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The emerging sex difference in adolescent depression: Interacting contributions of puberty and peer stress

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Abstract

This research investigated the developmental *stages* (pubertal status) and *contexts* (early or late timing relative to peers, and a context of stressful versus supportive peer relationships) in which the sex difference in depression unfolds. A sample of 158 youth (ages 9.6–14.8) and their caregivers provided information at two waves, 1 year apart, on puberty, peer stress, and depression. Pubertal status and timing (actual and perceived) interacted with sex to predict depression. Sex differences in depression were evident at particular levels of pubertal status and timing, both actual and perceived. Depression was associated with more mature pubertal status and early timing (both actual and perceived) in girls, but with less mature pubertal status and late timing (actual and perceived) in boys. These patterns held concurrently, and often over time, particularly in a context of stressful peer relationships (peer stress moderated sex-differentiated associations between puberty and depression). Of note, there were no significant sex differences in depression at any particular age. Thus, this research highlights important distinctions among the contributions of age, pubertal status, pubertal timing, and perceived timing to the sex difference in adolescent depression. More broadly, these findings contribute to our growing understanding of the interactions among physical, social, and psychological processes involved in the sex difference in adolescent depression.

Adolescence is a developmental period marked by a sharp increase in depression, as well as the time when the well-established sex difference in depression emerges (Hankin & Abramson, 2001). Adolescence also is characterized by multiple challenges, disruptions, and developments in biological, psychological, and social domains (Cicchetti & Rogosch, 2002). Among these are bodily changes associated with pubertal maturation (for a review, see Hayward, 2003b). Adolescents also experience a shift in social contexts to a greater emphasis on the peer domain (Savin-Williams & Berndt, 1990) while also experiencing more stress and disruption in peer relationships (Brown, 1990). Although adolescent depression, and the sex difference therein, have been linked to pubertal development (Angold, Costello, & Worthman, 1998) and to stress in the peer realm (Gore, Aseltine, & Colten, 1993; La Greca & Harrison, 2005; Rudolph, 2002), research examining the integration of these two factors in predicting the sex difference in depression is limited. The present study explored how pubertal development and peer stress contribute to the emerging sex difference in adolescent depression both concurrently and over time. In particular, this research investigated the developmental *timing* and the psychosocial *context* of the emerging sex difference in adolescent depression by exploring the extent to which development in relation to peers, and in the context of stressful peer relationships, explains the sex difference in adolescent depression.

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Sex Differences in Adolescent Depression

Prior to adolescence, rates of depression are similar for boys and girls (for reviews, see Hankin & Abramson, 2001; Hammen & Rudolph, 2003; Rudolph, Hammen, & Daley, 2006) or slightly favor boys (Anderson, Williams, McGee, & Silva, 1987; Hankin et al., 1998). Depression increases sharply in adolescence, particularly for girls (Kessler, Avenevoli, & Merikangas, 2001). Findings for boys are mixed, with some studies reporting slight increases (Angold & Rutter, 1992; Hankin et al., 1998; Weissman et al., 1987), and others reporting stable rates (Ge, Lorenz, Conger, Elder, & Simons, 1994; Twenge & Nolen-Hoeksema, 2002; Wichstrom, 1999) or even decreases (Angold & Erkanli, 1996). By midadolescence, a female/male ratio of approximately 2:1 in diagnostic-level depression is evident (ages 13–16; Angold et al., 1998; Hankin et al., 1998; McGee et al., 1990). Inconsistent evidence regarding the precise age of onset of this emerging sex difference might be explained by findings that pubertal development, rather than chronological age, accounts for the difference (Angold et al., 1998; Hayward, Gotlib, Schraedley, & Litt, 1999).

Pubertal Development and the Sex Difference in Depression

Pubertal development is a multifaceted process, involving physical and biological changes, as well as psychological and social experiences and implications (Graber, 2003; Petersen, Crockett, Richards, & Boxer, 1988). Both morphological development (e.g., growth of secondary sex characteristics) and physiological development (e.g., changes in hormonal concentrations) have been implicated in the sex difference in depression (for a review, see Angold et al., 1998). Because of our interest in how pubertal changes elicit psychological and social reactions from adolescents and those around them, the present study focused on morphological development and other bodily manifestations of puberty (e.g., skin and voice changes, growth spurt). Given that physiological development also plays a key role in adolescent depression (Angold, Costello, Erkanli, & Worthman, 1999; Paikoff, Brooks-Gunn, & Warren, 1991), an interplay between somatic and biological changes likely contributes to the emerging sex difference in depression.

Reflecting its multifaceted nature, the pubertal transition might heighten risk for depression for various reasons. First, puberty is physically disruptive, and marks a physical transition to adulthood at a time when adolescents are socially far from it. Second, pubertal changes bring about negative psychological (e.g., body image) and social effects (e.g., exclusion, victimization), which in turn heighten risk for depression. Puberty also brings hormonal changes linked to negative affect and depression (Angold et al., 1999; Susman, Dorn, & Chrousos, 1991). Just as pubertal hormones differ for boys and girls, the psychological and social effects of puberty differ greatly, and these sex differences might play a central role in the emerging sex difference in adolescent depression.

Consistent with this idea, several studies show that pubertal *status* (i.e., objective degree or stage of physical maturation at a single point in time; Graber, Petersen, & Brooks-Gunn, 1996; Susman & Rogol, 2004) is a key predictor of rising adolescent depression and the sex difference therein. More mature pubertal status in girls, but not in boys, consistently is related to higher rates of depressive disorders (Angold et al., 1998), symptoms, and mood (Benjet & Hernández-Guzmán, 2002; Ge, Elder, Regnerus, & Cox, 2001; Hayward et al., 1999; Patton et al., 1996; Siegel, Aneshensel, Taub, Cantwell, & Driscoll, 1998; Wichstrom, 1999). Ge, Conger, and Elder (2001a) found that the association between sex and depressive symptoms disappeared when pubertal status was accounted for, indicating that pubertal development explains a significant portion of the sex difference in adolescent depression. Similarly, Angold and colleagues (1998) found that morphological pubertal status, not age, accounted for the sex difference in depression; yet, in a later paper (Angold et al., 1999), the effect of morphological

pubertal status on depression in girls was explained by hormone levels (cf. Paikoff et al., 1991). Thus, despite strong evidence for the role of pubertal status in adolescent depression, the precise mechanisms are still unclear.

In addition to the stress of going through puberty, one's *timing* relative to peers (i.e., pubertal status relative to age; Susman & Rogol, 2004; Weichold, Silbereisen, & Schmitt-Rodermund, 2003) also has implications for adolescent well-being, perhaps even more so than pubertal status per se (Tobin-Richards, Boxer, & Petersen, 1983). Adolescents who develop early might be underprepared for such changes. They also might feel deviant and insecure about their difference and lack the social support of peers going through the same process (Peskin, 1973; Petersen, 1983; Ruble & Brooks-Gunn, 1982). Adolescents who develop late relative to their peers might similarly feel insecure about their physical difference, and they might feel left behind, both physically and socially, as their more developed peers transition into adolescence. Thus, adolescents who develop off-time in either direction might be at risk for psychosocial distress (for a review, see Weichold et al., 2003).

Indeed, research links pubertal timing with depression, particularly in girls. Compared to their on-time or late-maturing peers, early-maturing girls typically exhibit more depressive symptoms and mood (Benjet & Hernández-Guzmán, 2002; Brooks-Gunn & Warren, 1985; Ge, & Elder, Regnerus, & Cox, 2001a; Hayward et al., 1997; Kaltiala-Heino, Kosunen, & Rimpela, 2003; Siegel, Anmeshensel, Taub, Cantwell, & Driscoll, 1998; Stattin & Magnusson, 1990), internalizing symptoms (Caspi & Moffitt, 1991; Hayward et al., 1997), and general psychological distress (Ge, Conger, & Elder, 1996; Petersen & Crockett, 1985). There is some evidence that late maturation in girls also has negative psychological effects, suggesting a curvilinear pattern (Dorn, Susman, & Ponirakis, 2003; cf. Petersen & Crockett, 1985). Among boys, late maturation often is associated with elevated depressive symptoms compared to early and on-time maturation (Benjet & Hernández-Guzmán, 2002; Crockett & Petersen, 1987; Dorn et al., 2003; Huddleston & Ge, 2003; Weichold et al., 2003). Yet, some research finds that early-maturing boys also exhibit elevated depression (Alsaker, 1992; Kaltiala-Heino et al., 2003; Susman et al., 1985, 1991), suggesting a curvilinear relation between pubertal timing and depression for boys as well (for reviews, see Huddleston & Ge, 2003; Weichold et al., 2003).

Despite growing evidence for the effects of pubertal timing on depression, there is inconsistency in the pattern of reported effects. Furthermore, Angold and colleagues (1998) failed to find an effect of early timing, or its interaction with sex, on diagnostic-level depression. These discrepancies are likely accounted for, in part, by variability in how depression and pubertal timing are operationalized. For example, whereas some studies use continuous measures of pubertal timing, others use dichotomous variables, such as “early timing” versus all other youth (thus lumping together on-time and late developers; e.g., Angold et al., 1998).

Adolescents' *perceived* pubertal timing (i.e., subjective appraisals of whether they are on time, behind, or ahead of their peers; e.g., Graber, Lewinsohn, Seeley, & Brooks-Gunn, 1997; Weichold et al., 2003) also may influence well-being because of its implications for peer interactions and perceived normality (e.g., Alsaker, 1995; Dorn et al., 2003; Dubas, Graber, & Petersen, 1991; Tobin-Richards et al., 1983). Perceived early timing in girls consistently is linked to heightened depressive disorders (Graber et al., 1997; Graber, Seeley, Brooks-Gunn, & Lewinsohn, 2004), mood or symptoms (Ge, Conger, et al., 2001a; Kaltiala-Heino et al., 2003; Michael & Eccles, 2003; Siegel et al., 1998; Siegel, Yancey, Aneshensel, & Schuler, 1999; Wichstrom, 1999), and there is some evidence that perceived late timing in girls also has negative psychological effects (Alsaker, 1992; Dubas et al., 1991; Siegel et al., 1998; Tobin-Richards et al., 1983). Perceived *late* timing in boys is associated similarly with depressed mood or symptoms (Graber et al., 1997; Siegel et al., 1998, 1999), although some

curvilinear patterns also have been noted (Alsaker, 1992; Graber et al., 1997). Although perceived timing predicts depression in a similar way as actual timing, perceived timing tends to be more strongly associated with the psychosocial consequences of puberty, including depression, and to show more curvilinear effects (i.e., perceiving oneself to be off-time is a liability for boys and girls; Alsaker, 1992; Dubas et al., 1991; Michael & Eccles, 2003; Siegel et al., 1998).

It is important to note several areas of overlap among age, pubertal status, timing, and perceived timing. First, pubertal status, as a measure of maturational progression, is intimately linked to age. Second, because pubertal timing is, by definition, pubertal status adjusted for age, these three dimensions of development are interdependent. Third, actual and perceived pubertal timing overlap to some extent; however, research often finds stronger links for perceived timing, suggesting that adolescents' appraisals of their pubertal timing go beyond a straightforward calculation of pubertal stage adjusting for chronological age, likely considering psychological and social-contextual factors as well. As such, this study attempted to explore the similar and different contributions of these maturational variables to adolescent psychosocial adjustment.

The Social Context of Puberty and the Sex Difference in Depression

Given the social focus and tendency toward conformity in adolescence, and the “social stimulus value” that pubertal maturation creates (Petersen & Taylor, 1980, p. 137), pubertal development and its ensuing physical changes should be viewed within a social context. As adolescents begin to place a heightened emphasis on their peer relationships (Berndt, 1982; Brown, 1990; Csikszentmihalyi & Larson, 1984; Furman & Buhrmester, 1985, 1992; Savin-Williams & Berndt, 1990), relationship disruptions that occur during this time (Brown, 1990) may set the stage for increasing depression. In fact, the link between peer stress and depression (e.g., Goodyer, Wright, & Altham, 1990; Puig-Antich et al., 1993; Rubin et al., 1992; Rudolph et al., 2000) is heightened during adolescence (Wagner & Compas, 1990). Thus, the peer domain is a natural context for examining trajectories of development and depression in adolescence.

The heightened importance placed on peer relationships in adolescence is particularly evident in girls, who have stronger interpersonal caring orientations, connection-oriented goals, and concerns about peer evaluation than do boys (for a review, see Rose & Rudolph, 2006). Because girls particularly value having close peer relationships, experiences of conflict, low social support, and other forms of peer stress are likely to provide a salient context for understanding the rise in depression among adolescent girls. Consistent with these ideas, girls typically have a stronger depressive response to peer stress, or more broadly to interpersonal stress, compared to boys (Hankin, Mermelstein, & Roesch, 2007; Leadbeater, Blatt, & Quinlan, 1995; Oldenburg & Kerns, 1997; Rudolph, 2002; Rudolph & Hammen, 1999; Schraedley, Gotlib, & Hayward, 1999).

Reflecting a developmental psychopathology framework (for a review, see Cicchetti & Cohen, 2006), several researchers have proposed interactional models of puberty and peer relationships (Compas, Hinden, & Gerhardt, 1995; Graber, 2003; Magnusson, 1988; Montemayor & Flannery, 1990; Petersen, 1980; Simmons & Blyth, 1987). According to these models, an adolescent's relative level of peer stress versus support might exacerbate or buffer the adverse effects of puberty (Benjet & Hernández-Guzmán, 2002; Tobin-Richards et al., 1983). Drawing from these Person \times Environment models, we anticipated that puberty and peer stress would likely work together to explain the sex difference in adolescent depression. Specifically, we expected that pubertal development would be more strongly associated with depression in the

context of high peer stress than in the context of low peer stress, and this interactive effect would be most salient in girls.

Some research supports the idea that puberty interacts with life stress and the peer context to predict the sex difference in adolescent depression. For example, early pubertal maturation in girls interacted with having mixed-sex friends (Ge et al., 1996) and with greater exposure to life stress (Ge, Conger, et al., 2001a; also see Silberg et al., 1999) to predict heightened psychological distress and depressive symptoms over time. Notably, the sex difference in depressive symptoms disappeared after adjusting for the effects of pubertal timing, life stress, and their interaction (Ge, Conger, et al., 2001a). Brooks-Gunn and Warren (1989) found that the interaction between morphological pubertal status and life stress accounted for more variance in adolescent girls' negative affect than did either variable alone, or hormonal status. In contrast, Angold and colleagues (2003) did not find an interaction between physiological pubertal status and mean life event counts in a sample of girls. Once again, the discrepant findings across studies are likely accounted for, in part, by differing methodologies (e.g., aspects of puberty and domains of life stress assessed, interview vs. checklist assessments). At the same time, these discrepancies highlight the need for further research into the intersecting roles of puberty and psychosocial factors in determining risk for depression.

Overview of the Present Study

This study examined how puberty interacts with stressful peer experiences to contribute to the sex difference in depression, both concurrently and over time. To identify which specific aspects of maturation are critical for understanding the emerging sex difference, we compared the roles of pubertal status, pubertal timing, and perceived pubertal timing. We made three sets of predictions: Hypotheses 1–3.

Hypothesis 1

We predicted that more mature pubertal *status* would predict heightened depression in girls, but not in boys. Among girls, early actual and perceived pubertal *timing* (i.e., being ahead of one's peers) should be associated with the highest levels of depression, late timing (i.e., being behind one's peers) with lower but moderately elevated levels of depression, and on-time development with the lowest levels of depression. Thus, both positive linear and positive curvilinear (i.e., J-shaped quadratic) associations were expected between pubertal timing (actual and perceived) and depression in girls. Among boys, actual and perceived *late* timing, and to a lesser extent, early timing, were expected to be associated with more depression relative to on-time development (i.e., negative linear and positive curvilinear associations with depression were predicted, yielding a J-shaped curve opposite that of girls). Given prior findings, we expected similar patterns of results for actual and perceived timing, but stronger effects for the latter.

Hypothesis 2

Puberty and peer stress were expected to interact in predicting depression such that the depressive effects of puberty (as described in Hypothesis 1) would hold at high levels of peer stress more so than at low levels of peer stress. Specifically, we predicted that more mature pubertal status in girls, and actual and perceived off-time pubertal development in both girls (early timing and, to a lesser extent, late timing) and boys (late timing and, to a lesser extent, early timing), would be more strongly associated with depression in adolescents who experienced high levels of stress in their peer relationships. Hypotheses 1 and 2 were expected to hold both concurrently and longitudinally.

Hypothesis 3

Given the predicted pattern of interactions, we expected that girls would be more depressed than boys among adolescents who were (a) more pubertally mature (i.e., advanced pubertal status), (b) early developing relative to peers (i.e., early pubertal timing), and (c) self-perceived as early developing (i.e., early perceived pubertal timing). Although prior findings are inconsistent, we also predicted that boys might be more depressed than girls among adolescents who were (a) less pubertally mature, (b) late developing relative to peers, and (c) self-perceived as late developing. To examine whether the sex difference in depression was specific to puberty, or could be equally well predicted by age, we also explored whether there was a sex difference at any particular age.

Method

Participants

The present study consisted of data from the first two waves of a longitudinal investigation examining the development of depression during the transition to adolescence (for previous reports on this study, see Krackow & Rudolph, 2008; Rudolph, 2008; Rudolph & Flynn, 2007; Rudolph, Flynn, Abaied, Groot, & Thompson, in press). Participants in the longitudinal study included 167 families drawn from a mid-sized Midwestern city and several rural towns. The present research focused on a subsample of 158 youth (94.6%) who had pubertal development, peer stress, and depression information available at the initial assessment. Among this subsample (mean age 12.39, *SD* 1.21, range = 9.6–14.8; 51.9% female; 76.6% White, 13.3% African American, 10.1% other), socioeconomic status was diverse, with total family income below \$30,000 for 16.7% of the sample and above \$75,000 for 19.2% of the sample.

Recruited youth for the longitudinal study had participated in schoolwide screenings using the Children's Depression Inventory (CDI; Kovacs, 1982). Youth who participated in these screenings represented approximately 80% of targeted participants. For these screenings, researchers read the CDI aloud during classroom administrations, while youth wrote their answers. From the screening sample ($n = 1985$), we selected potential participants ($n = 468$) along the range of the CDI, oversampling slightly at the high end (i.e., whereas 15.8% of the screening sample had CDI scores above 18, 20.3% of the participants we targeted for recruitment fell into this category). Participants from the screening sample were recruited for the longitudinal study based on several factors, including CDI scores, a maternal caregiver in the home, and proximity to the university until the targeted sample was successfully recruited. Participants in the longitudinal study did not differ from nonparticipants in terms of sex, $\chi^2(1) = .39, ns$, ethnicity/race (White vs. minority), $\chi^2(1) = .02, ns$, or depressive symptoms at the time of screening, $t(280) = 1.11, ns$. Participants ($M = 12.41$) were slightly, but not meaningfully, younger than nonparticipants ($M = 12.65$), $t(275) = 2.28, p < .05$.¹

Of the 158 families who participated at Wave 1 (W_1), Wave 2 (W_2) data were available for 152 (96.2%). Participants at W_2 did not differ from nonparticipants in terms of sex, $\chi^2(1) = .01, ns$, age, $t(7.39) = .51, ns$, ethnicity (White vs. minority), $\chi^2(1) = 2.46 = ns$, or any of the W_1 puberty, stress, or depression variables, $ts(156) < 1.59, ns$.

¹Reasons for nonparticipation included being busy or not interested ($n=229$), having moved or being unreachable ($n=40$), chronic rescheduling ($n=5$), and failing to meet eligibility criteria ($n=27$). Exclusion criteria included having a non-English-speaking maternal care-giver and having a severe developmental disability that interfered with the ability to complete the assessment.

Procedure

Primary female caregivers were telephoned and told about the study. Caregivers provided written informed consent and youth provided written assent; participants then completed in-person sessions with two interviewers. Interviewers included a clinical psychology faculty member, several trained psychology graduate students, a post-BA research assistant (all of whom conducted diagnostic or stress interviews), and several advanced undergraduate research assistants (who conducted stress interviews and administered paper and pencil questionnaires). The assessments lasted approximately 3 to 4 hr. The families completed a follow-up assessment as close to 1 year later as possible (mean time interval = 1 year, 1 week). At each assessment, families received a cash stipend, and youth received a gift certificate.

Measures

Table 1 presents descriptive information for the measures used in the present study.

Assessment and coding of depression

The Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children—Epidemiologic Version 5 (Orvaschel, 1995) is a semistructured interview assessing youth psychopathology. Interviewers conducted separate interviews with youth and their caregivers. At W_1 , participants reported symptoms that had occurred over the youth's lifetime, with a particular focus on the past year. At W_2 , participants reported symptoms over the past year.

All diagnostic interviews were coded in consultation with a clinical psychology faculty member. A best-estimate approach (for a description, see Klein, Lewinsohn, Rohde, Seeley, & Olino, 2005; Klein, Ouimette, Kelly, Ferro, & Riso, 1994) was used to combine caregiver and youth information regarding the nature, severity, frequency, and resulting impairment of the reported symptoms according to the Diagnostic and Statistical Manual of Mental Disorders criteria (American Psychiatric Association, 1994). For each episode and type of depression (e.g., major depression, dysthymia),² interviewers provided ratings on a continuous 5-point scale: 0 = *no symptoms*, 1 = *mild symptoms*, 2 = *moderate symptoms*, 3 = *diagnosis with mild impairment*, and 4 = *diagnosis with severe impairment*. Separate ratings were given for the entire past year and for the current month at the time of assessment. Ratings across episode and type of depression were summed, such that higher ratings reflect more severe symptoms within a single diagnostic category, the presence of symptoms from multiple categories, and/or multiple episodes of depression (see also Davila, Hammen, Burge, Paley, & Daley, 1995; Hammen et al., 1995; Hammen, Shih, Altman, & Brennan, 2003; Hammen, Shih, & Brennan, 2004; Rudolph et al., 2000). Thus, these scores represent composite indexes of several different markers of depression severity. Validity of these scores was established through significant correlations with several self-report measures of depressive symptoms ($r_s = .47-.57$, $p_s < .001$). Independent raters coded audiotapes of 25% of the W_1 interviews. One-way random-effects intraclass correlation coefficients (ICCs) for depression ratings were strong for the past year (ICC = .95) and the past month (ICC = .97). Depression scores showed high stability for the past year ($r = .70$, $p < .001$) and the past month ($r = .67$, $p < .001$).

At W_1 , 49 youth (31.0%) had some depression over the past year (i.e., a score above zero for at least one type of depression), and 22 of these youth (13.9%) had a clinical diagnosis of depression or dysthymia. At W_2 , 52 youth (34.4%) had some depression over the past year, and 17 of these youth (11.3%) had a diagnosis. Scores on the depression summary index ranged

²Most depression diagnoses were either major depressive disorder or dysthymic disorder. There was one case of diagnostic-level depressive disorder NOS (specifically, recurrent brief depressive disorder). In addition, there were nine cases of symptom-level depression in these categories: adjustment disorder with depressed mood, depressive disorder NOS, and bereavement (a V-code with depressive features).

from 0 to 9 at W_1 and 0 to 7 at W_2 . There were no significant differences between W_1 and W_2 depression scores, either for the past month, $t(151) = .16, ns$, or the past year, $t(152) = .62, ns$. Using McNemar's test there were also no significant changes in the number of depression cases from W_1 to W_2 , $\chi^2_s(1) \leq .84, ns$.

Assessment and coding of peer stress

To assess peer stress, the Youth Life Stress Interview (Rudolph & Flynn, 2007), a revised version of the Child Episodic Life Stress and Chronic Strain Interviews (Rudolph & Hammen, 1999; Rudolph et al., 2000), was used. This semistructured interview elicits information from youth and their caregivers (in separate interviews) about the nature and intensity of chronic and episodic stress the youth experienced over the past year. This study focused on stress in peer relationships.

To assess chronic peer stress, interviewers asked standardized questions about stressful aspects of friendships (e.g., lack of friendships, poor quality friendships, infrequent contact with friends; lack of closeness, trust, or support; presence and severity of conflict, poor conflict resolution) and general peer relationships (e.g., fights with peers, being teased by peers, social isolation or exclusion from social activities). In addition to a series of structured prompts, interviewers asked follow-up questions as needed to elicit a detailed picture of each youth's degree of chronic stress in the peer domain.

To assess episodic peer stress, interviewers asked a general open-ended question about the youth's experience of stressful events with peers and gave specific prompts about particular types of events. Interviewers also asked follow-up questions to elicit detailed information about each reported event, including what occurred, the timing and duration of the event, and any objective consequences (such as sitting alone in the lunchroom for a week because of a falling out with a best friend).

Interviewers presented narrative information to a team of trained coders who had no knowledge of the youth's diagnostic status or subjective response to the stress (e.g., felt sad). Coders provided consensual ratings based on youth and caregiver reports. The relative weight of each report was determined based on the detail and credibility of objective information provided by the two informants. Chronic stress over the past year was rated on a 5-point scale: 1 = *no stress*, 2 = *mild stress*, 3 = *isolated stress*, 4 = *serious stress*, 5 = *severe stress*. Higher chronic peer stress ratings reflect higher levels of stressful conditions (e.g., teasing, fighting, exclusion) and lower levels of positive conditions (e.g., low support, poor quality of friendships). For episodic stress, coders rated the stressfulness or negative impact of each event, from 1 (*none*) to 5 (*severe*), reflecting how stressful the event would be for a typical child in the described circumstances. If only the youth or the caregiver reported an event, that information was used for coding. Episodic peer stress scores were calculated as the total of the objective stress ratings for each peer event with a stress rating above 1.

To determine reliability, information from 41 interviews (including 160 episodic stress events) was presented to two teams of coders, who gave independent ratings. One-way random-effects ICCs evidenced high reliability for the chronic peer stress rating (ICC = .96) and the objective episodic stress rating (ICC = .90). Cohen's kappa for agreement on whether an event was peer related or not was 1.00. As might be expected, stability was strong for chronic stress ($r = .67, p < .001$) and moderate for episodic stress ($r = .37, p < .001$).

Assessment of pubertal status and timing

Given this study's focus on how somatic changes associated with puberty influence depression, we followed precedent from past research by assessing secondary sex characteristics and other

physical changes of puberty (Dubas et al., 1991; Ge, Elder, et al., 2001; Hayward, 2003a; Petersen et al., 1988). Youth and their caregivers completed two assessments of youth's pubertal status.³ The first measure consisted of a series of drawings illustrating the stages of pubertal development specified by Tanner (1969), and adapted by Morris and Udry (1980). Each set of drawings consists of five stages, of breast development and pubic hair growth in girls, and of genital development and pubic hair growth in boys. Informants were instructed to indicate which of the drawings in each group most closely matched with the youth's current stage of development. Because of the sensitive and private nature of the drawings, caregivers first were asked for permission to give the questionnaire to youth, and then youth themselves were given the option of completing it. Complete or partial data were available for 118 of the youth respondents, and 140 of the caregivers.

Youths' self-ratings on the Tanner stages correlate well with physician ratings, and show strong kappa coefficients (e.g., between .81 and .91; Duke, Litt, & Gross, 1980; also see Dorn, Susman, Nottelmann, Inoff-Germain, & Chrousos, 1990; Morris & Udry, 1980; Schlossberger, Turner, & Irwin, 1992). In the present sample, youth and caregiver reports correlated well for girls' breast ($r = .83, p < .001$; 97% agreement within one category) and pubic hair development ($r = .69, p < .001$; 86% agreement within one category), and moderately well for boys' genital ($r = .47, p < .01$; 83% agreement within one category) and pubic hair development ($r = .65, p < .001$; 78% agreement within one category), similar to other studies (e.g., Dorn et al., 1990). Youth and caregiver reports were averaged into consensual ratings; for 49 cases, information was available from only one informant, and this information was used instead of a composite. It should be noted that the present sample included girls and boys across the full range of the Tanner stages: 29.6% of girls and 38.6% of boys had an average Tanner score between 1.0 and 2.0, 43.2% of girls and 42.9% of boys fell between 2.25 and 3.75, and 27.2% of girls and 18.6% of boys were rated between 4.0 and 5.0.

The second measure, the Pubertal Development Scale (PDS; Petersen et al., 1988), assesses growth spurt, body hair, skin changes (all youth), voice changes and facial hair (boys), and breast development and menarcheal status (girls). Each item is rated on a 1–4 scale (1 = *no development*, 2 = *development has just begun*, 3 = *development is definitely underway*, 4 = *development is complete*), with the exception of the menarche item (1 = *no*, 4 = *yes*). The PDS has been well validated, with interitem reliability ranging from the .50s to the .80s (median $\alpha = .71$ across three studies; Brooks-Gunn, Warren, Rosso, & Gargiulo, 1987; Petersen et al., 1988; Tobin-Richards et al., 1983). The PDS also has shown moderate correlations with physician ratings of the Tanner stages (r range .61–.67; Brooks-Gunn et al., 1987).

Complete or partial PDS data were available for 132 youth and 140 caregivers. Youth and caregiver reports on the PDS were strongly correlated in the present sample ($r_s = .88$ for girls, .72 for boys; $p_s < .001$) and were averaged into consensual ratings for each item. The five PDS items showed strong internal consistency ($\alpha = .86$ for girls and boys). For 24 youth, data were available from only one informant, and this information was used instead of a composite.

Creation of pubertal status and timing variables

Pubertal status—Based on a confirmatory factor analysis,⁴ a composite score for pubertal development was created by averaging the five PDS items and the two Tanner stage drawings (each item standardized within sex). These seven items showed strong reliability as a single scale, both for girls ($\alpha = .92$) and boys ($\alpha = .91$). All seven items were available for the majority of participants (135 of 158), and an additional 11 participants had five or six of the seven items.

³In fitting with the study's hypotheses, these were measures of secondary sex characteristics, not pubertal onset as measured via hormonal assay.

⁴Results of the confirmatory factor analysis can be obtained from the first author upon request.

Given that the Tanner stages often are used alone as an index of pubertal development (Brooks-Gunn & Warren, 1989; Dorn et al., 1990; Hayward et al. 1997; Morris & Udry, 1980), composite scores for an additional 12 participants with Tanner stage data alone ($n = 4$), or with the Tanner stages and an additional one to two items from the PDS ($n = 8$), were calculated.

Pubertal timing—To capture pubertal timing, residualized scores of pubertal status, adjusting for age, were computed separately for girls and boys (Alsaker, 1995; Dorn et al., 2003).

Perceived pubertal timing—Youths' perceived pubertal timing, relative to their peers, was assessed with the question: “Do you think your development is any earlier or later than most other [girls/boys] your age?” Response options included much earlier, somewhat earlier, about the same, somewhat later, and *much later*, yielding a continuous score ranging from 1 to 5. Responses were recoded so that *higher* scores reflected *earlier* pubertal timing, similar to the calculated pubertal timing item. Similar items have been used in other studies, and have strong predictive validity in relation to depression (Alsaker, 1992; Dubas et al., 1991; Graber et al., 1997, 2004; Michael & Eccles, 2003; Siegel et al., 1998, 1999; Wichstrom, 1999).

Results

Overview of analyses

A series of hierarchical multiple regression (HMR) analyses was conducted to examine the interacting contributions of puberty and peer stress to depression among girls and boys, both concurrently and over time, and to identify at what specific stages of maturation a sex difference in depression occurred. Concurrent analyses explored the associations among sex, W_1 puberty, W_1 peer stress, and depression occurring over the past year. Longitudinal analyses examined the associations among sex, W_1 puberty, peer stress occurring between W_1 and W_2 , and W_2 current depression. Longitudinal analyses were conducted both with (adjusted) and without (unadjusted) adjusting for W_1 depression.⁵ Preliminary analyses revealed similar patterns for chronic and episodic peer stress. Thus, a composite score reflecting both types of peer stress was used.

Linear effects—We first examined the hypothesized interactions among sex, puberty, and peer stress in predicting depression (Hypotheses 1–3). The three main effects were entered at the first step, all two-way interactions at the second step, and the three-way interaction at the third step. All continuous predictors were centered prior to analysis and calculation of the interaction terms. Significant interactions were interpreted and depicted following Aiken and West (1991), using 1 *SD* above and below the mean to represent high and low levels of the independent and moderator variables. For depiction purposes, significant two-way interactions were reanalyzed without the third variable or its interactions in the regression equations. To address Hypothesis 1, the two-way interactions between sex and puberty were interpreted in terms of differences in slope (i.e., sex differences in the association between puberty and depression). To address Hypothesis 2, we examined whether the interactive effects of sex and maturation were moderated by exposure to peer stress (i.e., the three-way interactions). To address Hypothesis 3, the concurrent interactions between sex and puberty were used to identify sex and maturational differences in depression. Specifically, these interactions were further analyzed with the Johnson–Neyman procedure for calculating regions of significant difference

⁵When adjusting for prior depression was not possible through HMR, such as when presenting descriptive statistics (Table 1), correlations (Table 2), or graphical representations of the data (Figure 7), a “residualized depression” score, consisting of W_2 depression, adjusting for W_1 depression (both measures over the most recent month), was used.

(see Pedhazur, 1997) to ascertain whether, and at which level of maturation, a sex difference in depression occurred.

Curvilinear effects—To fully test Hypotheses 1 and 2, we also examined curvilinear associations between pubertal timing, both actual and perceived, and depression. HMR was employed with both linear and curvilinear (quadratic term) pubertal timing variables entered in one step to predict depression. Given the hypothesized sex differences, these analyses were performed separately by sex. In cases where curvilinear effects were found, two and three-way interactions among the curvilinear puberty variable, sex, and peer stress in predicting depression were examined for exploratory purposes, with recognition that the sample size limited power to detect such high-order effects.

Descriptive and correlational findings

Table 1 presents descriptive statistics for each of the variables, separately for boys and girls. There were no sex differences in puberty, peer stress, or depression, $t_s(123-156) < 1.68$, *ns*. Table 2 presents correlations among the variables, separately by sex. These correlations provide a general picture of the associations among these variables in girls and in boys. Most notably, there were several associations between puberty (status, timing, and perceived timing) and depression that were positive in girls but negative (though many were nonsignificant) in boys. In general, more mature pubertal status and earlier pubertal timing, both actual and perceived, were associated with *higher* levels of depression in girls, but *lower* levels of depression in boys (with a few exceptions in boys; see Table 2). These correlations provide some initial support for Hypothesis 1. It also is interesting to note that unlike the puberty variables, age was uncorrelated with depression in girls, but was associated with lower levels of depression (particularly W_2 depression) in boys.

Sex, puberty, and peer stress predicting depression

Main effects—As seen in Table 3, there were some main effects of sex, puberty, and peer stress on depression. There was a consistent trend for girls to exhibit higher levels of depression than boys at W_2 . In addition, more mature pubertal status and earlier actual pubertal timing were associated with heightened depression in both sets of longitudinal analyses. In all analyses, higher levels of peer stress predicted heightened depression, both concurrently and longitudinally. These main effects, however, were qualified by several interactions.

Sex \times Puberty—Hypothesis 1 was supported by the Sex \times Puberty interactions predicting depression concurrently (for all puberty variables) and longitudinally, both with and without adjusting for prior depression (for perceived timing only). Table 4 presents these interactions without peer stress in the models (note that the longitudinal-unadjusted analyses for pubertal status and actual timing became marginally significant when peer stress was dropped from the models; thus, these interactions were depicted as well), Figures 1 through 3 illuminate the nature of these interactions. As depicted in Figure 1, *more* mature pubertal status was associated with higher levels of depression in girls both concurrently ($\beta = .25$, $p < .05$) and over time ($\beta = .22$, $p = .05$), whereas *less* mature pubertal status was associated with higher levels of depression in boys concurrently ($\beta = -.23$, $p < .05$) but not over time ($\beta = -.02$, *ns*). A similar pattern held for pubertal timing (see Figure 2): earlier timing relative to peers was associated with higher levels of W_1 and W_2 depression in girls ($\beta_s > .34$, $ps < .01$), whereas in boys the association was nonsignificant, in the opposite direction from girls at W_1 ($\beta = -.19$, *ns*), and in the same direction at W_2 ($\beta = -.18$, *ns*). A stronger and more consistent pattern emerged for perceived pubertal timing (see Figure 3). Among girls, perceived *early* timing was associated with higher levels of depression both concurrently and longitudinally without adjusting for prior depression ($\beta_s > .37$, $ps < .01$), whereas among boys, perceived *late* timing was associated with higher levels of depression ($\beta_s < -.26$, $ps < .05$). The same pattern held longitudinally

when adjusting for prior depression, although the individual slopes were smaller both for girls ($\beta = .15, p = .11$) and boys ($\beta = -.22, p = .07$).

Puberty \times Peer Stress—Hypothesis 2 was supported by the significant Pubertal Timing \times Peer Stress interactions predicting depression longitudinally (both with and without adjusting for prior depression), although these effects were not moderated by sex. The effects remained significant without sex in the model ($\beta s > .19, ps < .01$). As shown in Figure 4, earlier pubertal timing was associated with heightened depression among youth exposed to high ($\beta s > .43, p < .001$) but not low ($\beta s < .04, ns$) levels of peer stress.

Sex \times Puberty \times Peer Stress—Further support for Hypothesis 2 was provided by two marginal three-way interactions between sex, pubertal timing, and peer stress predicting depression concurrently, and between sex, perceived timing, and peer stress predicting depression longitudinally (adjusting for prior depression). As shown in Figure 5, at high levels of peer stress, *earlier* pubertal timing in girls ($\beta = .34, p < .05$), and *later* pubertal timing in boys ($\beta = -.38, p < .05$), were associated with higher levels of concurrent depression. At low levels of peer stress, the association between pubertal timing and depression was nonsignificant for girls ($\beta = .08, ns$) and boys ($\beta = -.05, ns$). A similar pattern emerged for perceived timing and depression in the longitudinal-adjusted analysis (see Figure 6). At high levels of peer stress, *earlier* perceived timing in girls ($\beta = .18, p = .05$), and *later* perceived timing in boys ($\beta = -.31, p < .05$), predicted higher levels of depression over time, adjusting for prior depression. At low levels of peer stress, the association between perceived timing and depression was nonsignificant for both girls ($\beta = -.10, ns$) and boys ($\beta = .05, ns$).

Curvilinear effects of puberty on depression

Sex differences—Table 5 presents the standardized beta coefficients for the effects of curvilinear (i.e., quadratic) pubertal timing on depression, separately for girls and boys. As shown, actual pubertal timing did not have a curvilinear relation with depression for either sex. Perceived pubertal timing, on the other hand, showed some curvilinear effects on depression for both girls and boys.

Figure 7 presents the nature of the curvilinear relations between perceived pubertal timing and depression. Consistent with Hypothesis 1, perceived early timing in girls was associated with the highest levels of depression, followed by perceived late timing. In contrast, perceptions of being on time were associated with low levels of depression. Although this curvilinear relation held both concurrently and over time, the longitudinal association was not significant when adjusting for prior depression. Similar to girls, boys' perceived off-time development in either direction was associated with elevated levels of depression longitudinally, both with and without adjusting for prior depression. However, consistent with Hypothesis 1, perceived *late* timing was associated with the highest levels of depression among boys, followed by perceived early timing.

In sum, among both girls and boys, perceiving oneself to be off-time relative to peers was associated with elevated depression, whereas perceiving oneself to be on-time was associated with lower levels of depression. Thus, whereas both girls and boys evidenced a positive curvilinear pattern (i.e., off-timing in either direction was problematic), the linear association between puberty and depression was positive in girls (early timing worse) and negative in boys (late timing worse).

Curvilinear associations in tests of moderation

Exploratory analyses were conducted to examine whether the curvilinear associations between perceived pubertal timing and depression were moderated by peer stress. All four main effects

(sex, linear perceived pubertal timing, curvilinear perceived pubertal timing, and peer stress) were entered in the first step (or second, in the longitudinal analyses that adjusted for W_1 depression), followed by an additional step for the five two-way interactions, and a final step for the two three-way interactions. A main effect for curvilinear perceived timing was found to predict depression both concurrently and longitudinally, even after adjusting for prior depression ($\beta s \geq .15, ps < .05$). In the analysis predicting concurrent depression, this main effect was qualified by a Sex \times Curvilinear Perceived Timing interaction ($\beta = .31, p < .01$). This is not surprising given that the curvilinear association between perceived timing and W_1 depression was significant in girls but not in boys (see Figure 7 and Table 5). The main effect on W_2 (adjusted for W_1) depression was qualified by a marginal Curvilinear Perceived Timing \times Stress interaction ($\beta = .17, p < .07$). Follow-up analyses revealed that the curvilinear association between perceived timing and depression held at high ($\beta = .27, p = .08$) but not low ($\beta = -.07, ns$) levels of peer stress. The remaining two- and three-way interactions with curvilinear perceived timing were not significant ($\beta s < .17, ns$).

Sex and maturational differences in depression

The final set of analyses investigated the stages of maturation at which the sex difference in depression occurred (Hypothesis 3). These analyses were based on the concurrent Sex \times Maturation interactions displayed in Table 4.

Pubertal status—The Johnson–Neyman procedure revealed that at less mature stages of pubertal development, boys and girls did not significantly differ in terms of depression. More precisely, the procedure projected that only at the very extreme low end of pubertal development (1.75 *SD* below the mean, or the least-developed 4% of the sample) would boys be more depressed than girls, and this projected value was too rare in the present sample to interpret (see Figure 1a). However, at increasingly more mature stages of pubertal development, girls were increasingly more depressed than boys. Specifically, among youth in the upper quartile of pubertal development (starting at 0.72 *SD* above the sample mean in pubertal status), rates of depression were significantly higher in girls than in boys. Follow-up analyses revealed that girls were more depressed than boys among youth whose PDS average was 2.0 or greater (on a 1–4 scale; pubertal development, on average, had barely started, was definitely underway, or seemed completed), $t(70) = 3.17, p < .01$, and among youth whose Tanner average was 3.0 or greater (on a 1–5 scale), $t(67) = 2.42, p < .05$.

Pubertal timing—Figure 2a illustrates that among later developing adolescents, boys experienced higher levels of depression, but among earlier developing adolescents, girls experienced higher levels of depression. The Johnson–Neyman procedure confirmed this pattern, such that among very late-developing youth (i.e., the latest 8% in this sample, or 1.38 *SD* below the mean and lower), boys were more depressed than girls, and among early-developing youth (i.e., the earliest 26% in this sample, or 0.65 *SD* above the mean and higher), girls were more depressed than boys.

Perceived pubertal timing—Figure 3a depicts a similar association between perceived timing and depression. According to the Johnson–Neyman procedure, among adolescents who responded that their pubertal development was “somewhat later” or “much later” than their peers, boys were more depressed than girls, and among adolescents who reported that their pubertal development was “somewhat earlier” or “much earlier” than their peers, girls were more depressed than boys.

Chronological age—To examine whether the sex difference in depression was specific to puberty, or could be equally well-predicted by age, we also explored whether there was a sex difference at any particular age. There were no main effects for age ($\beta s \leq .10, ns$) and no

interactions between sex and age ($|\beta|s \leq .13$, *ns*), indicating that there was no particular age during which the sex difference in depression was significant in this sample.

In sum, the two-way interactions between sex and maturation predicting depression provide support for Hypothesis 3: girls typically were more depressed than boys at more mature stages of pubertal development and when their pubertal timing, whether actual or perceived, was earlier than that of their same-sex peers. In addition, among adolescents who were late in their pubertal timing, or who perceived themselves to be later than their peers, boys were more depressed than girls. These analyses reveal that pubertal development, rather than chronological age, is the key maturational process involved in the emerging sex difference in adolescent depression.

Discussion

This study elucidated the complex nature of sex and maturational differences in depression, revealing important distinctions among various components of development in the emerging sex difference in depression. Whereas the preponderance of past research on puberty and depression focuses on girls, this study contributes to a small but growing body of research on these processes in boys (Ge, Conger, & Elder, 2001b; Huddleston & Ge, 2003). Following the principles of developmental psychopathology (Cicchetti, Rogosch, & Toth, 1994; Petersen & Hamburg, 1986; Sameroff, 1987), as well as recommendations in the field of puberty research (Graber, 2003; Hayward & Sanborn, 2002; Susman & Rogol, 2004), this research took a contextualized approach to understanding the developmental processes linking sex and puberty to depression. Of importance, this study's longitudinal design allowed for examining how these processes unfold over time.

The present findings confirmed the majority of the study hypotheses: (a) pubertal status and timing (both actual and perceived) predicted depression differentially for girls and boys, (b) the sex-differentiated effects of puberty on depression were partly dependent on a context of stressful peer relationships, and (c) the sex difference in depression was evident in particular maturational groups of adolescents (but, notably, not at a particular chronological age).

Sex and maturational differences in depression

By utilizing regions of significance tests to pinpoint the maturational turning point at which the sex difference in depression is evident, the present study advances current understanding of this complex developmental phenomenon. These tests also identified the particular points of actual and perceived pubertal timing at which a sex difference in depression exists. Consistent with Angold and colleagues (1998), girls were more depressed than boys starting at Tanner Stage III; the present research also identified this sex difference among early-developing adolescents and among self-perceived early developers. In contrast, among very late-developing adolescents and adolescents who rated their own development to be late, boys were more depressed than girls.

Sex differences were evident not only in the levels of depression experienced within particular pubertal development groups, but also in the associations between puberty and depression. In general, the effects of puberty on depression often were opposite in girls and boys. Whereas rates of depression were *higher* at progressively more mature stages of pubertal development among girls, they were either similar or *lower* across pubertal maturation for boys. Moreover, although perceived off-timing was detrimental for both sexes, perceived *early* timing in girls, but perceived *late* timing in boys, had the strongest consequences for depression. Indeed, the associations depicted in Figure 7 show a striking pattern of sex differences that are nearly mirror images.

Accounting for the sex difference in depression

Puberty, not age, emerged as a consistent predictor of the sex difference in depression. Furthermore, given that pubertal timing was calculated by adjusting pubertal status for age, the effects of pubertal timing on depression indicate that pubertal status influences depression above and beyond the influence of age. Although an effect of age would likely have been found with a sample spanning a larger age range, it is likely that age effects found in other research are, in part, because of their co-occurrence with pubertal maturation effects. These findings contribute to a growing body of research documenting differential roles of puberty versus age in the sex difference in adolescent depression (Angold et al., 1998; Patton et al., 1996).

The differential roles of actual versus perceived pubertal timing—Perhaps one of the most interesting findings that emerged from the present study is that actual and perceived pubertal timing showed different patterns of influence on depression. Of note, a recent study by Michael and Eccles (2003) revealed nearly identical patterns as the current study regarding the influence of actual timing (i.e., linear) versus perceived timing (i.e., curvilinear) on girls' psychological distress (including symptoms of depression and eating disorder). Together, findings from these two studies and others (Alsaker, 1992; Dubas et al., 1991) suggest that actual and perceived timing operate in different ways to affect adolescent adjustment, and raise an important question for continuing research: how and why might adolescents' ratings of perceived pubertal timing differ from their actual pubertal timing?

Most likely, the peer group that adolescents reference to compare their level of development consists of classmates, playmates, or school-mates of varying ages, not just peers of the same sex and age (Gargiulo, Attie, Brooks-Gunn, & Warren, 1987; Silbereisen & Kracke, 1997). Thus, perceived timing is likely to be determined not only by adolescents' pubertal status and age, but also by their age relative to peers in their social and academic circles. For example, two fully developed 12-year-old girls, one in fifth grade in an elementary school, and one in sixth grade in a middle school, are likely to perceive their pubertal timing quite differently. Moreover, there is evidence that earlier developing girls tend to socialize with older peers (Magnusson, 1988), thus influencing their perceived timing to be less early than their actual timing. Further research accounting for friends' ages, as well as grade and school variables, might help disentangle the differences between perceived and actual timing.

It also is possible that adolescents who rate themselves to be very off-time in their pubertal development (i.e., in the present study, only 13.7% of girls and 15.3% of boys rated themselves to be much earlier or later than their peers) include those who experienced some social adversity because of their off-timing, thus drawing attention to their development as distinct from their peers. Because perceived timing is influenced not only by actual timing but also by the peer context, it makes for a strong predictor of depression particularly when combined with peer stress. Indeed, in the present study perceived off-timing was linked to depression particularly in the context of stressful peer relationships.

Perceived timing also is likely to be influenced by the physical, psychological, and social salience of particular aspects of pubertal development, more so than actual timing is (Graber et al., 1996; Silbereisen & Kracke, 1997). Each of the different physical changes associated with puberty has unique personal, social, and cultural meanings, as well as consequences, for developing adolescents. For example, height and muscle mass are likely to be particularly important to boys, whereas breast development, body fat, and menarche might be particularly relevant to girls (Silbereisen & Kracke, 1997). Thus, whereas calculations of actual timing are based on several pubertal factors of varying degrees of salience, adolescents are likely to base their self-ratings of timing on one or two that are personally or socially salient. It is also notable that the bodily changes of puberty might be more publicly visible and, therefore, socially salient among girls (e.g., breast development and body fat) than among boys (e.g., genital development

and body hair); this difference might explain the stronger correlation between actual and perceived pubertal timing in girls, compared to boys, in the present study. Finally, the different components of pubertal development unfold in varying order from one adolescent to another, and thus adolescents might be on-time in some respects but off-time in others (Brooks-Gunn, 1987; Marshall & Tanner, 1970; Tanner, 1955, 1969). As a result, adolescents might perceive their timing to be more or less off-time because of a delay or advance in particular aspects of their development.

In addition to these theoretical explanations, a recent study by Michael and Eccles (2003) provides a potential empirical explanation for the difference between perceived and actual late timing: girls' perceived late timing was associated with feeling less attractive, less popular, and not fitting in with peers. In contrast, studies of actual timing in girls typically have not linked lateness to these types of perceived peer problems. Thus, it appears that being *subjectively* behind their peers contributes to slightly negative effects of late perceived timing in girls. Michael and Eccles also found that perceived early timing contributed to girls' weight concerns and other body image problems, which also have been reported for *actual* early timing (Tobin-Richards et al., 1983). These findings might help explain why in the present study and elsewhere, both actual and perceived early timing have been linked to depression and maladjustment in girls, whereas for late timing, only *perceptions* of being late contribute to slightly elevated adjustment difficulties. Further research on the differential roles of actual and perceived pubertal timing, and the factors that influence the latter, might help explain sex differences in the association between puberty and depression. Indeed, identifying adolescents who misperceive their pubertal timing, perhaps related to the cognitive distortions of depression, might prove to be a fruitful focus in explaining elevated rates of adolescent depression.

The social context of the emerging sex difference in adolescent depression

In a recent review, Graber (2003) noted the importance of considering the social context in which puberty unfolds (see also Weichold et al., 2003). Conducted in this spirit, the present study confirmed the prediction that the depressogenic effects of pubertal development would depend on social context, specifically, a context of stress in the peer domain. Multiple regression analyses revealed that several of the pathways between pubertal timing and depression held at high, but not low, levels of peer stress. Specifically, the concurrent associations between early pubertal timing and depression in girls, and between late pubertal timing and depression in boys, were intensified by the experience of stressful peer relationships, but tempered in the context of low-stress peer relationships. Similarly, the longitudinal associations between perceived early timing and subsequent (adjusted for prior) depression in girls, and between perceived late timing and depression in boys, were exacerbated by a context of peer stress, but muted in the context of low-stress peer relationships. Across both sexes, the longitudinal association between early pubertal timing and elevated depression, both with and without adjusting for prior depression, held at high, not low, levels of peer stress. Furthermore, the curvilinear association between perceived timing and subsequent (adjusted for prior) depression held in the context of high but not low peer stress.

Interpreting these findings in a diathesis-stress framework (Weichold et al., 2003; Zuckerman, 1999) suggests that off-time pubertal development, both actual and perceived, is a diathesis for depression that is activated when it occurs in the context of stressful peer relationships. In contrast, peer contexts that are positive and supportive might buffer against the depressive effects of actual and perceived pubertal deviance. In the present study, although actual and perceived early-developing girls and late-developing boys were prone to elevated rates of depression in general, adolescents who had supportive, low-stress peer relationships were resilient against the otherwise depression-inducing effects of off-time development.

Concurrent versus longitudinal patterns of findings

Comparing results from concurrent versus longitudinal analyses reveals important differences among the three puberty variables. The pattern of two-way interactions between sex and puberty, or the main effects of puberty when it did not interact with sex (Table 4), indicate that the depressive effects of pubertal status waned over time. Specifically, the interaction with sex was significant concurrently, marginal longitudinally, and nonsignificant when adjusting for prior depression. Although there was a main effect for pubertal status in the longitudinal-adjusted analyses, the effect size was relatively smaller. In contrast, the pubertal timing variables had a more enduring and robust effect on depression, concurrently and over time, even after adjusting for prior depression. Whereas perceived timing interacted with sex consistently in predicting depression, the interaction between sex and actual timing tapered off in the longitudinal analyses, leaving a strong main effect for timing on depression, even when adjusting for prior depression. In a similar pattern, pubertal status did not interact with stress (either with or without further moderation by sex) in predicting depression, but the two timing variables did.

Given that pubertal timing, actual or perceived, is a peer-referenced variable, it is not surprising that timing interacted with peer stress, and demonstrated longer lasting mental health outcomes, even when accounting for prior adjustment. In contrast, as an objective, nonsocially normed variable, it makes sense that pubertal status did not interact with peer stress, and its effect held concurrently (similar to past research) but was less powerful over time. Although research on the long-term effects of puberty on diagnostic-level depression is sparse, a recent investigation found that compared to their self-perceived on-time peers, self-perceived early-developing girls evidenced higher lifetime rates of major depressive disorder in the years between adolescence and young adulthood (age 24; Graber et al., 2004). Thus, the present findings contribute to growing evidence for pubertal timing as having an enduring effect on depression.

Contributions and Future Directions

The present research benefited from several methodological strengths; at the same time, there are areas for improvement. First, the broad age range of participants and the longitudinal design allowed for capturing rich variations in the developmental effects of age and puberty across a range of maturational stages. However, many of the participants in this sample were still undergoing pubertal changes at the time of the second assessment, and thus the present study was not able to capture much of the postpubertal end of their developmental trajectories. Furthermore, because boys, as a group, mature later than do girls (Tanner, 1969), the age range of the present sample might have restricted the range of development more in boys than in girls. In a related vein, as puberty is a dynamic, developmental process, future research would benefit from examining the influence of trajectories of puberty over time.

Second, the present sample was representative in terms of race (US Census Bureau, 2000) and diverse in terms of socioeconomic status. Despite this diversity, the sample was not large enough to test for ethnic or socioeconomic group differences. Although research examining ethnic differences in the associations among sex, puberty, peer stress, and depression is limited, there is enough evidence of both biological differences (e.g., differential timing of pubertal events) and sociocultural differences (e.g., different cultural meanings and values attached to pubertal development) to suggest that ethnicity, socioeconomic status, nationality, or related factors might further moderate the associations among puberty, peer stress, and depression (e.g., Ge et al., 2003; Hayward et al., 1999; Michael & Eccles, 2003; Siegel et al., 1999).

Third, the present study incorporated multi-informant assessment of pubertal development, peer stress, and depression. Building on previous checklist-based research, this study used semi-structured diagnostic and life stress interviews that provide more in-depth information

and are less subject to informant biases (Rudolph & Hammen, 1999; Rudolph et al., 2000). Although the use of diagnostic interviews provided a strong measure of depression, our sample size prevented us from predicting depression diagnoses. Instead, we used a continuous index of depression that incorporated multiple markers of severity into a single composite. Thus, our longitudinal regressions predicted youths' level of depression over time relative to their peers, rather than onsets or recurrences of depression diagnoses. Future research is needed to examine the interactive roles of sex, puberty, and peer stress in predicting diagnoses.

Another methodological strength is that both chronic and episodic stress were assessed, which were noted to be of central importance in studying adolescent stress and psychological adjustment (Compas, 1987). Finally, as recommended by Hayward (2003a), the present study assessed multiple aspects of pubertal development, with a particular focus on the bodily changes of puberty. This was essential for examining the study hypotheses, which centered on how the psychological and social experience of puberty contributed to depression. At the same time, there is evidence that hormones are a key factor in accounting for elevated depression among adolescent girls (Angold, Worthman, & Costello, 2003) and even that the effects of pubertal status are accounted for by hormonal differences (Angold et al., 1999; cf. Paikoff et al., 1991). Further research is needed to tease apart the relative, unique, and joint contributions of hormonal versus somatic changes in explaining the emerging sex difference in adolescent depression (Susman & Rogol, 2004).

Finally, because the present study slightly oversampled youth at the high end of the CDI (above 18), the results might not generalize to all youth. Yet, it is noteworthy that to the extent that other studies have examined some of the same issues, the present findings are quite consistent (e.g., the sex difference in depression that emerged at Tanner Stage III, consistent with Angold et al.'s [1998] findings using a representative sample). This consistency suggests that the oversampling procedure is unlikely to have skewed the present results to any great degree.

Implications and applications

The present research contributes to our growing understanding of adolescent development, including the associations among sex, puberty, peer stress, and depression, and of the epidemic of elevated rates of depression in adolescent and adult women. In addition to these theoretical contributions, this research also provides a few practical applications. First, perceived pubertal timing emerged as a powerful predictor of the sex-differentiated pattern of depression that appears in adolescence. This suggests a potentially useful, yet simple, method for psychologists and other professionals to identify youth at risk for adjustment problems. Furthermore, the findings for actual and perceived pubertal timing indicate that social comparisons regarding pubertal maturation have strong psychosocial influences on adolescent adjustment; these findings might have implications for how pubertal development could be discussed in psychoeducational contexts, such as sex education curricula, to foster more social acceptance of these common variations that often are regarded by adolescents as socially deviant. Finally, findings suggesting that feeling underprepared for puberty might put adolescents at risk for depression have implications for how parents and professionals might best educate youth about, and help prepare them for, this important life transition.

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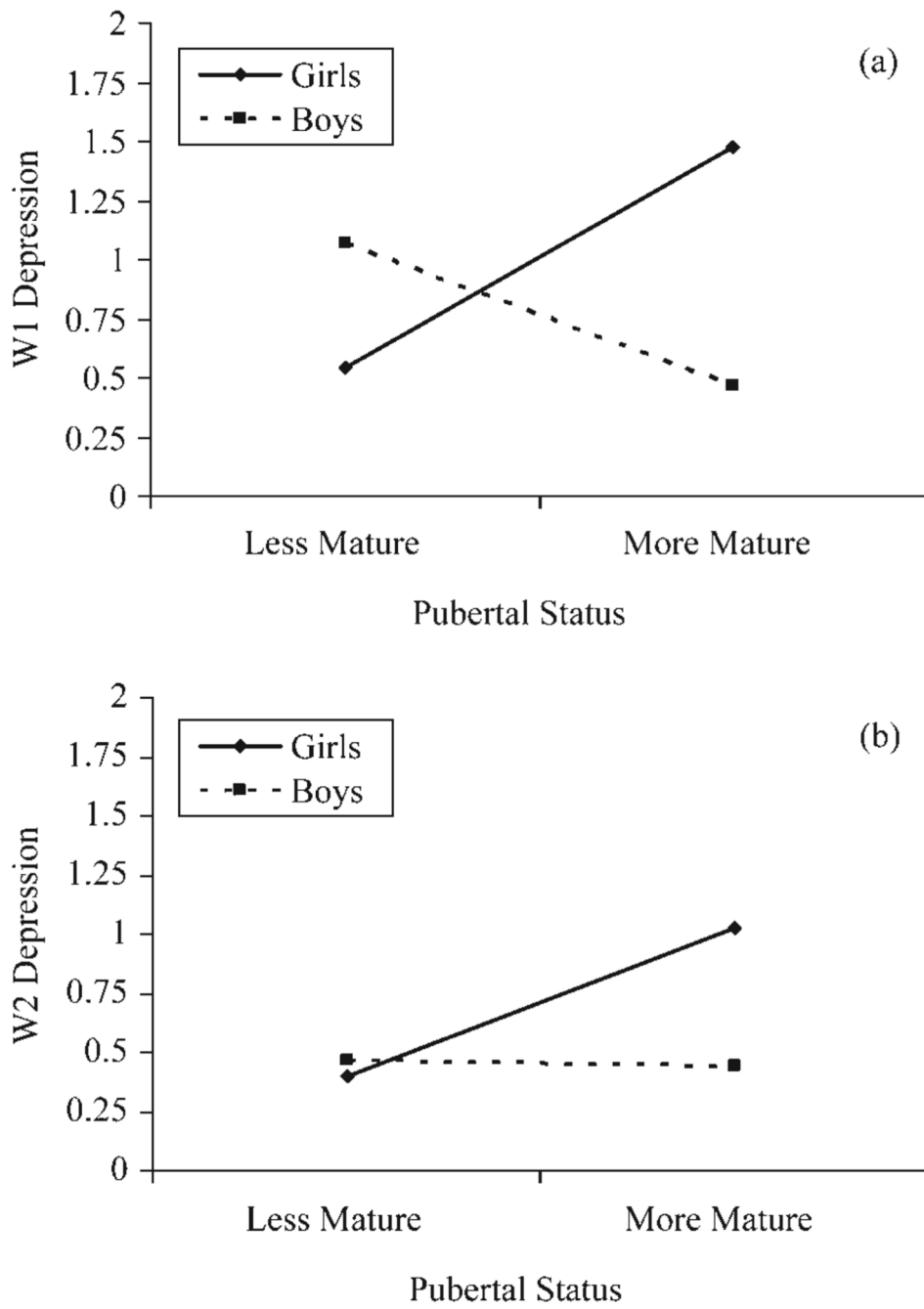


Figure 1. Sex \times Pubertal Status interaction predicting (a) concurrent and (b) longitudinal depression.

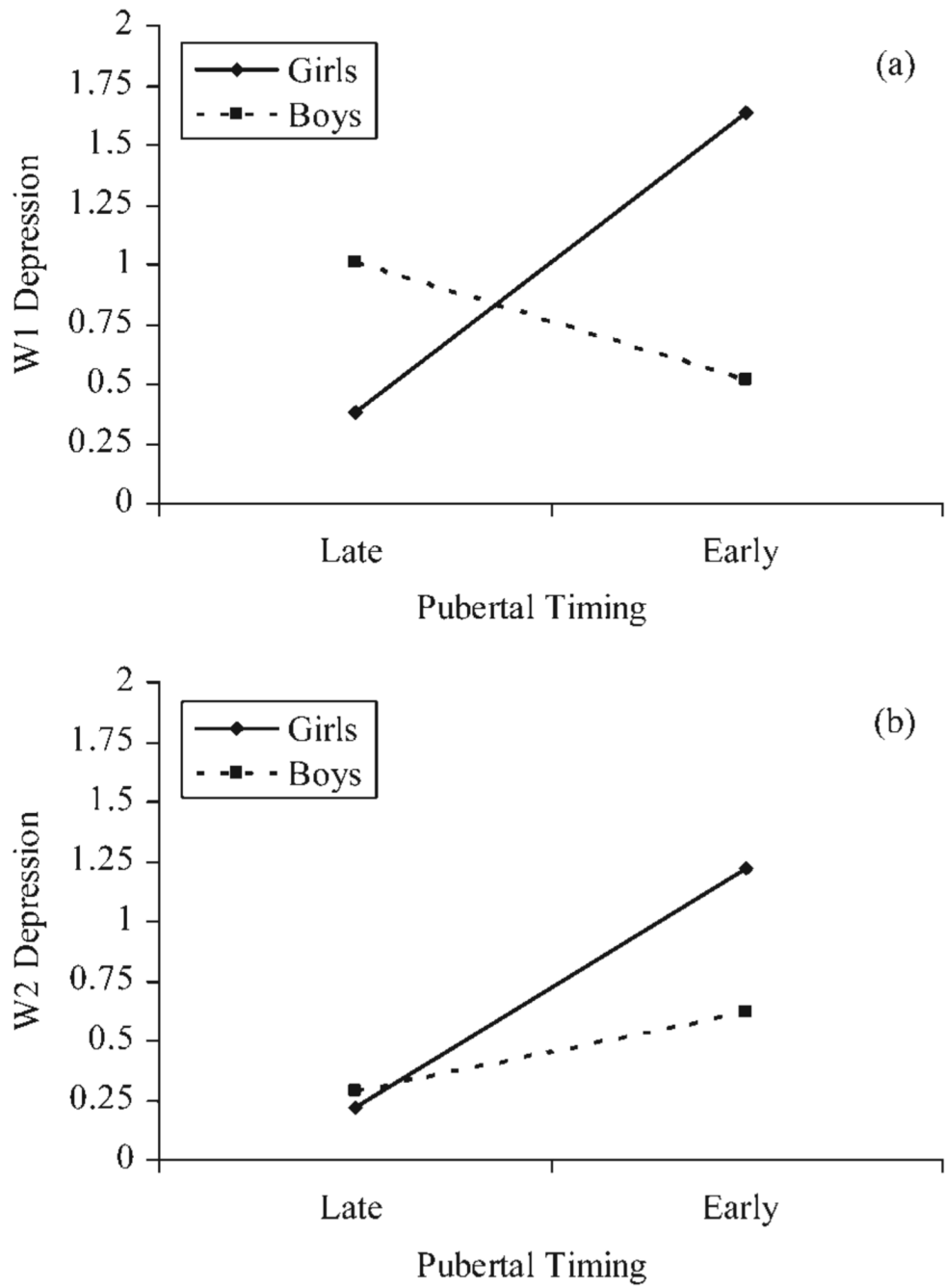


Figure 2. Sex × Pubertal Timing interactions predicting (a) concurrent and (b) longitudinal depression.

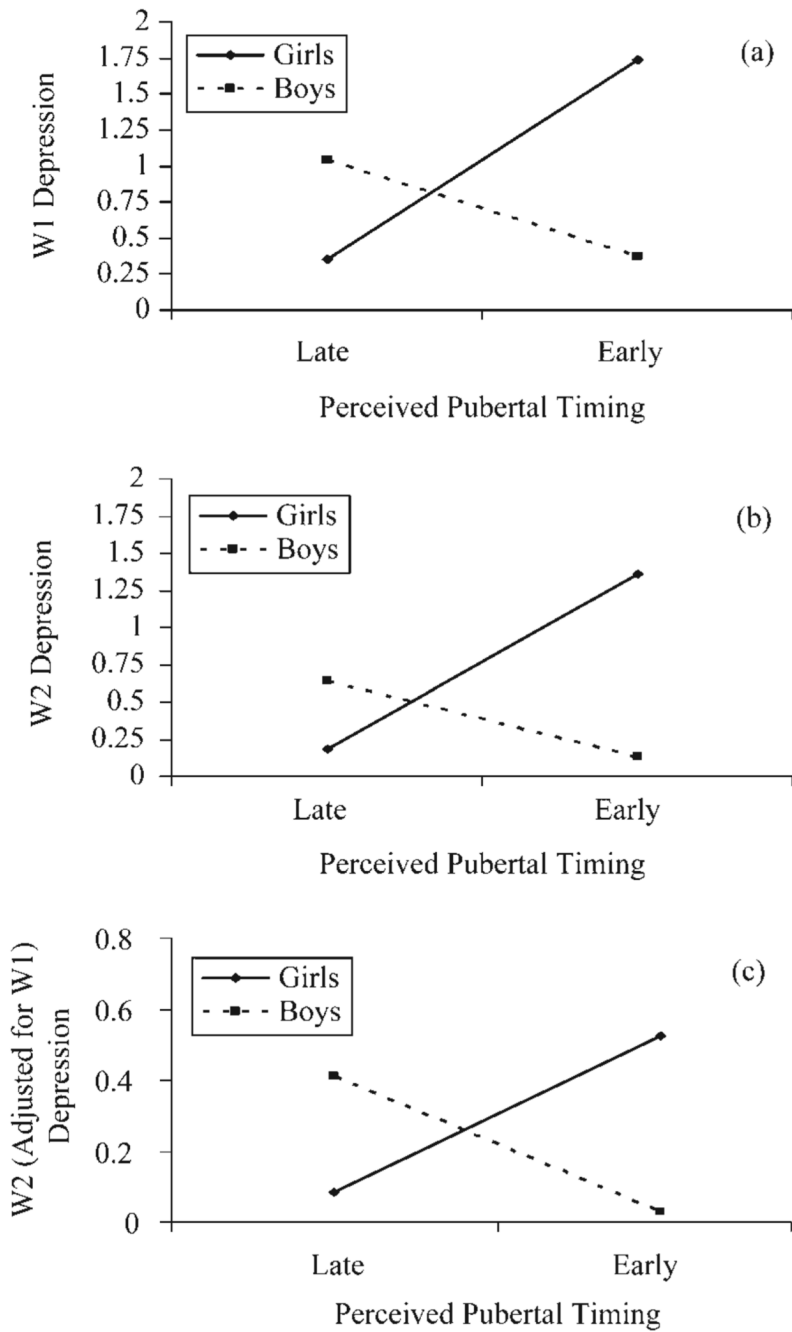


Figure 3. Sex \times Perceived Timing interactions predicting (a) concurrent, (b) longitudinal, and (c) longitudinal-adjusted depression.

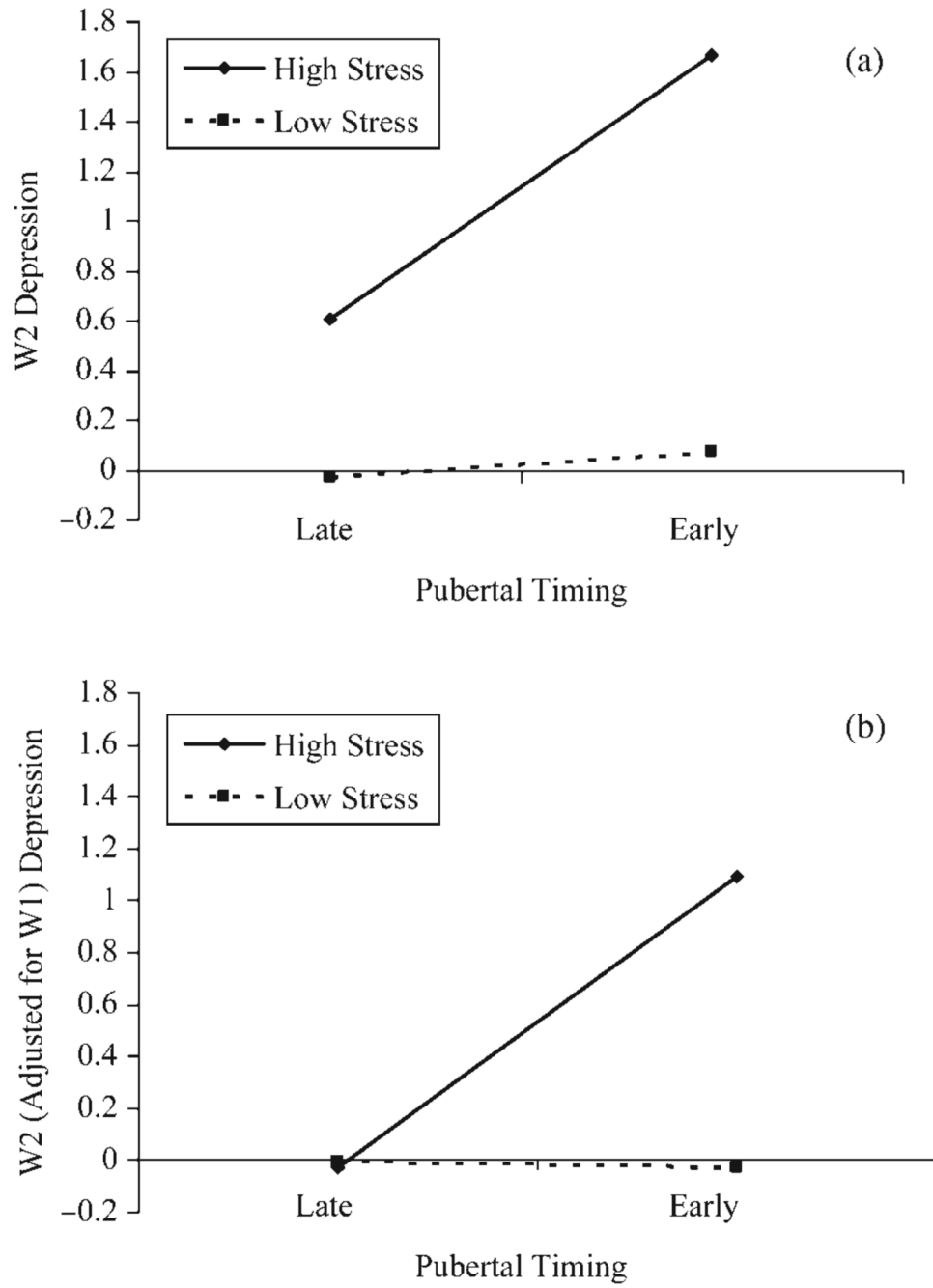


Figure 4. Pubertal Timing×Peer Stress interaction predicting (a) longitudinal and (b) longitudinal-adjusted depression.

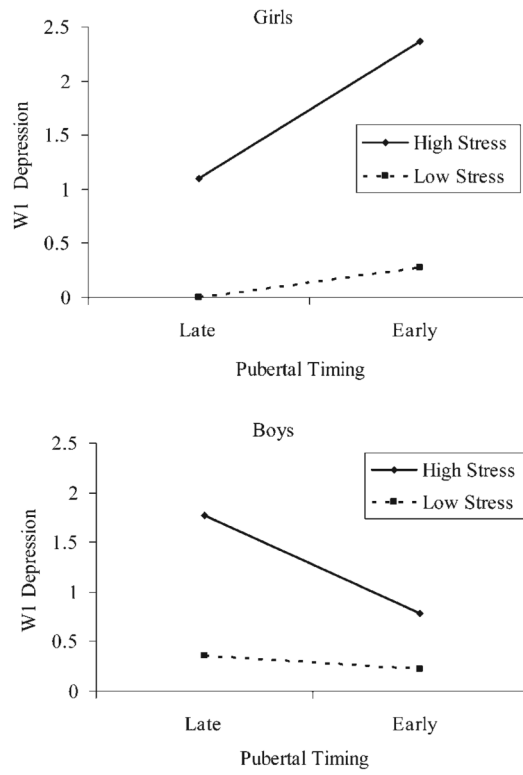


Figure 5. Sex × Pubertal Timing × Peer Stress interaction predicting concurrent depression.

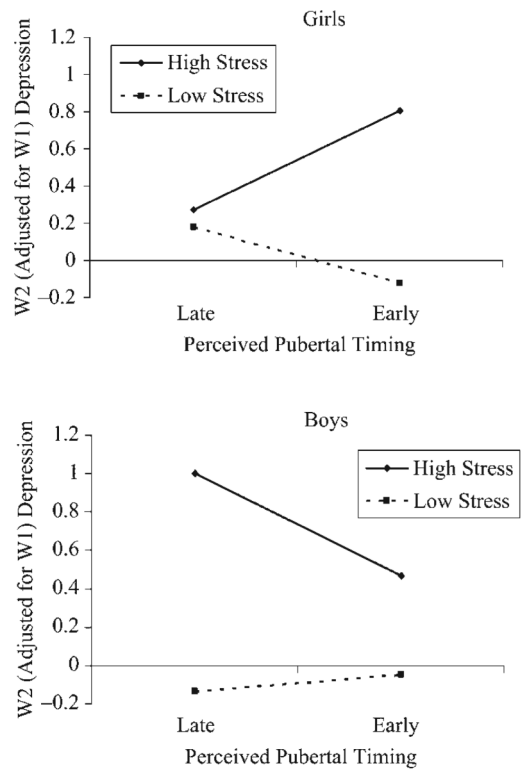


Figure 6. Sex × Perceived Timing × Peer Stress interaction predicting longitudinal-adjusted depression.

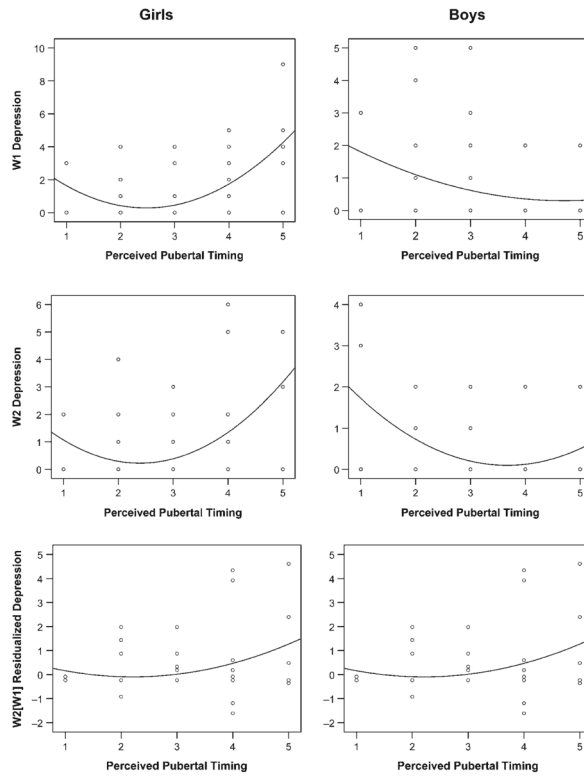


Figure 7. Curvilinear associations between perceived pubertal timing and depression.

Table 1

Descriptive statistics of all variables

	Girls			Boys		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Wave 1						
Age	82	12.37	1.27	76	12.41	1.15
Pubertal status	82	0.01	0.84	76	0.01	0.80
Pubertal timing	82	0.00	0.99	76	0.00	0.99
Perceived timing	66	3.05	0.97	59	3.00	0.93
Chronic peer stress	82	2.29	1.02	76	2.34	0.88
Episodic peer stress	82	3.96	4.10	76	3.64	4.06
Wave 2						
Chronic peer stress	78	2.08	0.89	71	2.23	0.91
Episodic peer stress	78	2.94	2.83	70	2.84	3.30
Depression						
Wave 1	82	1.01	1.84	76	0.76	1.31
Wave 2	78	0.71	1.41	73	0.45	0.91
Wave 2 residualized	78	0.37	1.04	73	0.09	0.94

Note: Wave 1 depression scores are based on the past year and Wave 2 depression scores are based on the past month. Wave 2 residualized depression consists of Wave 2 depression, adjusting for Wave 1 depression (both measures over the past month).

Table 2
Correlations among puberty, peer stress, and depression for girls and boys

	1	2	3	4	5	6	7	8	9	10	11
1. W ₁ age	—	.74 ^{***}	.00	.06	-.10	.04	-.03	.19 [†]	.03	-.02	-.06
2. W ₁ pubertal status	.64 ^{***}	—	.68 ^{***}	.37 ^{***}	.15	.21 [†]	.11	.27 [*]	.25 [*]	.22 [†]	.17
3. W ₁ pubertal timing	.00	.77 ^{***}	—	.50 ^{***}	.34 ^{**}	.28 [*]	.20 [†]	.19	.34 ^{**}	.35 ^{**}	.32 ^{**}
4. W ₁ perceived timing	-.02	.12	.19	—	.20	.31 [*]	.28 [*]	.17	.37 ^{**}	.39 ^{**}	.26 [*]
5. W ₁ chronic peer stress	-.19	-.08	.06	-.04	—	.57 ^{***}	.65 ^{***}	.38 ^{***}	.58 ^{***}	.49 ^{***}	.20 [†]
6. W ₁ episodic peer stress	-.16	-.11	-.01	.15	.48 ^{***}	—	.44 ^{***}	.38 ^{***}	.39 ^{***}	.49 ^{***}	.27 [*]
7. W ₂ chronic peer stress	-.13	-.01	.10	-.25 [†]	.70 ^{***}	.44 ^{***}	—	.53 ^{***}	.52 ^{***}	.58 ^{***}	.44 ^{***}
8. W ₂ episodic peer stress	-.23 [†]	-.23 [†]	-.11	.03	.21 [†]	.35 ^{**}	.44 ^{***}	—	.34 ^{**}	.31 ^{**}	.27 [*]
9. W ₁ depression	-.14	-.23 [*]	-.19	-.26 [*]	.48 ^{***}	.18	.49 ^{***}	.29 [*]	—	.75 ^{***}	.37 ^{***}
10. W ₂ depression	-.24 [*]	-.02	.18	-.30 [*]	.26 [*]	.29 [*]	.59 ^{***}	.40 ^{***}	.42 ^{***}	—	.82 ^{***}
11. W ₂ residualized depression	-.15	.15	.32 ^{**}	-.15	-.14	.09	.18	.20	-.31 ^{**}	.66 ^{***}	—

Note: W₁, Wave 1; W₂, Wave 2. Correlations for girls are above the diagonal, and correlations for boys are below the diagonal. Total numbers (N) range from 66 to 82 for girls and from 56 to 76 for boys, because participants did not complete the perceived pubertal timing rating or did not complete W₂ stress or depression interviews.

[†] $p < .10$.
^{*} $p < .05$.
^{**} $p < .01$.
^{***} $p < .001$.

Table 3
Main effects and interactions among sex, puberty, and peer stress in predicting depression concurrently and longitudinally

	Concurrent Depression			Longitudinal Depression Unadjusted			Longitudinal Depression Adjusted		
	Pubertal Status	Pubertal Timing	Perceived Timing	Pubertal Status	Pubertal Timing	Perceived Timing	Pubertal Status	Pubertal Timing	Perceived Timing
Step 1: main effects	$R^2 = .24$	$R^2 = .24$	$R^2 = .26$	$R^2 = .30$	$R^2 = .34$	$R^2 = .31$	$\Delta R^2 = .09$	$\Delta R^2 = .13$	$\Delta R^2 = .09$
Sex	.07	.07	.09	.12 [†]	.12 [†]	.16*	.11 [†]	.11*	.14*
Puberty	.03	.04	.05	.12 [†]	.24 ^{***}	.10	.11*	.23 ^{***}	.06
Peer Stress	.48 ^{***}	.47 ^{***}	.48 ^{***}	.52 ^{***}	.50 ^{***}	.51 ^{***}	.29 ^{***}	.28 ^{***}	.29 ^{***}
Step 2: two ways	$\Delta R^2 = .04$	$\Delta R^2 = .05$	$\Delta R^2 = .08$	$\Delta R^2 = .01$	$\Delta R^2 = .04$	$\Delta R^2 = .06$	$\Delta R^2 = .01$	$\Delta R^2 = .05$	$\Delta R^2 = .03$
Sex × Puberty	.24*	.26*	.36**	.07	.12	.36**	-.02	.02	.21*
Sex × Stress	.20 [†]	.15	.19	.08	.03	.10	.07	.02	.11
Puberty × Stress	-.01	.04	-.02	.06	.19**	-.06	.07	.23 ^{***}	.05
Step 3: three ways	$\Delta R^2 = .01$	$\Delta R^2 = .02$	$\Delta R^2 = .00$	$\Delta R^2 = .01$	$\Delta R^2 = .00$	$\Delta R^2 = .01$	$\Delta R^2 = .00$	$\Delta R^2 = .00$	$\Delta R^2 = .01$
Sex × Puberty × Stress	.18	.22 [†]	.07	-.16	.05	.14	-.08	.04	.22 [†]

Note: Except where R^2 is indicated, the values are standardized beta coefficients from the step of entry in hierarchical regression analyses.

- [†] $p < .10$.
- * $p < .05$.
- ** $p < .01$.
- *** $p < .001$.

Table 4

Sex × Puberty interactions predicting depression

	Concurrent Depression			Longitudinal Depression Unadjusted			Longitudinal Depression Adjusted		
	Pubertal Status	Pubertal Timing	Perceived Timing	Pubertal Status	Pubertal Timing	Perceived Timing	Pubertal Status	Pubertal Timing	Perceived Timing
Sex	.08	.08	.11	.11	.11	.16 [†]	.11 [†]	.11 [†]	.13 [†]
Maturation	.07	.13	.14	.13	.28 ^{***}	.15 [†]	.12 [†]	.24 ^{***}	.07
Interaction	.35 ^{**}	.39 ^{***}	.47 ^{***}	.20 [†]	.20 [†]	.49 ^{***}	.02	.03	.25 [*]

Note: Values are standardized beta coefficients from the step of entry in hierarchical regression analyses.

[†] $p < .10$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 5
Curvilinear effects of actual and perceived pubertal timing on depression

	Concurrent	Longitudinal	
		Unadjusted	Adjusted
Actual pubertal timing			
Girls	.12	.13	.05
Boys	.18	.18	.09
Perceived pubertal timing			
Girls	.44 ***	.37 **	.12
Boys	.12	.38 **	.34 **

Note: Values are standardized beta coefficients from hierarchical regression analyses.

**
 $p < .01$.

 $p < .001$.