

Pubertal Status, Sensation-Seeking, Impulsivity, and Substance Use in High School–Aged Boys and Girls

Grace Kong, PhD, Anne E. Smith, PhD, Thomas J. McMahon, PhD, Dana A. Cavallo, PhD, Ty S. Schepis, PhD, Rani A. Desai, PhD, MPH, Marc N. Potenza, MD, PhD, and Suchitra Krishnan-Sarin, PhD

Objective: To examine how factors such as pubertal status, sensation-seeking, and impulsivity are related to substance use (cigarettes, alcohol, and marijuana) in high school students and examine these associations by gender.

Methods: Ten public high schools in Connecticut participated in a survey of high-risk behaviors. Adolescents from grades 9 to 12 ($N = 3068$) completed measures of physical development (Pubertal Development Scale), perceived pubertal timing, impulsivity and sensation-seeking (Zuckerman-Kuhlman Personality Questionnaire—Form III), and cigarette, marijuana, and alcohol use in the past 30 days.

Results: Logistic regression analyses modeling each substance use (cigarettes, marijuana, and alcohol) and gender separately showed

that (1) early perceived pubertal timing was associated with cigarette use but Pubertal Development Scale was not associated with any substance use, (2) sensation-seeking was associated with use of all 3 substances, and (3) gender differences were detected: impulsivity was associated with use of all 3 substances among girls, but this was not found among boys.

Conclusion: Future studies should examine the relationship among pubertal status, sensation-seeking, and impulsivity from preadolescence through late adolescence to better understand how these relationships to substance use may change with time and growth.

Key Words: gender, impulsivity, puberty, sensation-seeking, substance use

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From the Department of Psychiatry (GK, TJM, DAC, MNP and SKS), Yale University School of Medicine, New Haven, CT; Child Study Center (AES), Yale University School of Medicine, New Haven, CT; Department of Psychology (TJM and MNP), Texas State University, San Marcos, TX; Department of Psychiatry (RAD), Yale University School of Medicine, VA Connecticut Healthcare System, West Haven; and Department of Neurobiology (MNP), Yale University School of Medicine, New Haven, CT

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Send correspondence and reprint requests to Grace Kong, PhD, Department of Psychiatry, Yale University School of Medicine, 34 Park Street, Room S-201, New Haven, CT 06519. E-mail: grace.kong@yale.edu

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Current epidemiological survey indicates that substance use is problematic among high school–aged youth; among 12th graders, 22.6% reported using marijuana, 40.0% alcohol, and 18.7% cigarettes in the past 30 days (Johnston et al., 2012). Adolescence is a critical developmental period when drug experimentation occurs and its use increases with age through adolescence to young adulthood and then declines thereafter (Chen and Jacobson, 2012).

One of the major correlates of substance use is the onset of puberty when significant neuroendocrinological changes occur, such as increases in adrenal and gonadal hormones, which are associated with the development of secondary sexual characteristics and brain functioning (Spear, 2000). Anatomical neuroimaging studies have shown that prefrontal areas are the last brain regions to mature (Giedd, 2004; Luna and Sweeney, 2004). As such, greater impulsivity, sensation-seeking, and substance use are evident during adolescence when prefrontal cortex may still be undergoing changes. Delayed prefrontal functioning has been linked with substance use (see the review by Goldstein and Volkow, 2002).

Epidemiological evidence also shows that the pattern of substance use differs by gender during adolescence (Chen and Jacobson, 2012; Johnston et al., 2012). For instance, girls have higher levels of substance use in early adolescence and boys show greater changes over time with higher levels of use in mid-adolescence and early adulthood (Chen and Jacobson, 2012). The different pattern of drug use may be linked to pubertal development, elevated levels of impulsivity, and

sensation-seeking. Women start and complete physical development earlier than men (Sun et al., 2002), and men have higher impulsivity and sensation-seeking than women (Zuckerman, 1994; Rosenblitt et al., 2001; Cross et al., 2011).

PUBERTAL STATUS AND SUBSTANCE USE

Increases in substance use occur with biological changes that accompany puberty. As such, physical pubertal development is associated with alcohol, cigarette, and marijuana use among adolescents, with most data indicating that early-maturing adolescents have greater likelihood of initiation and faster progression of substance use (Dick et al., 2000; Chung et al., 2005; Ge et al., 2006; Biehl et al., 2007; Downing and Bellis, 2009; Hayatbakhsh et al., 2009). This pattern is consistent with the maturation-deviance hypothesis, which states that adolescents whose development deviates from the norm experience heightened emotional distress, which, in turn, influences substance use behaviors (Tschann et al., 1994). Findings also point to gender differences in these associations; early-maturing girls report greater substance use (Ge et al., 2006; Graber et al., 1997), but less consistent findings exist for boys. Some studies find that late development for boys is related to greater risk for increased substance use (Wichstrøm, 2001), while others observe that the early development of both boys and girls is related to substance use (Westling et al., 2008).

The link between pubertal development on the basis of physical and associated objective pubertal status variables and substance use is inherently limited by reduced variations in overt signs of development among older adolescents, such as high school-aged youth (Graber et al., 1997). Among adults, early puberty is not associated with increased substance use (Viner et al., 2006); therefore, the association between early puberty with substance use may not be significant in a high school sample whose pubertal development is complete or near complete. Given this possibility, we examined both the pubertal timing on the basis of self-reported physical development and subjective appraisal of one's pubertal development relative to peers to assess both aspects of pubertal status.

Pubertal timing on the basis of perceptions of one's relative development compared with one's peers may more strongly influence the course of substance use behaviors than would actual pubertal development in high school (Graber et al., 1997; Storvoll et al., 2008) and young adult samples (Graber et al., 2004). Although also likely to correlate with physical pubertal development on the basis of physician ratings of physical characteristics, perceptions of pubertal timing relative to peers may encompass aspects that are not captured by the ratings of physical characteristics (Dubas et al., 1991). For instance, perceptions may include more subtle psychosocial traits or milestones that adolescents associate with development, including being teased or rejected, which may generate stress and low self-esteem and ultimately influence behaviors like engagement in sexual activity and substance use.

IMPULSIVITY/SENSATION-SEEKING AND SUBSTANCE USE

Impulsivity and sensation-seeking dramatically increase in adolescence and they can enhance our understanding of the link between pubertal status and substance use, especially

among a high school-aged sample when overt physical development may be less salient. Sensation-seeking is defined as willingness to take risks for novel experience or excitement (Zuckerman, 1994). Sensation-seeking is positively associated with the presence of sex hormones that is found at the onset of pubertal development (Zuckerman et al., 1980) and the association between pubertal status and substance use can be attributed to sensation-seeking in early-developing adolescents (Martin et al., 2002). Sensation-seeking may attract adolescents to engage in activities that are novel, impulsive, and potentially risky, including alcohol, cigarette, and marijuana use (Arnett, 1992; Crawford et al., 2003; Malmberg et al., 2010).

Impulsivity, defined as acting on impulse without thinking or planning (Zuckerman, 1994), is another trait that is increased in adolescence and has been linked to substance use (Verdejo-García et al., 2008). Sensation-seeking and impulsivity are conflated yet dissociable constructs; high sensation-seeking does not necessarily result from impulsive actions and not all impulsive behaviors are aimed at eliciting novel, exciting experiences (Steinberg et al., 2008). Sensation-seeking and impulsivity may have different associations with pubertal timing and substance use in a high school-aged sample because they follow different developmental trajectories; sensation-seeking sharply increases between ages 10 and 15 and slowly decreases thereafter, and impulsivity steadily increases from age 10 and into young adulthood (Steinberg et al., 2008). However, studies examining impulsivity and substance use that take pubertal status into account are sparse. Given that impulsivity increases over the course of adolescence (Steinberg et al., 2008), it is possible that along with sensation-seeking, impulsivity may also be correlated with substance use.

HYPOTHESES

We hypothesized that early perceived pubertal timing, high impulsivity, and high sensation-seeking would be associated with substance use (alcohol, cigarettes, and marijuana), but pubertal timing on the basis of self-report of physical development would not be associated with substance use among high school-aged adolescents. To explore gender differences in these relationships, we examined these associations separately by gender.

METHODS

Procedures

This study analyzed a cross-sectional survey of high school students conducted in 2006. Study procedures were described previously (Cavallo et al., 2010; Potenza et al., 2011). Briefly, all public 4-year high schools in the state of Connecticut were invited to participate. Ten schools representing a wide geographical region of the state and the 3 tiers of the state's district reference groups (DRGs) participated. District reference groups represent the socioeconomic status of the families in the school district, and sampling of schools across DRGs helped to enhance the generalizability of the data.

Following approval from the school principal, boards and/or superintendents, a passive consent procedure was used to obtain permission from a parent or legal guardian. Research

assistants administered the survey to the entire student body in assemblies, health, or English classes and informed students of the confidentiality and the voluntary nature of their participation. The survey took about 30 minutes to complete and all students were provided a pen for their participation. This study was reviewed and approved by the Yale Institutional Review Board.

Measures

The Pubertal Development Scale (PDS; Petersen et al., 1988) is a self-report scale that assesses children's stages of physical growth on height, skin changes, and pubic hair. Boys complete additional items on facial hair and voice changes; girls complete additional items on breast growth and menarche. Item responses fall on a scale from "1 = not started" to "4 = completed" with the exception of menarche, which is dichotomous ("yes/no"). The PDS is widely used in longitudinal and school-based studies and has been shown to reliably capture actual physical development in adolescents (Petersen et al., 1988; Patton et al., 2004). Pubertal Development Scale scores have shown moderate reliability (alpha coefficients ranging from 0.68 to 0.83; Petersen et al., 1988) and correlations between 0.61 and 0.67 with physical exams (Brooks-Gunn et al., 1987). Responses were averaged across the items to retain metric, resulting in a score indicative of stage of development. The Cronbach alpha of this scale in this sample was 0.79.

Perceived pubertal timing (PPT) relative to peers was assessed by averaging 2 questions ($\alpha = 0.85$): "Do you believe your development is (was) any earlier or later than most other boys/girls your age?" (Dubas et al., 1991) and "Compared with other kids your age, when did you start puberty?" Participants indicated their development on a 5-point Likert scale ranging from "much earlier/a lot before" to "much later/a lot later." The group who reported not knowing how their development compared with that of their peers ($n = 514$; 11.1%) was excluded from comparisons.

The use of cigarettes, marijuana, and alcohol was measured by asking about each substance use in the past 30 days. As there was limited variability in frequencies of substance use, items were dichotomized to indicate use (once or more) or no use of substances in the past 30 days.

Impulsivity and sensation-seeking was assessed using the 19 items from the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman et al., 1993). The impulsivity score was computed by adding the "true" responses of the 8 items of this subscale (eg, "I often do things on impulse.") and sensation-seeking score was computed by adding 11 items (eg, "I like to have new and exciting experiences and sensations even if they are a little frightening."). Factor analysis of this measure supported the 5-factor model of personality, in which impulsivity and sensation-seeking were 2 unique factors, and these subscales have shown good internal consistency (alphas ranging from 0.64–0.77; Zuckerman et al., 2002). In our sample, we detected Cronbach alpha of 0.77 for the sensation-seeking scale and 0.71 for the impulsivity scale. We used mean substitution to compute missing scores for the participants missing less than 50% of the items that comprised each subscale. Both list-wise deletion and mean substitution detected the same sig-

nificant results; therefore, we presented the results from mean substitution.

Participants

The sample consisted of 4637 students in grades 9 through 12. Of the total sample, 3068 participants (66.2%) with complete data on age, gender, PDS, PPT, cigarettes, marijuana and alcohol use, sensation-seeking, and impulsivity were included in the analyses.

Those with incomplete and complete data did not differ on age ($t_{(4510)} = 0.49, P = 0.62$), sensation-seeking ($t_{(3788)} = -0.73, P = 0.47$), and PPT ($t_{(3423)} = 1.81, P = 0.07$), but those with incomplete data were more likely to be boys ($\chi^2(1, 4468) = 231.67, P < 0.001$), use cigarettes ($\chi^2(1, 4637) = 135.88, P < 0.001$), alcohol ($\chi^2(1, 4637) = 4.61, P = 0.03$), and marijuana ($\chi^2(1, 4637) = 148.23, P < 0.001$), and be more impulsive ($t_{(3826)} = 3.11, P = 0.002$) and develop later on the basis of PDS scores ($\chi^2(1, 3989) = -3.87, P < 0.001$).

STATISTICAL ANALYSES

Chi-square and *t* tests were used to assess the differences between study variables and gender, and data completeness and all study variables. Those with complete data were selected for logistic regression to assess the use of cigarettes, marijuana, and alcohol in the previous 30 days separately for boys and girls. Each substance use was modeled separately and all models contained sensation-seeking, impulsivity, PDS, and PPT as independent variables while controlling for age. To correct the multiple comparisons, Bonferroni-determined *P*-values equal to or less than 0.008 were considered statistically significant.

RESULTS

Table 1 shows the demographic and study variables for study participants. Boys and girls did not differ on alcohol use, but more girls reported cigarette use and more boys reported marijuana use. Compared with girls, boys had greater impulsivity and higher PDS scores. The scores on PPT and sensation-seeking did not differ by gender.

Pubertal Development Scale and PPT correlated weakly ($r_{(3028)} = 0.14, P < 0.001$) and sensation-seeking and impulsivity correlated moderately ($r_{(3028)} = 0.57, P < 0.001$).

Logistic regression analysis modeling the use of 3 substances (alcohol, cigarettes, and marijuana) with PDS, PPT, sensation-seeking, and impulsivity as independent variables separately for boys and girls showed that sensation-seeking is associated with substance use for both boys and girls (Table 2). Different relationship between impulsivity and substance use was detected for boys and girls: among girls, impulsivity was associated with use of all 3 substances, but among boys, it was not associated with any substance use. Pubertal status differentially associated with use of substances; early PPT was associated with cigarette smoking for both boys and girls, but PDS was not associated with any substance use for both genders.

DISCUSSION

This study examined the role of pubertal timing (on the basis of self-reported physical development score [PDS] and

TABLE 1. Sample Characteristics on Study Variables

	Boys (n = 1202) %	Girls (n = 1826) %	χ^2/df
Age, yr			
13–14	11.6	14.3	13.71*
15–16	54.1	55.3	
17–18 and older	34.3	30.4	
Grade			
9th	28.2	28.0	0.01
10th	27.4	27.9	
11th	27.7	28.2	
12th	16.8	16.0	
Race/ethnicity			
Caucasian	74.0	75.5	0.05
Multirace	2.3	2.6	
Hispanic	11.5	11.8	
African American	5.8	5.7	
Asian	3.4	1.9	
Other	3.0	2.5	
Cigarette use in last 30 days	19.2	22.2	3.97*
Alcohol use in last 30 days	47.8	49.2	0.64
Marijuana use in last 30 days	28.5	25.0	4.52*
PDS, <i>M</i> (SD)	3.19 (0.64)	2.97 (0.45)	10.85†
PPT, <i>M</i> (SD)	3.16 (0.87)	3.12 (0.87)	1.09
Sensation-seeking, <i>M</i> (SD)	6.60 (2.87)	6.64 (2.83)	–0.44
Impulsivity, <i>M</i> (SD)	3.76 (2.18)	3.22 (2.18)	6.75†

* $P \leq 0.05$; † $P \leq 0.01$.

M, mean; PDS, pubertal development scale; PPT, perceived pubertal timing; SD, standard deviation.

on perceptions of pubertal timing relative to one’s peers [PPT]), sensation-seeking, and impulsivity in relation to substance use (alcohol, cigarette, and marijuana) for high school-aged boys and girls.

Consistent with our hypothesis, physical development determined by the PDS was not associated with past 30-day use of alcohol, cigarettes, and marijuana. This finding suggests that the relationship between early pubertal development and substance use may be more salient earlier in adolescent development, at initial stages of puberty. This interpretation is consistent with recent findings that the negative effects of early physical maturation attenuated as adolescents reached young

adulthood (Copeland et al., 2010). This sample of adolescents may have already progressed in pubertal stages, and therefore, other predictors specific to adolescence such as perceived pubertal timing, sensation-seeking, and impulsivity may be more strongly related to substance use.

Interestingly, we found substance-specific findings: among boys and girls, early perceived pubertal timing was associated with use of cigarettes but not use of alcohol or marijuana. The perception of early maturation compared with one’s peers may affect the social interactions and self-image more so than would actual physical maturation. Smoking cigarettes may represent one way that an adolescent expresses an image of the mature self; adolescent girls who smoke consider themselves sophisticated and worldly and that smoking promotes this image (Lloyd et al., 1997). As such, meanings that adolescents construct about smoking may become integrated into their social identity and may be important in making decisions to smoke. Alcohol and marijuana use may be less contingent upon one’s subjective appraisal of pubertal development; alcohol use may be more normative and acceptable in high school-aged youth (close to 50% reported drinking in the past 30 days) and marijuana use may be seen as more deviant and less linked to one’s identity.

We found that for both boys and girls, sensation-seeking was independently related to substance use (alcohol, cigarette, and marijuana). This is consistent with other findings that indicated that sensation-seeking motivates adolescents toward behaviors that are novel and exciting such as substance use (Arnett, 1992; Crawford et al., 2003; Malmberg et al., 2010).

Because nicotine, alcohol, and marijuana elicit rewarding effects (Chambers et al., 2003), those with strong sensation-seeking drives may continue to use substances to elicit such responses.

Even though boys had greater impulsivity than girls, impulsivity was significantly associated with use of all 3 substances among girls only. This finding corresponds to the adult literature that has also reported on gender differences in the association between impulsivity and substance use (Waldeck and Miller, 1997). For example, impulsivity prospectively predicted the increase of smoking in women and alcohol

TABLE 2. Logistic Regressions Associating the Risk of Substance Use and Impulsivity, Sensation Seeking, and Pubertal Timing Stratified by Gender*

	No Use Versus Use					
	Cigarette		Alcohol		Marijuana	
	OR	95% CI	OR	95% CI	OR	95% CI
Boys (n = 1202)						
Pubertal developmental scale	0.73	0.58–0.93	1.05	0.86–1.28	0.88	0.71–1.09
Perceived pubertal timing	1.28†	1.08–1.51	0.99	0.86–1.14	1.17	1.01–1.36
Sensation-seeking	1.16‡	1.09–1.25	1.16‡	1.10–1.22	1.13‡	1.01–1.17
Impulsivity	1.10	1.01–1.20	1.07	1.00–1.15	1.09	1.01–1.17
Girls (n = 1826)						
Pubertal developmental scale	1.21	0.91–1.61	1.22	0.96–1.54	0.94	0.73–1.22
Perceived pubertal timing	1.22†	1.06–1.40	1.12	1.00–1.26	1.14	1.00–1.29
Sensation-seeking	1.22‡	1.16–1.29	1.25‡	1.19–1.30	1.17‡	1.11–1.23
Impulsivity	1.16‡	1.09–1.24	1.11‡	1.05–1.17	1.16‡	1.08–1.22

*All analysis controlled for age and Bonferroni correction was applied for significance testing.

† $P \leq 0.008$; ‡ $P \leq 0.001$.

OR, odds ratio; PDS, pubertal development scale; SE, standard error.

consumption in men and women (Granö et al., 2004). It is unclear why impulsivity in girls but not in boys is related to greater substance use. The excluded missing data were more associated with boys and impulsivity; therefore, the association between impulsivity and substance use among boys detected in this study may not be generalized to all high school-aged boys. The potential bias that may exist in our data precludes us from making conclusive statements about the role of impulsivity, and its role in substance use among boys should not be ruled out without further research. Despite this limitation, we were still able to detect an association between early-perceived pubertal timing and cigarette use, and sensation-seeking and past 30-day use of cigarettes, alcohol, and marijuana in boys and girls.

Several other limitations should be taken into account when interpreting the findings of this study. This is a cross-sectional self-reported survey, and thus, accuracy of adolescents' actual substance use cannot be verified and directionality of the associations cannot be established. In addition, biological markers or physician ratings of pubertal development using tools such as Tanner staging were not used to determine pubertal development. Using the PDS to estimate the actual physical developmental status is inherently subjective and adolescents' ratings may not accurately represent their actual physical development. However, in contexts such as school settings where a physical examination is not feasible and the use of illustrations of body developmental stages may be concerning to school districts and/or parents, it represents an appropriate and valid substitution (Dorn et al., 2006), especially considering the PDS correlations with Tanner staging (Patton et al., 2004).

This study has several strengths: (1) examination of constructs that have been linked to prefrontal cortex and specific in adolescence such as puberty, sensation-seeking, impulsivity, and substance use; (2) a simultaneous comparison of 2 measures that encompass pubertal development and perceptions of pubertal timing; (3) a focus on past-30-day use of 3 of the most commonly used substances in adolescence: alcohol, cigarettes, and marijuana; and (4) exploration of these factors separated by gender in a nonclinical sample of high school-aged adolescents.

CONCLUSION

The sensation-seeking is associated with substance use for all adolescents; therefore, drug prevention efforts that use more effective antidrug messages targeting high sensation-seekers may be useful. Because sensation-seeking is biologically based better understanding of the neural mechanisms underlying this trait may inform targeted drug interventions. Our findings also suggest that among high school-aged adolescents, perceived pubertal timing compared with peers rather than physical pubertal development was associated with cigarette smoking. Perhaps, parents, educators, and clinicians who work with adolescents can focus on promoting a positive self-image that does not include cigarette smoking. Finally, future studies using longitudinal design should investigate how changes in physical development and subjective experience of pubertal timing influence sensation-seeking and impulsivity from early adolescence through late adolescence to better un-

derstand how these relationships to substance use may change with time and growth.

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