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Longitudinal Associations from Neurobehavioral Disinhibition to Adolescent Risky Sexual Behavior in Boys: Direct and Mediated Effects through Moderate Alcohol Consumption

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Abstract

Purpose—This longitudinal study tested the hypothesis that neurobehavioral disinhibition (ND) in childhood, mediated by alcohol use, portends risky sexual behavior (number of sexual partners) in mid-adolescence.

Methods—Participants were 410 adolescent boys. Neurobehavioral disinhibition was assessed at 11.3 years of age. Frequency and quantity of alcohol use on a typical drinking occasion were assessed at 13.4 years of age at first follow-up and sexual behavior at 16.0 years at second follow-up.

Results—Quantity of alcohol consumed on a typical drinking occasion, but not frequency of alcohol use, mediated the relation between ND and number of sexual partners.

Conclusions—These findings indicate that number of sexual partners in mid-adolescence is predicted by individual differences in boys' psychological self-regulation during childhood and moderate alcohol consumption in early adolescence, and that ND may be a potential target for multi-outcome public health interventions.

Keywords

Neurobehavioral Disinhibition; Sexual Risk Taking; Alcohol Use; Boys

Introduction

Youth risky sexual behavior remains a public health concern. One-third of all high school students report having engaged in sexual intercourse within the past three months and 14% admit to at least four sexual partners during their lifetime (CDC, 2010). Health ramifications are potentially severe considering that adolescents and young adults constitute almost half of

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the 19 million new cases of sexually transmitted diseases (Weinstock, Berman, & Cates, 2004; Hamilton, Martin, & Ventura, 2010). Early unprotected sex, particularly when there are a large number of partners, also increases risk for unintended pregnancy and live births with teenage mothers accounting for 400,000 annual births in the US (Gipson, Koenig, & Hindin, 2008). Identifying the childhood characteristics that presage risky sex affords the opportunity to target developmentally appropriate interventions in high risk individuals.

Alcohol use is frequently associated with risky sexual behavior (Cooper, 2002; Leigh & Schafer, 1993). Relationships between alcohol intake and risky sexual behavior become stronger as blood alcohol content rises, especially during sexual encounters with casual partners (Davis, George, Norris, Schacht, Stoner, Hendershot, et al., 2009; Kiene, Barta, Tennen, & Ameli, 2009), in turn contributing to enhanced risk for HIV infection (Baliunas, Rehm, Irving, & Shuper, 2009). Causal explanations for this association include expectancy theories, where an individual's sexual behavior is driven by pre-existing beliefs about the experience (i.e., expectancies), and alcohol myopia theory, where disinhibited sexual behavior results from an interaction between diminished cognitive functioning from acute alcohol intoxication and situation specific cues for sex (Cooper, 2006; George & Stoner, 2000).

Consequences related to alcohol misuse and risky sexual behavior argue for identifying common predisposing factors as potential targets for early intervention (Botvin, Griffin, & Nichols, 2006; Botvin, Schinke, & Orlandi, 1995). One strategy is to test whether early predictors of alcohol use are also statistically predictive of risky sex. However, with few exceptions (Caspi, Begg, Dickson, Harrington, Langley, Moffitt, & Silva, 1997), research testing causal models of the association between alcohol use and risky sex has focused on concurrent relatinoships in adulthood rendering it difficult to determine causality, or identify common predisposing factors in late childhood. To our knowledge, no research to date has investigated causal mediational pathways through which predisposing factors are related to alcohol consumption and risky sex.

Due to the absence of prospective investigations, the presaging factors accounting for longitudinal relationships between adolescent alcohol use and risky sex remain largely unknown. In an attempt to fill this gap, it was theorized in this study that low inhibitory control in childhood portends heavy alcohol use and subsequently risky sexual activity. Disinhibition has been considered an important component within broader factors (e.g., sensation seeking and executive function) previously associated, albeit largely through cross-sectional studies, with substance misuse and/or risky sexual behavior. Thus, in addition to demonstrating longitudinal relationships among study variables, a specific focus on disinhibition may contribute to conceptual clarity regarding these relationships. It is noteworthy that low inhibitory regulation has a strong genetic component (Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008) and is largely a manifestation of prefrontal cortex disturbance (McClelland, Cameron, Wanless, & Murray, 2007). Because self-regulation is integral to self-management and making healthy choices, this study utilized the neurobehavioral disinhibition (ND) trait, previously shown to predict risky health behaviors including substance use and unhealthy eating practices (e.g., Applehans, 2009; Tarter et al., 2003) to explore the underpinnings linking alcohol use and risky sex.

The study goal was to elucidate longitudinal relationships among psychological self-regulation in late childhood, and alcohol use and risky sex in adolescence. Hypothesized was that alcohol use is a mediator of the relationship between childhood psychological self-regulation and number of sexual partners in adolescence. Specifically, youth with poor psychological self-regulation would demonstrate patterns of higher alcohol intake and greater number of sexual partners. Also hypothesized was that, when entered into a single-

step multiple mediator model taking into account both frequency and quantity of alcohol intake, the direct effect of ND on number of sexual partners will be partially mediated by prior quantity, not frequency, of alcohol use. Analyses build upon previous research in at least three ways: tested are a) a common presaging factor to both alcohol misuse and sexual behavior (i.e., ND), b) specification regarding which particular patterns of alcohol misuse (i.e., moderate use vs. frequent use) are most associated with risky sex, and c) longitudinal mediational relationships over a period of 5 years.

Methods

Procedure

The sample consisted of boys enrolled from 1990 through 1996 in a longitudinal study conducted by the Center for Education and Drug Abuse Research (CEDAR) (see Tarter & Vanyukov, 2001 for overview). Participants were ascertained through their fathers who either qualified for substance use disorder (SUD) consequent to use of an illicit drug, or did not qualify for any major psychiatric diagnosis (Reynolds, Tarter, Kirisci, Kirillova, Brown, Clark et al., 2007). Several recruitment strategies were employed, including random digit dialing conducted by a market research firm, advertising in print media and public service announcements in electronic media. Previous analyses have revealed that the fathers with and without SUD closely resemble their respective populations (Tarter & Vanyukov, 2001).

The parent who provided informed consent for child participation was also asked to sign consent for a teacher report. A teacher was identified as the one with whom the adolescent spent the most time, asked to complete several questionnaires about the child, and subsequently compensated $10. Boys and parents were additionally informed that their privacy was protected by a Certificate of Confidentiality issued by the National Institute on Drug Abuse. Urine and breath samples were collected from the participants and analyzed before commencing the research protocol to ensure that performance was not influenced by the acute effects of drugs or alcohol. The protocol was administered in fixed order. Following evaluation, each family member was debriefed and paid for their time and travel. Participants who completed assessments at each of the three waves of data collection were compensated at total of $300.

Participants

Potential participants underwent an examination conducted by a registered nurse to determine the presence or history of neurological injury, physical disability, uncorrectable sensory impairment, or fetal alcohol effects. Participants were also required to have a full scale Wechsler Intelligence Scale for Children, Third Edition Revised (WISCIII-R) IQ of at least 80 and ability to read and speak English. Fifteen youth were excluded from the study due to these criteria. Of the 547 eligible youth, 543 (99.27%) completed measures of ND trait and quantity of alcohol used at baseline. Of these 543, 411 (75.69%) completed measures of quantity of alcohol used at first follow-up and number of sexual partners at second follow-up. One participant reported having a same-sex relationship and no opposite-sex relationships and was removed from analyses, resulting in a final sample size of 410.

Average socioeconomic status of the fathers was middle class commensurate with completing 13.9 years of education (SD = 1.86) and 45% had a SUD. Mean ages of the participants were 11.3 (SD = 0.94) at baseline, 13.4 (SD = 0.97) at first follow-up, and 16.0 (SD = 0.46) at second follow-up. Table 1 illustrates descriptive statistics for retained and non-retained participants at baseline and shows no differences for socioeconomic status using Hollingshead criteria (Hollingshead & Redlich, 2007), age, grade in school, ethnic

distribution, ND trait or quantity of alcohol used. Full scale IQ was significantly lower in the non-retained participants; however, both groups scored in the normal range of intelligence.

Measures

Neurobehavioral disinhibition—As described in prior studies, a standardized neurobehavioral disinhibition (ND) score was derived by using item response theory methods applied to indicators of affect, behavior, and cognition (Tarter, Kirisci, Mezzich et al., 2003). The affect dimension was assessed with the Revised Dimensions of Temperament Survey (Windle, 1992). On the basis of a previous finding that the estimate of the latent trait score of the difficult temperament index correlates very highly with the total number of positive responses (Kirisci & Blackson, 1996), we recorded the sum of endorsed responses. The behavior dimension was assessed by tabulating the number of conduct disorder, oppositional defiant disorder, and ADHD externalizing symptoms reported by the mother on the K-SADS-E (Orvaschel, Puig-Antich, Chambers, Tabrizi & Johnson, 1982) and the total score on the Disruptive Behavior Disorders Rating Scale (Pelham & Murphy, 1987) reported by the teacher. Internal reliability of this scale was very high (alpha= 0.95). The cognitive dimension of ND was evaluated by using a battery of tests measuring executive cognitive functions (Aytaclar, Tarter, Kirisci & Lu, 1999). These higher-order cognitive functions exercise a supervisory or control influence on emotional regulation and behavioral control. The specific tests administered by trained master's-level clinical associates were the Stroop, Porteus Mazes, vigilance, motor restraint, forbidden toys, and Block Design test of the WISC-III-R. The scores on these tests have been previously shown to constitute a single first-order factor (Aytaclar et al., 1999).

Alcohol use—Quantity of alcohol consumed was measured using a modified version of the Lifetime History of Alcohol Use survey (Skinner, 1982), which depicts multiple subject-defined phases of alcohol use (time periods of a consistent level of consumption) spanning the period between each visit. *Quantity of alcohol used* was assessed with two items in each subject-defined phase: 1) consumption of a "sip" or a "drink" of beer, wine, and liquor, and 2) the number of sips or drinks on those occasions. To compute an overall number of drinks, one "sip" was defined as 1 oz., as in prior research on alcohol use (Myrick, Anton, Li, Henderson, Drobes, Voronin, & George, 2004) and transformed into fractions of a drink using standard drink size guidelines specified by the National Institute on Alcohol Abuse and Alcoholism: beer, 12 oz.; wine, 5 oz; liquor, 1.5 oz. (NIAAA, 2012). Transformations were: Sip of liquor = 1/1.5 of drink = 1oz; Sip of wine = 1/5 glass = 1oz; Sip of beer = 1/12 glass = 1oz. An overall score for quantity of alcohol used was calculated using the sum of the number of ounces of beer, liquor, and wine consumed. For example, a participant who answered that he had "one sip" of "beer" and "one drink" of "wine" would be assigned a total alcohol quantity score of (1/12) + 1 = 1.08 drinks; a participant who answered that he had "one sip" of "liquor" and "one drink" of "wine" would be assigned a total alcohol quantity score of (1/1.5) + 1 = 1.67 drinks.

Frequency of alcohol use was assessed using an 11-point scale to indicate how frequently beer, wine, and liquor were consumed during each subject-defined phase. Response options were: every day, every 2nd day, once a week, weekends, every two weeks, every month, every three months, every six months, every nine months, and *once a year*. This was re-coded to represent days per year (e.g. "every day" = 365 days per year, "every six months" = 2 days per year). An overall frequency of alcohol use score represented the mean number of days per year of alcohol consumption. At baseline, the average frequency of consuming alcohol ranged from 0 to 60.33 days per year (M = 1.60, SD = 5.97). At 13.4 years of age the number of days per year ranged from 0 to 81.67 days (M = 1.70, SD = 6.46).

Sexual behavior—Participants 12 years of age or older were asked two items from the survey of risky sexual behavior was taken from the Pittsburgh Youth Study to measure the number of sexual partners in the past year (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998): "Altogether during the past year, how many persons of the opposite sex have you had as sexual partners?," and "Altogether during the past year, how many persons of the same sex have you had as sexual partners?." These questions were asked as part of a broader interview, where the adolescent was able to ask for clarification as to the meaning of "sexual partner." As stated above, the one participant reporting a same-sex partner was removed from analysis.

Data analysis strategy

Descriptive statistics and bivariate correlations were conducted on study variables. Analyses tested a multiple mediator model in which quantity and frequency of alcohol use at 13.4 years of age were entered as potential mediators of the direct relationship between ND at age 11.3 on frequency of sexual behavior at age 16.0. Path models of the hypothesized total, direct, and specific indirect effects were testing using a bootstrapping resampling procedure in SAS (Preacher & Hayes, 2008). Mediation exists when an independent variable X exerts its effects on a dependent variable Y through its effect on a mediator M (Baron & Kenny, 1986; MacKinnon, 2008). In a multiple mediator model, the total mediated effect of X on Y is the sum of the specific indirect effects of each of the mediators M. Mediated effects were estimated for 5,000 subsamples, sampled with replacement. Ninety-five percent bootstrap confidence intervals for specific indirect effect were the values defining the top and bottom 2.5% of the 5,000 estimates, ranked from low to high (Preacher & Hayes, 2008).

Analyses controlled for presence of father's alcohol use disorder and participant's gender, ethnicity, age, and baseline level of quantity of alcohol used. Because only a subset (2.5%) of participants reported having sexual partners at baseline, sexual behavior was not used as a covariate to maximize statistical power. Effect sizes (r) were calculated for all significant direct effects.

Results

Table 2 presents the distribution of the number of sexual partners at age 16.0. Twenty-five percent of the sample reported having had at least one sexual partner by mid-adolescence. No participants reported having same sex partners at baseline. At 16.0 years, the 39 (9%) participants who reported having had 3 or more sexual partners drank an average of 7.35 (SD = 6.22) drinks per occasion. Those with fewer partners drank on average 2.98 drinks (SD = 5.29).

Table 3 shows correlations between ND, alcohol use, sexual behavior, age, and father's alcohol SUD. Correlations were positively and statistically significant between ND at age 11.3 and quantity of alcohol use at ages 11.3 and 13.4, frequency of alcohol use at 16.0, and number of sex partners at ages 11.3, 13.4 and 16.0 years of age. All alcohol use variables were positively and significantly correlated with each other. Alcohol quantity and frequency at 13.4 years of age were correlated with number of sex partners at 16.0 years of age.

Figure 1 displays path coefficients for the test of mediating effects of quantity of alcohol and frequency of use on the relation between ND in late childhood and number of sexual partners in adolescence. ND at age 11.3 significantly predicted quantity of alcohol use on a typical occasion (t = 2.15, p < .05; r = .11) but not frequency of alcohol use (t = −0.04, p = n.s.) at age 13.4. ND also predicted number of sexual behaviors at age 16.0 (t = 2.82, p < .01; r = .16). In turn, quantity of alcohol use on a typical occasion (t = 4.78, p < .01; r = .22) but not frequency of alcohol use (t = −0.12, p = n.s.) predicted number of sexual partners at

age 16.0. There was a specific indirect effect of ND trait on number of sexual partners through quantity of alcohol used, controlling for the effect of frequency (*ab* path =0.026, 95% CI: (0.003, 0.087)) but not through frequency of alcohol use, controlling for the effect of quantity (*ab* path = 0.00, 95% CI: (-0.004, 0.009)). The product of coefficients also showed the significance of the mediating effect of quantity of alcohol used on sexual behavior at age 16 (Sobel test = 1.96, $p<0.05$). Including the amount of alcohol use in the model decreased the effect size of ND on sexual behavior from .16 to .14 (14%).

Discussion

Youth scoring high on ND in late childhood appear at heightened risk for multiple sexual partners by mid-adolescence. In addition, ND in childhood predicts quantity of alcohol use per drinking occasion at age 13.4, which in turn partially mediates the relation between ND and number of sexual partners at age 16.0. Results support a prospective role for ND as a presaging factor for risky patterns of alcohol use and number of sexual partners. This adds ND to the literature as a potential causal mechanism for the association between moderate alcohol use and sex with multiple partners.

Mediating effects of alcohol were specific to the amount of use per episode. This indicates that risky sexual behavior is due in part to adolescents' inability to disinhibit excessive drinking once a drinking episode begins (i.e., binge drinking), and not frequency of alcohol use *per se*. As such, study findings provide partial longitudinal support for an alcohol myopia model, where disinhibited sexual behavior results from diminished cognitive functioning resulting from intoxication (Cooper, 2006; George & Stoner, 2000). Support for expectancy theories is less clear. It could be presumed that if one expects that drinking alcohol will lead to sex, that frequency of alcohol use would be associated with sexual behaviors, which was not the case. However, a lack of an association between frequency of alcohol use and sexual behavior may reflect previous unsuccessful attempts at drinking to facilitate sexual encounters, leading adolescents to abandon alcohol consumption as a strategy to achieve sex-related goals.

Since alcohol use quantity was significantly related to later number of sexual partners, we suggest that public health interventions focus on preventing binge drinking in part by identifying youth with high ND so as to ameliorate one of its predisposing traits. Individuals may be detected by the ND trait measured in childhood through population screening. Then, selective interventions applied to at-risk youth can focus, in part, on promoting inhibitory control in late childhood and early adolescence. Selective prevention strategies can also be used in combination with universal prevention programs, those applied to all individuals regardless of risk status, as part of a tiered approach to prevention. Reviews from the field of prevention science have demonstrated potential in promoting inhibitory control, among other neuro-cognitive skills, through behavioral intervention (Diamond & Lee, 2011; Riggs, Greenberg, & Rhoades, 2011). Future research should explore the potential of similar programs to promote inhibitory control as a mediator of moderate drinking and risky sex.

It should be noted that effect sizes were "small" (Cohen, 1988), which are commonly reported in health behavior research (Rutledge & Loh, 2004). In addition, the prospective nature of a five-year longitudinal study design likely contributed to small effect sizes. A model including all variables while youth were 16 years of age was tested and yielded larger, "medium" effect sizes for ND on quantity of alcohol use ($r = .33$) and ND on number of sexual partners ($r = .30$), and a "small" effect size of quantity of alcohol use on number of sexual partners ($r = .16$).

Study limitations warrant consideration. Whereas previous studies have considered failure to use condoms (Morrison, Gillmore, Hoppe, Gaylord, Leigh, & Rainey, 2003), we were unable to include this indicator of risky sexual behavior in our analyses due to missing data and the relatively low number of adolescents who completed condom use items. It should be noted that Morrison and colleagues (2003) found no significant association between alcohol consumption and failure to use condoms in 112 adolescents. This may reflect the relatively small sample size of their study, or true heterogeneity in the strength of the relationships between alcohol consumption and both number of sexual partners and condom use.

Biases stemming from self-report data should be considered. These biases can be cognitive (i.e., comprehension, retrieval, response generation, decision-making) or situational (i.e., social desirability, desire for attention) in nature and can affect self-reports of adolescent substance use and sexual behavior in different ways (Brener, Billy, & Grady, 2003). Given that self-report assessment is often a necessity in large scale studies of health risk behaviors, it is important to recognize threats to validity resulting from the use of self-reports, and confirm findings using multi-method approaches to assessment when possible.

Results may not be generalizable to girls or same-sex relationships due to potential sex/sexual orientation differences in the prevalence of ND, alcohol use, and sexual behaviors; the strength of associations among study variables; and/or the ultimate causal factors responsible for associations between alcohol use and risky sex. Additionally, the term “sexual partner” may mean different things to different boys. Although adolescents were free to ask for clarification regarding the meaning of the term “sexual partner,” they may not have done so for any number of reasons. Therefore, there may have been some variation in how adolescent boys defined “sexual partners.” It is unclear how, if at all, this may have been related to other study variables and/or affected study results.

Limitations notwithstanding, underscored is the importance of ND during childhood as a predisposing trait for health-risk behaviors such as excessive alcohol use and casual sexual partners. Future research should ascertain whether this trait predicts other risky behaviors (e.g. driving a car, consuming foods having processed sugars or high fat concentration, etc.). From the prevention perspective, the results illustrate the importance of taking into account individual differences related to psychological self-regulation prior to the transition into adolescence when opportunities substantially increase to engage in a wide range of other behaviors with potentially serious adverse consequences. If successful, preventive interventions that focus on factors that commonly predict diverse health behaviors, such as ND, may have ameliorative effects on multiple health behavior problems.

Implications and Contributions

Rendering or ameliorating impairments related to low psychological self-regulation in childhood is important for reducing moderate patters of alcohol intake associated with sex with multiple partners in adolescence.

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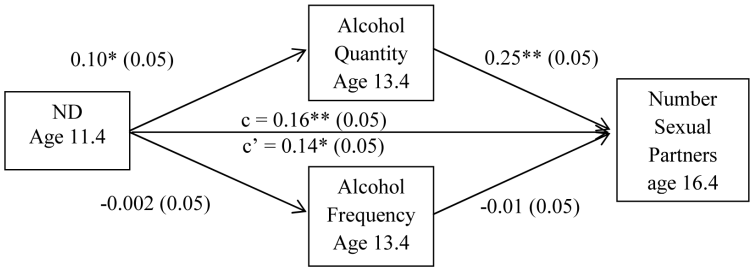

Figure 1. Effect of ND on number of sexual partners, mediated by alcohol use

Indirect effect through Alcohol Quantity = 0.026 (95% CI: 0.003, 0.087)

Indirect effect through Alcohol Frequency = 0.000 (95% CI: −0.004, 0.009)

Note: Control variables include ethnicity, age, father's alcohol use disorder and baseline alcohol quantity and frequency. Standardized estimates are followed by the standard error.

* $p < 0.05$, ** $p < 0.01$, ***$p < 0.001$

Table 1

Attrition analysis on demographics, IQ, ND and alcohol use

Characteristic	Retained (n= 410) n (%) or M (SD)	Non-retained (n= 132) n (%) or M (SD)	F or χ^2	p	
Age	11.34(0.94)	11.45(0.91)	1.29	0.26	
SES	41.71(13.29)	40.52(13.13)	0.81	0.37	
Grade in school	4.53(1.10)	4.56(1.08)	0.08	0.77	
IQ	109.34(15.72)	103.58(15.36)	13.59	< 0.001	
ND trait[^]	51.13(9.93)	52.74(11.02)	2.49	0.12	
Alc. Quantity (drinks/occasion)	0.25(0.50)	0.32(0.83)	1.36	0.24	
Alc. Freq. (mean days/year)	1.60(5.97)	0.69(2.00)	3.00	0.08	
Ethnicity					% Non-retained
Caucasian	323(78.78)	99(75.00)	1.14	0.56	30.65
African-American	77(18.78)	28(21.21)			36.36
Other/Mixed	10(2.44)	5(3.79)			50.00

[^] Neurobehavioral Disinhibition Trait

Note: Scores for alcohol quantity ranged from 0 to 4 drinks per occasion; Scores for alcohol frequency ranged from 0 to 60.33 days per year, on average, during which participant drank

Table 2

Number of sexual partners reported and quantity of alcohol consumed at 16 years of age

Sexual Partners		Drinks of Alc. Consumed		
No. Partners	**n (%)**	**n**	**M**	**(SD)**
0	306 (75%)			
1	41 (10%)	371 (90%)	2.98	5.29
2	24 (6%)			
3	17 (4%)	39 (10%)	7.35	6.22
4 or more	22 (5%)			
Total		411	4.40	5.52

Note: Range = 0 to 14 sexual partners

Table 3

Correlations between covariates, ND, alcohol use, and number of sexual partners

Variable	Age (yrs.)	1	2	3	4	5	6	7	8	9	10	11	12
1 Age	11.3	1.00											
2 Father Alc. SUD	11.3	0.05	1.00										
3 ND	11.3	−0.09	0.18***	1.00									
4 Alc. Quan (drinks)	11.3	0.23***	0.07	0.14**	1.00								
5 Alc. Quan (drinks)	13.4	0.29***	0.09	0.12*	0.30***	1.00							
6 Alc. Quan (drinks)	16.0	0.11*	0.13**	0.04	0.17***	0.27***	1.00						
7 Alc. Freq (days)	11.3	0.07	0.02	−0.05	0.18***	0.16**	0.19	1.00					
8 Alc. Freq (days)	13.4	0.13**	−0.02	0.01	0.18***	0.45***	0.20***	0.13**	1.00				
9 Alc. Freq (days)	16.0	0.08	0.06	0.12*	0.11*	0.30***	0.48***	0.14*	0.18***	1.00			
10 Sexual Partners ‡	11.3	0.23*	0.08	0.23**	0.14	0.14	0.03	−0.05	0.02	0.08	1.00		
11 Sexual Partners	13.4	0.22***	0.16***	0.11*	0.12*	0.36***	0.08	0.02	0.09	0.09	0.66***	1.00	
12 Sexual Partners	16.0	0.11*	0.17***	0.21***	0.05	0.29***	0.29***	0.06	0.11*	0.26***	0.24**	0.46***	1.00

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$

‡ n = 124 for number of sexual partners at baseline; n = 409 for number of sexual partners at Time 2