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Associations Between Menarcheal Timing and Behavioral Developmental Trajectories for Girls from Age 6 to Age 15

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Abstract

Substantial evidence from cross-sectional and short time-span longitudinal studies exists about negative associations between early pubertal maturation on a number of psychological outcomes. The objective of the present study was to assess the association between early maturation and developmental trajectories of social skills and internalizing and externalizing problems in girls from grades 1 through 9, including pre- and post-pubertal periods. The sample came from the NICHD Study of Early Child Care and Youth Development and included 398 Caucasian and 60 African American girls. Multilevel modeling revealed early maturing Caucasian girls were at risk for higher internalizing and externalizing problems and experiencing higher levels of problems pre-pubertally. African American youth had lower social skills and internalizing problems with no group differences due to early pubertal development. Findings are discussed in light of literature on continuity of girls' psychosocial development before and during the pubertal transition.

Keywords

Early pubertal timing; Menarche; Developmental trajectories; Social skills; Internalizing problems; Externalizing problems

Introduction

In the past 20 years of research, substantive evidence began to emerge documenting the negative psychological links between early pubertal timing in girls and a number of psychological outcomes including depression and internalizing symptoms, eating disorders, substance use, and delinquency (Mendle et al. 2007). However, questions remain in the

literature, as not all studies find such associations. Possible reasons for differences in findings include variation in how early maturation is defined (timing of secondary sexual characteristics, menarche, or hormonal increases), variation in the cut-off points used to define early maturation (Dorn et al. 2006), and whether studies take into account confounds of early maturation such as ethnicity and social class (Michael and Eccles 2003). In addition, findings are inconsistent regarding associations between pubertal timing and psychological outcomes. Due to differences in samples, researchers find the association between pubertal maturation and psychological outcomes ranging from early adolescence (Brooks-Gunn and Warren 1989; Ge et al. 2006; Warren and Brooks-Gunn 1989), mid-adolescence (Angold et al. 1998; Natsuaki et al. 2009), through young adulthood (Graber et al. 1997; Graber et al. 2004a, b). A question that remains unanswered is whether or not differences in behavior manifest prior to the onset of pubertal maturation.

To address current gaps in the literature, we examined developmental trajectories of social and problem behaviors for early and later maturing girls over a prolonged period from 1st grade until age 15. In order to investigate the association between menarche and social and behavioral problems, we also examined developmental outcomes prior to and following menarcheal onset. Finally, we were interested in possible differences in the associations between pubertal timing and social and problem behavior for groups of Caucasian and African American girls, an area of under-developed research (Ge and Natsuaki 2009), given that racial/ethnic differences in pubertal onset and mean menarcheal age have been previously reported (Biro et al. 2010; Herman-Giddens et al. 1997). To address the aforementioned research questions, a diverse sample of girls from the NICHD Study of Early Child Care and Youth Development (SECCYD) was used. NICHD SECCYD is a comprehensive longitudinal study that followed children from birth through age 15 and has multiple behavioral measures that allow us to extract information for the current study. The period of eight years included in the study contains time when girls are prepubertal (1st grade) in that they are not yet experiencing the hormonal and physical changes of puberty, until the age when almost all girls undergo pubertal changes (9th grade).

Pubertal Timing and Developmental Trajectories

Two studies to date have begun to examine associations between pubertal timing and trajectories of behavior or mood during adolescence. Using the National Longitudinal Study of Adolescent Health to examine trajectories of depressed mood from early adolescence to young adulthood, Natsuaki et al. (2009) found that trajectories of depressed mood from ages 12–23 could be best described as an inverse U-shaped trend, increasing from ages 12–14, reaching its peak between 15 and 16, and then gradually declining thereafter. Being off-time (early or late), compared to on-time development, was significantly associated with increased depressed mood at age 12, with early maturing girls at the highest risk for more depressed mood. However, the results suggested that the longitudinal association between early pubertal timing and depressed mood may gradually and subtly dissipate with age (Natsuaki et al. 2009). Despite the extended age interval, the study by Natsuaki and colleagues could not address the question of when depressive symptoms emerge and whether they precede menarcheal onset.

Another study (Lynne-Landsman et al. 2010) evaluated the moderating influence of trajectories of early childhood household risk on associations between early puberty and 8th-grade substance use in a longitudinal sample of over 1,000 youth of mainly European descent. Findings revealed that early timing was associated with higher rates of substance initiation only among individuals who had a history of high household risk. In the current study, the trajectories were determined for the developmental outcomes of social and problem behaviors.

Associations Between Pubertal Timing and Social and Problem Behavior

Many studies of pubertal timing focus on depression or depressive affect as outcomes, since gender differences in depression emerge between ages 11 and 16, when puberty is occurring for most girls (Brooks-Gunn and Warren 1985; Ge et al. 2001; Nolen-Hoeksema and Girgus 1994). In general, research has found a positive association between early pubertal timing in girls and depressive symptoms (Ge et al. 2006; Ge et al. 1996; Natsuaki et al. 2009; Weichold et al. 2003), however, focusing exclusively on the adolescent period. Early maturers also have been found to experience higher rates of lifetime history of major depressive disorder in young adulthood (Graber et al. 2004a, b). An examination of how both pubertal tempo (rate of interindividual change in parent-reported Tanner stages) and pubertal timing (more advanced Tanner development at an earlier chronological age) predicted depressive symptoms over a 4 year period during early adolescence found that pubertal timing was significantly predictive, while the tempo at which girls progressed through puberty was not significant (Mendle et al. 2010). Early puberty also has been associated with general internalizing symptoms such as psychosomatic complaints (Aro and Taipale 1987) and anxiety during adolescence (Reardon et al. 2009) and young adulthood (Graber et al. 2004a, b). Findings for African American girls have been more mixed with some studies showing significant associations between pubertal timing and internalizing symptoms (e.g., Carter et al. 2009; Ge et al. 2006) and other studies showing no significant links (e.g., Hayward et al. 1999). Clearly, more research is needed to examine associations between pubertal timing and internalizing problems in African American youth and to examine the nature of internalizing problem trajectories before and during the pubertal transition for girls across ethnic groups.

In regards to externalizing problems, many studies have found significant associations between early pubertal timing and delinquent behaviors such as shoplifting, vandalism, and fighting (Caspi and Moffitt 1991; Caspi et al. 1993; Magnusson et al. 1985). In their study of African American children, Ge et al. (2006) found that pubertal status and timing were significantly associated with the externalizing problems of oppositional defiant disorder, attention deficit disorder, and conduct disorder during early adolescence. A study using the NICHD SECC dataset found that early age of menarche in girls predicted greater sexual risk taking (i.e., frequency of sexual behavior) but not other risk taking behaviors such as delinquency and use of alcohol and drugs at age 15 (Belsky et al. 2010).

To our knowledge, no studies have examined associations between menarcheal timing on social skill development. The closest area of research includes studies assessing associations between pubertal development and interpersonal relationships or peer group composition. Graber and colleagues (Graber et al. 2004a, b) found that, among Caucasian females, early maturation compared to on-time maturation was associated with poorer quality relationships with family and friends, as well as having smaller social networks during young adulthood. Early maturers have been found to affiliate more with deviant peers compared with on-time and later maturing adolescents (Ge et al. 1996; Stattin and Magnusson 1990). In regards to interpersonal relationships, earlier maturing depressed youths tend to generate more stress in their social relationships (Rudolph 2008; Rudolph and Flynn 2007). Additionally, peer stress has been shown to moderate sex-differentiated associations between puberty and depression (Conley and Rudolph 2009). Together, these findings suggest that the pubertal transition is a time when girls may experience differing vulnerabilities to peer and social stress. One of the aims of the present study is to assess whether the pubertal transition and timing of puberty are associated with social skill development and internalizing and externalizing problems.

Connections Between Pre- and Post-pubertal Social and Problem Behavior

Few studies include measures of social and problem behaviors both prior to and after puberty. Caspi and Moffitt (1991) found that earlier puberty moderated the link between prior dispositional characteristics and adjustment. In other words, pre-pubertal problems were exacerbated for early developers. In addition, Rudolph and Troop-Gordon (2010) demonstrated that earlier pubertal maturation more strongly predicted subsequent depression in youths with prior depression and other personal risks (Rudolph and Troop-Gordon 2010). A major limitation of these studies was that they assessed behavior during a point when pubertal development was underway and may have already been affecting youths' behavior and mood. Our study further determines what patterns of social behavior and problems look like pre-pubertally (age 6) and during the pubertal transition for early and later developing girls. Earlier studies have not analyzed data by centering on age of menarche and examining time points prior to and after menarche (rather than centering on age). Our study employs a new method to examine questions that have been explored in previous studies of menarche (Brooks-Gunn and Ruble 1982; Koff and Rierdan 1996; Ruble and Brooks-Gunn 1982).

Pubertal Timing and Race/Ethnicity

Although research has established that pubertal timing is associated with a wide range of adolescent behaviors, most of these studies were based on Caucasian middle-class samples (Graber 2003). Pertinent research with more racially and ethnically diverse samples is gradually emerging (Cavanagh 2004; Ge et al. 2001; Hayward et al. 1997; Michael and Eccles 2003; Sarigiani et al. 1993; Siegel et al. 1998). It has been demonstrated that African American females and Latinas have been found to experience menarche earlier than their Caucasian counterparts (The National Heart Lung and Blood Institute Growth and Health Study Research Group 1992; Wu et al. 2002), although some research finds these racial and ethnic group differences are explained by socio-economic status (Obeidallah et al. 2000) or weight-gain indicators (Biro et al. 2010). The definition of *early* puberty may therefore vary by group, given possible differences in timing of menarcheal onset by ethnicity. Current research is also inconclusive about possible behavioral implications of early maturation within African American girls. No studies have explored possible ethnic differences in behavioral trajectories over time.

The Present Study

The purpose of the present study was to investigate associations between early pubertal timing and trajectories of social skills and internalizing and externalizing problems in a longitudinal sample of girls from first grade through mid-adolescence. The main questions addressed in the study are as follows. Do trajectories of social skills and internalizing and externalizing problems differ based on the pubertal timing group? Is there evidence that early maturing girls differ from other girls prepubertally and that social and problem behavior change at the time of and post puberty? Are there any differences in associations between pubertal timing and trajectories of social skills and problems behaviors for Caucasian and African American girls?

Method

The NICHD SECCYD

This study is based on the National Institute of Child Health and Development Study of Early Child Care and Youth Development (NICHD SECCYD). Study families were recruited in 1991 from 24 hospitals across 10 locations in the United States. A total of 8,986 women giving birth and their infants were screened for participation in the study. Families were excluded from participation due to prior criteria such as if the mother did not speak

English, was under 18 years old, had acknowledged substance abuse, or planned to move within 1 year. A total of 5,416 families met eligibility criteria. Study participants were selected from among eligible families based on conditional random sampling to insure that certain demographic criteria were met, such as the sample including at least 10% single-parent households and 10% ethnic minority mothers. Recruitment is described in more detail on the study website (<http://secc.rti.org>).

In total, 1,364 families with healthy newborns were recruited, completed a home interview at 1 month, and entered the study. Demographics for the study sample were similar to the communities from which families with young children were recruited. The total sample included 26% mothers with no more than a high school education at recruitment, 21% with incomes no greater than 200% of the poverty level, and 22% minority (NICHD Early Child Care Research Network 2005; Vandell et al. 2010). NICHD ECCRN (2005) describes the sampling plan in detail.

The analysis sample for the current study included all Caucasian and African American girls who had pubertal data and data on behavioral outcomes at any point in the 1st, 3rd, 4th, 5th, 6th grades and age 15 (grade 9). Hispanic girls were excluded from the present study due to their small sample size. The final sample was comprised of 398 Caucasian and 60 African American girls (75.8 and 69.8% of original sample, respectively), with an equivalent rate of missing data across the two groups ($\chi_1 = 1.13, p = .28$). Due to missing information on menarcheal onset, 127 Caucasian girls and 26 African American girls were excluded from the analysis. On average, non-excluded mothers of Caucasian girls tended to be older (Mean group difference = 1.59, t value = 2.958, $p = .003$) and better educated (Mean group difference = .74, t value = 2.936, $p = .003$). Excluded African American girls had a significantly higher level of income (Mean group difference = 2.638, t value = 2.754, $p = .008$). Hereafter, all statistical summaries are reported for the final sample of 458 girls.

At study enrollment, mothers of Caucasian girls were, on average, 29.51 years old ($SD = 5.1$) and significantly older ($t = 7.08, p < .001$) than mothers of African American girls (mean age = 24.48, $SD = 5.33$). They were also better educated ($t = 5.83, p < .001$), with 14.85 years of schooling on average ($SD = 2.37$) compared to an average of 13 years of education for African American mothers ($SD = 1.75$). Caucasian families had a higher income ($t = 6.36, p < .001$), assessed by the income-to-ratio scale, reporting, on average, the score of 4.37 ($SD = 3.14$) for Caucasian and 1.13 ($SD = 1.49$) for African American families. Finally, 87.2% of Caucasian mothers reported living with a husband or partner at the first grade assessment, while only 39.6% of African American mothers reported the same ($\chi_1 = 66.07, p < .001$). Clearly, two ethnic samples are very different in their demographic standing, which will be accounted for in statistical analyses.

Procedures and Measures

The girls in the current study were followed from first grade (age 6) through age 15. Specifically, girls and their families were assessed at home and in university laboratories when girls were in the 1st, 3rd, 4th, 5th, 6th grades and at age 15 (grade 9). Beginning when they were approximately 9.5 years old, girls received an annual health and physical development assessment from a nurse practitioner or physician and also answered questions about experiencing menarche.

This section focuses on the specific measures used in this study, and their role in the analysis. Additional details about data collection procedures and psychometric properties of the instruments can be found in the study's Manuals of Operation and Instrument Documentation (<http://secc.rti.org>). All parents provided consent and all children provided

assent. This study was approved by the Institutional Review Boards of all institutions involved in the study.

Pubertal Timing—A menarcheal age variable was computed based on the earliest self-report from each girl, from fourth grade annually through age 15, with the understanding that the earliest report would be the most accurate since it is closest to the actual menarcheal event. It has been found that accuracy of recall decreases as time between menarche and recall increases (Coleman and Coleman 2002). In general, excellent correlations have been found between physicians and girls' reports of menarche (Brooks-Gunn et al. 1987). Menarcheal report can also be more reliable than reports of physical characteristics (Herman-Giddens et al. 1997). In a study that evaluated the consistency of girls' categorization of early maturers on the basis of self-report of grade at first menstrual period, considerable stability in categorization was evident (Smolak et al. 2007).

Due to previous studies showing significant differences in menarcheal age between Caucasian and African American girls (e.g., Herman-Giddens et al. 1997), mean menarcheal age was computed separately by group. The mean menarcheal onset for Caucasian girls was 12.5 ($SD = 1.13$) and 11.83 ($SD = 1.09$) for African American girls, which is consistent with national norms (Herman-Giddens et al. 1997). Based on a t-test, the mean age of menarcheal onset for African American girls was significantly lower ($t = 4.3, p < .001$). Early timers were categorized as the earliest 34% of the sample within each ethnic group (or 0.4 of a standard deviation below the mean). The cut-off points for early Caucasian and African American developers were 12.0 years and 11.4 years, respectively. As a result, early menarche groups were comprised of 144 Caucasian and 20 African American girls. Other studies have also defined early pubertal timing as the earliest third of the sample (i.e., Ge et al. 2001). In the present study, we aimed to ensure a reasonable sample size for early-maturing African American girls. A more stringent cutoff for early timing would have been detrimental for power of the analysis.

Child Social Skills—Mothers reported on their children's social skills with the use of the Social Skills Rating System (SSRS) Parent Form (Gresham and Elliott 1990). The Social Skills scale identifies positive social behaviors, grouped under four sub-scales: Cooperation, Assertion, Responsibility, and Self-Control. Items are rated for frequency (0 = never, 1 = sometimes, 3 = very often) and importance. Standard SSRS scores were computed, which relate the extent to which a student's raw score exceeds or falls below the mean score of similar students with whom the instrument was standardized ($mean = 100, SD = 15$). For this sample, the items used to create the total standardized social skills score have high internal reliability (40 items, Cronbach's alphas range from 0.88 to 0.91 across time points).

We considered other indicators of social skills development in children, including teacher reports and self-report. However, those assessments were not available for all six time points, thus making it impossible to focus on temporal development pre- and post-puberty.

Child Internalizing Problems—Mothers reported on their children's internalizing problems with the use of the Child Behavior Checklist (CBCL/4–18) Parent form (Achenbach 1991). For each item, the parent was asked to rate how well the item describes the child currently or within the last 6 months: on a 3-point scale (0 = *not* true, 1 = *somewhat or sometimes* true, 2 = *very often or often* true). Normalized T-scores in the possible range of 31–100 are used in analyses. The T-score consists of information from the syndrome scales designated as Withdrawn, Somatic Complaints, and Anxious/Depressed. Internal reliability for the scale is high (31 items, Cronbach's alphas range from 0.85 to 0.87 across time points). Similarly to social skills, maternal-report of child externalizing problems was the only measure present at six times.

Child Externalizing Problems—Mothers also reported on their children's externalizing problems with use of the CBCL. For each item, the parent is asked to rate how well the item describes the child currently or within the last 6 months: on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *very often or often true*). Normalized T-scores in the possible range of 30–100 are used in analyses. The T-score consists of information from the syndrome scales designated as Delinquent Behavior and Aggressive Behavior. Internal reliability for the scale is high (33 items, Cronbach's alphas range from 0.89 to 0.91 across time points). Other measures of externalizing problems, assessed longitudinally, were unavailable.

Analytic Plan

To evaluate developmental trajectories of social skills, internalizing and externalizing behavioral problems for two ethnic groups of early and non-early menarche onset girls, we employed multilevel modeling (MLM; Laird and Ware 1982; Pinheiro and Bates 2000; Raudenbush and Bryk 2002; Singer and Willett 2003). In recent years, MLM became a standard approach for modeling longitudinal data due to its capacity to address questions of mean trajectories for observed groups (i.e. menarche and ethnic groups) as well as the extent of inter-individual variability. Additionally, the method accounts for non-balanced study design (Laird 1988; Philipson et al. 2008), such as the NICHD SECCYD sample, with observational points being non-equally spaced (i.e., a two-year interval between grades 1 and 3, a one-year interval between grades 3 through 6, and a four-year interval between grades 6 and age 15) and children dropping out of the study at various grade levels (only 375 girls, 81.9% of the sample, had complete data for all 6 time points).

Assuming a quadratic developmental trajectory, the model can be summarized in the following way:

$$Y_{it} = \beta_{00} + \beta_{10} * Grade + \beta_{20} * Grade^2 + u_{0i} + u_{1i} * Grade + \varepsilon_{it},$$

where the trajectory of interest, Y_{it} (i.e., social skills, internalizing and externalizing problems) is modeled from the initial level of the outcome, intercept β_{00} , and linear and quadratic slopes, β_{10} and β_{20} , respectively. These parameters are commonly referred to as fixed effects as they represent group means. Random intercept, u_{0i} , and slope, u_{1i} , effects correspond to individual deviations in model parameters from the group means for every study participant. These random effects are explicitly estimated by the model as variances, τ_0 and τ_1 with means of zero. Variance of the residual term ε_{it} is also estimated as σ^2 .

The focus of this paper is on trajectories of observed subgroups (i.e. Caucasian and African American and early and non-early menarcheal onset), which expands the model to accommodate group-specific trajectory parameters:

$$Y_{it} = \beta_{00} + \beta_{01} * AA + \beta_{02} * EarlyMen + \beta_{03} * AA * EarlyMen + \quad (1)$$

$$\beta_{10} * Grade + \beta_{11} * Grade * AA + \beta_{12} * Grade * EarlyMen + \beta_{13} * Grade * AA * EarlyMen + \quad (2)$$

$$\beta_{20} * Grade^2 + \beta_{21} * Grade^2 * AA + \beta_{22} * Grade^2 * EarlyMen + \beta_{23} * Grade^2 * AA * EarlyMen + \quad (3)$$

$$u_{0i} + u_{1i} * Grade + \varepsilon_{it}. \quad (4)$$

In the above equation, AA represents the African American subgroup and *EarlyMen* the early menarche subgroup, both coded as dummy variables. The specified model is straightforward when broken down into four components. Part 1 of the model estimates four intercept parameters, representing developmental levels at age 15 for four subgroups of girls (Caucasian and African American early and non-early menarche onset girls). Parts 2 and 3 yield estimates of group-specific linear and quadratic slopes, respectively. Random effects

(Part 4) are estimated of inter-individual variability in development. Four baseline demographic covariates (mother's age and education, family structure and SES) are also entered in the model to control for family differences. All covariates were centered: mothers' age at 28 years, mothers' education at 12 years, and SES at 4 levels. The grade variable was centered at grade 9 (age 15), such that grade 9 corresponded to the value of 0, grade 6 to the value of -3 and so on. A hierarchical backward elimination technique was used to arrive at the final model that included only significant predictors at the alpha level of .1. A liberal type-I error rate was selected due to the exploratory nature of the analysis and the small sample size for early menarche African American girls ($n = 20$). Maximum Likelihood (ML) estimates of model parameters were computed.

To address the second research question, testing a possible shift in development associated with menarcheal onset, a piecewise MLM was applied. A piecewise model allows slopes to vary across different ranges of time values. Interested in the shift associated with menarcheal onset, we estimated slopes for the periods prior to and following the onset. Because of the focus on the shift associated with menarcheal development, time was centered around the age of menarche onset, with zero values representing the onset, negative values representing age prior to onset, and positive values representing age post onset.

The following model was fit to three developmental outcomes:

$$Y_{it} = \beta_{00} + \beta_{01} * AA + \beta_{02} * EarlyMen + \beta_{03} * AA * EarlyMen + \quad (5)$$

$$\beta_{10} * AgeC + \beta_{11} * AgeC * AA + \beta_{12} * AgeC * EarlyMen + \beta_{13} * AgeC * AA * EarlyMen + \quad (6)$$

$$\beta_{20} * AgeC * MenInd + \beta_{21} * AgeC * MenInd * AA + \beta_{22} * AgeC * MenInd * EarlyMen + \quad (7)$$

$$\beta_{23} * AgeC * MenInd * AA * EarlyMen + \quad (8)$$

$$u_{0i} + u_{1i} * Grade + \epsilon_{it}$$

Due to centering, intercept parameters (Part 5) represent levels of the outcome variables for each subgroup at the time of menarche onset. Linear slopes (Part 6) are group-specific developmental paths prior to onset. Changes in slope values in each of the groups are modeled in Part 7, where *MenInd* is an indicator variable, with 0 s indicating measurements prior to menarche onset and 1 s after the onset. Part 8 represents the random variation in intercept and linear slope parameters across individuals. All data analyses were carried out in the open-source statistical package R v.2.11.0 (R Development Core Team 2010).

Results

Developmental Trajectories Across Grades 1 Through 9

Results of three multi-level models assessing developmental patterns across grades 1 through 9 for early and non-early girls of two racial groups are provided in Table 1. Corresponding graphical summaries are presented in Fig. 1. According to the model for social skills as the outcome variable, after controlling for the effects of baseline covariates, at age 15, Caucasian early and non-early girls had comparable levels of social skills (103 points). In comparison, African American girls had social skills about 10 points lower ($p < .001$). For the entire sample, there was an increase in social skills during late childhood (grades 3 through 6), followed by a decrease by age 15. For Caucasian early developers, the developmental trajectory was much shallower in comparison with the rest of the sample (see Panel A of Fig. 1). Developmental patterns of early and non-early African American girls were similar, represented by a single solid black line in Fig. 1 (Panel A).

Internalizing problems appeared to be a relatively stable construct. For a majority of the sample (African American early and non-early and Caucasian non-early girls), the level of internalizing problems was constant over time. For Caucasian non-early developers, the level of internalizing problems was estimated to be about 46.5 across all school years.

Internalizing problems of African American girls were lower: a marginal difference of 2.5 points ($p = .076$). Early menarche appeared to have a marginally significant effect on Caucasian girls, who exhibited almost 2-point higher levels of internalizing problems at age 15 and had a curvilinear development over time, with an increased level of internalizing problems at grades 5 and 6. Figure 1 (Panel B) presents graphical summaries of each group with a single line depicting internalizing problems of African American girls due to no between-group differences due to menarcheal onset.

For externalizing problems, the entire sample exhibited a homogenous developmental pattern with no between-group differences due to ethnicity or menarcheal onset (see a single line in Fig. 1 Panel C). A gradual decrease in externalizing problems was observed over time, with girls reaching the level of 47 points by age 15. For all aforementioned models, there was a significant inter-individual variability in intercept and slope model parameters, judging from estimated random effects (Table 1).

Changes in Developmental Trajectories Associated with Menarcheal Onset

Results of the piecewise MLM, testing change before and after menarche, are summarized in Table 2. Due to alignment according to physiological development, girls at the same menarcheal stage could be of different grade levels, which is important to remember for interpretational purposes. Social skills appeared to be relatively stable prior to menarcheal onset for the entire sample of girls. However, mothers of African American girls reported lower skills by about 9 points, on average ($p < .001$), compared to about 106 points for Caucasian girls (see Panel A in Fig. 2). After menarcheal onset, all girls exhibited decline in their social skills, with the linear slope of -1.15 ($p < .001$). No differences in social skills were detected between the early and non-early menarcheal groups (thus, a single grey line represents a developmental trajectory for Caucasian girls and a single black line for African American girls in Panel A of Fig. 2).

For internalizing problems, all girls exhibited a gradual linear decline across the entire developmental period (the slope of $-.11$; $p < .05$), with no change in developmental patterns following menarcheal onset. Between-group differences were detected, such that African American girls had the lowest level of internalizing problems ($p < .1$), followed by Caucasian non-early girls and Caucasian early developers ($p < .01$). All developmental trajectories are summarized in Panel B of Fig. 1, with a single black line representing both early and non-early African American groups, due to the lack of developmental differences between them.

Finally, for externalizing problems, all girls demonstrated a linear decrease in problems prior to menarche onset (slope of $-.41$, $p < .001$), followed by a change in slope to positive ($-.41 + .74 = .33$, $p < .001$) after menarche onset (see Panel C of Fig. 2). Early Caucasian girls had higher levels (by about 2 points, $p < .05$) of externalizing problems overall, compared to the rest of the sample.

Discussion

In the literature, multiple lines of evidence point to mainly negative associations between early pubertal timing and social and problem behavior in girls. However, most studies are limited to homogenous samples of Caucasian youth and a short developmental span of social and behavioral outcomes. Thus, research is unclear about the continuity of social and problem behavior across the prepubertal and pubertal years of development, as well as associations between pubertal maturation and behavior in African American youth. The present study was the first to examine associations between timing of menarcheal onset and developmental trajectories of girls from first grade through age 15—a broad period that

spans across prepubertal and pubertal years of development. Study objectives were to determine if the trajectories of social skills and internalizing and externalizing problems differed for early and later-maturing girls, if early maturing girls differed from other girls prepubertally and if social and problem behaviors changed at the time of and post menarche, and if the associations differed between early pubertal timing and developmental trajectories for Caucasian and African American girls. Since race is embedded in analyses of the first two questions, differences and similarities in the associations between early pubertal timing and social and problem behavior for Caucasian and African American girls are discussed in context of findings for the first two objectives. Implications of findings from the current study are described in our conclusion.

Development of Social Skills

To our knowledge, measures of social skills have generally not been included in studies of pubertal maturation and development, and this is the first study to examine the association between puberty and trajectories of social skills. Based on the results of MLM, the entire sample showed an increase in social skills during late childhood, followed by a decrease by age 15. This finding of mothers' reporting their daughters being less cooperative and pro-social across the pubertal transition is consistent with other studies demonstrating an increased level of parent-child conflict during this time period (Laursen et al. 1998; Steinberg 1987; Steinberg 1989). Further, Caucasian early developing girls had a shallower trajectory compared with non-early girls, with mothers reporting slightly lower social skills for early maturer during the early adolescent years. Mothers of African American girls (early and non-early) reported lower social skills overall compared with Caucasian girls. In a psychometric study involving factor structure analysis of the Social Skills Rating System, results were invariant for White and non-White groups (Walthall et al. 2005). However, this study was based on teacher-report forms and the present study includes maternal-report assessments. More psychometric research is needed to determine whether maternal perceptions of girls' social skills differ by race/ethnicity.

The piecewise multilevel analysis was used to test the association between menarcheal status and girls' trajectories, irrespective of grade in school. Findings from these models provide insight into how girls' trajectories change at the time of menarche, an event that occurs towards the end of the stages of pubertal maturation. Menarche was associated with a change in trajectories for social skill development: post-menarche, irrespective of the age at which it occurs, mothers reported a decrease in social skills for both Caucasian and African American girls. This significant association between menarcheal status and social skill trajectories is a novel finding and parallels our finding for change in externalizing problems before and after menarche (described below).

Trajectories of Internalizing Problems

Based on the results of MLM, the association between early maturation and internalizing problems was evident for Caucasian girls only. Early Caucasian developers demonstrated a distinctive curvilinear trajectory with an increased level of internalizing problems during the early adolescent years and a marginally higher level of internalizing problems at age 15, compared to Caucasian non-early girls. In addition, no effect of time was found for Caucasian non-early girls, who showed a constant level of internalizing problems across the entire observational period. The finding of the effect of early menarcheal onset on the overall level of internalizing problems resonates with findings in previous studies demonstrating adverse associations between early timing and depressive symptoms and internalizing problems in predominantly Caucasian samples (Ge et al. 2001; Graber et al. 1997; Graber et al. 2004a, b; Hayward et al. 1997; Kaltiala-Heino et al. 2003; Natsuaki et al. 2009; Weichold et al. 2003). This is the first study, however, to demonstrate that

developmental trajectories of internalizing problems also differ across the early and later-maturing groups of Caucasian girls.

Interestingly, we did not find an effect of early maturation on internalizing problem trajectories for African American girls. This finding is consistent with earlier evidence of the lack of associations between pubertal timing and primary caregivers' reports of internalizing symptoms (Ge et al. 2006) and levels of depressive symptoms for African American girls (Hayward et al. 1999). The current study is the first to demonstrate that African American girls tend to have lower levels of internalizing problems across the developmental span of grades 1–9, compared to Caucasian counterparts. In addition, the developmental pattern is flat and comparable to that of non-early Caucasian girls.

The association between menarcheal status and internalizing trajectories was not significant in the piecewise MLM. The trajectory pattern across groups was a slight linear decline from pre- to post-menarche. However, early maturing Caucasian girls showed higher overall levels of internalizing problems, indicating that these girls were more likely to experience higher internalizing problems than other girls prior to menarche, at an earlier stage of pubertal maturation. At the time that the early maturing girls are experiencing menarche, the majority of other girls are going through the pubertal transition, though they are not as advanced as early girls. Therefore, for early girls, it is likely the onset of puberty, rather than menarche itself, that is linked with their internalizing problems. Finding from the first set of trajectory models by grade would support this conclusion, since the early maturing Caucasian girls had an increase in internalizing problems from the 1st through 6th grades.

Trajectories of Externalizing Problems

For the developmental trajectory of externalizing problems, the analysis demonstrated a comparable path for the entire sample of girls: higher levels of externalizing problems were observed in the beginning of the study at grade 1, with a concaving downward trajectory over time, leading to decreased externalizing problems by age 15. Previous literature also describes major patterns of externalizing behavior as decreasing (Reef et al. 2010) from 4 to 18 years. The current study found that this pattern can be generalized to early and non-early developers for both Caucasian and African American groups. This finding is in contrast with a number of studies that report an association between pubertal timing and externalizing symptoms such as delinquent behaviors and alcohol use in African American (Ge et al. 2006) and Caucasian youth (Caspi and Moffitt 1991; Caspi et al. 1993; Magnusson et al. 1985; Costello et al. 2007). Another longitudinal study of the NICHD SECCYD dataset found early maturing girls exhibiting higher sexual risk taking at age 15, but no differences in delinquent behavior and alcohol and substance use (Belsky et al. 2010).

Post-menarche, mothers reported a decrease in girls' externalizing problems. Since the present study is the first one to examine links between pubertal maturation and trajectories of externalizing problems, our results cannot be directly compared to results from other studies, but there are consistencies in findings. In large scale psychiatric epidemiological studies, both pubertal status and timing have been associated in the development of both externalizing and internalizing problems (Angold et al. 1998; Graber et al. 1997; Graber et al. 2004a, b).

Similarities and Differences Between Caucasian and African American Groups

We examined potential differences and similarities in associations between pubertal timing and trajectories of social skills and problems behaviors for Caucasian and African American girls. Results from the trajectory analyses reveal that associations between early pubertal timing and social and problem behaviors were evident for Caucasian girls only. This finding

is consistent with some findings (Carter et al. 2009; Hayward et al. 1999) but inconsistent with other research using cross-sectional designs (e.g., Ge et al. 2006). Further research, both quantitative and qualitative, is needed to explore potential protective mechanisms for African American girls. In examining the models showing trajectories pre- and post-menarche, significant associations between menarcheal status and social skills and externalizing problems were found for African American girls as well as Caucasian girls. Additionally, for internalizing problems, African American and Caucasian girls had the same developmental pattern pre- and post- puberty (slight decline in problems). A finding that needs to be explored further is that mothers of African American girls reported lower social skills across the developmental period studied compared with mothers of Caucasian girls.

Limitations and Future Directions

Despite important contributions of the current study, a number of limitations need to be noted. We employed a large representative longitudinal sample of adolescent girls that were followed for the period of 9 years. A strength of the present study was that longitudinal reports of child social and problem behavior were previously not available with these age groups in studies of pubertal maturation. However, current findings are based on maternal reports of their children's development due to lack of longitudinal measures from teachers and children themselves. Future studies should examine longitudinal trajectories from multiple measures. A drawback to using only maternal report is that parents may not be as aware of the child's behavior and social skills in peer contexts during adolescence and of the child's internal emotional states. In addition, girls involved in more norm-violating activities may be apt to share less with their parents.

This is the first study to address longitudinal trajectories of development for African American girls. While the diverse sample allowed us to make important between-group comparisons, possible lack of differences between early and non-early African American girls can be attributed to a relatively small sample of early-maturing girls ($n = 20$). Future studies should continue exploring this important line of research by studying possible racial and ethnic between-group differences in a diverse sample of girls.

Data for the current study came from the NICHD SECCYD sample. By design, children were not assessed every year, with a gap of 1 year between grades 1 and 3 and a gap of 3 years between grades 6 and 9. The second three-year gap occurs during a developmental period where flux in social and problem behavior may occur. While we were able to account for data limitations analytically by employing MLM, statistical extrapolations cannot substitute real measurements in this crucial developmental period. Future research would benefit from longitudinal designs including annual social and problem behavior assessments pre-pubertally through adolescence.

The current study expanded the lower boundaries of developmental patterns by including first grade girls in the trajectory analysis. Beginning a study of pubertal maturation at this earlier age addressed a critical need in the literature (Susman and Dorn 2009). However, the upper bound of development in our study was limited to age 15. This time interval was ideal for examining behavioral problems for early-maturing girls during early to mid-adolescence. However, it limited the sample to girls who experienced menarche by age 15; thus, late maturers are under-represented in the current sample and should be further studied. Although research has examined associations between pubertal timing and depressed mood through young adulthood (e.g., Natsuaki et al. 2009), more research is needed on examining trajectories of a broader set of developmental outcomes beyond adolescence. Our study was the first to include trajectories of social skill development and we did find differences in maternal-report of social skills between Caucasian and African American girls. A

recommendation is for future work with diverse samples to include social skills as outcomes in addition to more traditionally investigated internalizing and externalizing problems.

Conclusion

In this study, we addressed a need for a longer-term perspective on associations between pubertal maturation and psychosocial development. Specifically, we tested associations between pubertal maturation (early timing, menarcheal status) and trajectories of social and problem behavior in Caucasian and African American girls across the 9 year period from first grade through age 15. Ours is the first trajectories study that covered this age span and that examined conditioned trajectories based on menarcheal onset. Current results shed light on whether associations between puberty and psychosocial outcomes demonstrate continuity from earlier phases of development. In particular, consistent with previous findings, early maturing Caucasian girls appear most at risk for internalizing and externalizing problems. A new finding in the present study is that the higher levels of problems in these girls were evident pre-pubertally. The results also suggest a number of novel research directions such as including social skill development in work with diverse samples. In regards to implications for prevention and intervention, our results support the suggestions outlined by Susman and Dorn (2009). Schools should include more innovative educational programs on the role of puberty in the health and development of adolescents at an earlier point in time and also implement earlier health promotion and disease prevention efforts focused on enhancing the development of coping and social skills during the pubertal transition. The finding that early maturing Caucasian girls showed higher levels of internalizing problems pre-pubertally speaks to the need to continue research regarding potential contextual factors, such as poor relationships within the home, that could contribute to the higher levels of pre-pubertal problems and earlier menarche.

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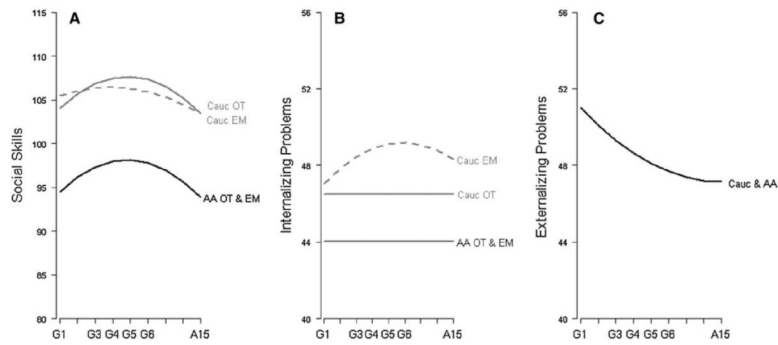


Fig. 1. Estimated development patterns of social skills, internalizing and externalizing problems based on multilevel modeling for Caucasian (*grey*) and African American (*black*) girls with early (*dashed*) and on-time (*solid*) menarche onset

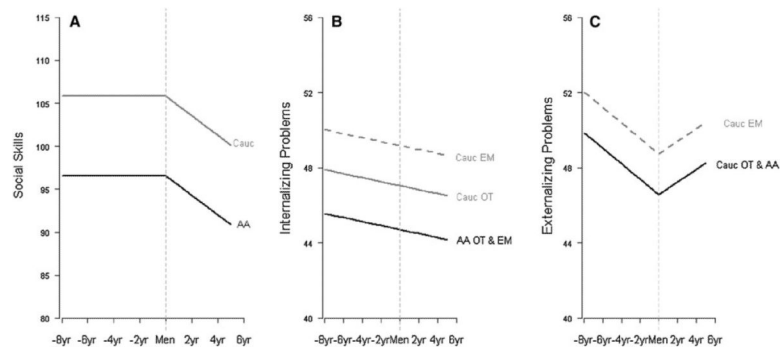


Fig. 2. Estimated pre- and post-menarcheal development patterns of social skills, internalizing and externalizing problems based on the piecewise multilevel modeling AA African American, *Cauc* Caucasian, *OT* on time/non-early menarche, *EM* early menarche

Table 1

Parameter estimates from three multi-level models assessing developmental trajectories from grade 1 to Age 15

Model parameters	Beta coefficient	SD	p-value
Model for social skills			
Intercept	103.04	2.0	<.001
Grade	-2.04	.28	<.001
Grade^2	-.25	.03	<.001
Menarche.Early	-0.92	1.64	.577
African American	-9.56	2.26	<.001
Grade* Menarche.Early	.88	.47	.059
Grade^2* Menarche.Early	.13	.05	.012
Mom's age	-.13	.14	.341
Mom's education	.98	.34	.004
SES	.48	.24	.059
Living with partner	-1.0	1.83	.586
Random effects: $\tau_0 = 13.02$ [95% CI: 11.89;14.28]; $\tau_1 = 1.42$ [1.23; 1.64]; $\sigma^2 = 8.49$ [8.19; 8.79]			
Model for internalizing problems			
Intercept	46.48	1.23	<.001
Grade	-.25	.17	.139
Grade^2	-.01	.02	.646
African American	-2.47	1.39	.076
Menarche.Early	1.84	1.03	.074
Grade* Menarche.Early	-.55	.29	.052
Grade^2* Menarche.Early	-.09	.03	.007
Mom's age	-.18	.09	.038
Mom's education	-.03	.21	.868
SES	.25	.15	.092
Living with partner	.87	1.13	.44
Random effects: $\tau_0 = 8.19$ [7.49; 8.97]; $\tau_1 = .69$ [.57; .84]; $\sigma^2 = 5.32$ [5.14; 5.51]			
Model for externalizing problems			
Intercept	47.14	1.15	<.001
Grade	.11	.12	.374
Grade^2	.06	.01	<.001
Mom's Age	-.20	.09	.027
Mom's education	-.50	.22	.022
SES	-.36	.16	.024
Living with partner	.52	1.15	.650
Random effects: $\tau_0 = 9.57$ [8.84; 10.36]; $\tau_1 = .79$ [.68; .91]; σ^2			

Table 2

Parameter estimates from three piecewise multi-level models assessing the shift in developmental associated with menarche onset

Model parameters	Beta coefficient	SD	<i>p</i> -value
Model for social skills			
Intercept	105.84	1.87	<.001
AgeC	.01	.10	.925
AgeC*MenInd	-1.15	.34	<.001
African American	-9.25	2.26	<.001
Mom's age	-0.13	.14	.354
Mom's education	1.0	.34	.003
SES	.51	.24	.035
Living with partner	-1.08	1.84	.556
Random effects: $\tau_0 = 12.13$ [95% CI: 11.20; 13.14]; $\tau_1 = 1.31$ [1.14; 1.52]; $\sigma^2 = 8.62$ [8.32; 8.93]			
Model for internalizing problems			
Intercept	47.05	1.18	<.001
AgeC	-0.11	.05	.041
Menarche.Early	2.13	.82	.009
African american	-2.33	1.38	.093
Mom's age	-.18	.09	.041
Mom's education	-.04	.21	.857
SES	-.25	.15	.090
Living with partner	.87	1.12	.438
Random effects: $\tau_0 = 7.55$ [6.98; 8.17]; $\tau_1 = .64$ [.53; .78]; $\sigma^2 = 5.33$ [5.15; 5.52]			
Model for externalizing problems			
Intercept	46.58	1.22	<.001
AgeC	-.41	.06	<.001
AgeC*MenInd	.74	.19	<.001
Menarche.Early	2.16	.94	.022
Mom's age	-.17	.10	.078
Mom's education	-.43	.24	.071
SES	-.43	.17	.011
Living with partner	.20	1.22	.870
Random effects: $\tau_0 = 8.87$ [8.23; 9.56]; $\tau_1 = .72$ [.62; .83]; $\sigma^2 = 4.84$ [4.67; 5.01]			