (95% CI)‡	Adjusted OR (95% CI)†	Adjusted OR (95% CI)‡
Met vigorous PA recommendations in college	0.79 (0.69, 0.90)	0.83 (0.72, 0.96)	0.75 (0.67, 0.83)	0.77 (0.69, 0.87)
Female	1.46 (1.28, 1.65)	1.41 (1.24, 1.60)	1.63 (1.48, 1.79)	1.59 (1.45, 1.75)
Race				
White	1.00	1.00	1.00	1.00
African-American	0.93 (0.71, 1.22)	0.89 (0.67, 1.17)	1.12 (0.90, 1.39)	1.08 (0.87, 1.34)
Asian	1.50 (1.23, 1.82)	1.45 (1.19, 1.78)	1.45 (1.24, 1.69)	1.42 (1.21, 1.66)
Other	1.27 (0.95, 1.69)	1.24 (0.92, 1.66)	1.25 (1.00, 1.56)	1.23 (0.98, 1.54)
SEP (attended college)				
Both parents	1.00	1.00	1.00	1.00
Only one parent	1.08 (0.91, 1.28)	1.06 (0.89, 1.25)	1.11 (0.97, 1.27)	1.09 (0.96, 1.24)
Neither parent	1.18 (1.01, 1.36)	1.12 (0.96, 1.31)	1.09 (0.95. 1.25)	1.05 (0.92, 1.21)
Weight status				
Underweight	1.14 (0.81, 1.61)	1.12 (0.80, 1.59)	1.00 (0.78, 1.29)	0.99 (0.77, 1.28)
Normal	1.00	1.00	1.00	1.00
Overweight	1.12 (0.95, 1.30)	1.13 (0.97, 1.33)	1.15 (1.02, 1.30)	1.17 (1.03, 1.32)
Obesity	1.22 (0.98, 1.51)	1.23 (1.00, 1.52)	1.34 (1.12, 1.62)	1.35 (1.13, 1.63)
Class II obesity	1.63 (1.20, 2.22)	1.66 (1.22, 2.26)	1.92 (1.55, 2.40)	1.95 (1.56, 2.44)
Socializing				
High (2+ h and 5+ friends)		1.00		1.00
Low (≤2 h or <5 friends)		2.23 (1.94, 2.56)		1.77 (1.58, 1.99)

* PA indicates physical activity; OR, odds ratio; CI, confidence interval; SEP, socioeconomic position; and BMI, body mass index.
† Adjusted for response rate, meeting vigorous physical activity recommendations in high school, sex, age, weight status, race, ethnicity, socioeconomic position, and year in school.
‡ Adjusted for response rate, meeting vigorous physical activity recommendations in high school, sex, age, weight status, race, ethnicity, socioeconomic position, year in school, and socializing.

was produced for the model predicting mental health and a z-score of 6.45 was produced for the model predicting perceived stress.

Using the models with all covariates (i.e., response rate, meeting vigorous PA in high school, sex, age, weight status, race, ethnicity, SEP, year in school, and socializing) we also tested for moderation. We included the following interaction terms in separate models for each outcome: vigorous PA and sex, vigorous PA and race. The interaction terms were not significant in the models for mental health (vigorous PA and sex, $p = .85$; vigorous PA and race, p range = .64–.86) or for perceived stress (vigorous PA and sex, $p = .18$; vigorous PA and race, p range = .07–.67).

DISCUSSION

The results support our first hypothesis because students who met vigorous PA recommendations in college were less likely to report poor mental health and perceived stress than students who did not meet recommendations. Similar directionality and magnitude of the associations between poor mental health and vigorous PA as well as perceived stress and vigorous PA were expected and observed because poor mental health and perceived stress are highly correlated.

Our results support our second hypothesis that socializing partially mediates the relationships between vigorous PA and mental health as well as vigorous PA and perceived stress. Thus, this indicates that part of the positive benefits of vigorous PA on mental health and perceived stress occurs through a socializing pathway.

With regards to our third hypothesis that sex and race moderate the relationship between vigorous PA and mental health as well as vigorous PA and perceived stress, the results do not appear to support this hypothesis. We fit models with interaction terms for vigorous PA and sex as well as vigorous PA and race. However, none of the interactions terms were significant, indicating that the relationship between vigorous PA and mental health and the relationship between vigorous PA and perceived stress does not differ by sex or by race/ethnicity.

Overall, there appears to be an association between vigorous PA and mental health as well as vigorous PA and perceived stress among college students. The findings from our study are consistent with previous work exploring PA and mental health.[4,5,24] These findings, along with existing research, may provide further evidence for promoting PA among the college population, where PA levels normally decrease.[21,22] Creating environments where students can easily engage in PA may help prevent decreases from high school. Several previous studies have examined the effect of the built and social environment on PA. Factors such as crime, scenery, and seeing other active individuals influenced PA among an adult population,[40] and among high school females, schools with social environments supporting PA (e.g., principal support, school PA team, and prominent messages supporting PA) were associated with higher amounts of vigorous PA.[41] To the authors' knowledge, no studies specifically examine the effect of the built and social environment on PA among college students. A multiple behavior intervention utilizing an overall image of fitness to encourage healthy behaviors among college students saw improvements in health behaviors over time.[42] However, additional research in this area is needed.

Table 4
Logistic Regression Model Estimates for Mediation Analyses, N = 14,706*

	Estimate†	Standard Error	*p*
Poor mental health			
(1) Vigorous PA → socializing	−0.32	0.04	<0.0001
(2) Vigorous PA → poor mental health	−0.24	0.07	0.0007
(3) Vigorous PA → poor mental health (controlling for socializing)	−0.80	0.07	<0.0001
Perceived stress			
(1) Vigorous PA → socializing	−0.32	0.04	<0.0001
(2) Vigorous PA → perceived stress	−0.29	0.06	<0.0001
(3) Vigorous PA → perceived stress (controlling for socializing)	−0.57	0.06	<0.0001

* Vigorous PA indicates meeting vigorous physical activity recommendations in college.
† Adjusted for response rate, meeting vigorous physical activity recommendations in high school, sex, age, weight status, race, ethnicity, socioeconomic position, year in school, and socializing.

The findings from this study have implications for interventions for PA and mental health and stress. Although temporality still needs to be established, given the relationship, interventions aiming to increase PA could improve mental health outcomes and be a stress management tool. Likewise, interventions that aim to improve mental health or stress management may want to consider including PA components. In addition, PA and mental health interventions should incorporate a social component in order to be more effective.

The cross-sectional nature of this study limits the ability to examine whether vigorous PA is causally linked with mental health and perceived stress as well as whether socializing is on the causal pathway between vigorous PA and mental health and vigorous PA and perceived stress. High school vigorous PA was determined through recall of usual PA and may be subject to recall bias. This was evident in the present data with a positive association between year in school and vigorous PA in high school, which may reflect a bias toward greater PA because of the greater length of recall time. However, there is no evidence that PA significantly decreased among high school seniors over this short time frame. Analyses in the present study were adjusted for both year in school and age to partially account for potential recall bias. Longitudinal data are needed to more accurately assess the impact of PA on mental health and perceived stress as well as to assess socializing as a mediator. In order to maintain a reasonable survey length, the scales used to assess mental health and perceived stress were also shortened versions of a full, more in-depth scale. Although the reliability and validity of the shortened scales are still relatively high, future research examining the impact of PA on mental health and perceived stress may want to consider using the full scales in order to more accurately measure mental health and perceived stress. Relatedly, our indicators for socialization involved measures of the number of friends and the amount of time spent socializing. Although these seem like reasonable measures, they have not been directly validated as a good measure of socialization. This is a limitation of the study and future research should develop and test an improved measure of socialization. In addition, the low response rate may have resulted in bias that influenced the results, although the direction of this potential bias is uncertain. Analyses were conducted using data weighted to the known sex, age, and race makeup of each school. This method of weighting may help reduce nonresponse bias by providing more information on groups where fewer individuals may have participated in the survey, with the assumption that our variables of interest are dependent on these demographic characteristics and that those who did not participate are not substantially different than those who did participate. Despite these limitations, this the first study to use a nationally representative data from college students to examine the relationship between vigorous PA and mental health as well as vigorous PA and perceived stress and assess the impact of socializing on these relationships.

In conclusion, there appears to be an inverse association between vigorous PA in college and both poor mental health and perceived stress. This relationship remained after accounting for socializing. However, additional research using longitudinal data is needed to more accurately assess the influence of PA on mental health and perceived stress from high school to college. Among college stu-

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

Limited existing research suggests there may be a relationship between increased PA and improved mental health outcomes, particularly among adults.

What does this article add?

These analyses indicate that among college students, vigorous PA is positively associated with better mental health and lower perceived stress. However, previous studies had not been able to examine the impact of socializing on the relationship. Based on our analyses, socializing partially mediates the relationship between vigorous PA and mental health as well as vigorous PA and perceived stress. This finding suggests that part of the benefits of vigorous PA on mental health and perceived stress occur through a socializing pathway.

What are the implications for health promotion practice or research?

Intervention strategies targeting physical activity and mental health should integrate social aspects into the design in order to increase intervention effectiveness among college students. College campus health services should integrate mental, physical, and social health components in order to encourage more holistic health among students.

dents in particular, peer support interventions aimed at either increasing or maintaining PA levels could help improve mental health and reduce perceived stress as well as maintain physical health. In addition, mental health and stress management interventions could potentially include PA components combined with social support.

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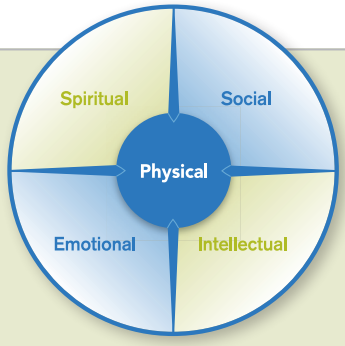

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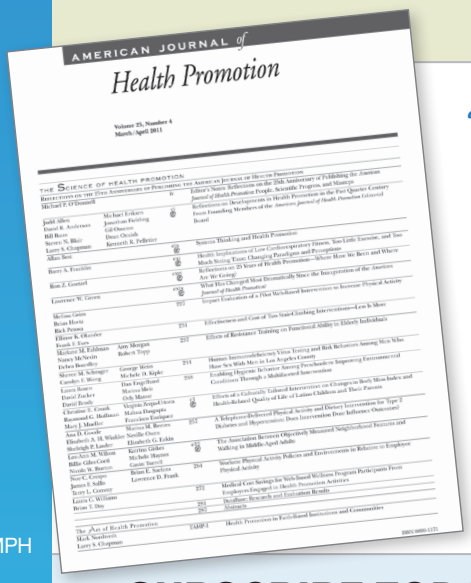
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