HHS Public Access

Author manuscript

J Adolesc Health. Author manuscript; available in PMC 2022 June 01.

Published in final edited form as:

J Adolesc Health. 2021 June ; 68(6): 1197–1203. doi:10.1016/j.jadohealth.2021.01.020.

Girls' Pubertal Timing and Tempo and Mental Health: A Longitudinal Examination in an Ethnically-Diverse Sample

J. Deardorff, PhD[1], **K. Marceau, PhD**[2], **M. Johnson, PhD**[1], **J. Reeves**[3], **F. M. Biro, MD**[4], **A. Kubo, PhD**[5], **L.C. Greenspan, MD**[6], **C. Laurent, MS**[5], **G.C. Windham, PhD**[7], **S.M. Pinney, PhD**[8], **L.H. Kushi, ScD**[5], **R.A. Hiatt, MD, PhD**[9]

[1]Community Health Sciences Division, School of Public Health, University of California, Berkeley, 2121 Berkeley Way West, Room 6163, Berkeley, CA US 94720-7360

[2]Human Development and Family Studies, Purdue University; Hanley Hall, Room 225 1202 West State St., West Lafayette, Indiana US 47907-2055

[3]Department of Psychology, University of California, Berkeley, 2121 Berkeley Way West, Berkeley, CA US 94720-1650

[4]Division of Adolescent Medicine, Cincinnati Children's Hospital Medical Center, Burnet Campus, 3333 Burnet Ave., Cincinnati, Ohio US 45229-3039

[5]Division of Research, Kaiser Permanente Northern California, Kaiser Permanente Division of Research, 2000 Broadway, Oakland, CA US 94612

[6]Department of Pediatrics, Kaiser Permanente, 2238 Geary Blvd, San Francisco, CA US 94115

[7]Environmental Health Investigations Branch, California Department of Public Health, 850 Marina Bay Parkway, 850 Marina Bay Parkway, Building P, 3rd Floor, Richmond, CA 94804-6403

[8]Department of Environmental Health, University of Cincinnati College of Medicine, University of Cincinnati, Kettering Hall, Room 208, Cincinnati, OH US 45267

[9]Department of Epidemiology and Biostatistics, University of California, San Francisco, Mission Hall, 550 16th Street, 2nd Floor, San Francisco, CA US 94158-2549

Abstract

Purpose: Earlier timing and faster tempo of puberty have been linked to adolescents' poor mental health. Previous research rarely adjusted for childhood mental health, did not use physical

Address correspondence to: Julianna Deardorff, Community Health Sciences Division, School of Public Health, University of California, Berkeley, 2121 Berkeley Way West, Room 6163, Berkeley, CA 94720-7360, jdeardorff@berkeley.edu, office: 510-642-7334.

Implications and Contributions

Associations between timing and tempo of puberty and girls' mental health differ by race/ethnicity suggesting that certain groups may be more vulnerable during the pubertal transition. This variability may be driven by contextual risk and protective factors that are unique across ethnic groups and could inform prevention efforts.

Completing Financial Interests: All authors declare they have no actual or potential competing financial interests. The first author wrote the first draft of this paper and received no compensation.

examination to assess puberty, and excluded Latinas and Asian Americans. This study addressed these limitations.

Methods: We followed 822 girls, recruited at ages 6–8, for 8 years. Breast and pubic hair development and anxiety and depressive symptoms were assessed prospectively and repeatedly. Structural equation models tested whether pubertal timing and tempo were associated with adolescent mental health symptoms and whether associations varied by ethnicity. Models were adjusted for childhood mental health symptoms, BMI, and family income.

Results: Earlier breast development was associated with higher depressive symptoms among Whites ($\beta = -0.19$; $p<.01$) and higher anxiety symptoms among Latinas ($\beta = -0.26$; $p<.05$), but lower depressive symptoms among Asians ($\beta = 0.24$, $p<.05$). Later pubic hair development ($b = 0.24$; $p<.05$) and faster pubic hair tempo ($\beta = 0.26$; $p<.01$) were associated with higher anxiety symptoms among Latinas. Faster pubic hair tempo was associated with lower depressive symptoms among Asians ($\beta = -0.34$; $p<.05$). Tempo of breast development showed no associations.

Conclusions: Findings confirmed that earlier breast development was associated with higher mental health symptoms for Latina and White girls, but was protective among Asians. Results for pubic hair and pubertal tempo were inconsistent, requiring future examination. While targeted interventions to prevent mental health problems among early-maturing girls are critical, there is variability among who might benefit most.

Keywords

adolescence; puberty; anxiety; depression; body mass index; girls

Early puberty is linked to negative mental health outcomes for girls, including anxiety and depression.[1,2] Compared to decades ago, puberty is starting earlier in the U.S.,[3] which may place many girls at risk for emotional problems during adolescence. Moreover, Blacks and Latinas start puberty earlier than Whites suggesting they may be at even higher risk. Pubertal tempo, or the pace at which girls progress through puberty, may also influence mental health[4] but is largely understudied. A critical issue across extant studies is a lack of study population diversity. Few studies include race/ethnic groups in sufficient numbers to determine whether effects vary across groups. Thus, the current study examined associations between pubertal timing and tempo and girls' mental health in a large ethnically-diverse sample.

The notion that early pubertal timing leads to negative mental health is guided by robust theory. Research supports the developmental readiness hypothesis,[5,6] which posits that girls who start puberty earlier than their peers may not be cognitively and socially prepared for the changes they experience, and this transition can be psychologically daunting. Early maturers may compare themselves negatively to others their age and experience body image issues.[7] In addition, early-maturing girls attract older peers and romantic partners, which can lead to risky behaviors and increased anxiety and depressive symptoms.[8] While research documents that early puberty is linked to adverse mental health outcomes,[8–11] less is known about pubertal tempo. Based on the "maturation compression" hypothesis, researchers have posited that girls who progress through puberty quickly (faster tempo) may be unprepared

for the vast number of changes they rapidly experience and therefore be vulnerable to mental health problems. Empirical findings, however, have been inconsistent.[4,12–14]

Marceau et al. examined pubertal timing and tempo (assessed by physical exam) and behavioral health outcomes and found that girls' early timing of breast and pubic hair development and faster tempo of pubic hair development were associated with higher adolescent internalizing symptoms.[4] In contrast, Beltz et al. analyzed longitudinal twin data and showed no associations between pubertal timing and tempo (assessed using self-report) and depressive symptoms.[12] An interesting aspect of Beltz's study was the use of multiple analytic approaches (i.e., longitudinal growth curve models with linear and logistic estimation; traditional models using age at menarche to assess timing; and time from pubertal onset to menarche to assess tempo). Across all estimation strategies, results were consistently null. Despite numerous strengths, these studies included predominantly White youth, so conclusions are not generalizable to other race/ethnic groups.

The limited research examining ethnic variation in pubertal timing and depression has yielded inconsistent results.[15–17] Some researchers have suggested that early puberty may be a risk factor for White but not Black girls. Hayward et al. examined a large representative sample of youth and found that early menarche was a significant predictor of depressive symptoms for White girls, but not Blacks or Latinas[18]. These researchers and others have posited that ethnic differences may be explained by greater body dissatisfaction among early-maturing Whites.[16,18,19] However, a recent study of mostly Black and White girls revealed a complex pattern of associations with pubertal timing and tempo.[13] Results showed that early pubertal timing and faster tempo were associated with depressive symptoms for both ethnic groups, but that associations with tempo were limited to childhood, with no associations in adolescence.

Differences in study design may, in part, help explain mixed findings in the literature. First, pubertal development is often measured using self-report, which may bias findings if depressed/anxious individuals are more likely to misreport their pubertal status. Some studies use age at menarche as their sole measure of timing, but menstruation starts late in the pubertal process. Few studies use Tanner staging by physical examination collected over a sufficient period of time to assess tempo, and many start after puberty had begun for most girls. Second, many studies fail to include prepubertal body mass index (BMI) and socioeconomic status as covariates, although both are related to pubertal timing[20,21] and depression.[22–24] Third, studies inconsistently account for child mental health symptoms when examining adolescent outcomes, yet early symptomatology is correlated with mental health in the second decade of life.[25–28] Moreover, prepubertal anxiety has been shown to be associated with earlier pubertal development,[29] underscoring the need to adjust for childhood mental health symptoms. Finally, with notable exceptions,[13,14] few studies examined *both* pubertal timing *and* tempo and mental health symptoms, and rarely in ethnically-diverse samples.[30]

The current study employed a cohort design with data collected prospectively in regular visits over 8 years, starting at ages 6–8y, in an ethnically-diverse sample. We assessed pubertal timing and tempo and anxiety and depressive symptoms in childhood and

adolescence, and included BMI and family income as covariates. We hypothesized that earlier timing and faster tempo of pubertal development would put girls at risk for anxiety and depressive problems in adolescence, even when adjusting for childhood anxiety and depressive symptoms. Given research suggesting that White girls may be more vulnerable to the negative effects of early puberty, we hypothesized that early pubertal timing and faster tempo would lead to poorer mental health symptoms among Whites compared to the other race/ethnic groups.

Methods

Participants and Procedure

This project was part of the NIH-funded Puberty Studies of the Breast Cancer and the Environment Research Program (BCERP).[31] We utilized data from two cohorts of girls (n=822) and their caregivers (predominantly mothers), who were enrolled between 2004 and 2007 (6–8 years old) at Cincinnati Children's Hospital Medical Center (CCHMC) and Kaiser Permanente Northern California (KPNC).[32] A third location, Mount Sinai School of Medicine, was not included because mental health was not assessed on the same schedule. Girls with pre-existing medical conditions known to influence puberty or a psychiatric condition that limited participation were excluded. Participants attended annual clinic visits at KPNC and biannual visits at CCHMC, during which anthropometric and pubertal data were collected.[32] Each visit included a caregiver interview and, starting in year 6, a child interview. Review boards at each institution approved study procedures.

Measures

Pubertal development was assessed using clinic-based Tanner staging[33] conducted by research assistants under the supervision of a board certified pediatric endocrinologist,[32] with annual quality assurance checks to confirm accurate staging. Visual inspection and palpation were used to distinguish breast from adipose tissue. For overweight girls, two research assistants performed palpation to determine whether tissue was glandular or fatty tissue. Pubic hair was assessed by visual inspection.

Breast and pubic hair stages were assessed repeatedly from mean age 7 to 15.5 years. Assessment was completed approximately every six months for 6 years (starting at baseline) and then yearly for three more years at CCHMC (14 assessments total) and annually at KPNC (9 assessments total). Girls missing all pubertal assessments ($N = 3$) were not included. Repeated measures of breast and pubic hair data were subjected to nonlinear growth models in order to obtain measures of timing (i.e., age at the midpoint of puberty, Tanner stage 3 – higher scores indicate being older at Tanner 3, or later timing) and tempo (i.e., rate of development at the midpoint of puberty, Tanner stage 3 – higher scores indicate progressing through more stages per year, or faster tempo) following established procedures.[4] From these models, individuals' Bayes Empirical Estimates of timing and tempo were saved for use in hypothesis testing models.

Anxiety and depressive symptoms were assessed annually starting at baseline (through year 8) using the Behavioral Assessment System for Children, 2 (BASC-2).[34] The BASC-2

assesses a range of symptoms mapping onto clinical disorders for youth ages 2–25 years. We focused on the Anxiety and Depression subscales and utilized data from two time points: first (childhood) and last (adolescence) assessment for each individual. Generally, first assessment was at baseline (Year 1; Y1) and last assessment was at final administration of the BASC-2 (Year 8; Y8). However, Y2 and Y7 data were used if scores were missing at Y1 or Y8, respectively. Prior to Y6, primary caregivers reported on girls' symptoms. Starting at Y6, adolescents reported on their own symptomatology. Data were treated continuously, rather than using clinical cut-points, to capture the emergence of symptoms in this non-clinical sample.

Body mass index (BMI) at baseline was calculated as weight in kg/height in meters squared. For weight, we used a Tanita scale (www.tanita.com). For height, we used a mounted wall stadiometer. Weight was measured without shoes and in light clothing and rounded to the nearest 0.5 kg. Height was measured to the nearest 0.1 cm with the participant in stocking feet and head in the neutral position. BMI values were standardized for age and z-scores calculated, using methods and standard distributions as provided by the Centers for Disease Control and Prevention. BMI z-scores were treated continuously.

Race/ethnicity at baseline was reported by the caregiver and was categorized as Black, Latina, Asian American, and White following an hierarchical algorithm that made each race/ethnicity category mutually exclusive.[3,32,35] Girls were assigned using the criteria that Black race superseded other race/ethnicity designations and Latina superseded all others; all participants were uniquely defined using these criteria. Thus, biracial/multiracial girls were categorized based on this algorithm into mutually exclusive groups. An "Other" group (N=1) was excluded from analyses.

Income at baseline was reported by caregivers based on annual household income which was divided by number of people in the household. Given income differences between study regions, site was included as a covariate in models.

Analytic Strategy

Structural equation modeling (SEM) was employed to test hypotheses using Mplus software, Version 7.[36] We tested manifest variable models, wherein childhood anxiety/depressive symptoms predicted timing and tempo of puberty (breast and pubic hair modeled separately), which in turn predicted anxiety/depressive symptoms in adolescence (outcomes modeled separately). Family income and BMI, assessed at Y1, were included as covariates, regressed on timing, tempo, and anxiety/depressive symptoms in adolescence, and associated with childhood anxiety/depressive symptoms. Study site was a covariate in all models.

We fit an unconditional model wherein the means, variances, and path estimates were estimated freely for each race/ethnicity. We then fit a series of nested models to test for race/ethnic differences by constraining the means and variances of variables (measurement invariance) as well as path estimates across all groups. A decrement in model fit would indicate race/ethnic difference, in which case the unconditional model is reported.

Because outcome data were collected at Y7/Y8 and puberty was conceptualized as a predictor of these outcomes, we set timing and tempo scores to missing for individuals who had estimated timing at mid-point of puberty later than their Y7 assessment to preserve the integrity of the temporal sequence in the models. We excluded these individuals because their midpoint would have occurred after their outcome measures. T-tests showed that girls who were excluded due to late timing of breast development did not differ in anxiety, t(563) = .32, p = .75, or depressive symptoms, t(564) = 0.39, p = .70, at the last assessment from those who were retained. There were no differences in anxiety for those who were excluded due to late timing of pubic hair development, t(563) = 0.42, p = .68. However, girls excluded for later timing of pubic hair development had lower depressive symptoms than those included, t(564) = 2.07, p = .04.

Results

Descriptives.

Participants' ages ranged from 6–8.9 years at first assessment and 12.8–17.9 years at final assessment (Table 1). Girls were racially diverse: 224 (27.3%) Black, 123 (15.0%) Latina, 57 (6.9%) Asian American, and 418 (50.9%) White. Racial/ethnic distribution differed by site: KPNC 97 (21.9%) Black, 108 (24.3%) Latina, 52 (11.7%) Asian American, and 187 (42.1%) White; CCMHC 127 (33.6%) Black, 15 (4.0%) Latina, 5 (1.3%) Asian American, and 231 (61.1%) White. There were more Latina and Asian girls at KPNC, and more Black girls at CCMHC, reflecting the demographics of the regions. Breast and pubic hair stages, stratified by age and race/ethnicity, are presented in Supplemental Tables S1 and S2. Correlations among study variables are presented in Supplemental Table S3.

Race/Ethnic Difference Tests.

Nested models suggested race/ethnic differences in means, variances, and path estimates in models for depression and anxiety for breast and pubic hair development. Thus, parameter estimates from the fully unconstrained model are presented.

Breast development and depressive symptoms.

Controlling for covariates, earlier breast development predicted increases in depressive symptoms over time only among White girls ($\beta = -0.19$; $p<.01$; Figure 1). Among Asian girls, earlier breast development predicted decreases in depressive symptoms over time ($\beta = 0.24$; $p<.05$). Tempo of breast development was not associated with depressive symptoms in adolescence for any race/ethnic group.

Breast development and anxiety symptoms.

Controlling for covariates, earlier breast development predicted increases in anxiety for Latinas only ($\beta = -0.26$; $p<.05$; Figure 2). Tempo of breast development was not related to anxiety symptoms in adolescence for any race/ethnic group.

Pubic hair development and depressive symptoms.

Controlling for covariates, earlier pubic hair was not associated with depressive symptoms for any group (Figure 3). Among Asian girls, faster tempo predicted decreases in depressive symptoms over time ($\beta = -0.34$; $p<.05$).

Pubic hair development and anxiety symptoms.

Controlling for covariates, results were significant only among Latinas (Figure 4), such that later pubic hair development ($b = 0.24$; $p<.05$) and faster tempo of pubic hair development ($b = 0.26$; $p<.01$) were associated with increased anxiety over time.

Discussion

This is the first study to examine timing and tempo of breast and pubic hair development and associations with anxiety and depressive symptoms, measured in childhood and adolescence. Our sample was ethnically diverse and extends previous research by including Latinas and Asians. Findings revealed that earlier breast development put White girls at risk for increased depressive symptoms in adolescence, even when controlling for childhood depressive symptoms. This association was not significant for Black girls or Latinas, supporting our hypothesis that early-maturing White girls may be more vulnerable to depressive symptoms. However, earlier breast development was associated with increased anxiety symptoms among Latinas, but not other race/ethnic groups including White girls. For Asians, earlier breast development was associated with *lower* depressive symptoms in adolescence. These results add to a field where ethnic differences are rarely examined[30] and confirm that pubertal timing effects may be specific to certain race/ethnic groups.[16,17]

Findings for pubic hair were mixed. Contrary to expectations, later pubic hair development (rather than earlier) was associated with increased anxiety symptoms for Latinas. In contrast, faster tempo of pubic hair development was associated with significantly higher anxiety in this group. Scarce research has been conducted on timing and tempo of puberty among Latinas, and even less research has examined pubic hair. Further exploration with young Latinas to understand the implications of earlier and faster pubic hair development and related neuroendocrine processes is warranted.

Among Asian girls (the smallest group in our sample, N=57), findings were the most inconsistent with past literature. Later (rather than earlier) timing of breast development was associated with increased depressive symptoms, while faster pubic hair tempo was associated with lower (rather than higher) adolescent depressive symptoms. Our research and that of others demonstrates that Asian and White girls, on average, tend to experience breast development later than Black and Latina girls in the U.S..[3] Given that breast development is noticeable to others (as opposed to pubic hair), it is possible that Asian girls in the U.S. compare themselves to their non-Asian peers and experience heightened vulnerability to depression when they develop breasts later or more slowly, even if later development is biologically normative for their race/ethnic group. There may be a positive social (peer) response to experiencing earlier or faster development among Asians because it aligns them with their non-Asian counterparts, which may translate into less peer exclusion

and fewer mental health symptoms in adolescence. However, if this were true, then we would expect the same phenomenon to occur in White girls, who also mature later than Blacks and Latinas, which was not corroborated in our data. Because these anomalous findings have not been reported previously, replication is needed with larger Asian samples that allow for examination of Asian subgroups. Moreover, future research should identify whom girls compare themselves to when experiencing early or late pubertal development, and whether social contextual factors play a role in how girls cope with off-time development. This is discussed further below.

With the exception of anxiety among Latinas, faster pubertal tempo was not associated with mental health problems in our study, which is consistent with some studies[4,12,14] but differs from others.[6,13] Using a large community-based sample, Keenan et al.[13] found that both early-maturing African American and White girls were at higher risk for depressive symptoms, whereas our findings were significant only for Whites. Keenan also found that faster pubertal tempo was associated with depressive symptoms for both ethnic groups during childhood; however, consistent with our findings, this association did not persist into later adolescence. Study design and measurement differences may account for our divergent findings. In contrast to Keenan, we assessed pubertal stage by clinical exam (versus self-report). We also began assessing puberty and mental health at ages 6–8y because we were interested in the potential influence of prepubertal mental health on pubertal timing and tempo, whereas Keenan began assessment of puberty at 9y and depression at 10y. Finally, Keenan's study used combined self- and parent-report of the Child/Adolescent Symptoms Inventory-4th Edition to assess depressive symptoms, while we used the BASC-2.

Our findings should be considered in light of limitations. Some girls transitioned to Tanner stage 2 prior to baseline. Our analytic strategy accounted for this left censoring by centering the logistic growth function at Tanner stage 3 and setting the upper and lower asymptotes at stages 1 and 5, respectively. Thus, even if individuals were past stage 1 at Y1, the model projects backward to the individuals' prepubescent beginnings. Also, we switched from parent to adolescent report of mental health over the course of the study. Although adolescents may report more accurately on their own anxiety and depression, this change in reporters could explain lack of stability in symptomatology from childhood to adolescence. Like most studies, we could not account precisely for when Tanner stage transitions occurred given the intervals between visits, however, the model accounted for speed of transition and was able to estimate transitions. Finally, we lacked cultural, contextual and racial identity measures to better understand the differences observed across race/ethnic groups. Despite limitations, our study exhibits strengths including its longitudinal design with an ethnically-diverse sample, gold standard measures of puberty, and use of a clinically relevant tool with strong psychometric properties to assess internalizing symptoms.

Findings have implications for future research and intervention. Given that early breast development was a risk factor for mental health symptoms among White (depressive symptoms) and Latina (anxiety symptoms) adolescents, clinicians who work with school-aged children and young teens should regularly screen for mental health symptoms among early-maturing girls. Further research is needed, however, to determine why early pubertal timing presented less risk for some race/ethnic groups and even appeared to be protective in

some instances. It is possible that cultural (e.g., positive body image) or contextual (e.g., ethnically dense schools, neighborhoods) factors protect some early-maturing girls of color from experiencing negative outcomes. If so, these protective factors may provide clues for how to mitigate negative effects for other race/ethnic groups. Research examining neighborhood and peer processes shows that early puberty interacts with contextual factors to put girls of color at risk for problematic outcomes.[37,38] For example, White et al. found that early pubertal timing among Mexican-origin girls led to depressive symptoms among those who were living in neighborhoods with less Latino representation compared to ethnically dense Latino neighborhoods.[38] Similarly, Seaton and Carter found that early-maturing Black girls who perceived lower public regard for their race (i.e., the belief that the broader society views African Americans negatively) and who attended nonmajority Black schools reported more depressive symptoms, while those with higher public regard were less affected by early puberty.[39] Future research should delve further into how racial identity, self-perceptions of puberty and social context influences girls' experiences of puberty.[40]

Although our Asian group was small and findings require replication, this study represents the first to examine these associations among Asian Americans. Asian girls in this study came primarily from one site (KPNC) and were diverse in terms of their families' countries of origin, so there may be within-group variability that could not be tested given small cell sizes. Findings may not be generalizable to all Asian subgroups. Future studies of early puberty and social and emotional outcomes should be conducted within Asian subgroups, taking into account country of origin, generational status, ethnic identity, and cultural factors, to determine how experiences may differ among various groups.

In general, accurate pubertal information is critical for all girls to help them navigate this period of their life successfully. Opportunities exist to engage in robust pubertal education efforts within clinics, schools, and in on-line settings to mitigate negative outcomes. There is an urgent need for such efforts be culturally-grounded, better coordinated, and rigorously evaluated.[30] All girls, not just early maturers, would benefit from stronger empirically-based puberty education to promote positive experiences, better mental health, and overall well-being during the pubertal transition.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments:

This research was funded by the National Institutes of Health [grant numbers U01ES012801, U01ES019435, U01ES019453, U01ES12770, U01ES019457, P30ES006096, K01DA039288, and K12HD052163]

Abbreviations:

BMI	body mass index
SEM	Structural Equation Model

References

1. Copeland WE, Worthman CM, Shanahan L, Costello EJ, Angold A. Early pubertal timing and testosterone associated with higher levels of adolescent depression in girls. Journal of the American Academy of Child and Adolescent Psychiatry. 2019;58(12):1197–1206. [PubMed: 30768421]
2. Deardorff J, Hayward C, Wilson KA, Bryson S, Hammer LD, Agras S. Puberty and gender interact to predict social anxiety symptoms in early adolescence. J Adolesc Health. 2007;41(1):102–104. [PubMed: 17577541]
3. Biro FM, Greenspan LC, Galvez MP, et al. Onset of breast development in a longitudinal cohort. Pediatrics. 2013;132(6):1019–1027. [PubMed: 24190685]
4. Marceau K, Ram N, Houts RM, Grimm KJ, Susman EJ. Individual differences in boys' and girls' timing and tempo of puberty: modeling development with nonlinear growth models. Dev Psychol. 2011;47(5):1389–1409. [PubMed: 21639623]
5. Caspi A, Moffitt T. Individual differences are accentuated during periods of social change: The sample case of girls at puberty. J Pers Soc Psychol. 1991;61(1):157–168. [PubMed: 1890586]
6. Ge X, Brody GH, Conger RD, Simons RL, Murry VM. Contextual amplification of pubertal transition effects on deviant peer affiliation and externalizing behavior among African American children. Dev Psychol. 2002;38(1):42–54. [PubMed: 11806701]
7. Petersen AC, Taylor B. The biological approach to adolescence: Biological change and psychological adaptation. In: Adelson J, ed. Handbook of adolescent psychology. New York: Wiley; 1980:117–155.
8. Graber JA. Pubertal timing and the development of psychopathology in adolescence and beyond. Horm Behav. 2013;64(2):262–269. [PubMed: 23998670]
9. Copeland WE, Shanahan L, Miller S, Costello EJ, Angold A, Maughan B. Outcomes of early pubertal timing in young women: A prospective population-based study. Am J Psychiatry. 2010;167(10):1218–1225. [PubMed: 20478880]
10. Mendle J, Ryan RM, McKone KMP. Age at menarche, depression, and antisocial behavior in adulthood. Pediatrics. 2017;141(1).
11. Beltz AM. Gendered mechanisms underlie the relation between pubertal timing and adult depressive symptoms. J Adolesc Health. 2018;62(6):722–728. [PubMed: 29784116]
12. Beltz AM, Corley RP, Bricker JB, Wadsworth SJ, Berenbaum SA. Modeling pubertal timing and tempo and examining links to behavior problems. Dev Psychol. 2014;50(12):2715–2726. [PubMed: 25437757]
13. Keenan K, Culbert KM, Grimm KJ, Hipwell AE, Stepp SD. Timing and tempo: Exploring the complex association between pubertal development and depression in African American and European American girls. J Abnorm Psychol. 2014;123(4):725–736. [PubMed: 25314262]
14. Mendle J, Harden KP, Brooks-Gunn J, Graber JA. Development's tortoise and hare: pubertal timing, pubertal tempo, and depressive symptoms in boys and girls. Dev Psychol. 2010;46(5):1341–1353. [PubMed: 20822243]
15. Ge X, Kim IJ, Brody GH, et al. It's about timing and change: Pubertal transition effects on symptoms of major depression among African American youths. Dev Psychol. 2003;39(3):430. [PubMed: 12760513]
16. Hamlat EJ, Stange JP, Abramson LY, Alloy LB. Early pubertal timing as a vulnerability to depression symptoms: differential effects of race and sex. J Abnorm Child Psychol. 2014;42(4):527–538. [PubMed: 24014162]
17. Carter R, Caldwell CH, Matusko N, Antonucci T, Jackson JS. Ethnicity, perceived pubertal timing, externalizing behaviors, and depressive symptoms among black adolescent girls. J Youth Adolesc. 2011;40(10):1394–1406. [PubMed: 21088874]
18. Hayward C, Gotlib IH, Schraedley PK, Litt IF. Ethnic differences in the association between pubertal status and symptoms of depression in adolescent girls. J Adolesc Health. 1999;25(2):143–149. [PubMed: 10447041]
19. Franko DL, Striegel-Moore RH. The role of body dissatisfaction as a risk factor for depression in adolescent girls: are the differences Black and White? Journal of Psychosomatic Research. 2002;53(5):975–983. [PubMed: 12445587]

20. Deardorff J, Abrams B, Ekwaru JP, Rehkopf DH. Socioeconomic status and age at menarche: an examination of multiple indicators in an ethnically diverse cohort. Ann Epidemiol. 2014;24(10):727–733. [PubMed: 25108688]
21. Lee JM, Appugliese D, Kaciroti N, Corwyn RF, Bradley RH, Lumeng JC. Weight Status in Young Girls and the Onset of Puberty. Pediatrics. 2007;119(3):624–630.
22. Shanahan L, Copeland WE, Costello EJ, Angold A. Child-, adolescent- and young adult-onset depressions: Differential risk factors in development? Psychol Med 2011;41(11):2265–2274. [PubMed: 21557889]
23. Sjoberg RL, Nilsson KW, Leppert J. Obesity, shame, and depression in school-aged children: a population-based study. Pediatrics. 2005;116(3):e389–e392. [PubMed: 16140683]
24. Hillman JB, Dorn LD, Huang B. Association of anxiety and depressive symptoms and adiposity among adolescent females using Dual Energy X-ray Absorptiometry. Clin Pediatr. 2010;49(7):671–677.
25. Hankin BL. Depression from childhood through adolescence: Risk mechanisms across multiple systems and levels of analysis. Curr Opin Psychol. 2015;4:13–20. [PubMed: 25692174]
26. Gaffrey MS, Tillman R, Barch DM, Luby JL. Continuity and stability of preschool depression from childhood through adolescence and following the onset of puberty. Compr Psychiatry. 2018;86:39–46. [PubMed: 30077052]
27. Costello EJ, Mustillo S, Erkanli A, Keeler G, Angold A. Prevalence and development of psychiatric disorders in childhood and adolescence. Arch Gen Psychiatry. 2003;60(8):837–844. [PubMed: 12912767]
28. Bornstein MH, Hahn CS, Haynes OM. Social competence, externalizing, and internalizing behavioral adjustment from early childhood through early adolescence: Developmental cascades. Dev Psychopathol. 2010;22(4):717–735. [PubMed: 20883577]
29. Knight JA, Kehm RD, Schwartz L, et al. Pre-Pubertal Internalizing Symptoms and Timing of Puberty Onset in Girls. Am J Epidemiol. 2020.
30. Deardorff J, Hoyt LT, Carter R, Shirtcliff EA. Next steps in puberty research: Broadening the lens toward understudied populations. J Res Adolesc. 2019;29(1):133–154. [PubMed: 30869847]
31. Hiatt RA, Haslam SZ, Osuch J. The Breast Cancer and the Environment Research Centers: transdisciplinary research on the role of the environment in breast cancer etiology. Environ Health Perspect. 2009;117(12):1814–1822. [PubMed: 20049199]
32. Biro FM, Galvez MP, Greenspan LC, et al. Pubertal assessment method and baseline characteristics in a mixed longitudinal study of girls. Pediatrics. 2010;126(3):e583–590. [PubMed: 20696727]
33. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. Arch Dis Child. 1969;44(235):291–303. [PubMed: 5785179]
34. Reynolds CR, Kamphaus RW. BASC-2: Behavior Assessment System for Children: Manual. Circle Pines, MN: AGS Pub.; 2004.
35. Hiatt RA, Stewart SL, Hoeft KS, et al. Childhood socioeconomic position and pubertal onset in a cohort of multiethnic girls: implications for breast cancer. Cancer Epidemiol Biomarkers Prev. 2017;26(12):1714–1721. [PubMed: 28939588]
36. Muthén LK, Muthén BO. Mplus User's Guide. Seventh Edition. Los Angeles, CA: Muthén & Muthén; 1998–2012.
37. Carter R, Seaton EK, Rivas-Drake D. Racial identity in the context of pubertal development: Implications for adjustment. Dev Psychol. 2017;53(11):2170. [PubMed: 29094978]
38. White RMB, Deardorff J, Gonzales NA. Contextual amplification or attenuation of pubertal timing effects on depressive symptoms among Mexican American girls. J Adolesc Health. 2012;50(6):565–571. [PubMed: 22626482]
39. Seaton EK, Carter R. Pubertal timing, racial identity, neighborhood, and school context among Black adolescent females. Cultural Diversity and Ethnic Minority Psychology. 2017;24:40–50. [PubMed: 28493734]
40. Carter R, Blazek JL, Kwesele C. Perceptions of pubertal timing relative to peers: Comparison targets and social contexts of comparison. Cultural Diversity & Ethnic Minority Psychology. 2020;26(2):221–228. [PubMed: 31021141]

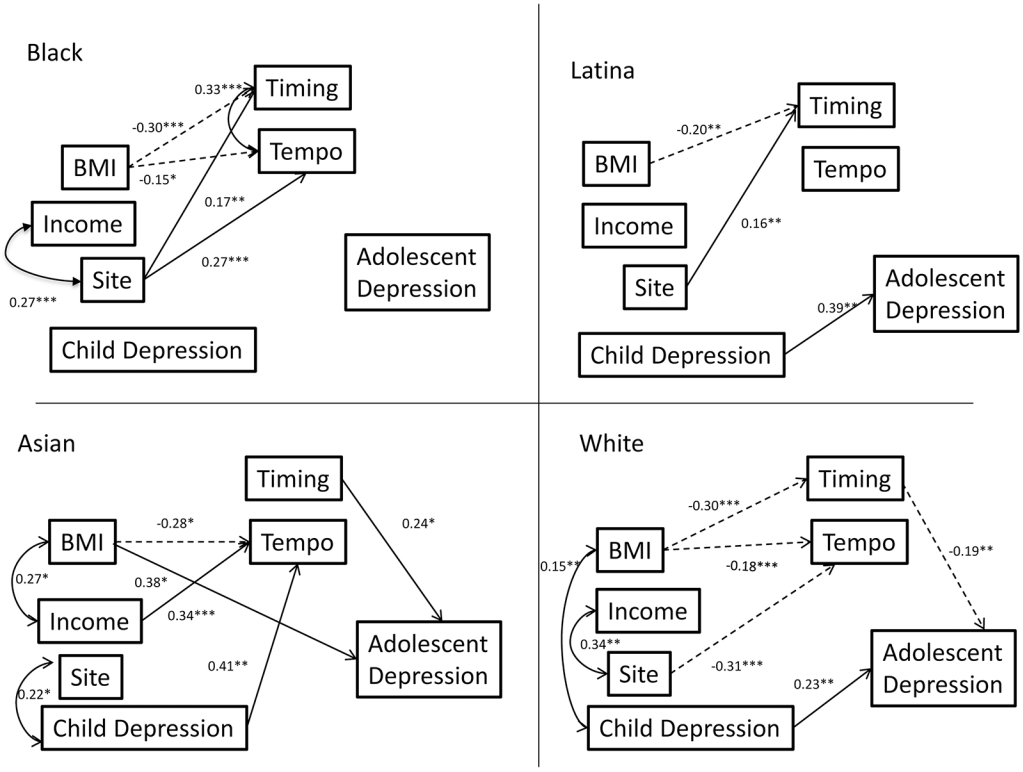

Figure 1. Results from models examining covariates, timing and tempo of breast development, and adolescent depressive symptoms with standardized beta coefficients. Solid lines indicate significant positive relationships, dashed lines indicate significant negative relationships.

*p<.05; **p<.01; ***p<.001.

Chi-square(4) = 1.54, p = .82; RMSEA = .00; CFI = 1.0; TLI = 1.18, AIC = 13968.87, BIC = 14609.66, SRMR = .01

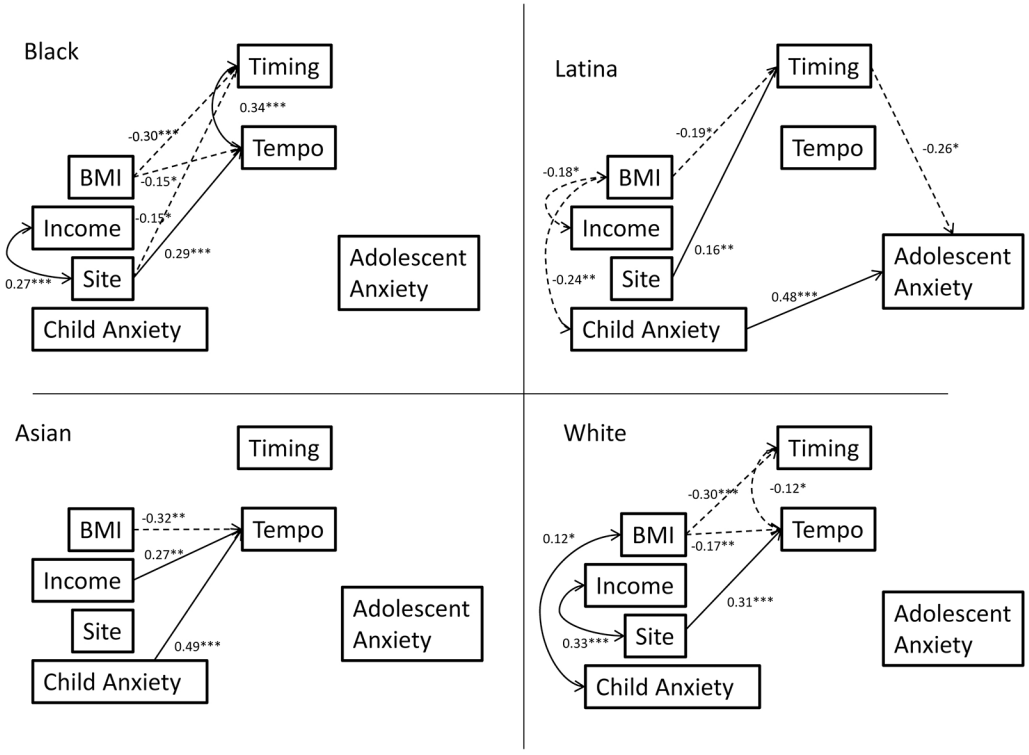

Figure 2. Results from models examining covariates, timing and tempo of breast development, and adolescent anxiety symptoms with standardized beta coefficients. Solid lines indicate significant positive relationships, dashed lines indicate significant negative relationships.

*p<.05; **p<.01; ***p<.001.

Chi-square(4) = 5.37, p = .25; RMSEA = .04; CFI = .99; TLI = .90, AIC = 14558.69, BIC = 15199.49, SRMR = .02

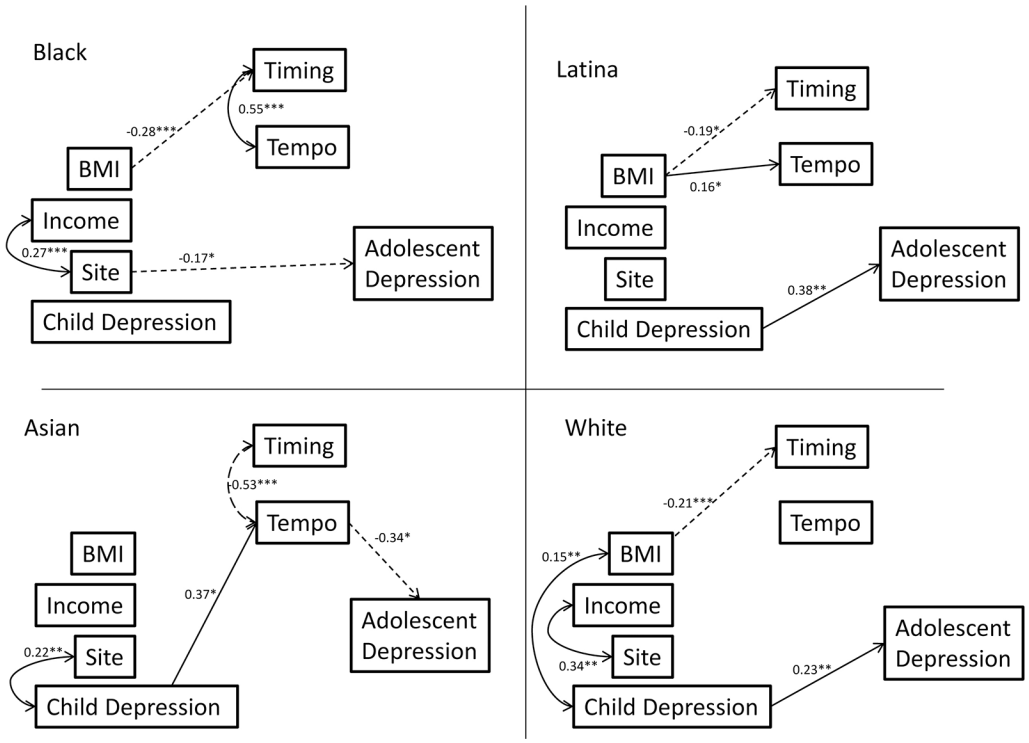

Figure 3. Results from models examining covariates, timing and tempo of pubic hair development, and adolescent depressive symptoms with standardized beta coefficients. Solid lines indicate significant positive relationships, dashed lines indicate significant negative relationships.

*p<.05; **p<.01; ***p<.001.

Chi-square(4) = 1.29, p = .86; RMSEA = .00; CFI = 1.0; TLI = 1.31, AIC = 14793.20, BIC = 15433.99, SRMR = .01

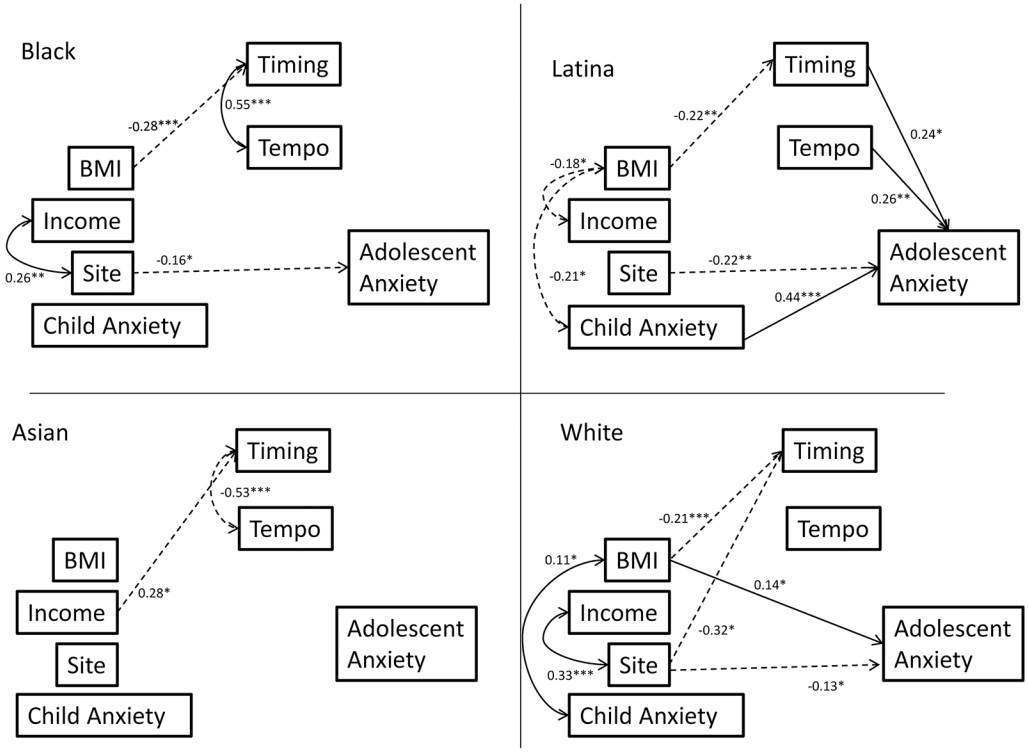

Figure 4. Results from models examining covariates, timing and tempo of pubic hair development, and adolescent anxiety symptoms with standardized beta coefficients. Solid lines indicate significant positive relationships, dashed lines indicate significant negative relationships.

*p<.05; **p<.01; ***p<.001.

Chi-square(4) = 6.47, p = .17; RMSEA = .06; CFI = .98; TLI = .73, AIC = 15386.73, BIC = 16027.53, SRMR = .01.

Table 1.

Descriptive statistics for key study variables by race/ethnicity.

	Total N = 822	Black N = 224	Latina N = 123	Asian N = 57	White N = 418	Ethnicity differences
Age at Baseline (m, SD)	7.26 (0.54)	7.24 (0.57)	7.31 (0.51)	7.38 (0.47)	7.24 (0.53)	F(3) = 1.68
BMI z scores (m, SD)	17.03 (2.88)	17.66 (3.26) [a]	18.06 (3.68) [a]	15.8 (1.58) [a]	16.56 (2.31)	F(3) = 12.30***
Family Income						F(3) = 62.47***
$12k–<$25K	181 (24.4%)	93 (49.7%)	48 (40.7%)	4 (7.4%)	36 (9.4%)	
$25K–<$50K	136 (18.4%)	36 (19.3%)	28 (23.7 %)	10 (18.5%)	62 (16.2%)	
$50K–<$75K	125 (16.9%)	24 (12.8%)	16 (13.6%)	7 (13%)	78 (20.4%)	
$75K–<$100K	284 (38.3%)	29 (15.5%)	25 (21.2%)	31 (57.4%)	199 (52.1%)	
>$100K	15 (2%)	5 (2.7%)	1 (.8%)	2 (3.7%)	7 (1.8%)	
Breast Development						
Timing (m, SD)	11.48 (0.89)	10.94 (0.89) [a]	11.56 (0.16) [a]	11.63 (0.13)	11.73 (0.80)	F(3) = 43.54***
Tempo (m, SD)	0.83 (0.17)	0.79 (0.18) [a]	0.87 (0.82) [a]	0.86 (0.13)	0.83 (0.17)	F(3) = 7.58***
Pubic Hair Development						
Timing (m, SD)	11.59 (1.17)	10.77 (1.15) [a]	11.77 (1.00)	12.43 (1.01)	11.88 (1.00)	F(3) = 66.80***
Tempo (m, SD)	0.88 (0.25)	0.81 (0.30) [a]	0.93 (0.22)	0.82 (0.26) [a]	0.91 (0.22)	F(3) = 9.94***
Anxiety symptoms						
Baseline (m, SD)	49.92 (9.83)	48.82 (10.60)	53.22 (11.11) [a]	50.55 (10.78)	49.46 (8.75)	F(3) = 4.88**
Last Assessment (m, SD)	48.37 (10.21)	49.27 (10.50)	48.15 (10.11)	48.36 (10.42)	47.97 (10.04)	F(3) = 0.59
Depression symptoms						
Baseline (m, SD)	49.60 (8.65)	48.43 (9.11)	52.34 (10.64) [a]	49.49 (8.46)	49.43 (7.70)	F(3) = 4.51**
Last Assessment (m, SD)	44.73 (7.51)	46.45 (9.48) [a]	45.16 (7.69)	43.10 (4.96)	43.87 (6.22)	F(3) = 5.10**

Family Income: There was also an option for <12K at the lower end of the scale; however, no participants chose this option.

Breast Development: Timing is centered at Tanner stage 3, the midpoint of pubertal development.

Anxiety and depressive symptoms were assessed using the BASC-2: Behavioral Assessment System for Children, Second Edition; raw scores presented.

Ethnicity differences were tested using PROC GLM.

[a] indicates a significant difference in the mean level compared to the White (reference) group. For family income (measured conitinuously), Hispanic and Black family income differed from White family income. These effects persisted when adjusted for family size.