J Youth Adolescence (2008) 37:736–746
DOI 10.1007/s10964-008-9274-y

EMPIRICAL RESEARCH

Self-Rated Pubertal Development, Depressive Symptoms and Delinquency: Measurement Issues and Moderation by Gender and Maltreatment

Sonya Negriff · Michelle T. Fung · Penelope K. Trickett

Received: 12 November 2007 / Accepted: 17 January 2008 / Published online: 7 February 2008

Abstract This cross-sectional study examined relationships between pubertal development, depressive symptoms and delinquency in a sample of 241 males and 213 females aged 9–13 years. Four objectives were set forth for this study: (1) to examine relationships between pubertal stage or timing and depressive symptoms and delinquency; (2) to compare continuous and categorical measures of pubertal timing; (3) to examine gender as a moderator of these relationships, and (4) to examine maltreatment as a moderator of these relationships. Results indicated that mature pubertal stage and early (continuous) pubertal timing were both related to higher delinquency whereas only early pubertal timing was related to depressive symptoms. Categorical timing was not related to depressive symptoms or delinquency. Neither gender nor maltreatment were found to be moderators. These findings provide evidence against equating pubertal stage, continuous timing, and categorical timing, and highlight the need to identify possible moderators in research on pubertal development.

Keywords Pubertal stage · Pubertal timing · Depressive symptoms · Delinquency · Measurement

S. Negriff (✉)
Division of Adolescent Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA
e-mail: sonya.negriff@cchmc.org

M. T. Fung
Department of Psychiatry, University of Chicago, Chicago, IL, USA
e-mail: mfung@yoda.bsd.uchicago.edu

P. K. Trickett
School of Social Work, University of Southern California, Los Angeles, CA, USA
e-mail: pennyt@usc.edu

Introduction

Research on adolescent development suggests that pubertal development is linked to a number of adjustment difficulties. In particular, early pubertal development is associated with delinquency (Haynie 2003), externalizing behavior (Ge et al. 2002), conduct disorder (Ge et al. 2006), earlier sexual activity (Kaltiala-Heino et al. 2003), substance use (Costello et al. 2007), disordered eating (Graber et al. 1994), and depression (Ge et al. 2003; Kaltiala-Heino et al. 2003). While these studies find early pubertal timing to be detrimental, others find that late timing is also associated with delinquency (Williams and Dunlop 1999) and depression (Graber et al. 1997). In addition, relationships between pubertal development and these deleterious outcomes appear to vary between genders and may be affected by contextual factors such as childhood maltreatment. However, before turning to these issues, some clarification of the measurement of pubertal development and classification of pubertal timing is necessary.

Methodological Issues Regarding Pubertal Development

A major methodological limitation of the current research on puberty is that several measures of pubertal development are in use but there is little evidence that supports their equivalency. Even when the same measures are used in different studies, varying methods may be used to construct pubertal variables (e.g. pubertal stage and pubertal timing). It is imperative to define and differentiate pubertal stage (the individual's level of pubertal development at a certain point in time) and pubertal timing (whether the individual's pubertal development occurs earlier than, later

than, or at the same time as most of their peers) because they provide different information regarding physical and reproductive development. It is also important to distinguish the impact of pubertal stage versus timing because if depressive symptoms are related to stage but not timing, it would indicate that simply advancing through puberty will correspond with increased depressive symptoms. However, if depressive symptoms are related to pubertal timing but not pubertal stage, it would indicate that attaining a more mature pubertal stage at an early age will put an individual at risk for depressive symptoms.

Few studies have examined both pubertal stage and pubertal timing methods simultaneously. Angold et al. (1998) found that pubertal stage better predicted gender differences in depressive symptoms than did chronological age or pubertal timing. Contrary to previous findings, pubertal timing did not predict gender differences in depressive symptoms. The implication is that the nature of the association between puberty and gender differences in depressive symptoms may be contingent upon the definition and measurement of puberty employed. In contrast to Angold et al. (1998), Ge and colleagues found that both early timing and more mature stage were related to higher levels of depressive symptoms and externalizing problems in males and females (Ge et al. 2003; Ge et al. 2006). Given the disagreement between these results, there is clearly a need for further comparisons of pubertal stage and timing measures.

Furthermore, pubertal timing may be operationalized both continuously and categorically (early, on-time, and late). Overall, studies report differing methods for assigning timing groups, and often the methods used are not clearly described. Most studies have employed categorical pubertal timing groups, creating the groups based on the sample distribution (± 1 standard deviation for early and late timing groups; Ge et al. 2003) or on national norms reported by Tanner (1978) or Duke and colleagues (1982) for the average age at menarche or a certain Tanner stage (Angold et al. 1998; Ge et al. 2001; Graber et al. 2006; Kaltiala-Heino et al. 2003). Studies that have employed a continuous measure of pubertal timing have either used the residual obtained after regressing pubertal stage on age, separately for gender (Dorn et al. 2003; Susman et al. 2007) or have standardized pubertal stage scores by age group and gender (Ge et al. 2001). There has been no direct comparison across these different methods to determine if an early maturer classified via their relative standing in the sample distribution is similarly classified when using the national norms. Of concern is the outdated nature of those norms, which were established over three decades ago with European American middle-class adolescents but are still being used by researchers to establish age cut-offs for timing groups. More recent evidence (Herman-Giddens 2006; Kaplowitz et al. 2001) suggests that pubertal development occurs earlier for contemporary adolescents than those in the studies by Tanner (1978) and Duke et al. (1982). Therefore, this study used pubertal timing classified via these norms as well as pubertal timing classified via the sample distribution to demonstrate whether these norms are useful in a contemporary, ethnically diverse sample.

Pubertal Development, Depressive Symptoms, and Delinquency: Gender Differences

Previous research indicates that early pubertal maturation is associated with psychological and behavior problems in females, but with good psychosocial adjustment in males (Stattin and Magnusson 1990). However, more recent research is less clear about these gender differences. Some studies find depressive symptoms only in early maturing females (Graber et al. 2006; Hayward et al. 1997; Rierdan and Koff 1991), some find that both early maturing females and males are at risk (Ge et al. 2006; Kaltiala-Heino et al. 2003), and others find no association (Angold et al. 1998; Canals et al. 1995). Thus, while some evidence indicates that the relationship between puberty and depressive symptoms varies based on gender, continued investigation is needed.

Similar to the research on depressive symptoms, several studies point to an association between early pubertal maturation and high levels of externalizing behavior (Ge et al. 2002), bullying, truancy (Kaltiala-Heino et al. 2003), and disruptive behavior (Graber et al. 1997) in both genders. Regarding delinquency in particular, research findings support an association with early maturation in both single (Caspi et al. 1993; Cota-Robles et al. 2002; Haynie, 2003; Obeidallah, Brennan, Brooks-Gunn, & Earls, 2004) and mixed gender samples (Beaver and Wright 2005; Lynne et al. 2007). However, there is evidence that for males both early and late pubertal development are associated with higher delinquency (Williams and Dunlop 1999). Therefore, while most studies indicate that early maturation is associated with higher delinquency in both genders, differences in methodologies (e.g. sample size, gender composition of sample, Tanner Stage vs. age at menarche, pubertal stage vs. timing) lend difficulty to the cumulative interpretation of their results.

Pubertal Development, Depressive Symptoms, and Delinquency: Maltreatment

Evidence suggests that contextual variables (e.g. neighborhood disadvantage, stressful life events, deviant peer

affiliation) moderate the relationship between puberty and various psychosocial difficulties (Ge et al. 2001; Lynne et al. 2007; Obeidallah et al. 2004). Off-time pubertal development is often distressing for the individual, which may compromise their ability to cope with other challenging experiences. For instance, early maturation and recent stressful life events are associated with the highest levels of depressive symptoms in females (Ge et al. 2001). One of the most stressful events that an individual can experience is childhood maltreatment, which is linked to a number of psychosocial difficulties. Elevated rates of depression and depressive symptomatology have been found in children, adolescents, and adults with histories of child abuse (Kaufman and Charney 2001; Toth et al. 1992). Similarly, more adolescents with a history of maltreatment have been found to engage in delinquent behavior than those without a history of maltreatment (Bolton et al. 1977; McCord 1983; Zingraff et al.1993). Clearly, coping with past or ongoing maltreatment and its consequences is difficult in itself. Given the evidence that off-time pubertal development amplifies the risk for maladjustment, it is probable that experiencing both maltreatment and off-time development may significantly increase an individual's risk for psychosocial problems. This study sought to examine whether maltreatment moderates the relationship between pubertal development and depressive symptoms and delinquency.

The Current Study

As pubertal stage and pubertal timing have rarely been examined within the same study, the first objective of the current study was to compare the association of each construct to depressive symptoms and delinquency. It was hypothesized that more mature pubertal stage and early pubertal timing would both be related to higher delinquency and depressive symptoms. The second objective addressed categorical and continuous methods of classifying pubertal timing. It was hypothesized that the continuous timing measure would be a stronger predictor of both outcomes than the categorical timing measure. Third, the interaction between pubertal development and gender was examined. It was hypothesized that pubertal development would more strongly predict depressive symptoms for females and delinquency for males. Lastly, the interaction between pubertal development and maltreatment experience was examined, where maltreatment was considered as a stressor that may exacerbate the impact of pubertal development. It was hypothesized that the relationship between pubertal development and depression and delinquency would be stronger in the maltreatment group than in the comparison group.

Method

Participants

The present study used data from the initial assessment of an ongoing longitudinal study examining the effects of maltreatment on adolescent development. The sample used in the present study comprised 454 adolescents aged 9–13 years (241 males and 213 females).

Recruitment

The participants who comprised the maltreatment group ($N = 303$) were recruited from active cases in the Children and Family Services (CFS) of a large west coast city. The inclusion criteria were: (1) a new substantiated referral to CFS in the preceding month for any type of maltreatment (e.g. neglect, physical abuse, sexual abuse); (2) child age of 9–12 years; (3) child identified as Latino, African-American, or Caucasian (non-Latino); (4) child residing in one of 10 zip codes in a designated county at the time of referral to CFS. With the approval of CFS and the Institutional Review Board of the affiliated university, potential participants were contacted via postcard and asked to indicate their willingness to participate. Contact via mail was followed up by a phone call.

The comparison group ($N = 151$) was recruited via mail using names from school lists of children aged 9–12 years residing in the same 10 zip codes as the maltreatment group.

Demographics

Participants were compared on a variety of demographic information. The maltreatment and comparison groups were not significantly different on age, ($M = 10.93$ years, $SD = 1.16$), gender, or ethnicity. The total sample comprised 53% males and 47% females. The ethnic composition was 38% African American, 39% Latino, 12% Biracial, and 11% Caucasian.

Procedure

Assessments were conducted at an urban research university. After assent and consent were obtained from the adolescent and their caretaker, the adolescent was administered an array of questionnaires and tasks during a four-hour protocol. The measures used in the following analyses represent a subset of the questionnaires administered during the protocol, which also included hormonal, cognitive,

and behavioral measures. Both the child and caretaker were paid for their participation according to the National Institutes of Health Normal Volunteer Program.

Measures

Pubertal Development

Pubertal stage: Pubertal stage was measured using the adolescent's self-report on the Tanner stages. Five stages of pubertal development are represented by sets of serial line drawings that depict the development of two different secondary sexual characteristics from prepubertal (stage = 1) to postpubertal (stage = 5) (Morris and Udry 1980). Female drawings are of breast development and pubic hair growth, male drawings are of genital development and pubic hair growth. The Tanner stages have shown high validity and reliability (Marshall and Tanner 1969, 1970). Self-report on Tanner stages are highly correlated with physician assessment and sufficient when rough estimation of pubertal stage is adequate (Dorn et al. 1990). For the present study, pubertal stage was defined as the score on the Tanner breast pictures for females, and the score on the genital pictures for males. Pubic hair stage was not included because it corresponds to different age norms than breast/genital stage; pubic hair and breast/genital development are linked to different hormones systems that do not necessarily come online at the same time (Grumbach 2002). Further, of the two, breast/genital growth are more salient secondary sexual characteristics and have been found to be more reliably measured (Brooks-Gunn et al. 1987). In this sample, Tanner breast/genital stage scores and Tanner pubic hair stage scores were highly correlated ($r = .74$, $p < .001$).

Continuous pubertal timing: As per Ge et al. (2001), scores on the Tanner stage self ratings were standardized within the sample for each age (9, 10, 11, 12) and gender. Higher scores indicated earlier maturation relative to peers of the same age and gender within the sample.

Categorical pubertal timing: General population norms have been established for the ages at which each of the five breast/genital Tanner stages should be reached for each gender (Tanner 1978), using these guidelines individuals were assigned to early (coded as 3), on-time (coded as 2), or late (coded as 1) timing groups.

Delinquency

Adolescent Delinquency Questionnaire: Participants reported delinquent behavior within the past 12 months via 23 items from the self-report Adolescent Delinquency Questionnaire (ADQ; adapted from Huizinga and Morse 1986). Computerized administration was used to ensure participant confidentiality. For the present study, three scales were used: status offences (6 items, e.g. "run away from home", $\alpha = .74$), person offences (7 items, e.g. "carried a hidden weapon", $\alpha = .83$), and property offences (10 items, e.g. "damaged or destroyed someone else's property on purpose", $\alpha = .92$). Square root transformations were applied to each composite scale score to reduce skewness.

Depressive Symptoms

Children's Depression Inventory: Self-report depressive symptoms were obtained from raw scores on the 27-item Children's Depression Inventory (CDI; Kovacs 1981, 1992). Each item contains three answer options with statements such as "I am sad all the time" and "I feel like crying every day" indicating the highest level of depressive symptoms. The range of possible scores is 0–54. Alpha reliabilities for the CDI have been adequate in various samples and it has been shown to correlate strongly with other measures of childhood depressive symptoms (Kovacs 1992). In the present sample, Cronbach's alpha for all 27 items was .86.

Results

Descriptives

The means, standard deviations, and ranges of the core variables can be found in Table 1. Correlations between all the variables can be found in Table 2. As shown in Table 2, pubertal stage and continuous timing were significantly correlated with all three delinquency scales ($p < .05$) but not with depressive symptoms.

Comparing Pubertal Stage and Pubertal Timing

Structural Equation Modeling (SEM) with AMOS v5.0 (Arbuckle 2003) was used to examine the relationships

Table 1 Means and standard deviations (*SD*) of core variables

	Tanner breast stage	Tanner genital stage	Delinquency			Depressive symptoms
			Status	Person	Property	
N	211	235	415	436	430	445
Mean	1.85	2.27	2.04	1.45	1.60	9.33
SD	0.76	0.92	4.01	1.45	5.67	7.24
Range	1–5	1–5	0–30	0–35	0–50	0–45

Table 2 Correlations between core variables

	Pubertal stage	Continuous timing	Categorical timing	Delinquency			Depressive symptoms
				Status	Person	Property	
Puberty							
Pubertal stage	1.00						
Continuous timing	.72**	1.00					
Categorical timing	.37**	.49**	1.00				
Delinquency							
Status	.25**	.15**	.02	1.00			
Person	.18**	.12*	.03	.70**	1.00		
Property	.17**	.11**	.01	.73**	.77**	1.00	
Depressive symptoms	.07**	.09	−.05	.30**	.25**	.25**	1.00

* $p < .05$, ** $p < .01$

between pubertal development, depressive symptoms, and delinquency. Two separate models were examined, one with pubertal stage entered as a manifest variable and the other with continuous pubertal timing; otherwise the two models were identical. Direct effects were modeled between puberty and depressive symptoms (a manifest variable) and delinquency (a latent variable). Maltreatment status (maltreated vs. non-maltreated) and ethnicity (African American, Caucasian, Latino, Biracial) were included in the model to control for their effects on the dependent variables. Covariance was included between depressive symptoms and delinquency. These models were first run with the total sample. Overall, the models showed good fit; $\chi^2 = 23(6)$, RMSEA = .08 and $\chi^2 = 12(6)$, RMSEA = .05 for the pubertal stage and pubertal timing models, respectively. More mature pubertal stage ($\beta = .21$, $p < .01$) and earlier pubertal timing ($\beta = .13$, $p < .01$) both positively predicted delinquency. Unique to the pubertal timing model, earlier timing was marginally related to depressive symptoms ($\beta = .09$, $p < .10$). Depressive symptoms and delinquency were significantly correlated in both models ($rs = .30$, $p < .01$; see Fig. 1a, b).

Comparing Categorical and Continuous Pubertal Timing

To address this objective, two models were tested, one with continuous pubertal timing as a manifest variable and the other with categorical pubertal timing (see Fig. 1b, c). The models were otherwise identical to those described above. Both models showed good fit; $\chi^2 = 8(6)$, RMSEA = .03 and $\chi^2 = 12(6)$, RMSEA = .05 for the categorical timing and continuous timing models, respectively. The relationship between continuous pubertal timing and delinquency was significant ($\beta = .13$, $p < .01$) whereas the relationship depressive symptoms was marginally significant ($\beta = .09$, $p < .10$). Categorical pubertal timing was not significantly related to either delinquency or depressive symptoms, and was thus excluded from further analyses.

Multiple Group Analyses: Moderation by Gender

Multiple group SEM was used to examine the moderating effect of gender separately for pubertal stage and pubertal timing using the models defined above (Fig. 1a, b). For pubertal stage, the model was simultaneously fit to both groups (males and females), first allowing all parameters to vary across groups (unrestricted model), then constraining the factor loadings to be equal across groups (factor loadings restricted model), and finally requiring all factor loadings, regression weights, and covariances to be equal across the groups (fully restricted model).

The chi-square difference tests showed that the unrestricted model and the factor loadings restricted model were not significantly different from each other, indicating measurement invariance of delinquency (see Table 3). However, the fully restricted model was significantly different from the factor loadings restricted model ($\Delta\chi^2 = 13.57$ (6), $p < .05$) indicating that gender moderated one or more structural parameters in the models. Subsequently, to determine whether the parameters between pubertal stage and each dependent variable (depressive symptoms and delinquency) were significantly different between males and females, each path in turn was constrained to be equal across groups. The difference in fit between the model in which all the parameters were freely estimated and the one in which one of the paths was restricted shows whether that specific path is moderated by gender. The results indicated that the relationships between

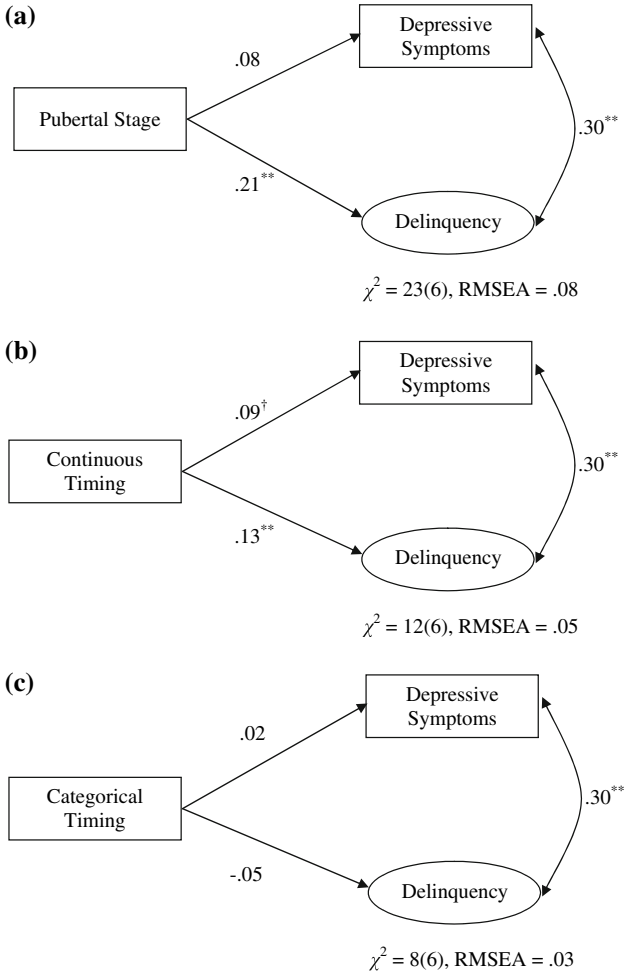

Fig. 1 Structural Equation Models examining relationships between pubertal development, depressive symptoms and delinquency for the total sample. Note. (**a**) Pubertal Stage: 1 = least mature, 5 = most mature. (**b**) Continuous Timing: higher score = earlier maturation. (**c**) Categorical Timing: 3 = early, 2 = on-time, 1 = late. Covariates omitted for simplicity: Maltreatment Status 1 = Maltreated group, 0 = Comparison group; Ethnicity- African American, Hispanic, Caucasian, Biracial. * $p < .05$, ** $p < .01$, † $p < .10$

pubertal stage and depressive symptoms and delinquency were not significantly different for males and females. The only parameter that differed between groups was the path between maltreatment (a covariate) and delinquency.

The same procedure was repeated for the continuous timing model. Similarly to the pubertal stage model, the chi-square difference tests showed that the unrestricted model and the factor loadings restricted model were not significantly different from each other, indicating measurement invariance of delinquency. However, the fully restricted model was significantly different from the factor loadings restricted model ($\Delta\chi^2 = 14.23$ (6), $p < .05$) indicating that gender moderated one or more structural parameters in the models. Each path in turn was constrained to be equal across groups and as with the pubertal stage model the only path found to differ between groups was that between maltreatment (a covariate) and delinquency. Although the relationships between puberty and depressive symptoms and delinquency were not significantly different between genders, some significant estimates emerged for one gender and not the other. For males, continuous pubertal timing significantly predicted delinquency ($\beta = .18$, $p < .01$) (see Table 4), whereas for females it marginally predicted depressive symptoms ($\beta = .12$, $p < .10$).

Multiple Group Analyses: Moderation by Maltreatment Status

The same procedures as described above were used to test whether maltreatment moderated relationships in the models; the model was fit simultaneously to the maltreatment and comparison group testing progressively more restricted models. Gender and ethnicity were included to control for their independent effects on depressive symptoms and delinquency. For pubertal stage, the unrestricted model and the factor loadings restricted model did not differ significantly from each other. However, both were significantly different from the fully restricted model ($\Delta\chi^2 = 19.76$ (6), $p < .01$) signifying that an interaction was present and thus maltreatment moderated one or more paths in the models (see Table 3). Parameter estimates for each group indicated that maltreatment status did not moderate the relationships between pubertal stage and depressive symptoms and delinquency. The only parameter that was significantly different between groups was the path between gender (a covariate) and delinquency.

Similar to the pubertal stage model, maltreatment did not moderate the primary relationships of interest for the pubertal timing model. Although the relationships between puberty and depressive symptoms and delinquency were not significantly different between the two groups, the model for the maltreated group showed significant effects that were not found in the comparison group. For the maltreated group, pubertal stage was significantly related to delinquency ($\beta = .20$, $p < .01$) and marginally related to depressive symptoms ($\beta = .12$, $p < .10$), while pubertal timing was significantly related to delinquency ($\beta = .15$, $p < .05$; see Table 4). In addition, depressive symptoms and delinquency were significantly correlated in the maltreated group but not in the comparison group for both stage and timing.

Discussion

Overall, the results of this study agree with the bulk of the literature which shows that mature pubertal stage and early pubertal timing are related to increased delinquency. Of

Table 3 Multiple group analyses: fit statistics and comparisons of nested models

	Pubertal stage				Continuous timing			
	χ^2	*df*	RMSEA	$\Delta\chi^2$ (Δdf)	χ^2	*df*	RMSEA	$\Delta\chi^2$ (Δdf)
Gender								
1. Unrestricted	32.66	12	.06		23.28	12	.05	
2. Factor loadings restricted	32.93	14	.06		23.53	14	.04	
1 versus 2				.27 (2)				.25 (2)
3. Fully restricted	46.50	20	.05		37.76	20	.04	
2 versus 3				13.57* (6)				14.23* (6)
Maltreatment status								
1. Unrestricted	30.01	12	.06		20.86	12	.05	
2. Factor loadings restricted	33.99	14	.06		24.74	14	.02	
1 versus 2				3.98 (2)				3.88 (2)
3. Fully restricted	53.75	20	.06		45.61	20	.06	
2 versus 3				19.76** (6)				20.87** (6)

* $p < .05$, ** $p < .01$

Table 4 Parameter estimates from multiple group analyses

	Unstandardized estimates (SE)		Standardized estimates	
	Males	Females	Males	Females
Gender				
Pubertal stage				
Stage → Depressive Sxs	0.52 (.51)	1.16 (.67)	.07†	.12†
Stage → Delinquency	0.24 (.08)	0.11 (.08)	.21**	.10*
Delinquency ↔ Depressive Sxs	2.53 (.53)	1.48 (.44)	.36**	.26**
Continuous timing				
Timing → Depressive Sxs	0.42 (.47)	0.88 (.56)	.06	.12†
Timing → Delinquency	0.19 (.07)	0.04 (.06)	.18**	.05
Delinquency ↔ Depressive Sxs	2.55 (.54)	1.52 (.54)	.36**	.27**
	Unstandardized estimates (SE)		Standardized estimates	
	Maltreatment	Comparison	Maltreatment	Comparison
Maltreatment status				
Pubertal stage				
Stage → Depressive Sxs	1.00 (.53)	0.31 (.62)	.12†	.04
Stage → Delinquency	0.23 (.07)	0.10 (.08)	.20**	.12
Delinquency ↔ Depressive Sxs	2.64 (.50)	0.64 (.41)	.35**	.14
Continuous timing				
Timing → Depressive Sxs	0.55 (.44)	0.83 (.55)	.07	.12
Timing → Delinquency	0.16 (.06)	0.03 (.07)	.15*	.03
Delinquency ↔ Depressive Sxs	2.72 (.51)	0.63 (.40)	.36**	.14

Note: SE = Standard errors. * $p < .05$, ** $p < .01$, † $p < .10$

significance is the comparison of pubertal stage and pubertal timing measures and the finding that depressive symptoms are predicted by early pubertal timing but not pubertal stage. The lack of moderation by gender indicates that early puberty is a risk for depression and delinquency for both males and females. In addition, maltreatment did not moderate the relationship between pubertal development and depression and delinquency, which may be due in part to the amalgam of maltreatment experiences present in the maltreated group.

Pubertal Stage vs. Pubertal Timing

In the pubertal development literature, some studies have found that only pubertal stage predicts depressive symptoms (Angold et al. 1998), whereas others have found effects for both stage and timing (Ge et al. 2003, 2006). In addition, stage versus timing effects have not previously been investigated with regards to delinquency. The findings from the present study provide evidence that both more mature pubertal stage and early pubertal timing are associated with higher delinquency, while only early pubertal timing is related to depressive symptoms. This discrepancy indicates that while stage and timing may exert similar effects for some domains (i.e. delinquency), there may be others for which they do not operate similarly (i.e. depressive symptoms). The absence of stage effects for depressive symptoms found in this study is in opposition to a number of previous studies (e.g. Angold et al. 1998; Ge et al. 2003, 2006), however this may be due to the use of different measures of puberty across studies. Even though pubertal stage and timing appear to affect delinquency in a similar direction, the mechanisms underlying these relationships are ostensibly different.

It has been proposed that early maturing individuals (who are more advanced in their pubertal stage than their same-age peers) are invited into older peer groups, which increases exposure to delinquency and antisocial behavior (Beaver and Wright 2005; Felson and Haynie 2002). The integral difference between pubertal stage and timing is that the concept of pubertal timing presupposes that attaining a certain stage of pubertal development at an earlier or later age than peers is detrimental, whereas for pubertal stage, a certain level of maturity (regardless of the age at which that stage was attained) is associated with higher risk for difficulties. As an adolescent matures they become involved in developmentally appropriate activities including minor delinquency (indicating stage effects). If an individual is drawn into these groups at a younger age than is typical, their cognitive development may not be as advanced as their physical appearance may indicate and thus the mismatch provides the impetus for adjustment difficulties (indicating timing effects) (Peskin 1973).

Similar explanations have been proposed for depressive symptoms. In particular, early maturers may not be cognitively prepared to deal with the multiple transitions and stressors inherent in adolescence and thus have more difficulty coping (Caspi and Moffitt 1991; Ge et al. 1996 2001). Although these specific mechanisms were not investigated in the present study, the differences that were found between stage and timing in relation to depressive symptoms and delinquency should provide reason to do so in a similarly diverse sample.

Categorical vs. Continuous Pubertal Timing

To our knowledge, this is the first study to compare classification by categorical versus continuous pubertal timing. Many studies have found an association between categorical pubertal timing groups and depressive symptoms or delinquency (e.g. Angold et al. 1998; Caspi et al. 1993; Ge et al. 2002; Kaltiala-Heino et al. 2003). Contrary to these studies and in line with our hypotheses, categorical pubertal timing was not related to delinquency and depressive symptoms but continuous pubertal timing was significantly related to both. Thus, while both continuous and categorical methods have been used in the previous literature, these results suggest that significant relationships may be masked if timing categories are created using the national norms reported by Tanner (1978). Additionally, some researchers also argue that these national norms may not pertain to the small population subsamples used for research because pubertal development may be more relevant in the context of the maturational level of the peer group rather than the general population (Ge et al. 1996). Efforts are underway to establish more current norms for classifying pubertal timing groups that would replace the outdated norms shown to be inadequate in this study (Herman-Giddens, 2006).

Moderation by Gender and Maltreatment

A number of studies have found that the impact of puberty varies based on gender (e.g. Ge et al. 2001; Graber et al. 1997), thus it was expected that the relationship between pubertal development and depressive symptoms or delinquency would be significantly different for males and females. However, we found that gender did not moderate the relationships between pubertal development and depressive symptoms and delinquency. This lack of moderation indicates that more mature pubertal stage and earlier pubertal timing are related to higher levels of delinquency, regardless of gender. As the majority of the evidence points to early maturation as a risk for both males and females (Cota Robles et al. 2002; Ge et al. 2002, 2003; Haynie 2003), the present findings add support to the equivalence of these relationships across gender. Though males have largely been neglected in the literature on puberty, the findings presented here indicate that they may experience as many negative outcomes as females when negotiating puberty.

Similarly to the between-gender analyses, the second set of multiple group analyses revealed no moderator effects of maltreatment. That is, both mature pubertal stage and early pubertal timing predicted delinquency for the maltreated and comparison adolescents. Although the parameter estimates were significant for the maltreatment group but not

for the comparison group (indicating the maltreatment group was driving the effect), they were not significantly different from each other. The absence of an interaction between maltreatment and puberty was contrary to expectations; however, this is the first study to examine maltreatment as a moderator of pubertal development. Given that maltreatment types show differential relationships with maladaptive outcomes (Trickett 2001), more specific characteristics of maltreatment should be examined to determine if there are certain types that may interact with puberty while others do not.

Limitations

Some limitations should be noted when interpreting the present findings. The use of maltreatment as a dichotomy may have masked specific relationships associated with different forms of maltreatment. In particular, the lack of an interaction effect between puberty and maltreatment may be due to the large variation of abuse experiences included in this group. Second, the cross-sectional design of this study limits our understanding of the transitional process that puberty entails, as well as changes in the tempo of pubertal development which may affect various outcomes (Ge et al. 2003). Additionally, only one marker of puberty (self-reported breast/genital development) was used in the assessment of pubertal development. Tanner breast/genital stage scores were chosen because they are the most salient secondary sexual characteristics and have been found to be more reliable than reports of pubic hair development (Brooks-Gunn et al. 1987). However, given that puberty is viewed as a set of related changes in various physiological systems, the use of a single marker restricts interpretation of findings to that specific developmental characteristic. Although physician report and self-report on the Tanner stages have been found to be highly correlated, there may be some error associated with the adolescent's own report of their development which needs to be taken into consideration when interpreting the findings. Lastly, because the participants were at the young age range for puberty, many may be just experiencing the initial stages and therefore the full impact may not yet be detectable. On the other hand, because the initial stages are being captured, the immediate effects of pubertal onset may be more clearly delineated. Following individuals through their pubertal development will contribute to a clearer picture of the associated psychosocial difficulties.

Conclusions

The results of this study show that both mature pubertal stage and early pubertal timing are related to delinquent behavior, whereas only early timing is related to depressive symptoms. In addition, these associations were not moderated by gender or maltreatment. This finding indicates that pubertal development and negative outcomes are similarly related in males and females, and in maltreated and comparison adolescents. While some potential differences emerged between genders and maltreatment and comparison groups, there is need for replication and clarification. In addition to identifying risk variables, future research should also aim to describe the mechanisms by which puberty affects various outcomes. Given the similarity between pubertal stage and timing results, mediational models should be examined to determine whether the pathways by which they affect adjustment difficulties are the same. The identification of mediators and moderators should provide opportunities for intervention and prevention of maladaptive outcomes associated with off-time pubertal development. Future studies should strive to use adequate measures of pubertal development as well as to identify appropriate measures for the research questions being addressed. The results clearly caution against using categorical timing groups based on outdated norms. Lastly, longitudinal studies would greatly contribute to the understanding of the developmental trajectories associated with off-time pubertal development by clarifying whether the negative effects are short-term and limited to adolescence, or long-term more persistent difficulties.

Acknowledgments This research was supported by funding from a National Institutes of Health R01 grant HD39129, Penelope K. Trickett P.I. We would like to thank Elizabeth J. Susman and Lorah D. Dorn for comments and advice on earlier drafts of this article. We would also like to acknowledge the YAP lab for support and comments.

References

Angold, A., Costello, E. J., & Worthman, C. M. (1998). Puberty and depression: The roles of age, pubertal status and pubertal timing. *Psychological Medicine, 28*, 51–61.

Arbuckle, J. L. (2003). *Amos 5.0 [Computer Software]*. Chicago: Smallwaters.

Beaver, K. M., & Wright, J. P. (2005). Biosocial development and delinquency involvement. *Youth Violence and Juvenile Justice, 3*(2), 168–192.

Bolton, F. G., Reich, J. W., & Gutierres, S. E. (1977). Delinquency patterns in maltreated children. *Victimology, 2*, 349–357.

Brooks-Gunn, J., Warren, M. P., Rosso, J., & Gargiulo, J. (1987). Validity of self-report measures of girls' pubertal status. *Child Development, 58*, 829–841.

Canals, J., Marti-Henneberg, C., Fernández-Ballart, J., & Domènech, E. (1995). A longitudinal study of depression in an urban Spanish pubertal population. *European Child & Adolescent Psychiatry, 4*(2), 102–111.

Caspi, A., Lynam, D., Moffitt, T. E., & Silva, P. A. (1993). Unraveling girls' delinquency: Biological, dispositional, and contextual contributions to adolescent misbehavior. *Developmental Psychology, 29*(1), 19–30.

Caspi, A. L., & Moffitt, T. E. (1991). Individual differences are accentuated during periods of social change: The sample case of

girls at puberty. *Journal of Personality and Social Psychology, 61*(1), 157–168.

Costello, E. J., Sung, M., Worthman, C., & Angold, A. (2007). Pubertal maturation and the development of alcohol use and abuse. *Drug and Alcohol Dependence, 88S*, S50–S59.

Cota-Robles, S., Neiss, M., & Rowe, D. C. (2002). The role of puberty in violent and nonviolent delinquency among Anglo American, Mexican American, and African American boys. *Journal of Adolescent Research, 17*(4), 364–376.

Dorn, L. D., Susman, E. J., Nottelmann, E. D., Inoff-Germain, G., & Chrousos, G.P (1990). Perceptions of puberty: Adolescent, parent, and health care personnel. *Developmental Psychology, 26*, 322–329.

Dorn, L. D., Susman, E. J., & Ponirakis, A. (2003). Pubertal timing and adolescent adjustment and behavior: Conclusions vary by rater. *Journal of Youth and Adolescence, 32*(3), 157–167.

Duke, P. M., Jennings, D. J., Dornbusch, S. M., & Seigel-Gorelick, B. (1982). Educational correlates of early and late sexual maturation in adolescence. *Journal of pediatrics, 100*, 633–637.

Felson, R. B., & Haynie, D. L. (2002). Pubertal development, social factors, and delinquency among adolescent boys. *Criminology, 40*(2), 967–988.

Ge, X., Brody, G. H., Conger, R. D., Simons, R. L. (2006). Pubertal maturation and African American children's internalizing and externalizing symptoms. *Journal of Youth and Adolescence, 35*(4), 531–540.

Ge, X., Brody, G. H., Conger, R. D., Simons, R. L., & McBride-Murray, V. (2002). Contextual amplification of pubertal transition effects on deviant peer affiliation and externalizing behavior among African American children. *Developmental Psychology, 38*(1), 42–54.

Ge, X., Conger, R. D., & Elder, G. H. (2001). Pubertal transition, stressful life events, and the emergence of gender differences in adolescent depressive symptoms. *Developmental Psychology, 37*(3), 404–417.

Ge, X., Kim, I. J., Brody, G. H., Conger, R. D., Simons, R. L., Gibbons, F. X. et al. (2003). It's about timing and change: Pubertal transition effects on symptoms of major depression among African American youths. *Developmental Psychology, 39*(3), 430–439.

Graber, J. A., Brooks-Gunn, J., Paikoff, R. L., & Warren, M. P. (1994). Prediction of eating problems: An 8-year study of adolescent girls. *Developmental Psychology, 30*(6), 823–834.

Graber, J. A., Brooks-Gunn, J., & Warren, M. P. (2006). Pubertal effects on adjustment in girls: Moving from demonstrating effects to identifying pathways. *Journal of Youth and Adolescence, 35*(3), 413–423.

Graber, J. A., Lewinsohn, P. M., Seeley, J. R., & Brooks-Gunn, J. (1997). Is psychopathology associated with the timing of pubertal development? *Journal of the American Academy of Child and Adolescent Psychiatry, 36*(12), 1768–1776.

Grumbach, M. M. (2002). The neuroendocrinology of human puberty revisited. *Hormone Research*, *57*(S2), 2–14.

Haynie, D. L. (2003). Context's of risk? Explaining the link between girls' pubertal development and their delinquent involvement. *Social Forces, 82*(1), 355–397.

Hayward, C., Killen, J. D., Wilson, D. M., Hammer, L. D., Litt, I. F., Kraemer, H. C., et al. (1997). Psychiatric risk associated with early puberty in adolescent girls. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*(2), 255–262.

Herman-Giddens, M. E. (2006). Recent data on pubertal milestones in United States children: The secular trend toward earlier development. *International Journal of Andrology, 29*, 241–246.

Huizinga, D., & Morse, B. (1986). *Adolescent Delinquency Questionnaire (ADQ).* Unpublished instrument.

Kaltiala-Heino, R., Kosunen, E., & Rimpela, M. (2003). Pubertal timing, sexual behavior and self-reported depression in middle adolescence. *Journal of Adolescence, 26*, 531–545.

Kaltiala-Heino, R., Marttunen, M., Rantanen, P., & Rimpela, M. (2003). Early puberty is associated with mental health problems in middle adolescence. *Social Science and Medicine, 57*, 1055–1064.

Kaplowitz, P. B., Slora, E. J., Wasserman, R. C., Pedlow, S. E., Herman-Giddens, M. E. (2001). Earlier onset of puberty in girls: Relation to increased body mass index and race. *Pediatrics, 108*(2), 347–353.

Kaufman, J., & Charney, D. (2001). Effects of early stress on brain structure and function: Implications for understanding the relationship between child maltreatment and depression. *Development and Psychopathology, 13*, 451–471.

Kovacs, M. (1981). Rating scales to assess depression in school-age children. *Acta Paedopsychiatrica, 46*, 305–315.

Kovacs, M. (1992). *Child depression inventory manual*. Toronto: Multi-Health System.

Lynne, S. D., Graber, J. A., Nichols, T. R., Brooks-Gunn, J., & Botvin, G. J. (2007). Links between pubertal timing, peer influences, and externalizing behaviors among urban students followed through middle school. *Journal of Adolescent Health, 40*, 181.e7–181.e13.

Marshall, W. A., & Tanner, J. M. (1969). Variations in patterns of pubertal changes in girls. *Archives of Disease in Childhood, 44*, 291–303.

Marshall, W. A., & Tanner, J. M. (1970). Variations in patterns of pubertal changes in boys. *Archives of Disease in Childhood, 45*, 13–23.

McCord, J. (1983). A forty year perspective on child abuse and neglect. *Child Abuse and Neglect, 7*, 265–270.

Morris, N. M., & Udry, R. J. (1980). Validation of a self-administered instrument to assess stage of adolescent development. *Journal of Youth and Adolescence, 9*(3), 271–280.

Obeidallah, D., Brennan, R. T., Brooks-Gunn, J., & Earls, F. (2004). Links between pubertal timing and neighborhood contexts: Implications for girls' violent behavior. *Journal of the American Academy of Child and Adolescent Psychiatry, 43*(12), 1460–1468.

Peskin, H. (1973). Influence of the developmental schedule of puberty on learning and ego functioning. *Journal of Youth and Adolescence, 2*(4), 273–290.

Rierdan, J., & Koff, E. (1991). Depressive symptomotology among very early maturing girls. *Journal of Adolescent Health, 20*, 415–425.

Stattin, H., & Magnusson, D. (1990). *Paths through life-Vol. 2: Pubertal maturation in female development*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Susman, E. J., Dockray, S., Schiefelbein, V. L., Herwehe, S., Heaton, J. A., & Dorn, L. D. (2007). Morningness/eveningness, morning-to-afternoon cortisol ratio, and antisocial behavior problems during puberty. *Developmental Psychology, 43*(4), 811–822.

Tanner, J. M. (1978). *Fetus into man*. Cambridge, MA: Harvard University Press.

Toth, S. L., Manly, J. T., & Cicchetti, D. (1992). Child maltreatment and vulnerability to depression. *Development and Psychopathology, 4*, 97–112.

Trickett, P. K., Noll, J. G., Reiffman, A., & Putnam, F. W. (2001). Variants of intrafamilial sexual experience: Implications for short- and long-term development. *Development and Psychopathology, 13*, 1001–1019.

Williams, J. M., & Dunlop, L. C. (1999). Pubertal timing and self-reported delinquency among male adolescents. *Journal of Adolescence, 22*, 157–171.

Zingraff, M. T., Leiter, J., Myers, K. A., & Johnson, M. C. (1993). Child maltreatment and youthful problem behavior. *Criminology, 31*, 173–202.

Author Biographies

Sonya Negriff is a Research Fellow in the Division of Adolescent Medicine at Cincinnati Children's Hospital Medical Center. She received her Ph.D. in developmental psychology from the University of Southern California. Her research interests focus on pubertal development and associated health and behavior problems.

Michelle T. Fung is a Postdoctoral Scholar in the Department of Psychiatry at the University of Chicago. She received her Ph.D. in developmental psychology from the University of Southern California. Her major research interests involve various aspects of externalizing and antisocial behavior, including measurement, risk and protective factors, genetic and environmental influences, and correlated outcomes.

Penelope K. Trickett is the David Lawrence Stein/Violet Goldberg Sachs Professor of Mental Health in the School of Social Work at the University of Southern California. Dr. Trickett earned her Ph.D. from the New School for Social Research in New York. She is a developmental psychologist whose research, for the last 20 years, has focused on the developmental consequences of child abuse and/or neglect on children and adolescents and on the characteristics of families in which such abuse occurs.