Pubertal Timing and Adolescent Sexual Behavior in Girls

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Girls who experience earlier pubertal timing relative to peers also exhibit earlier timing of sexual intercourse and more unstable sexual relationships. Although pubertal development initiates feelings of physical desire, the transition into romantic and sexual relationships involves complex biological and social processes contributing both to physical maturation and to individual interpretations of pubertal experiences. Using a sample of female sibling pairs ($n = 923$ pairs) from the National Longitudinal Study of Adolescent Health, the present study investigated associations among menarche and perceived pubertal timing, age of first sexual intercourse (AFI), and adolescent dating and sexual behavior using a behavioral genetic approach. Genetic factors influencing age at menarche and perceived pubertal timing predicted AFI through shared genetic pathways, whereas genetic factors related only to perceived pubertal timing predicted engagement in dating, romantic sex, and nonromantic sex in the previous 18 months. These results suggest that a girl's interpretation of her pubertal timing beyond objective timing is important to consider for the timing and the contexts of romantic and reproductive behavior.

Keywords: adolescence, sexual behavior, romantic relationships, perceived pubertal timing

The onset of romantic relationships and sexual behavior in adolescent girls is rooted in the physical changes of puberty. The initiation of dating and sexual behavior is influenced not only by the biological changes of puberty but also by individual-level interpretations of pubertal changes (Brooks-Gunn, 1984). The biological onset of puberty and the psychological views of and reactions to maturation are moreover molded by distinct genetic and environmental pathways, which might carry over to influence subsequent sexual timing and behavior.

Behavioral genetic approaches have been used to address complex developmental trajectories, such as the onset of sexual behavior, that are often confounded by unmeasured or difficult-to-control third variables. These quasi-experimental approaches can identify the genetic and shared-environmental confounds that contribute to complex associations between predictors and behavior, facilitating inferences about cause and effect. The current article uses a behavioral genetics approach to distinguish the roles of girls' perceived pubertal timing and age at menarche as precursors to age at first sexual intercourse (AFI), and sexual activity inside and outside of romantic relationships. We address two topics: (a) the relations of both age at menarche and perceived pubertal timing to timing and context of sexual behavior, and (b) the

relative importance of the genetic and environmental pathways that contribute to these associations.

Pubertal Timing and Sexual Maturation

Puberty is the first step in the process of reproductive maturation, beginning with the development of secondary sex characteristics. In girls, pubertal changes include general body growth and skeletal maturation, the growth of breasts, changes in body shape and weight, and onset of menarche (Goldstein, 1976). There is considerable individual variability in when children experience the physical changes of puberty. Consistently, a wide body of research links an earlier timing of girls' physical maturation relative to their peers with an earlier transition to other reproductive milestones, including earlier initiation of sexual intercourse (Rowe, 2002; Udry, 1979; Zimmer-Gembeck & Helfand, 2008).

The association between pubertal timing and age at first sex might be accounted for, at least in part, by a biological mechanism. Early maturers experience surges of androgen hormones such as testosterone at a younger chronological age, and levels of testosterone are one predictor of sexual behavior and motivation (Halpern, Udry, & Suchindran, 1997). In females, changes in testosterone levels modestly predict sexual desire and the transition to sexual intercourse (Halpern et al., 1997). Researchers suggest that weaker associations between hormone levels and sexual behavior reported for females compared with males are attributable to heightened effects of the social environment in girls (Crockett, Bingham, Chopak, & Vicary, 1996). Indeed, the impact of early pubertal timing on first sexual intercourse in girls varies by race and ethnicity, suggesting that culture-related social factors play a role in the how girls transition to reproductive maturity (Cavanagh, 2004).

These findings indicate that socio-environmental factors, beyond biological reproductive capability, also contribute to the association between pubertal timing and earlier sexual intercourse. An adolescent might select new environments and behaviors due to subjective feelings of maturity and also be responded to differently by peers and family members. For example, early-maturing girls might have difficulties maintaining friendships with peers who have not developed at a similar rate and befriend older peers and peers of the opposite sex (Magnusson, 1988). Associating with older and opposite-sex peers increases early-maturing girls' involvement in the social norms of older adolescents, opening up a social platform for earlier sexual intercourse (Vanoss-Marin, Coyle, Gomez, Carvajal, & Kirby, 2000) and other behaviors associated with sexual onset (e.g., alcohol use; Wichstrom, 2001). Vanoss-Marin et al. (2000), for example, reported that middle school girls with older boyfriends were more likely to experience unwanted sexual advances and earlier onset of sexual intercourse than teens without romantic partners or teens who had relationships with same-age peers.

Complementing these peer relations might be patterns of parent–child interactions that facilitate involvement in older and mixed-sex peer groups and subsequent involvement in sexual activity. On average, conflict between parents and teens increases as children move from childhood to adolescence (Shanahan, McHale, Osgood, & Crouter, 2007). Conflict with parents, in turn, predicts earlier onset of sexual intercourse (Davis & Friel, 2001). For example, African American adolescents experiencing conflict with a parent tend to have sexual intercourse at an earlier age, and this association is magnified among physically mature teens (McBride, Paikoff, & Holmbeck, 2003). Parents might moreover grant a mature-looking adolescent more freedom and less scrutiny, with low parental-monitoring related to earlier sexual intercourse (Zimmer-Gembeck & Helfand, 2008). Taken together, the social environments more common to early-maturing teens might lend opportunities for engagement in sexual intercourse.

Pubertal Timing and Sexual Contexts

In addition to questions of *when* an individual becomes sexually active are questions regarding *the context* in which individuals engage in sexual behaviors. Although early-maturing girls tend to initiate sexual activity ahead of peers, adolescent romances are a relatively normative behavior. More than 70% of adolescents have been involved in a romantic relationship by the end of high school (Carver, Joyner, & Udry, 2003), with almost 65% of adolescents engaging in sexual intercourse over the course of these relationships (Grello, Welsh, & Harper, 2006). Furthermore, approximately one third of sexually active adolescents engage in sexual intercourse both inside and outside romantic relationships (Manning, Longmore, & Giordano, 2005). Colloquially, these nonromantic sexual experiences are termed *hooking up* or *casual sex*.

Emerging findings suggest that the correlates of adolescent sexual activity vary according to the context of sexual behavior. Specifically, casual sex differentially predicts symptoms of depression (Mendle, Ferrero, Moore, & Harden, 2012) and delinquent behavior (Harden & Mendle, 2011) relative to sex within a romantic relationship. Sexual behavior outside a romantic relationship context is also less likely to involve consistent use of birth control and discussion of sexually transmitted diseases and contraceptive use compared with sexual

behavior in a romantic context (Kaestle & Halpern, 2005). Considering the physical and psychological risks associated with particular contexts of sexual behavior, outlining the antecedents of specific contexts of sexual behavior is of interest.

A paucity of research has addressed conditions that predict engagement in various relationship contexts. At a family-wide level, adolescents who reside with two biological parents are less likely to engage in sexual activity outside a romantic relationship (Manning et al., 2005). The reason for this is unclear. Two biological parents might provide a model of stable and monogamous relationships, or the absence of one or more biological parents might create a stressful home environment, lower parental monitoring, and engagement in a variety of deviant behaviors, including earlier and (subsequently) casual sex. However, the strongest predictor of engagement in casual sex is simply prior sexual experience. Girls who initiated sexual intercourse at a younger age are more likely to have non-relationship sexual activity and higher numbers of sexual partner (Elo, King, & Furstenberg, 1999; Manning et al., 2005). Thus, to the extent that early-maturing girls transition to sexual activity at a younger age, they might be hypothesized to have a greater likelihood of non-relationship sexual behaviors.

These perspectives are consistent with *life history theory* (Belsky, Steinberg, & Draper, 1991), which posits that pubertal timing is an essential precursor to engagement in particular patterns of sexual relationships. Life history theory predicts that early puberty will be triggered by recurrent, ongoing stressful early experiences, such as father absence, family conflict, or low socioeconomic status. Earlier puberty, in turn, is thought to precipitate a "reproductive strategy" characterized by earlier initiation of sex and higher numbers of sexual partners and short-term, uncommitted sexual relationships (i.e., an unrestricted sociosexual orientation). This strategy focuses reproductive efforts on quantity of offspring, rather than quality of parenting, which ensures higher chances for the proliferation of one's genes in a threatening and uncertain environment.

Despite this theoretical prediction, no previous study has directly tested whether the timing of puberty is associated with sexual intercourse in nonromantic relationships, and studies on the relation between pubertal timing and other outcomes associated with an "unrestricted" reproductive strategy have yielded mixed results. Consistent with life history theory, earlier pubertal timing does predict earlier pregnancy and greater likelihood of single parenting (Udry, 1979). Five studies, however, have investigated the effect of age at menarche on number of sexual partners and reported null results (for review, see Ellis, 2004). Two additional studies (Hoier, 2003; Neberich, Penke, Lehnart, & Asendorpf, 2007) did not find significant associations between pubertal timing and sociosexual orientation, as measured by participants' self-reports of attitudes toward monogamous sexual relationships, pair bonds, and parental investment. It is therefore unclear whether early-maturing girls are more likely to engage in sexual intercourse in a nonromantic and unrestricted pattern compared with later-maturing girls.

Perceived Pubertal Timing

Research on puberty and sexual behavior has commonly used a variety of measures to gauge pubertal timing. Self-reported age at menarche is considered a valid and reliable assessment, as women's reports are consistent across time and with medical records from childhood (Casey et al., 1991; Dorn, Sontag-Padilla, Pabst,

Tissot, & Susman, 2013). Self-perceptions of pubertal timing, including self-reports of pubertal changes and comparisons with peers, are considered less valid indices, because perceptions of pubertal timing tend to be only weakly related to the more "objective" indicators of timing (Dorn & Biro, 2011). Although perceived pubertal timing measures might not directly gauge how early or late a girl's development is, they could capture psychological processes that are important for the transition to adult-like behaviors, including sex.

Psychological perceptions of events, unlike objective realities, are a reflection of how an event might be idiosyncratically experienced, through "the eye of the beholder" (Mischel, 1977). Perceptions of a salient developmental event bridge the gap between individual-level emotional and cognitive processes and external environments. The perception is a product of factors unique to the event (e.g., intensity of the situation), as well as qualities of the individual (e.g., personality). In the case of pubertal timing, a girl's perceived timing likely reflects factors such as observation of physical development in same-sex peers who serve as a comparison group; feedback from social exchanges (e.g., interest from opposite-sex peers); actual pubertal timing; and individual differences in sensitivity to these biological and environmental inputs. The idea that adolescents interpret and respond to salient events according to trait levels of affect, cognition, and personality is congruent with Caspi and Moffitt's (1991) theory that individual differences are magnified during developmentally meaningful time periods. As girls navigate a changing social landscape, they assimilate salient puberty-related experiences into their existing mental processes and behavioral tendencies and interpret these experiences in a manner that is harmonious with these characteristics. Responses to meaningful developmental milestones such as adolescent pubertal timing thus elicit and magnify personality traits.

In addition, a desire for adolescents to "seek maturity" is hypothesized to occur in order to close the gap between biological and social maturity (Moffitt, 1993). Whether an adolescent perceives her pubertal maturation to be "early" versus "late" could therefore be a salient predictor of maturity-seeking behaviors, which include and correlate with sexual behavior. In support of this view, Deppen, Jeannin, Michaud, Alsaker, and Suris (2012) reported a direct association between girls' perceived early pubertal timing and engagement in first sexual intercourse before the age of 16. Galambos, Kolaric, Sears, and Maggs (1999) reported that perceived maturity predicted adolescent problem behavior, including relations with the opposite sex, delinquency, and drug use after controlling for chronological age and pubertal status.

The Utility of a Behavioral Genetics Approach

Due to the biological, psychological, and social domains concomitantly contributing to both pubertal timing and sexual behavior, distinguishing the specific aspects of pubertal timing that affect the onset and contexts of adolescent sexual behavior is a difficult task. The current study applies a behavioral genetics design as a means of parsing objective and perceived pubertal timing precursors to sexual behavior into genetic and environmental factors. Unlike the traditional partitioning of variance of behavioral phenotypes to determine heritability, we leverage the methodology to determine whether the associations between pu-

bertal timing and sexual behavior are genetically or environmentally mediated.

Genetic Correlation Between Puberty and Sexual Behavior

Although many developmentalists tend to think of adolescent sexual behavior as environmentally determined, the link between pubertal timing and the onset of reproductive behaviors might in fact be attributed to heritable individual differences. Pubertal timing is moderately to strongly heritable; for age at menarche, approximately 61%–68% of the variance is accounted for by genes (Doughty & Rodgers, 2000; Eaves et al., 2004). Sexual behavior demonstrates more variable heritability estimates, with the heritability of AFI falling between 15% and 49% (Segal & Stohs, 2009; see Harden, 2013, for a review). The nascent work on the relational contexts of sexual behavior reports 23%–93% heritability, depending on age group (Harden & Mendle, 2011). Most important, previous behavioral genetic work suggests that genetic factors actually account for the connection between objective pubertal timing and the onset of sexual behavior (Rowe, 2002). Rowe reported that the genetic components underlying age at menarche and age at first intercourse correlated, $r = .72$. One interpretation of this result is that both pubertal timing and sexual intercourse are affected by common genetically determined physiological pathways (i.e., genetic factors responsible for pubertal timing initiate biological changes that increase sexual desire).

It is also possible that unique genetic variance, specific to the *experience* of pubertal timing, has predictive utility for sexual behavior. Previous behavioral studies considering both age at menarche and perceived timing report that genetic factors contributing to these two constructs are only moderately correlated (.20–.36; Harden, Mendle, & Kretsch, 2012). Thus, although some genetic variation accounting for psychological perceptions might be attributable to biological timing, there is a significant proportion of genetic variance unique to perceptions of pubertal timing, which might capture separate biological processes, such as the emotional and cognitive processing of pubertal timing-related cues important for psychological interpretations.

Beyond a common genetic mechanism accounting for the link between pubertal timing and sexual behavior, there is also the possibility that genetically-influenced traits shape the likelihood of individuals encountering particular environments (i.e., *gene-environment correlation*). Early developers who experience higher levels of androgen hormones, and associated physical changes, at a younger age than peers might also experience a social environment characterized by higher levels of attention from boys, more romantically charged interactions, and more frequent social contact with older adolescents. Exposure to these environments might facilitate engagement in sexual activity. Similarly, genetic variation affecting how an adolescent perceives her pubertal timing might also shape romantic and sexual environments. For example, genetic factors accounting for extraversion might explain the extent to which an individual engages in or enjoys social situations in which puberty-related social cues—such as attention from older peers—are likely to occur. To the extent that an adolescent has more social experiences in which she is treated or behaves as if she is older, the more likely she might be to internalize these social

experiences as reflective of advanced maturation (see Munafo & Flint, 2011, for a review of the heritability of personality traits).

Behavioral Genetic Methodology

The sibling-comparison design used in the present research provides a means of accounting for the impact of shared genetic effects, as well as potential confounding environmental variables shared between siblings reared in the same household. By modeling the genetic similarities between sisters, we can establish whether and to what extent phenotypic associations between pubertal timing variables and sexual behavior are attributable to genetic factors. These models make use of the cross-trait, cross-twin correlation between variables (e.g., age at menarche in Twin 1 and age at first sexual intercourse in Twin 2). If this cross-trait, cross-twin correlation is higher in more genetically related sisters compared with less genetically related sisters (e.g., monozygotic twins compared with dizygotic twins and full siblings), this is evidence that shared genes contribute to the association.

Sisters might also be similar for environmental reasons. Behavioral genetic models identify sources of environmental influence that serve to make children raised in the same family similar as the *shared environment*. This factor is fixed to be 100% identical between sisters, under the assumption that the shared environment of siblings does not differ by genetic relatedness. Last, the sibling comparison approach also allows for the estimation of *unshared environment,* or environmental influences, which differ across members of a sibling pair. The unshared environment captures unique experiences, such as birth order, peer groups, or teachers that contribute to differences between siblings in measured behavioral phenotypes.

In the current study, we employed a sibling-comparison design to investigate the environmental and genetic pathways between both age at menarche and perceived pubertal timing with (a) AFI, and (b) engagement in dating, sexual activity inside a romantic partnership, and sexual activity outside a relationship. These latter three outcomes are collectively referred to as *relationship contexts* from this point on. As previous behavioral genetic work has identified the relation between age at menarche and AFI to be attributable to shared genetic influences (Rowe, 2002), we similarly hypothesized that genetic variance specific to age at menarche predicts AFI. In contrast to AFI, very little is known regarding the genetic antecedents of the relationship contexts of sexual behavior. We expected that perceived pubertal timing would predict both AFI and engaging in multiple relationship contexts, above and beyond age at menarche.

Method

Participants

Data were drawn from the National Longitudinal Study of Adolescent Health (Add Health; Udry, 2003), a nationally representative study assessing adolescent health and risk behavior collected in four waves between 1994 and 2008. A stratified random sample of U.S. high schools was targeted by the study, and 79% of schools selected agreed to participate ($N = 134$ schools). Of participating schools, 96% administered a confidential in-school interview during the 1994–1995 academic year ($N = 90,118$).

From this in-school sample, 20,745 participants (10,480 females) were randomly selected to complete a 90-min in-home interview between April and December of 1995 (Wave 1 interview, mean age = 16.12 years, $SD = 1.67$). Three follow up interviews were completed in 1995–1996 (Wave II interview), 2001–2002 (Wave III), and 2007–2009 (Wave IV). For sensitive topics, participants listened through earphones to audio-recorded questions and entered answers into a laptop.

To obtain the sibling pairs sample, adolescents reported to have a twin, half sibling, or unrelated sibling residing in the same household who was between 11 and 20 years old were selected from the school rosters. Sibling pairs were selected regardless of their attendance on the day of the in-school interview and regardless of whether one sibling attended a different school. Additionally, a probability sample of full siblings was selected from the in-school sample. In total, the sibling pairs sample selected for in-home interviews included 783 twin pairs, 1,252 full-sibling pairs, 442 half-sibling pairs, 172 cousin pairs, and 662 unrelated sibling pairs. Jacobson and Rowe (1999) conducted analyses comparing the sociodemographic composition (including age, ethnicity, and maternal education) of the sibling pairs in the Add Health sample to the full sample and reported negligible differences. In the present study, all 923 female–female sibling pairs in Add Health were used (including 145 monozygotic twin pairs, 115 dizygotic twin pairs, 369 full sibling pairs, 117 half sibling pairs, 65 pairs of cousins raised in the same household, and 112 nonrelated pairs). Twin pair zygosity was determined through 11 molecular genetic markers, as well as responses to four questionnaire items addressing physical appearance and how often the respondent was mistaken for her twin (Harris, Halpern, Smolen, & Haberstick, 2006). Approximately 51% of the sample was White, 26% African American, 14% Hispanic, 6% Asian, and 3% identified as "other non-Hispanic."

Measures

Age at menarche. Participants were asked at Waves I and II if they had "ever had a menstrual period," and, if so, during which month and year they had experienced their first menstrual cycle. At Wave III, participants responded to the item, "How old were you when you got your period for the first time?" To reduce telescoping bias, we used the first reported age at menarche, which was most often Wave 1 (87% of the sample). The mean age at menarche was 12.23 years ($SD = 1.43$; range: 7–19 years).

Perceived pubertal timing. In order to capture an adolescent's self-perception of pubertal timing, three self-reported items on physical development reported at Wave 1 were standardized within age group (in accordance with previous studies assessing perceived pubertal timing, e.g., Harden et al., 2011; Wichstrøm, 2001). Standardization was carried out with respect to the full Add Health sample; this capitalized on more participants per age group to better reflect deviations in perceptions of physical maturation relative to adolescents of the same age. A composite score for each individual was created by averaging these standardized scores across the three items. The resulting measure reflects how developed an adolescent describes herself relative to adolescents of the same age, indicating the extent that pubertal timing is perceived as early, on time, or late. The first item assessed general level of development relative to peers ("How advanced is your physical

development compared with other girls your age?” where 1 = “*I look younger than most*” and 5 = “*I look older than most*”). The next two items asked participants to assess changes in body shape. Changes in breast development were rated on a scale where 1 = “*My breasts are about the same size as when I was in grade school*” and 5 = “*My breasts are a whole lot bigger than when I was in grade school; they are as developed as a grown woman's breasts.*” Likewise, curviness was rated from 1 = “*My body is about as curvy as when I was in grade school*” to 5 = “*My body is a whole lot more curvy than when I was in grade school.*” The average of the three standardized items was taken. Higher scores indicate that an adolescent perceived more physical changes relative to how other same-age adolescents perceived themselves. Scores on this scale ranged between −6.82 and 5.01. The mean perceived pubertal timing was −0.21 (SD = 2.41).

Age at first sexual intercourse (AFI). At each wave, participants were asked, “Have you ever had sexual intercourse? When we say sexual intercourse, we mean when a male inserts his penis into a female's vagina.” If so, participants reported the month and year that they had sexual intercourse for the first time. To minimize telescoping bias, we used the age reported in the earliest wave that the participant endorsed having sex, assigning the variable as missing when age of first sex preceded 11 years of age (which seemed potentially nonconsensual, n = 9 cases). The mean AFI for the sample was 16.49 years (SD = 2.20), ranging from 11 to 25 years old.

Dating and sexual activity. Participants were asked during the Wave 1 interview whether they had a “special romantic relationship” within the past 18 months; if the participant answered “yes,” she was classified as dating (Dating = 1). In the case that an adolescent denied having a special romantic relationship but in a separate question confirmed that she had told another nonrelated person that she “liked or loved them” and had held hands and kissed the person, the participant was also classified as being in a dating relationship. For each dating relationship (up to three), adolescents reported whether they had sexual intercourse in that relationship by privately returning a card stating, “We had sexual intercourse.” If the adolescents answered yes to sexual intercourse in any of the dating relationships, they were classified as having romantic sex (Romantic sex = 1). In a subsequent section, all participants who indicated having sexual intercourse responded to the question, “Not counting the people you have described as romantic relationships, have you ever had a sexual relationship with anyone?” If adolescents answered “yes” to this question, they were classified as having nonromantic sex (Nonromantic sex = 1). This coding scheme creates three separate relationship context variables that were not mutually exclusive categories. For example, adolescents who reported sexual activity both in and out of romantic relationship were scored as Dating = 1, Romantic sex = 1, Nonromantic sex = 1 (n = 241). Adolescents who reported that they were virgins at Wave 1 (n = 1,194) were classified as not having romantic or nonromantic sex (Dating = 1 or 0, depending on report; Romantic sex = 0, and Nonromantic sex = 0). We could then use each of these three relationship contexts as outcomes in three independent models, assessing which pubertal timing variables predicted engagement in dating, romantic sex, and nonromantic sex.

Data Analyses

We analyzed data using structural equation modeling in the software program Mplus (Muthén & Muthén, 1998–2010), using full information maximum likelihood to account for missing data. We determined absolute model fit using the confirmatory fit index, Tucker–Lewis index, and root-mean-square error of approximation.

We first estimated a series of behavioral genetic models decomposing the variance of the measured phenotypes into three latent factors: additive genetic (A); shared environmental (C); and nonshared environmental (E; Neale & Cardon, 1992). The ACE model of sibling pairs reared together assumes that at a population average, monozygotic twins share 100% of their segregating genes, dizygotic twins and full siblings share 50%, half siblings 25%, cousins 12.5%, and nonrelated siblings share 0% of their segregating genes. To the extent that siblings are more similar in a phenotype consistent with genetic similarity (i.e., monozygotic twins show greater similarity than dizygotic twins and full siblings, and so on), a trait is modeled to have genetic contribution, captured in the latent genetic factor labeled A. The shared environmental factor, C, represents all environmental experiences that are shared between siblings at the family level (e.g., socioeconomic status, family structure, school district) that contribute to sibling similarity that is not accounted for by genetic similarity. Finally, the nonshared environmental factor labeled E accounts for experiences that are unique to each sibling (e.g., differential treatment from parents or different peer groups) that serve to make siblings dissimilar. This latent factor additionally includes measurement error.

Before constructing final models assessing the theorized relationships among variables, we tested preliminary univariate models to inform the selection of final models. Specifically, we wanted to ensure optimal fit and to include only those variance components that accounted for significant proportions of variance. In line with previous analyses of the Add Health data (Harden et al., 2012), preliminary models indicated that shared environmental contributions to age at menarche and perceived pubertal timing were negligible and could be dropped from a model without a significant decline in model fit (full results available upon request). Similarly, the shared environment variance components had negligible contribution to dating, romantic sex, and nonromantic sex and could be dropped from each of these models without significant change in model fit (consistent with Harden & Mendle, 2011). Finally, modeling genetic, shared environment, and unique environment variance components for AFI yielded adequate fit, and removing shared environment reduced the fit of the model significantly ($\Delta\chi^2$ = 24.63, Δdf = 1, p = .00). Thus, we proceeded with our final trivariate models (Models 1, 2, 3, and 4), including only genetic and unique environment factors (AE) for age at menarche, perceived pubertal timing, dating, romantic sex, and nonromantic sex, and included all three variance components (ACE) for AFI.

Model 1 assessed the genetic and environmental influences of both age at menarche and perceived pubertal timing on AFI (Figure 1). The parameters of interest in Model 1 are the regressions of AFI on the additive genetic (A) and nonshared environmental (E) variance components of age at menarche (bA31 and bE31) and perceived pubertal timing (bA32 and bE32). These regressions tested (a) whether the genetic and nonshared environ-
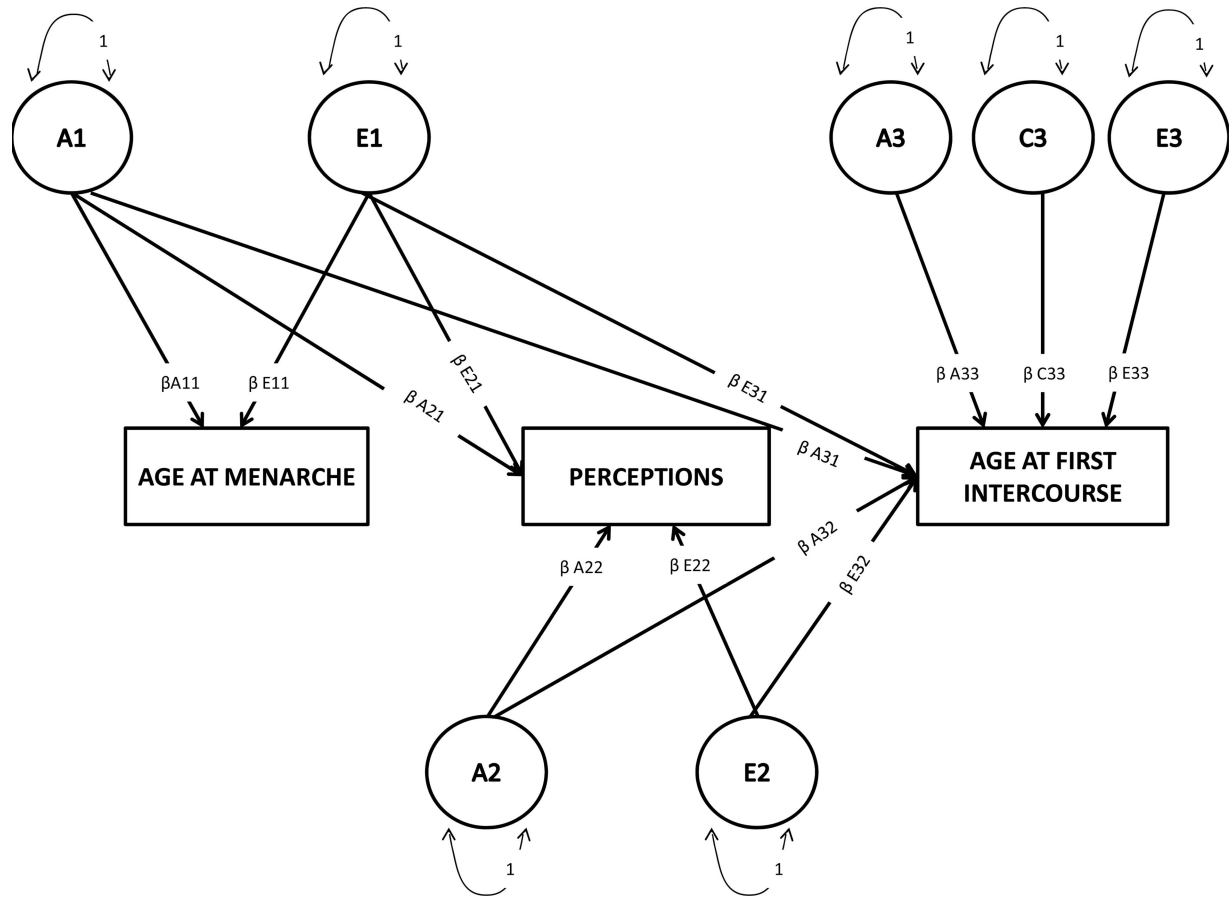
Figure 1. Final structure of Model 1 for age at menarche, perceived pubertal timing, and age at first intercourse (AFI). A = additive genetic; C = shared environment; E = nonshared environment. Only one twin is illustrated. Correlations among genetic factors (e.g., correlation between A1 of Sibling 1 and A1 of Sibling 2) are fixed according to genetic similarity (e.g., 1 for monozygotic twins, .5 for dizygotic twins and full siblings, and so on). Shared environmental factors (C3 for Sibling 1 and C3 for Sibling 2) are fixed to correlate at 1. Unique environmental factors are fixed to correlate at 0. Error variance is fixed to 1. All labeled pathways (parameters βA11–βE33) are free.

mental factors that influence timing of menarche also predict AFI (*b*A31 and *b*E31), and (b) whether, after accounting for the genetic and environmental determinants of age at menarche, the genetic and nonshared environmental influences on perceived pubertal timing account for additional variance in AFI (*b*A32 and *b*E32). Model 1 therefore addresses the pubertal timing factors contributing to *when* adolescents initiate sexual intercourse.

Three additional models ([Figure 2](#)) target *the contexts* in which adolescents engage in sexual intercourse by assessing the extent that genetic and environmental factors accounting for age at menarche and perceived pubertal timing relate to dating (Model 2), romantic sex (Model 3), and nonromantic sex (Model 4). The regressions of interest are those of the relationship contexts on the additive genetic (A) and nonshared environmental (E) variance components of age at menarche (*b*A31 and *b*E31) and perceived pubertal timing (*b*A32 and *b*E32). These regressions estimate the extent to which genetic and unique environmental influences on timing of menarche predicts (a) whether an adolescent dates, engages in romantic sex, or engages in nonromantic sex (*b*A31 and

*b*E31) and (b) the extent to which genetic and unique environmental experiences accounting for perceived pubertal timing predict these behaviors (*b*A32 and *b*E32) after age at menarche is taken into account.

Results

Preliminary Analyses

Before fitting genetic models, we estimated the general associations between pubertal variables and sexual behavioral outcomes (see [Table 1](#)). Older age at menarche was significantly negatively correlated with earlier perceived pubertal timing ($r = -.24$, $p < .01$) and positively correlated with older AFI ($r = .21$, $p < .01$). Earlier perceived pubertal timing also significantly negatively correlated with older AFI ($r = -.15$, $p < .01$). Additionally, we compared the sibling pair correlations for each variable. As shown in [Table 1](#), these correlations, as expected, were higher between monozygotic twins than for less genetically related siblings, sug-
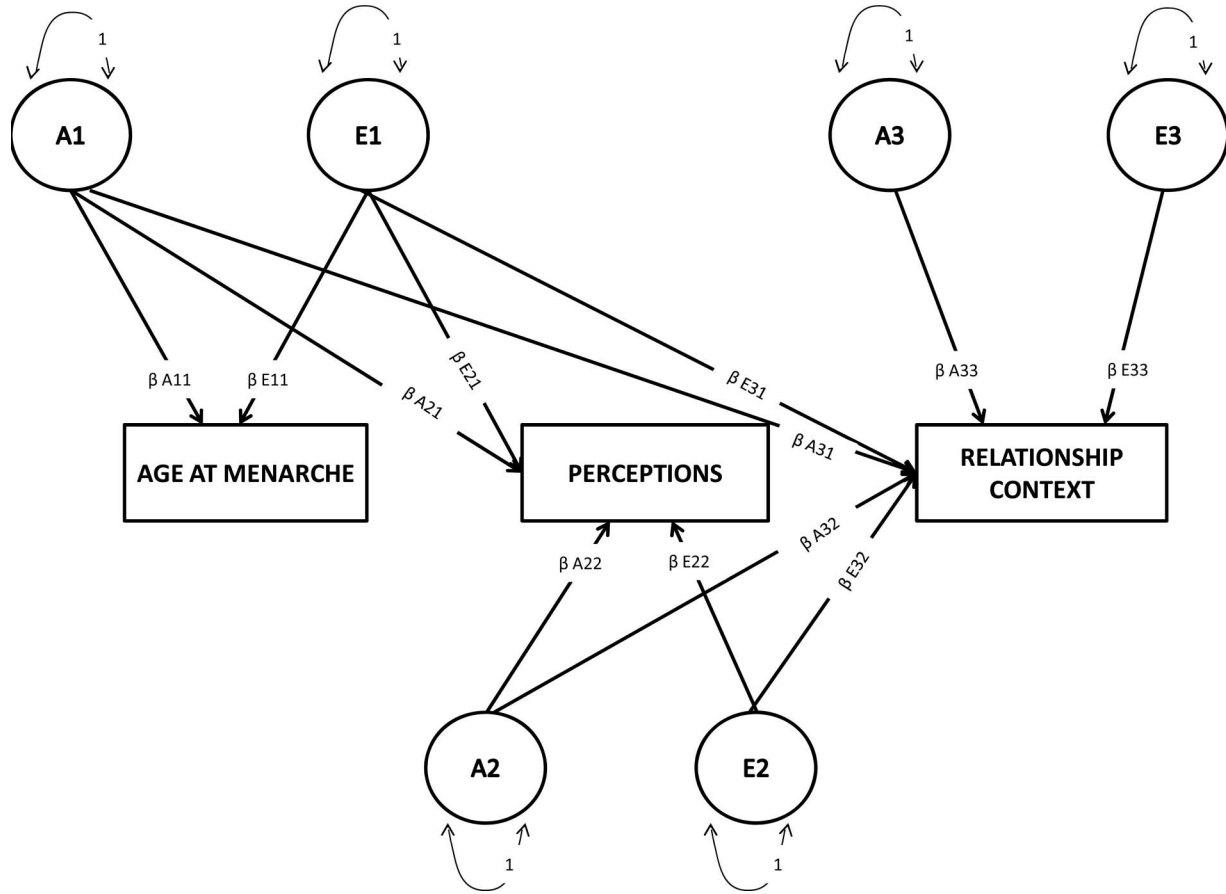
Figure 2. Final structure of Models 2–4 for age at menarche, perceived pubertal timing, and three relationship contexts (dating, romantic sex, and nonromantic sex). A = additive genetic; E = nonshared environment. Only one twin is illustrated. Correlations among genetic factors (e.g., correlation between A1 of Sibling 1 and A1 of Sibling 2) are fixed according to genetic similarity (e.g., 1 for monozygotic twins, .5 for dizygotic twins and full siblings, and so forth) Unique environmental factors are fixed to correlate at 0. Error variance is fixed to 1. All labeled pathways (parameters $\beta A11$– $\beta E33$) are free.

gesting that genes contribute to age at menarche, perceived pubertal timing, AFI, and the three relationship contexts.

Last, we compared age at menarche and perceived pubertal timing in individuals who engaged and did not engage in dating, romantic sex, and nonromantic sex. The mean age at menarche was significantly lower for adolescents who dated ($M = 12.19$) compared with those who did not date ($M = 12.35$; $t = 2.13$, $df = 1673$, $p < .05$). Differences in age at menarche were nonsignificant between girls who engaged in romantic sex ($M = 12.25$) versus those who did not ($M = 12.25$; $t = -0.07$, $df = 1643$, $p > .05$). Girls who had nonromantic sex demonstrated significantly earlier mean ages at menarche ($M = 12.07$) than girls who did not ($M = 12.29$; $t = 2.66$, $df = 1666$, $p < .01$).

With regard to perceived pubertal timing, adolescents who engaged in all three contexts reported earlier perceived timing compared with adolescents who did not date ($M = 0.09$ [dating] vs. $M = -0.80$ [no dating]; $t = -7.10$, $df = 1674$, $p < .01$), did not have romantic sex ($M = 0.32$ [romantic sex] vs. $M = -0.40$ [nonromantic sex]; $t = -5.36$, $df = 1644$, $p < .01$) and did not have nonromantic sex ($M = 0.30$ [nonromantic sex] vs.

$M = -0.35$ [no nonromantic sex]; $t = -4.55$, $df = 1668$, $p = .08$), although this latter difference was not significant.

Behavioral Genetic Models

Does pubertal timing predict age at first sexual intercourse? In Model 1, we fit a behavioral genetic model of age at menarche, perceived pubertal timing, and AFI ($\chi^2 = 237.96$, $df = 176$, $p = .00$, RMSEA = 0.05). The variance components, regression coefficients, and indices of fit for Model 1 and all other final models are displayed in Table 2. Because the relation between pubertal timing and sexual behavior has been found to vary by race, all models were tested with race (White vs. non-White) added as a covariate. The results of the variance estimates for age at menarche, perceived pubertal timing, and AFI suggest that these phenotypes are moderately heritable, consistent with previous literature.

Model 1 tested the extent to which genetic factors and unique environmental factors influencing age at menarche and perceived pubertal timing predict AFI. As previously reported in analyses of

this data set (Harden et al., 2012), genetic factors accounting for age at menarche predicted perceived pubertal timing (bA21 = −0.30, p < .01). Genetic variance accounting for age at menarche significantly predicted AFI (bA31 = 0.25, p < .01). This is consistent with previous findings on female twins from Wave 1 of the Add Health data sample (Rowe, 2002). Additionally, genetic variance unique to perceived pubertal timing (bA31 = −0.18, p < .01) significantly predicted AFI. Unique environment factors accounting for age at menarche and perceived pubertal timing did not significantly predict AFI. This finding suggests that the environmental factors contributing to age at menarche and similarly unique environmental variance accounting for perceived timing are independent of the environmental factors that account for AFI.

Does pubertal timing predict adolescent relationship contexts? Models 2–4 investigated the influence of age at menarche and perceived pubertal timing on engagement in dating, romantic sex, and nonromantic sex. Because sibling differences in engagement in these behaviors at Wave 1 could be due to age differences among participants, we added age as a statistical covariate to these three models. All models had good model fit, and all genetic and unique environmental variance components significantly contributed to their respective measure after accounting for the construct(s) entered prior (see Table 2).

As was the case for Model 1, genetic factors accounting for age at menarche predicted perceived pubertal timing (labeled bA21 in Figure 2). In all three models, neither genetic nor environmental factors underlying age at menarche significantly predicted dating, romantic sex, or nonromantic sex (see bA31 and bE31 in Figure 2). In contrast, perceived pubertal timing significantly predicted all three relationship contexts of sexual behavior through genetic pathways (portrayed as bA32 in Figure 2). Genetic factors influencing perceived pubertal timing predicted whether an adolescent engaged in dating relationships (bA32 = 0.20, p < .05), sex in romantic relationships (bA32 = 0.34, p < .01), and nonromantic sex (bA32 = 0.28, p < .01).

Discussion

The current study suggests that genetic factors accounting for age at menarche and perceived pubertal timing are contrasting predictors of sexual and romantic behavior. Both age at menarche and, to a lesser extent, perceived pubertal timing relate to AFI. However, solely girls' perceptions of pubertal timing predict recent engagement in three contexts in which romantic and sexual behavior occurred. In other words, how reproductively mature a girl believes herself to be predicts engagement in three types of romantic or sexual behaviors, whereas objective pubertal timing predicts the onset of sexual behavior.

The finding that common genetic variance contributes to both age at menarche and AFI is consistent with results obtained by Rowe (2002) in initial analyses of the Add Health data. Our results build upon Rowe's findings, by extending this genetic association to a larger, full sibling sample and by using all four waves to obtain the earliest reported AFI, which corrects for the small number of participants reporting sexual initiation at Wave 1. Furthermore, we identified a small amount of additional genetic variation unique to perceived pubertal timing that also relates to AFI. This finding is consistent with a previous report of an association between per-

Table 1
Sample Statistics, Sibling Pair Correlations, and Phenotypic Correlations Among Variables

	M	SD	N	MZ twins	DZ twins	Full siblings	Half siblings	Cousins	Nonrelated siblings	1	2	3	4	5
1. Age at menarche	12.23	1.43	1,828	0.61 (n=142)	0.31 (n=111)	0.30 (n=364)	0.20 (n=114)	0.22 (n=65)	0.08 (n=110)	—				
2. Perceived timing	−0.21	2.41	1,816	0.45 (n=139)	0.37 (n=111)	0.18 (n=362)	0.22 (n=109)	0.10 (n=64)	0.03 (n=110)	−0.24	—			
3. Age at first intercourse	16.93	2.72	1,698	0.62 (n=130)	0.45 (n=96)	0.42 (n=321)	0.24 (n=102)	0.19 (n=59)	0.38 (n=93)	0.21	−0.15	—		
4. Dating	0.65	0.48	1,825	0.51 (n=139)	0.28 (n=114)	0.25 (n=367)	0.14 (n=110)	0.18 (n=65)	0.15 (n=111)	−0.04	0.16	−0.25	—	
5. Romantic sex	0.26	0.44	1,791	0.76 (n=134)	0.10 (n=109)	0.12 (n=354)	0.17 (n=106)	0.12 (n=59)	0.29 (n=111)	0.01	0.13	−0.35	0.44	—
6. Nonromantic sex	0.21	0.41	1,816	0.45 (n=139)	0.20 (n=111)	0.20 (n=359)	0.11 (n=110)	0.21 (n=65)	0.19 (n=111)	−0.06	0.11	−0.37	0.26	0.46

Note. Age at menarche, perceived timing, and age at first intercourse are continuous, and dating, romantic sex, and nonromantic sex are categorical. Correlations among continuous variables are Pearson coefficients and correlations among two dichotomous variables are phi coefficients. Correlations significantly different than zero at p < .05 are shown in bold. Numbers of complete pairs are shown in parentheses. MZ = monozygotic; DZ = dizygotic.

Table 2

Variance Composition, Standardized Regression Coefficients, and Model Fit Statistics for Final Models

Variable	Model 1: Age at first intercourse	Model 2: Dating	Model 3: Romantic sex	Model 4: Nonromantic sex
Variance composition				
$A_{Menarche}$	**.62**	**.58**	**.58**	**.58**
$E_{Menarche}$	**.38**	**.42**	**.42**	**.42**
$A_{Perceptions}$	**.44**	**.4**	**.4**	**.4**
$E_{Perceptions}$	**.56**	**.6**	**.6**	**.6**
$A_{Sexual\ behavior}$	**.34**	**.75**	**.89**	**.69**
$C_{Sexual\ behavior}$	**.28**	—	—	—
$E_{Sexual\ behavior}$	**.38**	**.25**	**.11**	**.31**
Regression coefficients				
$\beta A11$	**.78 (.03)**	**.75 (.05)**	**.75 (.05)**	**.75 (0.05)**
$\beta E11$	**.62 (.03)**	**.63 (.04)**	**.63 (.04)**	**.63 (0.04)**
$\beta A22$	**.63 (.04)**	**.60 (.10)**	**.60 (.10)**	**.60 (0.10)**
$\beta E22$	**.71 (.04)**	**.74 (.08)**	**.74 (.08)**	**.74 (0.08)**
$\beta A33$	**.55 (.08)**	**.80 (.08)**	**.77 (.06)**	**.74 (0.08)**
$\beta C33$	**.50 (.05)**	—	—	—
$\beta E33$	**.59 (.04)**	**.46 (.08)**	**.28 (.07)**	**.50 (.09)**
$\beta A21$	**−.30 (.05)**	**−.28 (.12)**	**−.28 (.12)**	**−.28 (.12)**
$\beta E21$	−.02 (.05)	−.05 (.13)	−.05 (.13)	−.05 (.13)
$\beta A31$	**.25 (.05)**	.06 (.07)	.07 (.08)	−.15 (.10)
$\beta E31$	.01 (.05)	−.07 (.07)	.00 (.09)	.05 (.10)
$\beta A32$	**−.18 (.06)**	**.20 (.09)**	**−.34 (.09)**	**−.28 (.12)**
$\beta E32$	−.06 (.04)	.07 (.06)	.07 (.06)	.07 (.09)
Model fit				
Root-mean-square error of approximation	.05	.06	.04	.04
Comparative fit index	.89	.85	.93	.9
Tucker–Lewis index	.92	.87	.94	.92
Chi-square (*df*), *p*	237.96 (176), .00	345.70 (236), .00	304.39 (236), .00	294.01 (236), .01

Note. Final models labeled according to sexual behavior outcome variable. The regression coefficients are labeled according to the path diagrams in Figures 1 and 2. The pathways unique to genetic and environmental variance of each phenotype are presented first (e.g., A1 and E1 to age at menarche, A2 and E2 to perceptions, and so on) in sequential order, followed by the cross paths in sequential order (e.g., A1 and E1 to Perceptions, A1 and E1 to age at first intercourse, followed by cross paths from A2 and E2). Variance composition reflects the percentage of variance accounted for by genetic and environmental factors for each phenotype, calculated by squaring the standardized genetic or environmental path and dividing by the total variance. Race used as statistical covariate in all models. Age used as a statistical covariate in Models 2–4. Parameters significantly different than zero at *p* < .05 are shown in bold.

ceptions of pubertal timing and age at first intercourse (Deppen et al., 2012).

The genetic factors that account for the association of age at menarche and AFI may reflect pleiotropic genetic effects, as the identified genetic variance could contribute to both pubertal timing-related differences in the secretion of gonadal hormones and, relatedly, sexual drive and feelings of desire (Halpern et al., 1997). Similarly, the genetic factors unique to perceived pubertal timing that predict AFI may capture pleiotropic genetic effects due to an overarching mechanism, such as socioemotional tendencies (see more detailed discussion later) to be sensitive to the social environment, affecting both perceptions of pubertal timing (in response to social cues inferring maturity) and sexual behavior (in response to social interaction with potential partners). This interpretation is consistent with findings linking perceived maturity to additional outcomes involving behavioral responses to social influence, including drug use and relations with the opposite sex (Vanoss-Marin et al., 2000; Wichstrøm, 2001).

Perceptions of pubertal timing hold psychological significance beyond how objectively early or late an adolescent is, as individual-level interpretations of pubertal experiences are inevitably shaped by more than objective indicators. Our results suggest that genetic factors that are unique to perceived pubertal timing

(i.e., independent of objective timing) relate to recent engagement in romantic and sexual behavior in all contexts (e.g., dating, romantic sex, and nonromantic sex). One interpretation of this genetic association is that genetically influenced cognitive and emotional tendencies contribute to how individuals interpret experiences and navigate their social worlds. The idea that dispositional tendencies play a key role in pubertal experiences is not novel: Caspi and Moffit (1991) provided empirical evidence that individual differences are elicited to a greater degree by developmentally meaningful events, citing pubertal timing as a prime example. Earlier pubertal timing therefore accentuates natural dispositions as adolescents navigate changing situations and social interactions by assimilating these experiences into their existing mental processes and behavioral tendencies. The perception of pubertal timing reflects how an adolescent interprets and internalizes events according to trait levels of sensitivity to (and subsequently emotional and cognitive processing of) puberty-related cues.

A second interpretation of the genetic association between perceived pubertal timing and engagement in romantic and sexual behavior in the last 18 months is that perceived pubertal timing reflects biological processes contributing to pubertal changes that are not captured by age at menarche. Although the onset of

menarche and the development of secondary sex characteristics reflect the same phase of pubertal development (gonadarche; Dorn & Biro, 2011), there might be additional genetically based developmental mechanisms contributing to secondary sex characteristics that could account for the association between perceived pubertal timing and engagement in relationship contexts. For example, genetic variation contributing to individual differences in breast size, curviness, or hormone levels (independent of genetic variation accounting for age at menarche) might concomitantly influence perceived pubertal timing, sexual desire, and social experiences facilitating dating and sexual activity.

Contrary to previous findings, we found that earlier perceived pubertal timing related to all three relationship contexts. Thus, girls' perceptions of pubertal experiences, beyond age at menarche, predict recent engagement in romantic and sexual behavior in general, rather than distinguishing different types of romantic and sexual behavior. In terms of the outcomes of these social contexts, previous studies reported that nonromantic sex (but not dating and romantic sex) relates to symptoms of depression and delinquency (Harden & Mendle, 2011; Mendle et al., 2012). The fact that perceived pubertal timing does not distinguish recent engagement in types of romantic and sexual behavior suggests that pubertal timing does not serve to identify risk for engagement in nonromantic sex, specifically.

It is worth noting that our null results for environmental pathways between pubertal timing and sexual behavior are incongruent with life history theory, which predicts that family-level early stressful experiences contribute to accelerated reproductive development, sporadic relationships, and sexual activity with uncommitted partners. Earlier menarche is considered the initial step in a trajectory of "unrestricted" sexual behavior; however, we found no environmental (or genetic) associations between timing of menarche and adolescents' involvement in dating, romantic sex, or nonromantic sex. Specifically, by using three independent models, we found that whether an adolescent engages in multiple possible romantic and sexual behaviors is not related to physiological reproductive capability. Likewise, this framework would predict an environmentally mediated pathway between age at menarche and accelerated reproductive behavior, but we did not find environmental variation accounting for age at menarche to predict AFI. Thus, our genetically informed design suggests that the environmental effects contributing to pubertal timing are minimally related to sexual behavior, at least in this sample of adolescents.

Limitations

The antecedents of romantic and sexual behavior are complex, and it is important to note that the significant genetic effects of age at menarche and perceived pubertal timing on the present sexual outcomes account for only a fraction of the total variance. The majority of variance is accounted for by unique genetic and environmental factors. Genetic influences could range from impulsive or sensation-seeking tendencies, predisposition for sociability or dependency, to physical attractiveness. Broader family or cultural contexts (experienced differently by each sister), as well as peer groups or relationships with parents, could account for environmental influences independent of pubertal timing. These possibilities merit future investigation.

It is also worth noting that as in many behavioral genetic studies, we did not detect significant shared environment factors contributing to measures of pubertal timing. Behavioral genetic methodologies are limited in parsing experiences that are shared by siblings, partly due to these experiences reflecting genetic similarities between parents and children and partly due to family experiences having *different* effects on each member of a sibling dyad (consequently modeled as unique environmental influences). Although establishing shared environment influences is a common difficulty in the sibling comparison design, it does not impair our ability to infer the extent that genetic and environmental factors account for an association between two variables—here, pubertal timing and sexual behaviors.

Last, although the present study assumes that dating and sexual outcomes are preceded by subjective experiences of puberty, it is important to note that the cross-sectional analyses do not allow us to determine the temporal sequencing of these associations. In particular, it is possible that engaging in dating or sexual relationships contributes to perceived pubertal timing, rather than perceived timing serving as an antecedent of relationship contexts. To the extent that a girl behaves as a reproductively mature individual, she might infer and report a greater level of perceived development. In addition, our sample did not include adolescent males. This is partly a byproduct of the nature of puberty, which lacks a sufficient male counterpart to age of menarche. This makes it difficult to differentiate typical physiological processes from subjective perceptions. We suspect, however, that for males the effects of perceived development would be similar to those for females. Indeed, prior research assessing boys' pubertal timing through subjective peer comparisons support that these measures predict the timing of first sexual intercourse (Crockett et al., 1996).

Conclusions

The transition to reproductive maturity carries significance for adolescents' mental and physical health (Kaestle & Halpern, 2005; Mendle, Turkheimer, & Emery, 2007). The experience of puberty and the initiation of sex can be intense and tumultuous, as these developmental processes unfold in a period where individual differences and social influences become increasingly important. The results of the present study suggest that the timing of reproductive behavior reflects genetically mediated processes. In addition, how mature an adolescent perceives herself to be is related to three independent contexts of romantic and sexual behavior. These findings help to disentangle the biological and psychological processes important for the transition to romantic and reproductive behavior. Beyond biological readiness, how adolescent girls interpret their pubertal experiences is important for recent engagement in romantic and sexual behaviors.

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