Pubertal Timing, Social Competence, and Cigarette Use: A Test of the Early Maturation Hypothesis

Erika Westling, Ph.D., **Judy A. Andrews, Ph.D.**, and **Missy Peterson, M.A.**
Oregon Research Institute, Eugene, Oregon

Abstract

Purpose—The timing of pubertal maturation has been associated with cigarette use, but the exact mechanisms by which maturation influences cigarette use are unclear. One hypothesis posited to explain this association is the early maturation hypothesis, that boys and girls who mature earlier than their peers have developed physically before their social resources have fully developed, leaving them ill-equipped to deal with challenges that may arise when entering physical maturity. This prospective study examines the relations between pubertal timing, social competence, and cigarette use in a sample of 1013 boys and girls, followed from 5th through 12th grade.

Methods—Latent growth modeling (LGM) was utilized to predict cigarette use across high school years (grades 9–12) from pubertal timing assessed in 5th grade (for girls) and 6th grade (for boys) as mediated by social competence across grades 6 to 8.

Results—Earlier pubertal maturation predicted cigarette use in 9th grade and increased cigarette use across high school. Earlier maturation also predicted lower social competence in 6th grade. For girls, social competence partially mediated the relation between pubertal timing and cigarette use.

Conclusions—The data supported the early maturation hypothesis for both boys and girls, as earlier maturers were more likely to smoke in 9th grade and had lower social competence in 6th grade. However, social competence partially mediated cigarette use for girls only. The mechanisms by which negative outcomes are associated with pubertal maturation appear to differ by gender.

Keywords

gender differences; pubertal timing; substance use; adolescence; social competence

Gender Differences in Pubertal Timing, Social Competence, and Cigarette Use: A Test of the Early Maturation Hypothesis Cigarette use by American youth continues to be a major

Corresponding Author: Erika Westling, Oregon Research Institute, 1715 Franklin Blvd., Eugene, OR, 97403. Phone: 541-484-2123; Fax: 541-484-1108. erikaw@ori.org.

Implications and Contribution
In a sample of 1013 boys and girls followed from 5th through 12th grade, earlier pubertal maturers had lower social competence in 6th grade and higher cigarette use in 9th grade. For girls, social competence mediated the relation between pubertal timing and cigarette use, indicating possible areas for intervention.

public health issue, with many adolescents initiating use before age 18 (1,2). Almost half (46.1%) of high school students have tried cigarettes in their lifetimes (1), and 19.2% of 12th graders have used cigarettes in the last month (2). Experimenting with cigarettes at a young age can result in daily smoking fairly rapidly, as children can experience symptoms of withdrawal after smoking just one cigarette a month (3). Cigarette smoking appears to occur at earlier ages and at greater rates for girls who mature physically before their peers (4,5), and some studies also find this association for boys (6,7) although findings for males are mixed with other studies showing no detrimental effects of early maturation (8). Non-early maturers do not appear to "catch up" in rates of substance use seen in early maturers by late adolescence (9).

One hypothesis posited to explain the link between pubertal timing and substance use is the *early maturation* hypothesis. This hypothesis suggests that early maturers are at increased risk for psychosocial maladaptation because their regular course of development has been interrupted (10). Earlier maturers have had less time to socially, cognitively, and physically adjust, resulting in a gap between physical and social maturity. Since they appear more physically mature then their same-age peers, they may be expected to demonstrate social and cognitive competence beyond their years, when in fact they may demonstrate lower competence because of an interruption in the normal course of their development. Development of physical, cognitive and behavioral systems occur at different times and are driven by dependent as well as independent biological processes (11); physical development is not indicative of cognitive or emotional development. In fact, advanced physical development may indicate a widening gap between physical development and an adolescent's cognitive abilities to regulate affect and behavior (11). Although the early maturation hypothesis is the most commonly accepted hypothesis to explain the relation between early pubertal timing and substance use, it is rarely tested (12).

The transition from childhood to adolescence often results in increasing social, behavioral, and environmental stressors and challenges (13). While negative outcomes such as substance use have been associated with early pubertal maturation for both sexes, the associations tend to be stronger for girls, and the pathways and processes by which negative outcomes are linked to timing of maturation may differ by sex. Early maturing girls appear to be especially vulnerable to life stress, as they show heightened reactivity in response to stress (14), but both early maturing boys and girls exhibit excessive excitability or emotionality (15).

One possible mechanism linking early pubertal maturation to early substance use per the early maturation hypothesis is social competence, which may not be delayed in earlier pubertal maturers. Social competence is defined as "a child's ability to engage and respond to peers with positive feelings, to be of interest to peers and be highly regarded by them, to take the lead as well as follow, and to sustain the give-and-take of peer interaction" (16). A socially competent child is able to select appropriate behaviors in different contexts, to interpret social cues effectively in a variety of situations, and to anticipate consequences of behaviors for the self and for others. They make friends more easily. For children and adolescents, social competence is a protective factor, associated with positive psychosocial adjustment and low levels of risk behaviors, including substance use (17).

Although the relation between the timing of puberty and substance use has been well documented, particularly for girls, the early maturation hypothesis has not been systematically tested. This paper examines the relation between early maturation and cigarette use across the high school years and examines social competence as a mediating mechanism for both genders. We hypothesized that: 1) Earlier maturing boys and girls are more likely to use cigarettes across the high school years, and they are also less socially

competent, compared to later maturers; and 2) Social competence will mediate the relation between early pubertal timing and cigarette use.

Methods

Participants

Data were from participants in the ongoing Oregon Youth Substance Use Project (OYSUP). The OYSUP used a cohort-sequential design, beginning when students were in 1st through 5th grade (five grade-based cohorts). Data from grades 5 through 12 were used in analyses. A representative sample of 1075 students was recruited from 15 elementary schools in a working-class community of approximately 50,000 people in Western Oregon. Participants, their parents and teachers completed eight annual or biannual assessments across nine years. A detailed description of study procedures is given in Andrews et al. (18).

For the current study, data are from a subsample of 1013 students. Eligible participants had at least one of the following: 1) parent ratings of pubertal development in 5th grade (girls) or 6th grade (boys); 2) teacher ratings of social competence in 6th–8th grade; and 3) self-reported cigarette use in high school, 9th–12th grade.

About half of the sample were girls (n = 508); the sample was primarily European American (85.5%), with 7.1% Hispanic American, 1.3% African American, 2.2% Asian American, and 2.2% American Indian or Alaskan Native. About 40% of the sample was eligible for a free or reduced lunch under Title 1, an indicator of low family income. The subsample was compared to the full study sample on key variables, and there were no significant differences in sex, ethnicity, or eligibility for free or reduced lunch.

Statistical Analysis

Latent growth modeling (LGM) (19) was used to test a model wherein pubertal timing was related to the growth in cigarette use across high school (grades 9–12), through the development of social competence across grades 6 through 8. LGM is used to estimate growth over time and takes full advantage of the repeated longitudinal assessments used in this study. With LGM, we obtained estimates of both the mean level and variance of the intercept (initial level) and slope (change over time) of cigarette use and social competence. The inclusion of a quadratic factor was evaluated in the cigarette growth model, and fit significantly better than a growth model with just the linear factor. As the quadratic factor is highly correlated with the linear factor, only the linear factor was predicted in the structural model. All models were analyzed with Mplus Version 5.21 (20) using maximum likelihood estimators with robust standard errors (MLR), which is recommended for non-normal, skewed variables, such as cigarette use. Missing data were estimated using Full Information Maximum Likelihood methods (21).

The Satorra-Bentler scaled chi-square statistic adjusts the chi-square statistic and standard errors to account for the non-normal distribution of the data (22), and was used to assess absolute fit, but is sensitive to sample size issues (23). Additional model fit statistics, specifically the root mean square error of approximation (RMSEA) and the comparative fit index (CFI) were used. A RMSEA of .05 indicates a close model fit and values of CFI .95 indicate good fit (24).

Gender differences in the models were tested using multiple group analysis. The fit of a model wherein all parameters were fixed to be equal across genders was evaluated against a model where each parameter was freed sequentially. A significant difference in Satorra-Bentler scaled chi-squares (25) indicated a gender difference in that parameter estimate.

The criteria recommended by Holmbeck (26), which follows the criteria set forth by Baron and Kenny (27), and extended to structural equation modeling by Hoyle and Smith (28), were used to examine the mediating role of social competence in explaining the relation between pubertal maturation and cigarette use. Both the model with a direct effect between pubertal timing and cigarette use and the model showing both direct and indirect paths must fit the data well. Finally, the fit of a model wherein the direct path from pubertal timing to cigarette use was allowed to be free was compared to the fit of a model where that direct path was set to zero. We tested the significance of the indirect path using the Sobel test, as recommended by MacKinnon and Dwyer (29).

Measures

Pubertal Timing—An adapted form of the Pubertal Development Scale (PDS) (30,31) was completed by parents to assess pubertal status of girls in 5th grade and boys in 6th grade. Onset of pubertal development generally ranges from 8 to 13 for girls, and from 9.5 to 13.5 for boys (32,33). To increase the reliability of the measure, if both parents completed the assessment, we averaged across parents (between parent rs = .78 for boys and .85 for girls). The adapted form of the PDS has been shown to provide reliable parent reports for 5th and 6th grade girls and boys (31). Items used to assess girls' pubertal status were growth of body hair, skin change, growth spurt, breast change, and menarche (α=.74); items for boys were the first three, plus voice change and facial hair growth (α=.68). Responses to items ranged from 1 (*no pubertal development or change)* to 4 (*pubertal development or change completed*); items were averaged. To obtain an estimate of relative pubertal maturation, or pubertal timing, we used the residuals of PDS scores regressed on age. This measure controls for age, and is a measure of pubertal timing in comparison to peers. Higher scores, or positive residuals, indicate *earlier* maturation relative to same-age peers.

Cigarette Use—Cigarette use was measured using self-report of frequency of cigarettes smoked in the last year (*Never (0), Once (1), A Couple of Times (2), Some Each Month (3), Some Each Week (4), or Some Each Day (5)*).

Social Competence—Teachers who knew the student assessed social competence using a teacher version of the Social Competence subscale of the Perceived Competence Scale for Children (34). This subscale is comprised of three bipolar items (easy/hard to make friends; popular/unpopular; has/does not have a lot of friends) in which the rater chooses one pole as more accurate and rates it as "really true" or "sort of true" for that child; items were summed. The scale ranged from 3 (endorsing really true to all negative poles) to 12 (endorsing really true to all positive scales), with a higher score indicating higher social competence. Cronbach's alphas ranged from .69 to .94, decreasing with grade.

Results

Descriptive Statistics

In 9th grade, 79% of the sample reported "never" trying a cigarette and 3% were smoking daily. By 12th grade, 56% had never tried smoking and 14% were smoking daily. Percentages, means and standard deviations of cigarette use in the last year are shown by grade and gender in Table 1. Girls smoked significantly more than boys in the 10th grade, t(742)=2.32, p<.05. There were no other significant gender differences. There were no differences as a function of cohort (grade at the first assessment) for any grade.

The means, standard deviations, and t-tests of equality of means between boys and girls of teachers' evaluation of their students' social competence are in Table 2. Girls across all three grades were rated by their teachers as more socially competent than boys. There were no

differences as a function of cohort for any grade. The intra-class correlation within elementary schools at T1 for teacher-rated social competence was low at .005, indicating little clustering within school, so school was not included as a variable in our analyses.

Latent growth models for cigarette use and social competence

The quadratic factor of growth in cigarette use across the high school years (grades 9–12) fit the data well (CFI=1.00; RMSEA=.000; 90% CI .000, .000). These model fit indices were better than those for the linear model of growth in cigarette use across high school (CFI =. 956; RMSEA=.069; 90% CI 0.046, 0.096). These findings in conjunction with the Satorra-Bentler Scaled χ^2_{diff} ($\Delta df=4$, n=956) =26.39, p<.001) comparing the two models indicated that the quadratic term should be included in all models. The mean of the intercept (M=.52) and slope (M=.23) of cigarette use differed significantly from zero, and the variances for both the intercept and slope were significant (p<.05). Multiple group analysis by gender showed significant gender differences in the variance of both the intercept (χ^2_{diff}($\Delta df=1$, n=990)=6.14, p<.05) and slope (χ^2_{diff}($\Delta df=1$, n=990)=4.41, p<.05), with girls having a higher mean intercept and more variance than boys.

The growth model for social competence across grades 6 to 8 fit the data well, χ^2(1, n=985)=.094, p=.76; CFI=1.000; RMSEA=.000; 90% CI .000, .057. The mean of both the intercept (M=8.43) and slope (M=.11) differed significantly from zero (p<.05). The variance of the intercept (5.15), but not the slope (.32) differed significantly from zero. Multiple group analysis showed that girls had a higher mean intercept, χ^2_{diff}(1, n= 985)=22.87, p<. 001, and slope of social competence, χ^2_{diff}(1, n=985)=17.06, p<.001. There was no difference in the variance.

To meet the first criteria of mediation, and test the first hypothesis, we examined a model wherein growth in cigarette use across grades 9 through 12 was regressed on pubertal timing. The model fit the data well per the recommended fit indices (CFI= 1.00; RMSEA= . 000; 90% CI .000, .046). For the full sample, pubertal timing predicted the intercept of cigarette use (B=.16; p<.01) and slope (B=.08; p<.05). Multiple group analysis showed significant paths from pubertal timing to the intercept of cigarette use for both girls (B=.13; p<.01) and boys (B=.18; p<.01), indicating that both boys and girls with earlier pubertal timing were likely to use more cigarettes in the 9th grade.

To fulfill the second criteria of mediation and continue testing the first hypothesis, we tested a model of both the direct and indirect effect of pubertal timing on the intercept and slope of cigarette use through the intercept and slope of social competence. The model fit the data well according to the recommended fit indices (CFI=.999; RMSEA=.012; 90% CI .000, . 034). Pubertal timing significantly predicted the intercept of cigarette use (B=.14, p<.01) and the intercept of social competence (B=−.16, p<.01), supporting our first hypothesis. The path from the intercept of social competence to the intercept of cigarette use was also significant (B=−.16, p<.05), as was the direct path from pubertal timing to the slope of cigarette use (B=.10, p<.05). No other structural paths were significant. Multiple group analysis (see Figure 1) suggested one significant gender difference (Satorra-Bentler Scaled χ^2_{diff}($\Delta df =1$, n=1013)=90.39, p<.001) in the path from the intercept of social competence to the intercept of cigarette use; this path was significant for girls (B=−.34; p<.01), but not for boys (B=.05, ns). There was another gender difference in the path from pubertal timing to the intercept of cigarette use; this path was significant for girls (B=.11, p<.01) and approached significance for boys (B=.15, p=.06). Multiple group analyses also showed that the path between pubertal timing and the slope of cigarette use was not significant for either sex.

To fulfill the third criteria of mediation, we compared the fit of the model in which the significant direct and indirect paths (through the intercept of social competence) from pubertal timing to the intercept of cigarette use was estimated to the fit of a model with the direct path from pubertal timing to the intercept of cigarette use set to zero. Supporting mediation by social competence, the difference between the two models was significant (Satorra-Bentler Scaled $\chi^2_{diff}(\Delta df =1, n=1013)=17.97$, p<.001).

Since the path from the intercept of social competence to the intercept of cigarette use was only significant for girls, we conducted separate Sobel tests for each gender. The Sobel test confirmed that the indirect path was significant for girls, Sobel=2.22, p<.01, supporting a meditational effect of social competence explaining the relation between pubertal timing and the intercept of cigarette use. This effect was not significant for boys, Sobel=−.34, *ns.*

Discussion

While the early maturation hypothesis is discussed theoretically in many research articles, the specific components of the hypothesis, such as social competence, have not yet been directly evaluated. In this prospective study, we tested social competence as a mediator of pubertal timing and cigarette use in a sample of children followed from 5th to 12th grade. Confirming our first hypothesis, earlier maturers tended to smoke more as 9th graders, and to have a steeper increase in smoking from 9th to 12th grade. In addition, as predicted by the early maturation hypothesis, boys and girls with earlier pubertal timing had lower social competence in 6th grade, although earlier pubertal timing did not affect growth in social competence. Our second hypothesis was supported only for girls; there was an indirect effect through social competence in 6th grade whereby earlier pubertal timing in 5th grade was related to smoking in 9th grade. In the full model, the path from pubertal timing to cigarette use was marginally significant for boys (p=.06), and the path from pubertal timing to the slope of cigarette use was no longer significant for either sex. Thus, similar to some other studies (e.g., 8), we found the association between earlier pubertal timing and cigarette use to be stronger for girls than for boys.

We did not find a gender difference in the prediction of social competence from pubertal timing. Both boys and girls with earlier pubertal timing had lower social competence in grade 6, supporting one proposed mechanism of the early maturation hypothesis. To our knowledge this is the first study to examine social competence and pubertal timing in a representative adolescent population, although other studies have shown negative outcomes such as higher internalizing symptoms for earlier maturing boys and girls (e.g., 14). Early maturers may have a widening gap between their physical appearance and social maturity (10,11), and advanced physical maturation may actually delay development in other areas due to biological changes in reactivity and responses to stress (14,15). Our findings provide evidence for a delay in the development of social competence for early maturers. Recent neuroscience research on the development of the adolescent brain indicates that the prefrontal cortex, involved with decision making and moderating social behaviors, is maturing throughout adolescence and emerging adulthood (15). Adolescents who begin puberty earlier than their peers may have the largest gap between physical development of their bodies and neurocognitive development of their brains.

Although results from this study support the early maturation hypothesis by demonstrating a link between early pubertal timing and lower social competence, social competence explained the relation between pubertal timing and cigarette use only for girls. Early developing girls may be teased, feel excluded, or be rejected by their peers because of their maturation, and may not know how to react appropriately given their level of cognitive development and social competence. They may smoke cigarettes in order to "fit in" with

peers (35). In support of this position, Andrews and colleagues (36) found that girls' perceptions of smokers as "cool", "exciting" and "popular" predicted willingness to smoke as well as subsequent cigarette use. This relation was not shown for boys. Girls appear to value their close peer relationships more than boys during adolescence, and are more susceptible to difficulties in these friendships (37). Thus they may be more easily swayed by peer pressure to participate in activities such as smoking. Girls who are low in social competence may also experience increased anxiety, and nicotine appears to alleviate anxiety in females but not in males (38).

Additional research is needed to explain the gender differences we observed in this sample, specifically why social competence did not mediate the relation between pubertal timing and cigarette use for boys. Future research replicating this finding and examining possible biological differences that could account for this association is warranted. Studies of changes in arousal, reactivity, brain development, and motivations may pinpoint specific ways in which pubertal development affects behavior and social development for adolescents.

Limitations and Strengths

Study limitations include the following four issues. First, pubertal timing was assessed using parent report, rather than actual physical development. However, the PDS is a widely used measure, parent reports are reliable measures comparable to child self-reports (31), and external perceptions of puberty may be more relevant than actual pubertal development for these research questions (39). Second, although our sample was representative of the community in which it was gathered, participants were primarily Caucasian, limiting the generalizability of our findings to this racial/ethnic group. Third, our measure of cigarette use over the last year was self-report, and it is possible that participants did not honestly report their use. However, report of lifetime use was consistent across assessments, and participants were assured of their confidentiality (18). We used this outcome measure, rather than cigarette use in a shorter time frame, such as the last week, because it had more variance and we also wanted to capture even infrequent amounts of cigarette use as this can rapidly result in dependence in adolescents (3). Finally, the reliability of our social competence measure decreased across grades. When kids are in 6th grade they have more classes with the same teachers, so their teachers likely know them better compared to later grades. This decreased reliability in the measurement of social competence may explain why we had significant associations with the intercept (6th grade level), but not with the slope (change from 6th–8th grade).

There were several strengths of this study. First, the prospective, cohort-sequential study design allowed us to examine the associations between early possible risk factors and later cigarette use. Further, both social competence and cigarette use were measured across time, allowing for not only an investigation of these variables at a single time point, but also a prediction of growth in these variables across time. Second, we used a stratified random sample from 15 elementary schools, which increases the generalizability of our findings. Third, we obtained information from multiple sources (children, parents and teachers), and used these in the construction of our constructs, thus eliminating mono-method bias as a potential explanation for the links between constructs.

Findings from this study have implications for prevention. First, parents and teachers need to be aware that earlier maturers are at risk for early initiation of smoking, and may also be delayed in skills such as social competence. Programs that target increasing social competence, such as The Life Skills Program (40) may be useful as prevention tool, particularly for earlier maturing girls. Further investigation into the proposed mechanisms of

the early maturation hypothesis, especially to clarify the relationships seen for boys, is needed in order to fully inform prevention efforts.

Acknowledgments

References

1. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance – United States, 2009. Surveillance Summaries. 2010 Jun.4:2010.Morbidity and Mortality Weekly Report. 59(SS-5)

2. Johnston, LD.; O'Malley, PM.; Bachman, JG.; Schulenberg, JE. Smoking stops declining and shows signs of increasing among younger teens. University of Michigan News Service; Ann Arbor, MI: Dec 14. 2010 Retrieved 03/14/2011 from http://www.monitoringthefuture.org

3. Doubeni CA, Reed G, Difranza JR. Early course of nicotine dependence in adolescent smokers. Pediatrics. 2010; 125(6):1127–33.10.1542/peds.2009-0238 [PubMed: 20439592]

4. Lanza ST, Collins LM. Pubertal timing and the stages of substance use in females during early adolescence. Prevention Science. 2002; 3:69–82. [PubMed: 12002560]

5. Dick DM, Rose RJ, Viken RJ, Kaprio J. Pubertal timing and substance use: Associations between and within families across late adolescence. Developmental Psychology. 2000; 36:180–189.10.1037/0012-1649.36.2.180 [PubMed: 10749075]

6. Tschann JM, Adler NE, Irwin CE Jr, Millstein SG, Turner RA, Kegeles SM. Initiation of substance use in early adolescence: The roles of pubertal timing and emotional distress. Health Psychology. 1994; 13(4):326–333.10.1037/0278-6133.13.4.326 [PubMed: 7957011]

7. Westling E, Andrews JA, Hampson SE, Peterson M. Pubertal timing and substance use: The effects of gender, parental monitoring, and deviant peers. Journal of Adolescent Health. 2008; 42(6):555–563.10.1016/j.jadohealth.2007.11.002 [PubMed: 18486864]

8. Graber JA, Lewinsohn PM, Seeley John R, Brooks-Gunn J. Is psychopathology associated with the timing of pubertal development? Journal of the Academy of Child and Adolescent Psychiatry. 1997; 36:1768–1776.

9. van Jaarsveld CHM, Fidler JA, Simon AE, Wardle J. Persistent impact of pubertal timing on trends in smoking, food choice, activity, and stress in adolescence. Psychosomatic Medicine. 2007; 69:798–806.10.1097/PSY.0b013e3181576106 [PubMed: 17942841]

10. Brooks-Gunn J, Petersen AC, Eichhorn D. The study of maturational timing effects in adolescence. Journal of Youth and Adolescence. 1985; 14:149–161.10.1007/BF02090316

11. Steinberg L. Cognitive and affective development in adolescence. Trends in Cognitive Sciences. 2005; 9(2):69–74.10.1016/j.tics.2004.12.005 [PubMed: 15668099]

12. Ge X, Natsuaki MN. In search of explanations for early pubertal timing effects on developmental psychopathology. Current Directions in Psychological Science. 2009; 18(6):327–331.10.1111/j.1467-8721.2009.01661.x

13. Ge X, Lorenz FO, Conger RD, Elder GH, Simons RL. Trajectories of stressful life events and depressive symptoms during adolescence. Developmental Psychology. 1994; 30:467–483.10.1037/0012-1649.30.4.467

14. Natsuaki MN, Klimes-Dougan B, Ge X, Shirtcliff EA, Hastings PD, Zahn-Waxler C. Early pubertal maturation and internalizing problems in adolescence: Sex differences in the role of cortisol reactivity to interpersonal stress. Journal of Clinical Child & Adolescent Psychology. 2009; 38(4):513–524.10.1080/15374410902976320 [PubMed: 20183638]

15. Dahl RE. Adolescent brain development: A period of vulnerabilities and opportunities. Annals of the New York Academy of Sciences. 2004; 1021:1–22. [PubMed: 15251869]

16. Sroufe, LA.; Cooper, RG.; DeHart, G. Child development: Its nature and course. 3. New York: McGraw Hill; 1996.

17. Brion-Meisels S, Selman RL. Early adolescent development of new interpersonal strategies: Understanding and intervention. School Psychology Review. 1984; 13:278–291.

18. Andrews J, Tildesley E, Hops H, et al. Elementary School Age Children's Future Intentions and Use of Substances. J Clin Child Adol Psychol. 2003; 32(4):556–567.10.1207/S15374424JCCP3204_8

19. Muthén, BO. Analysis of longitudinal data sets using latent variable models with varying parameters. In: Collins, LM.; Horn, JL., editors. Best methods for the analysis of change: Recent advances, unanswered questions, future directions. Washington, CD: American Psychological Association; 1991. p. 1-17.

20. Muthén, LK.; Muthén, BO. Mplus user's guide. Los Angeles, CA: Muthén & Muthén; 1998/2009.

21. Enders CK. A primer on maximum likelihood algorithms available for use with missing data. Structural Equation Modeling. 2001; 8:128–141.10.1207/S15328007SEM0801_7

22. Satorra, A.; Bentler, PM. Scaling corrections for chi-square statistics in covariance structure analysis. American Statistical Association: 1988 Proceedings of the Business and Economics Sections; 1988. p. 308-313.

23. Joreskog, KG. Testing structural equation models. In: Bollen, KA.; Long, JS., editors. Testing structural equation models. Newbury Park, CA: Sage Publishers; 1993. p. 294-316.

24. Hu LT, Bentler PM. Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. Psychological Methods. 1998; 3:424–453.

25. Satorra, A. Scaled and adjusted restricted tests in multi-sample analysis of moment structures. In: Heijmans, RDH.; Pollock, DSG.; Satorra, A., editors. Innovations in multivariate statistical analysis. A Festschrift for Heinz Neudecker. London: Kluwer Academic Publishers; 2000. p. 233-247.

26. Holmbeck GN. Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures. Journal of Consulting and Clinical Psychology. 1997; 65:599–610.10.1037/0022-006X.65.4.599 [PubMed: 9256561]

27. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology. 1986; 512:1173–1182.10.1037/0022-3514.51.6.1173 [PubMed: 3806354]

28. Hoyle RH, Smith GT. Formulating clinical research hypotheses as structural equation models: A conceptual overview. Journal of Consulting and Clinical Psychology. 1994; 62:429–440.10.1037/0022-006X.62.3.429 [PubMed: 8063970]

29. MacKinnon DP, Dwyer JH. Estimating mediated effects in prevention studies. Evaluation Review. 1993; 17:144–158.10.1177/0193841X9301700202

30. Petersen AC, Crockett LJ, Richards M, Boxer AM. A self-report measure of pubertal status: Reliability, validity, and initial norms. Journal of Youth and Adolescence. 1988; 17:117–133.10.1007/BF01537962

31. Carskadon MA, Acebo C. A self-administered rating scale for pubertal development. Journal of Adolescent Health. 1993; 14:190–195. [PubMed: 8323929]

32. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in girls. Archives of Diseases in Childhood. 1969; 44:291–303. [PubMed: 5785179]

33. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in boys. Archives of Diseases in Childhood. 1970; 45:13–23. [PubMed: 5440182]

34. Harter S. The Perceived Competence Scale for Children. Child Development. 1982; 53:87–97.10.2307/1129640

35. Griffin KW, Epstein JA, Botvin GJ, Spoth RL. Social competence and substance use among rural youth: Mediating role of social benefit expectancies of use. Journal of Youth and Adolescence. 2001; 30(4):485–498.10.1023/A:1010449300990

36. Andrews JA, Hampson SE, Barckley M, Gerrard M, Gibbons FX. The effect of early cognitions on cigarette and alcohol use in adolescence. Psychology of Addictive Behaviors. 2008; 22:96–106.10.1037/0893-164X.22.1.96 [PubMed: 18298235]

37. Rudolph KD. Gender differences in emotional responses to interpersonal stress during adolescence. Journal of Adolescent Health. 2002; 30(4):3–13.10.1016/S1054-139X(01)00383-4 [PubMed: 11943569]

38. File SE, Fluck E, Leahy A. Nicotine has calming effects on stress-induced mood changes in females, but enhances aggressive mood in males. The International Journal of Neuropsychopharmacology. 2001; 4(4):371–376.10.1017/S1461145701002577 [PubMed: 11806862]

39. Dorn LD, Dahl RE, Woodward HR, Biro F. Defining the boundaries of early adolescence: A user's guide to assessing pubertal status and pubertal timing in research with adolescents. Applied Developmental Science. 2006; 10(1):30–56.10.1207/s1532480xads1001_3

40. Botvin, GJ. Preventing adolescent drug abuse through Life Skills Training: Theory, methods, and effectiveness. In: Crane, J., editor. Social Programs That Work. New York: Russell Sage Foundation; 1998. p. 225-257.
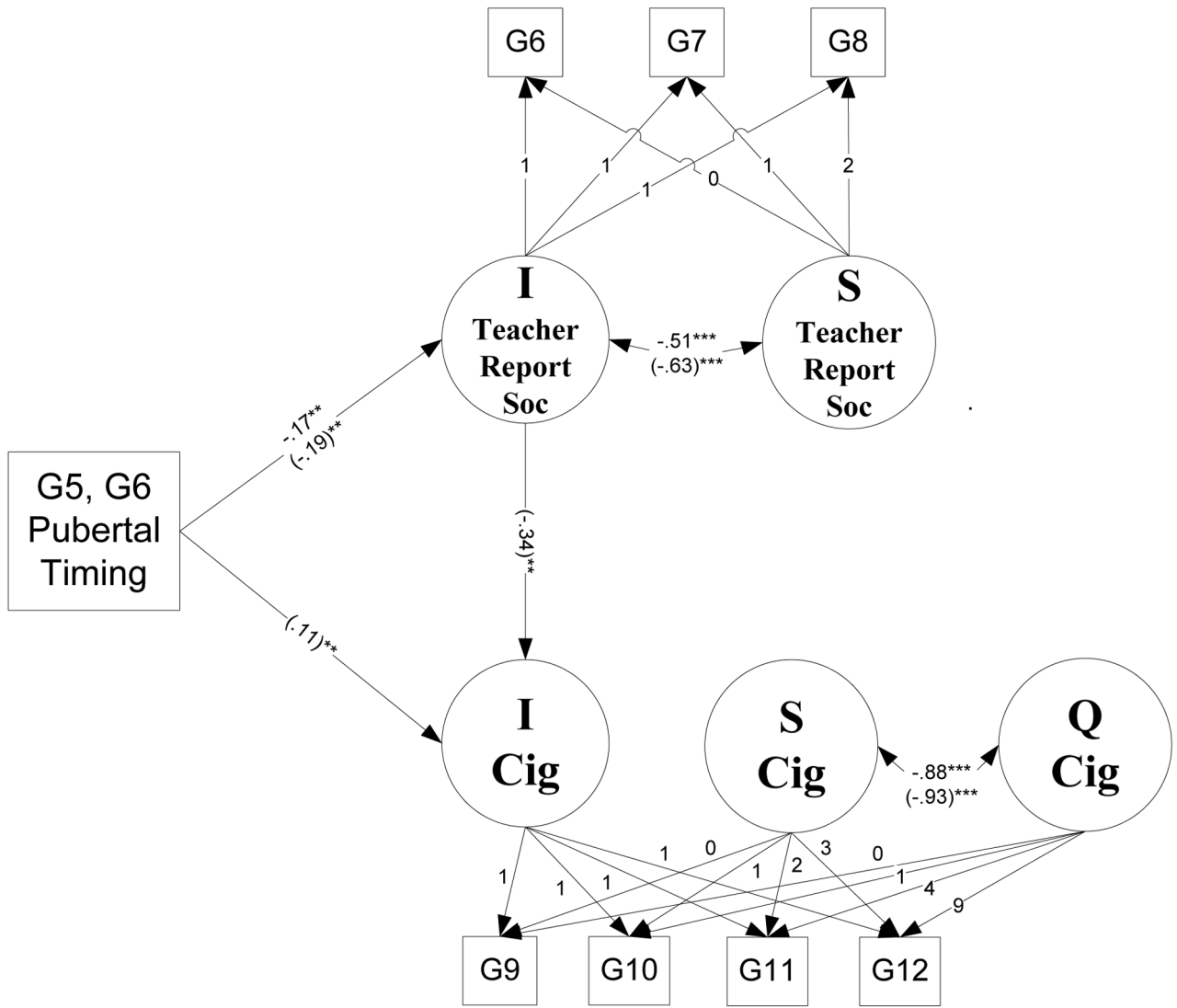
Figure 1.
Latent growth model (multiple group analysis) of self-reported cigarette use in the last year in Grades 9 through 12 (G9, G10, G11 and G12), in which pubertal timing at Grade 5 (G5) for girls and Grade 6 (G6) for boys predicted the Intercept of teacher reported social competence in Grades 6 through 8 (G6, G7, G8), and, for girls only, pubertal timing predicted the Intercept of cigarette use and the Intercept of social competence predicted the Intercept of cigarette use. Unstandardized estimates are shown separately for boys and girls (girls appear in parentheses). Only paths significant for one or both genders are shown. I = Intercept; S = Slope; Q = Quadratic. **p<.01. ***p<.001.

Table 1

Percentages, Means and Standard Deviations of Cigarette Use in Last Year by Grade and Sex.

	Grade 9		Grade 10		Grade 11		Grade 12	
	Boys (n=372)	Girls (n=389)	Boys (n=373)	Girls (n=371)	Boys (n=266)	Girls (n=276)	Boys (n=181)	Girls (n=172)
Did not smoke	81.5	76.9	74.0	67.9	61.7	65.6	51.9	59.9
Smoked once	4.8	6.9	5.6	7.8	8.6	6.9	9.4	4.1
Smoked a couple of times	7.8	7.7	10.7	10.5	16.2	8.3	17.7	13.4
Smoked some each month	1.9	1.8	3.2	1.9	2.6	3.3	3.9	3.5
Smoked some each week	2.2	1.8	2.1	1.9	3.4	4.3	4.4	4.7
Smoked some each day	1.9	4.9	4.3	10.0	7.5	11.6	12.7	14.5
M	.44	.59	.67	.92	1.00	1.09	1.38	1.33
SD	1.07	1.30	1.32	1.62	1.55	1.77	1.78	1.88

Note. M = Mean; SD = Standard Deviation. Range for cigarette use in all grades is 0 to 5.

Table 2

Means, Standard Deviations and Tests for Mean Differences of Teacher-Rated Social Competence by Grade and Sex.

	Grade 6		Grade 7		Grade 8	
	Boys (n=355)	Girls (n=353)	Boys (n=355)	Girls (n=347)	Boys (n=339)	Girls (n=369)
M	8.32	8.76	8.29	9.07	8.51	9.01
SD	2.54	2.29	2.39	2.24	1.98	1.92
t-test for equality of means	2.39 *		4.46 ***		3.41 **	
df	706		700		706	

Note. Higher scores indicate higher rated social competence; M = Mean; SD = Standard Deviation; df = degrees of freedom. Range for social competence in all grades is 3 to 12.

*
p<.05.

**
p<.01.

***
p<.001.