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Review article

Transitions in Body and Behavior: A Meta-Analytic Study on the Relationship Between Pubertal Development and Adolescent Sexual Behavior



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A B S T R A C T

The present meta-analysis studies the relations of pubertal timing and status with sexual behavior and sexual risk behavior among youth aged 10.5–22.4 years. We included biological sex, age, and ethnicity as potential moderators. Four databases were searched for studies (published between 1980 and 2012) on the relation between pubertal timing or status and sexual behavior. The outcomes were (1) sexual intercourse; (2) combined sexual behavior; and (3) risky sexual behavior. Earlier pubertal timing or more advanced pubertal status was related to earlier and more sexual behavior, and earlier pubertal timing was related to more risky sexual behavior. Further, the links between (1) pubertal status and combined sexual behavior and (2) pubertal timing and sexual intercourse status, combined sexual behavior, and risky sexual behavior were stronger for girls than boys. Most links between pubertal status, timing, and sexual behavior and sexual risk behavior were stronger for younger adolescents. Moderation by ethnicity did not yield consistent results. There was significant variation in results among studies that was not fully explained by differences in biological sex, age, and ethnicity. Future research is needed to identify moderators that explain the variation in effects and to design sexual health interventions for young adolescents.

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IMPLICATIONS AND CONTRIBUTION

Research comparing the effects of pubertal status and timing across different sexual outcomes is lacking. This meta-analysis gives a systematic overview of research examining these links. Early developing adolescents engage in earlier and more (risky) sexual behavior—these effects were stronger for girls.

Recent perspectives on adolescent development view sexual development as a normative task of this life phase [1]. However, the early initiation of sexual behavior has also been linked with increased risk for unwanted pregnancies, sexually transmitted infections (STIs), and depression [2,3]. Given the obvious link between pubertal development and sexual reproduction

capacity, the onset of puberty has been associated with the initiation of sexual desires and behavior. It is less clear to what degree pubertal development is related to sexual activity and whether early pubertal development is particularly problematic for the development of risky sexual behavior.

Although qualitative reviews and a large body of quantitative work have shown support for the relationship between pubertal timing and sexual development, no meta-analytic review exists that quantifies the magnitude of this relationship or that explains variation in results across studies. Moreover, although most studies

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focus on whether (vaginal) sexual intercourse has occurred, sexual development consists of a broad range of physical behaviors besides intercourse including activities such as kissing, petting, and oral sex. The primary objective of the present meta-analysis is to examine and quantify the association between pubertal status and timing with nonrisky and risky coital and noncoital sexual behaviors.

Not only do studies vary in terms of the sexual behaviors examined, but there is also substantial variation in how pubertal status and timing are assessed. Pubertal status is most often measured using (1) Tanner scale ratings made by a trained professional of adolescent pubic hair development (males and females), and breast development (females), or penis and testicular development (males); (2) adolescent self-report of these characteristics using photographs or line drawings; or (3) questionnaire measures of pubertal characteristics (growth spurt, acne, pubic hair, menarche, and voice change). Pubertal timing is often assessed using (1) adolescent self-report of age at growth spurt, age at the first ejaculation, or voice change (males), or age at menarche (females); (2) age-adjusted measures of pubertal status (stage-normative); or (3) adolescent self-perceptions of whether their pubertal development is early, on time, or late (peer-normative). There is a moderate consistency across these different methods, however, the degree to which the adolescents rate themselves as more or less developed than their peers might not just reflect their physical development but might also reflect the degree to which they feel psychologically or behaviorally more mature [4–6]. Therefore, the second objective is to compare whether the magnitude of the association between pubertal development and sexual behavior and risky sexual behaviors depends on how pubertal development was assessed.

Drawing from a developmental systems approach which acknowledges that development in one domain (such as sexual development) does not occur independent from other domains (such as the social domain), we also examine whether the relation between pubertal and sexual development is also associated with individual differences in age, sex, or ethnic background. Previous research has shown that boys and girls show different patterns of pubertal development [7] and these differences are also suggested to relate to differences in social status and well-being [2,3,8–10]. Therefore, in the present meta-analysis, we examine whether the effects of pubertal status and timing on sexual behavior and sexual risk behavior are different for boys and girls. Further, as adolescents move from a parent- to a peer-focused context during adolescence [11], they are faced with more opportunities to engage in intimate and sexual behavior. Therefore, we also examine whether the effects of puberty on adolescents' sexual development vary depending on the adolescents' age. The link between pubertal development and sexual behavior might be stronger at younger ages, particularly in risky sexual behavior, because younger adolescents may not have the social and cognitive skills to engage in safer sexual behavior. However, stronger effects might also be found in older adolescents because they are less restricted by parents. Finally, research has shown several inconsistent racial and ethnic differences in pubertal [7,12] and sexual development [13,14]. Therefore, we examine whether these links are moderated by the ethnic background of adolescents.

The present study

The primary objective of the present meta-analysis is to examine and quantify the association between pubertal status and timing with sexual behavior and risky sexual behavior. With

this meta-analysis, we answer the following questions: Within the research literature published between 1980 and 2012, are pubertal timing and status related to sexual behavior and sexual risk behavior? If related, is this relation moderated by the way pubertal development is assessed (pubertal status or pubertal timing and stage-normative or peer-normative), or the age when pubertal development was assessed, sex, and ethnicity?

Although, initially our intention was to study differential effects of pubertal development on a range of sexual behaviors, most studies have examined either only sexual intercourse or have lumped together several sexual behaviors. Therefore, we have made the distinction between three sexual behavior categories as follows: (1) sexual intercourse status (had sexual intercourse or not) and age at the first sexual intercourse; (2) combined sexual behavior (studies that include sexual intercourse *and* noncoital sexual behaviors, in their combined measure of sexual behavior); and (3) sexual risk behaviors such as a combined measure of sexual risk behavior, unwanted pregnancy, contracting STIs or human immunodeficiency virus (HIV), noncondom/contraception use, and drug/alcohol use during sex.

Methods

Sample of studies

We searched four electronic databases (Scopus, MEDLINE, Web of Science, and PsycINFO) using variations and Boolean connectors of the key terms such as pubertal development, menarche, spermarche, spermatogenesis, breast development, adrenarche, gonadarche, oogenesis, adolescents, and sexual behavior. To supplement these searches, we searched reference lists of reviewed studies and contacted key authors in the field. To be included in the meta-analysis, studies had to be: (1) published in a peer-reviewed, English language journal; (2) empirically examined and reported the relation between pubertal development and adolescents' (risky) sexual behaviors; (3) published between January 1980 and December 2012; and (4) must include adolescents with a mean age ≤ 24 years.

Information extracted from each study included: (1) age, sex, and/or ethnicity of sample; (2) pubertal development measure(s); (3) sexual behavior measure(s); and (4) effect size(s). Thirty percent of the studies were independently coded by two coders (including the first author, L.B.). Intrarater reliability was good (correlations, .68–.99). Any inconsistencies in the coding were checked by another independent coder and reconciled. Data were entered into SPSS 20.0 (SPSS Inc., Chicago, IL) and analyzed with the SPSS macro [15].

First, effect sizes were calculated or recoded using the Pearson product-moment correlation (r) such that higher r values indicated a stronger relation between pubertal status, or timing, and (risky) sexual behavior. If a study reported results on group differences (t , F , or odds/risk ratio), their results were converted to r [15]. Second, all r values were converted to the Fisher z (zr). Third, for each effect size, we calculated a relative weight for zr , taking into account the sample size. To yield an interpretable overall effect size, the weighted mean effect size was then converted back to r (ESr).

Pubertal development

Pubertal status. Several studies included self-report occurrences of physical pubertal events (e.g., the first spontaneous nocturnal emission, menarche, Tanner drawings [16,17], Pubertal Development Scale (PDS) [18], Index of Adolescent Development, or

ratings of physical maturity by coders [19] as markers of adolescents' pubertal status. Some studies ($k = 5$) reported using a pubertal status measure, in a sample of same-aged participants. Using a measure of pubertal status among same-aged participants does not just assess how advanced someone is in their pubertal development, rather it creates a measure of pubertal timing by assessing how far advanced someone is in their pubertal development compared with their same-aged peers. Therefore, these studies were coded as using a pubertal timing measure.

Pubertal timing. Most studies used one of the following three ways to assess pubertal timing: (1) a self-report measure of adolescents' perceptions of pubertal timing (i.e., "Is your pubertal development early or late compared to peers?"); (2) age at menarche; or (3) the PDS total score adjusted for age (that is, the total score was converted to a z score within each age and gender group). Those studies that reported a comparison between early and on time ($k = 3$), or on time and late ($k = 3$) were also included and recoded such that a positive relation would indicate a stronger effect for the early (vs. on time) or the on time (vs. late) group. We classified studies as using a "stage-normative" measure of pubertal timing on the basis of self-reported pubertal status ($k = 38$), when for example, the PDS or physical ratings of adolescent's appearance was used. We classified other studies as using a "peer-normative perceived" measure of pubertal timing when youth reported on his or her perception of their own pubertal timing in comparison with peers ($k = 26$). In our analyses, we tested whether the links to sexual behavior and sexual risk behavior were moderated by the measure of pubertal timing (stage-normative vs. peer-normative). We analyzed studies using age at menarche separately from the other studies.

Sexual development

Sexual intercourse. All studies used a self-report measure of either age at the first sexual intercourse or sexual intercourse status. Most studies did not define sexual intercourse and if they did, they defined it as vaginal sexual intercourse. For the inclusion of studies under the category of sexual intercourse, they either had to use the term "sexual intercourse" or explain sexual intercourse as vaginal sexual intercourse. The studies that did not include sexual intercourse in their sexual behavior measure, or combined that with other sexual behaviors, were included under "combined sexual behavior."

Combined sexual behavior. Several self-report measures were used to assess behaviors other than, or in addition to, sexual intercourse. Only six studies used a combined sexual behavior that did not include sexual intercourse. These studies used measures on self-reports of noncoital sexual behavior such as petting, kissing, caressing, and oral sex. There were 30 studies that used a combined measure of noncoital sexual behaviors and coital sexual behaviors. We grouped these two categories together (purely noncoital and combined coital and noncoital) into the combined sexual behavior measure. To explore whether the inclusion of purely noncoital ($k = 6$) and combined coital and noncoital measures ($k = 30$) made a difference in relation to pubertal development, we tested the moderation of these two forms of measuring combined sexual behavior. There was only one study [20] that reported on the link between pubertal development and individual (noncoital) sexual behavior (e.g., kissing and caressing), and therefore, we were unable to do separate analyses on specific behaviors.

Risky sexual behavior. Measures of risky sexual behavior included questions about unwanted pregnancy, contracting

STIs/HIV, noncondom/contraception use, and drug/alcohol use during sex. Some studies included a measure of risky sexual behavior that comprised multiple risky behaviors. The number of studies examining different categories of risky sexual behavior measures was too small to analyze separately.

Moderators

Age. For age, we included the mean age of the sample. If not reported, we took the median age of the reported range of ages.

Sex. Studies were classified according to the sex composition of the sample: (1) boys; (2) girls; and (3) mixed. In our moderator analyses, we used dummy variables (boys vs. girls; mixed vs. girls; and mixed vs. boys) to compare the different samples.

Ethnicity. Unfortunately, there were only two studies that reported results separately for ethnic groups other than black participants. One study had results reported separately for white and Latina girls [13], the other only included Hispanic girls in their study [21]. Most studies include a wide range of ethnic backgrounds in their sample, with the most predominant ethnic groups being white or black/African American. Further, some studies reported results separately for white and black/African American adolescents. Therefore, for the present study, we were only able to examine differences in the associations between pubertal development and sexual behavior and sexual risk behavior between black or white adolescents. Thus, for ethnicity, we included the percentage of "black" adolescents in the sample if this was reported.¹ If, in a study, it was reported that a sample was 100% white, this was coded as 0% black participants. Enough studies were found to examine four relations as follows: pubertal status and pubertal timing with and sexual intercourse status; pubertal timing with combined sexual behavior; and age at menarche with age at sexual intercourse.

Data analyses

To examine the heterogeneity of effect sizes across studies, we assessed the Q statistic. This statistic indicates the variability across effect sizes that may be explained by other sources and indicates the need to examine moderators, if this statistic is significant [15]. We analyzed the data using fixed effects models and random effects models. Because the present meta-analysis includes small samples of effect sizes, we only report the fixed effects model results.² We examined sex, age, and ethnicity of the sample, stage-normative versus peer-normative measure of pubertal timing, and purely noncoital combined sexual behavior versus combined sexual behaviors that included coitus as potential moderators in the relation between pubertal status or timing and (risky) sexual behavior. The moderation analyses yielded β values those when significant indicate an interaction between the moderator and predictor (pubertal status or timing) in their effect on the sexual behavior outcomes.

Results

Description of studies: overview of included studies

Initially, 70 studies were found. In total, 50 independent studies met the inclusion criteria, with a total of 112 effect sizes. [Table 1](#)

¹ For the purpose of this meta-analysis, samples with black or African American adolescents are categorized as "black."

² Results of the random effects models are available from the corresponding author on request.

Table 1
Included studies and characteristics

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r
Sexual intercourse								
(1) Arim et al., 2011 [22]	Pubertal timing relative to peers on the basis of PDS	Intercourse status	(1) Boys	13	Canada	—	3,700	.03
(2) Benson et al., 1995 [23]	Timing of age at menarche or the first semen release	Virginity loss (yes/no)	(2) Girls 50% Boys; 50% Girls	13	U.S.A.	33% black 45% Hispanic 27% white	3,564 307	.27 .32
Bingham et al., 1990 [24]	Age at menarche	Age at the first sexual intercourse	Girls	17	U.S.A.	—	1,717	.17
(1) Brown et al., 2006 [25]	Pubertal timing relative to peers	Sexual intercourse status (yes/no) at follow-up (2 years later)	50% Boys; 50% Girls	13.7	U.S.A.	(1) 100% black	526	.13
(2) Campbell et al., 2005 [26]	Pubertal status on the basis of secondary sexual characteristics, the first erection, and first spontaneous nocturnal emission	Intercourse status	Boys	15	Zimbabwe	(2) 100% white 100% black	491 437	.06 .09
(1) Cavanagh, 2004 [13]	Age at menarche	Sexual intercourse status	Girls	13.88	U.S.A.	(1) 100% white	882	.20
(2) (1) Crockett et al., 1996 [27]	Pubertal timing relative to peers of the same age and gender	Timing of the first intercourse (early, middle, or late)	(1) Girls	16.5	U.S.A.	(2) 100% Latina —	149 166	.40 .06
(2) Deardorff et al., 2005 [28]	Age at menarche	Age at the first sexual intercourse	(2) Boys Girls	20.5	U.S.A.	13.8% black 31.4% Latina 28.7% Non-Hispanic white 23.9% Native 2.0% other	123 666	.04 .27
(1) Deppen et al., 2012 [29]	(1) Perception of pubertal timing (on time vs. early) on time is reference group	Sexual intercourse before the age of 16 years	Girls	18	Switzerland	18.1% parental non-Swiss origin	890	.20
(2)	(2) Perception of pubertal timing (on time vs. late) on time is reference group					17.4% parental non-Swiss origin	778	.31
Durant et al., 1990 [21]	Age at menarche	Engaging in premarital coitus	Girls	17	U.S.A.	100% Hispanic	202	.25
Edgardh, 2000 [30]	Menarche ≤11 years	Coitarche <15 years; coitarche >15 years	Girls	17	Sweden	—	712	.21
Edgardh, 2002 [31]	Pubertal timing assessed with early puberty (the first ejaculation before the age of 13 years)	Intercourse status	Boys	17	Sweden	13% Immigrant background	647	.19
Felson and Haynie, 2002 [32]	Pubertal status assessed with PDS items on pubic hair; facial hair; and voice changes. Items were summed.	Sexual intercourse (yes/no)	Boys	14.1	U.S.A.	54% white	5,700	.20
Gaudineau et al., 2010 [33]	Early menarche (before the age of 11 years)	Sexual intercourse before the age of 5 years	Girls	15	France	—	1,072	.20
Johnson and Tyler, 2007 [34]	Pubertal status assessed with status question for boys and menarche onset question for girls	Age at the first sexual intercourse	52% Boys; 48% Girls	12.59	U.S.A.	—	2,494	.11

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Table 1
Continued

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r
Kahn et al., 2002 [35]	Age at menarche	Age at the first sexual intercourse	Girls	20.4	U.S.A.	59% white 12% black 13% Hispanic 9% Asian 7% other	504	.16
Kim and Smith, 1999 [36]	Age at menarche	Age at the first sexual intercourse	Girls	19.5	U.K.	—	228	.34
(1) Khurana et al., 2012 [37]	Pubertal status assessed with Tanner drawings (boys, genitals and body hair; girls, breast and pubic hair)	(1) Intercourse status	48% Boys; 52% Girls	13.4	U.S.A.	55% Non-Hispanic white 28% Non-Hispanic black 9% Hispanic	347	.26
(2)		(2) Intercourse status 1 year later						.26
Koo et al., 2012 [38]	Pubertal status (boys, questions about body and voice change; girls, questions about breast development and body hair).	Intercourse status	45.1% Boys; 54.9% Girls	10.5	U.S.A.	99% African-American	408	.26
(1) Kuzman et al., 2007 [39]	(1) Age at menarche; on time compared to early	Sexual intercourse before the age of 16 years	Girls	15.5	Croatia	—	656	.19
(2)	(2) Age at menarche; Late compared to early						284	.31
(1) Kvaalem et al., 2011 [40]	Pubertal timing relative to peers at wave 1	Coital onset at wave 2 (2 years later)	(1) Boys	14	Norway	—	1,246	.09
(2)			(2) Girls			—	1,343	.04
(3)	Pubertal timing relative to peers at wave 2	Coital onset at wave 3 (5 years later)	(3) Boys	15.6		—	598	.03
(4)			(4) Girls			—	662	.04
(1) Lam et al., 2002 [20]	(1) Age at the first emission (first conscious ejaculation)	Sexual intercourse (yes/no)	Boys	16	Hong Kong	—	1,905	.12
(2)	(2) Age at menarche		Girls				1,907	.06
(1) Meschke et al., 2000 [41]	(1) Age at menarche	Age at the first sexual intercourse (age <16 years; age ≥16 years; inexperienced)	Girls	16.5	U.S.A.	100% white	268	.28
(2)	(2) Age at growth spurt		Boys	16.5			157	.12
(1) Michaud et al., 2006 [42]	(1) Pubertal timing relative to peers; early versus average	Sexually active	Girls	18	Switzerland	—	2,771	.18
(2)	(2) Pubertal timing relative to peers; late versus average						2,314	.13
(3)	(3) Pubertal timing relative to peers; early versus on time		Boys				3,359	.16
(4)	(4) Pubertal timing; relative to peers; Late versus on time						3,018	.15
Miller et al., 1997 [43]	Age at menarche	Age at the first sexual intercourse	Girls	20.5	U.S.A.	28.7% black	386	.06
Neberich et al., 2010 [44]	Age at menarche	Age at the first sexual intercourse	Girls	21.4	Germany	—	381	.17
(1) Ostovic and Sabini, 2005 [45]	Pubertal timing assessed with ages at several pubertal development events	Intercourse status	(1) Girls	21.8	U.S.A.	58.8% white 27% Asian or Asian-Indian 4.3% black 3.2% Hispanic 6.7% other	141	.06
(2)		(2) Boys		22.4			124	.12

Table 1
Continued

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r	
Part et al., 2011 [46]	Pubertal timing assessed with ages at menarche and spermarche	Intercourse status	46.9% Boys; 53.1% Girls	15.5	Estonia	—	959	.17	
(1) Phinney et al., 1990 [47]	Age at menarche	Age at the first sexual intercourse	Girls	17	U.S.A.	(1) 100% black	581	.29	
(2) Rosenthal et al., 2001 [48]	Age at menarche	Age at initial sexual intercourse	Girls	14.5	U.S.A.	(2) 100% nonblack 78% black 22% white	1,253	.17	
(1) Rosenthal et al., 1999 [49]	Physical development timing (less or about as mature as peers vs. more mature than peers)	Timing of sexual intercourse (early or late initiator)	(1) Boys	16.6	Australia	—	94	.20	
(2) Spencer et al., 2002 [50]	Pubertal timing assessed with ages at several pubertal development events	Intercourse status	(2) Girls	12.5	U.S.A.	84% white 16% black	147	.16	
Vanoss Marín et al., 2000 [51]	Menarcheal status	Sexual intercourse (yes/no)	43% Boys; 57% Girls	11.5	U.S.A.		188	.14	
Combined sexual behavior									
(1) Brown et al., 2006 [25]	Pubertal timing relative to peers	Precoital sexual activity (kissing—oral sex) at follow up (2 yrs later)	Girls	50% Boys; 50% Girls	13.7	U.S.A.	(1) 100% black	526	.22
(2) (1) Campbell et al., 2005 [24]	Pubertal status on the basis of secondary sexual characteristics, first erection, and first spontaneous nocturnal emission	(1) Light petting	Boys	15	Zimbabwe	(2) 100% white 100% black	491	.08	
(2) (1) Flannery et al., 1993 [52]	Pubertal status (Tanner line drawings)	(2) Heavy petting	Boys	13.5	U.S.A.	78% Caucasian parents 15% Hispanic parents	397	.51	
(2) (1) Hipwell et al., 2010 [53]	Onset of menarche at the age of 11 years (yes/no)	Sexual experience (kissed-intercourse)	(1) Boys	11.58	U.S.A.		397	.53	
(2)		(1) None versus moderate sexually intimate behavior at the age of 12 years	(2) Girls			54.8% African-American 39% European-American 6.2% multiethnic or belonging to another ethnic group	604	.18	
(2)		(2) Mild versus moderate sexually intimate behavior at the age of 12 years	Girls				581	.08	
(1) James et al., 2012 [8]	Pubertal maturation (combined measure incl PDS) at time 1 (grade 6). Recoded as pubertal timing ^a	Timing of sexual debut at time 7 (grade 12)	Girls	11.86	U.S.A.	82% European-American 14% African-American 4% other	129	.33	
(2)		Average of first sexual encounter, and first sexual intercourse.	Boys	13.86			109	.17	
(1) Lam et al., 2002 [20]	Age at the first emission (first conscious ejaculation)	(1) Kissing	Boys	16	Hong Kong	—	1,912	.11	
(2)		(2) Caressing					1,908	.11	
(3)		(3) Kissing	Girls				1,905	.10	
(4)		(4) Caressing					1,892	.09	
(1) Meschke and Silbereisen, 1997 [54]	Pubertal timing compared with peers	Age at the first personal sexual experience	Girls	16.75	Germany	(1) West Germany	227	.06	
(2)						(2) East Germany	128	.21	
(3)			Boys			(3) West Germany	242	.06	

(continued on next page)

Table 1
Continued

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r
(4)						(4) East Germany	105	.16
(1) Miller et al., 1998 [55]	PDS pubertal timing (standardized)	Sexual behavior (held hands-intercourse)	(1) Boys	12.9	U.S.A.	95% white	152	.17
(2)			(2) Girls				169	.13
(1) Negriff et al., 2011 [56]	(1) Tanner breast/genital at wave 1	Sexual activity summed across eleven activities at wave 1	53% Boys; 47% Girls	11	U.S.A.	38% African-American 39% Latino 12% Biracial 11% Caucasian	454	.23
(2)	(2) Tanner pubic hair at wave 1							.20
(3)	(3) PDS at wave 1	Sexual activity summed across eleven activities 1 year later						.09
(4)	(4) Tanner breast/genital at wave 1							.23
(5)	(5) Tanner pubic hair at wave 1							.20
(6)	(6) PDS at wave 1	Sexual activity summed across eleven activities 2 years later						.12
(7)	(7) Tanner breast/genital at wave 1							.09
(8)	(8) Tanner pubic hair at wave 1							.06
(9)	(9) PDS at wave 1							.08
(1) Ostovic and Sabini (2005) [45]	Pubertal timing assessed with ages at several pubertal development events	Age at the first sexual arousal	(1) Girls	21.8	U.S.A.	58.8% white 27.0% Asian or Asian-Indian 4.3% black 3.2% Hispanic 6.7% other	148	.47
(2)			(2) Boys	22.4			129	.46
(1) Price et al., 2009 [57]	Pubertal status at the age of 13 years assessed with Tanner line drawings	Sexual behavior (oral and/or coital) at the age of 15 years	(1) Girls	13	U.S.A.	90% European-American 4% African-American 2% Asian-American 2% Hispanic 2% Native American	127	.15
(2)			(2) Boys				110	.23
(1) Savin-Williams, 1995 [58]	Age at pubertal onset	(1) First homosexual sexual experience	Boys	20.9	U.S.A.	—	71	.30
(2)		(2) First heterosexual sexual experience					41	.07
(1) Smith et al., 1985 [59]	(1) Pubic hair stage assessed with Tanner drawing.	Sexual behavior (kissing-intercourse)	Girls	13.5	U.S.A.	100% white	433	.93
(2)	(2) Estrogen development assessed with a Tanner drawing of breast development and three items assessing perception of breast and hip development, and general “curviness”.							.54
(3)	(3) Pubertal status measured by 10 items		Boys				378	.87
Van Ryzin (2011) [60]	Physical maturity assessed with two items on body hair and skin changes. Recoded as pubertal timing ^a	Sexual experimentation (items on kissing–touching below the waist summed)	52% Boys; 48% Girls	14	U.S.A.	88% Euro-American 7% mixed ethnic background 2% Hispanic 1% African-American 1% Native American 1% Asian American	363	.11

Table 1
Continued

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r
(1) Van Zalk et al., 2011 [61]	Pubertal status assessed with a partial PDS	(1) Lifetime intercourse frequency (no—several times) wave 1	52% Boys; 48% Girls	13.73	Sweden	13% first born immigrant 12.5% second born immigrant	750	.18
(2)		(2) Lifetime intercourse frequency (no—several times) wave 2						.21
(3)		(3) Impulsive sexual behavior (sleeping on the first night) wave 1						.14
(4)		(4) Impulsive sexual behavior (sleeping on the first night) wave 2						.21
Risky sexual behavior Aruda, 2010 [62]	Age at menarche	Condom use	Girls	18	U.S.A.	36% Hispanic and 50.2% black 17% white 4% American-Indian .3% Asian 22% other	305	.56
Belsky et al., 2010 [63]	Age at menarche	Risky sexual behavior at the age of 15 years	Girls	12.5	U.S.A.	82% white 12% black 6% Hispanic	526	.25
(1) Boden et al., 2011 [64]	Age at menarche	(1) Pregnant by the age of 18 years	Girls	13.5	New Zealand	—	497	.73
(2)		(2) One or more STI by the age of 18 years						.63
Durant et al., 1990 [21]	Age at menarche	Contraceptive behavior	Girls	17	U.S.A.	100% Hispanic	85	.25
(1) Halpern et al., 2007 [65]	Pubertal timing relative to peers	Sex for drugs or money	(1) Boys	14	U.S.A.	79% white 14% black 7% other	1,879	.03
(2)			(2) Girls	13.9			2,239	.33
(3)		Combination sex and drug use	(3) Boys				1,879	.13
(4)			(4) Girls				2,239	.21
(1) Marceau et al., 2011 [66]	(1) Tanner pubic hair	Risky sexual behavior	Boys	15.5	U.S.A.	100% white	326	.03
(2)	(2) Tanner genital development						326	.04
(3)	(3) Tanner pubic hair		Girls				340	.05
(4)	(4) Tanner breast development						343	.04
(1) James et al., 2012 [8]	(1) Pubertal timing at time 1 assessed with the PDS and IAD, partialling out age. Recoded as pubertal timing ^a	Risky sexual behavior 6 years later	Girls	11.86	U.S.A.	82% European-American 14% African-American 4% other	129	.25
(2)	(2) Pubertal timing at time 3 assessed with the PDS and IAD, partialling out age	Risky sexual behavior 4 years later	Boys	13.56			109	.02
Shew et al., 1994 [67]	Age at menarche	HPV infection (yes/no)	Girls	17	U.S.A.	48% white 44% black 7% other	208	.06
(1) Siebenbruner et al., 2007 [19]	Physical maturity rated by coders at the age of 13 years. Recoded as pubertal timing ^a	(1) High-risk versus sexual abstainers. Sexual risk behavior at the age of 16 years. Composed of number of sexual partners and contraception use.	54% Boys; 46% Girls	13	U.S.A.	Mother's ethnicity: 86% Caucasian 10% African-American 4% Native American or Asian	118	.04

(continued on next page)

Table 1
Continued

	Puberty measure	Sexual behavior measure	Sex of sample	Mean age	Country	Ethnicity	N	r
(2)		(2) Low-risk versus sexual abstainers. Sexual risk behavior at the age of 16 years. Composed of number of sexual partners and contraception use.					122	.07

IAD = Index of Adolescent Development; PDS = Pubertal Development Scale.

The included studies and study characteristics are presented in order of sexual behavior measure, and then in order of alphabet.

The numbers in front of the author list represent multiple effect sizes from the same study.

Puberty measure presents the pubertal timing or status measure used in the study; sexual behavior measure presents the measure that was used to assess sexual behavior or risky sexual behavior.

Sex of sample includes 100% boys (Boys), 100% girls (Girls), or a mix of boys and girls; percentages are denoted.

Mean age denotes the mean age of the sample included in the analyses; if the mean sample was not reported, the median age of the range was included in the analyses. Country denotes the country in which the study was conducted. Ethnicity denotes the reported percentages of adolescents with ethnic backgrounds.

We included percentage of black/African American adolescents in the moderator analyses and the bold percentages represent the values included in the moderator analysis. N denotes the number of participants in the particular analysis. Recoded effect size denotes the recoded effect sizes to *r*.

^a The effect sizes by James et al. (2012) and Van Ryzin (2011) were categorized under pubertal timing–age at combined sexual behavior because their pubertal status measure was assessed in a group of young adolescents with a narrow age-range. The effect sizes by Siebenbruner (2007) were categorized under pubertal timing–risky sexual behavior because their pubertal status measure was assessed in a sample of adolescents with the same age.

presents the included studies across the separate meta-analyses. Samples included a total of 87,334 adolescents (min = 41, max = 5,700). The mean ages of the adolescents in these studies ranged from 10.5 to 22.4 years, with an overall mean of 15.10 years (standard deviation, 2.82). Of the included effect sizes, 51 were all girl samples, 32 were all boy samples, and 29 were mixed samples. Of these, most ($k = 71$) were from the United States, see Table 1.

Results of the separate meta-analyses

In what follows, we show correlation effect sizes (ES_r) that emerged from our meta-analysis, and whether the relations between pubertal development and sexual behavior and sexual risk behavior were moderated by pubertal timing measure, coital or noncoital sexual behavior measure, sex, age, and ethnicity of the sample (see Table 2 for the overall effect size and heterogeneity analyses). Only if the Q statistic was significant (heterogeneity of effect sizes), was it necessary to conduct moderation results (Table 3). For discontinuous moderators (sex, pubertal

timing measure, and coital or noncoital behavior), we report the effect size and confidence intervals per group in Table 4. For continuous moderators, we report the β value of the moderation in Table 3 and the direction of effects in text.

Pubertal status and sexual behavior and risky sexual behavior

Sexual intercourse. There was only one study that examined the link between pubertal status and age at sexual intercourse [34], and another that studied the link between menarcheal status and sexual intercourse status [51]. Both studies found a significant small positive association between status and sexual intercourse (ES_r = .11 and ES_r = .19, respectively). No further analyses were conducted using these studies.

With a meta-analysis on five effect sizes, the results showed a small to moderate positive link between pubertal status and intercourse status (ES_r = .20). That is, adolescents who are more advanced in pubertal development were more likely to have had intercourse. Follow-up moderation analyses revealed that this

Table 2
Omnibus Q statistic for the separate meta-analyses

	N	Q omnibus	df	p	k	ES (95% confidence interval)
Pubertal status						
Age at sexual intercourse ^a	2,494	—	—	—	1	.11 (—)
Sexual intercourse status ^{a,b}	1,242	—	—	—	1	.19 (—)
Sexual intercourse status	7,239	9.93	4	.042	5	.20 (.18–.22)
Combined sexual behavior	6,065	1,279.12	12	<.001	13	.42 (.39–.44)
Pubertal timing						
Age at sexual intercourse	2,355	18.42	6	.005	7	.21 (.17–.25)
Sexual intercourse status	28,050	163.19	18	<.001	19	.14 (.13–.15)
Age at combined sexual behavior	1,303	9.24	6	.161	7	.13 (.08–.19)
Combined sexual behavior	9,610	65.29	18	<.001	19	.14 (.12–.16)
Risky sexual behavior	10,049	133.08	11	<.001	12	.16 (.14–.18)
Age at menarche						
Age at sexual intercourse	7,779	79.21	12	<.001	13	.21 (.19–.23)
Sexual intercourse status	4,212	31.99	4	<.001	5	.15 (.11–.18)
Combined sexual behavior	4,982	4.37	3	.225	4	.10 (.08–.13)
Risky sexual behavior	2,118	192.49	5	<.001	6	.51 (.48–.54)

^a We were unable to test heterogeneity of effect sizes because only one study could be included for this analysis.

^b This category includes the link of menarcheal status and sexual intercourse status, but has been categorized under pubertal status.

Table 3
Moderating effects of gender, age, and ethnicity for the different meta-analyses

	Moderator						
	Sex			Age ^a	Ethn. ^b	PT ^c	Coital ^d
	Boys (0) versus girls (1)	Mixed (0) versus girls (1)	Boys (0) versus mixed (1)				
Pubertal status							
Age at sexual intercourse ^e	—	—	—	—	—	—	—
Sexual intercourse status ^{e,f}	—	—	—	—	—	—	—
Sexual intercourse status	—	—	ns	ns	-.71*	—	—
Combined sexual behavior	.35***	.73***	-.49***	-.35***	—	—	ns
Pubertal timing							
Age at sexual intercourse	ns	—	—	.76***	—	ns	—
Sexual intercourse status	.40***	ns	.26*	ns	ns	.33***	—
Age at combined sexual behavior ^g	—	—	—	—	—	—	—
Combined sexual behavior	.39*	.42**	ns	.25*	ns	ns	ns
Risky sexual behavior	.70***	.60***	ns	-.40***	—	-.29*	—
Age at menarche							
Age at sexual intercourse	—	—	—	-.27*	.38**	—	—
Sexual intercourse status	—	—	—	-.63***	—	—	—
Combined sexual behavior ^g	—	—	—	—	—	—	—
Risky sexual behavior	—	—	—	-.15*	—	—	—

Dashes represent moderator analyses that could not be tested because of lack of variance or nonreport of moderator.

Coital = combined sexual behavior measure includes coital or does not include coital behaviors; Ethn. = ethnicity; ns = not significant; PT = Pubertal timing measure.

^a Positive values indicate stronger relations for older youth. Negative values indicate stronger relations for younger youth.

^b Positive values indicate stronger relations for samples with a higher percentage of black adolescents. Negative values indicate stronger relations for samples with a lower percentage of black adolescents.

^c 0 = Peer-normative pubertal timing; 1 = stage-normative pubertal timing.

^d 0 = Exclusively noncoital; 1 = coital.

^e We were unable to test moderation effects because only one study could be included for this analysis.

^f This category includes the link of menarcheal status and sexual intercourse status but has been categorized under pubertal status.

^g We were unable to test moderator effects because there was no heterogeneity in effect sizes.

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

link was weaker for samples with a higher percentage of black adolescents.

Combined sexual behavior. With a meta-analysis on 13 effect sizes, we found a moderate to large positive association between pubertal status and combined sexual behavior ($ESr = .42$). Adolescents who are more advanced in pubertal development were more likely to be engaged in sexual behavior. Moderation analyses indicated that this link was much stronger for girls than boys and mixed-sex samples. In contrast, this link was stronger for boys compared to mixed-sex samples. Further, this link was stronger for younger samples. There was no moderation by type of combined sexual behavior (coital or noncoital).

Pubertal timing and sexual behavior and risky sexual behavior

Sexual intercourse. With a meta-analysis on 19 effect sizes, we found a small positive association between pubertal timing and

sexual intercourse status ($ESr = .14$). Adolescents with an early pubertal timing were more likely to be engaged in sexual intercourse. Moderation analyses revealed that this link was much stronger for girls than boys, and much stronger for mixed-sex samples than boys. Further, this link was somewhat stronger for studies that used a stage-normative pubertal timing measure compared with a peer-normative pubertal timing measure, although this difference is small to medium.

With a meta-analysis on seven effect sizes, we found a small to moderate positive association between pubertal timing and age at sexual intercourse ($ESr = .21$). Adolescents with an early pubertal timing engaged in sexual intercourse at a younger age. This link was stronger for older adolescents but there was no moderation by pubertal timing measure (peer-normative vs. stage-normative).

Combined sexual behavior. With a meta-analysis on 19 effect sizes, we found a small positive association between pubertal timing and combined sexual behavior status ($ESr = .14$). Adolescents with

Table 4
Effect sizes and confidence intervals for significant categorical moderators

	Moderator				
	Sex			Pubertal timing measure	
	Boys	Girls	Mixed	Peer-normative	Stage-normative
Pubertal status					
Combined sexual behavior	.48 (.44–.51)	.72 (.69–.74)	.19 (.15–.22)	—	—
Pubertal timing					
Sexual intercourse status	.11 (.09–.13)	.17 (.15–.19)	.16 (.12–.20)	.13 (.11–.14)	.15 (.13–.17)
Combined sexual behavior	.13 (.10–.16)	.29 (.19–.40)	.15 (.12–.17)	—	—
Risky sexual behavior	.07 (.04–.10)	.24 (.21–.26)	.05 (–.07 to .18)	.18 (.16–.20)	.06 (.01–.10)

Dashes represent moderator analyses that could not be tested because of lack of variance or nonreport of moderator, or where differences were not significant.

an early pubertal timing were more likely to be engaged in sexual behavior. Moderation analyses revealed that this link was much stronger for girls than mixed-sex samples and compared to boys, and stronger for older adolescents. There was no moderation by type of combined sexual behavior (coital vs. noncoital) and no moderation by pubertal timing measure (peer-normative vs. stage-normative).

With a meta-analysis on seven effect sizes, we found a significant small positive association between pubertal timing and age at the first sexual behavior ($ESr = .13$; no heterogeneity of effect sizes). That is, adolescents with an early pubertal timing were more likely to engage in their first sexual experience at a younger age.

Risky sexual behavior. With a meta-analysis on 12 effect sizes, we found a small positive association between pubertal timing and risky sexual behavior status ($ESr = .16$). Adolescents with an early pubertal timing engaged in more risky sexual behavior. This link was much stronger for girls than boys and mixed-sex samples. This link was also stronger for younger adolescents and much stronger when a peer-normative pubertal timing measure was used, compared with when objective stage-normative pubertal timing measure was used.

Age at menarche and sexual behavior and risky sexual behavior

Sexual intercourse. With a meta-analysis on 13 effect sizes, we found a small to moderate positive association between age at menarche and age at sexual intercourse ($ESr = .21$). Adolescents with a younger age at menarche engaged in sexual intercourse at a younger age. Moderation analyses revealed that this link was stronger for younger adolescents and for samples with a higher percentage of black adolescents.

There were only five effect sizes that examined the link between age at menarche and sexual intercourse status. We found a small positive association that showed that adolescents with a younger age at menarche were more likely to have engaged in sexual intercourse ($ESr = .15$). This link was stronger for younger adolescents. Of these five studies, three did not report ethnicity of the sample and two examined the link between age at menarche and sexual intercourse status separately for Latina and Hispanic girls. The mean effect size of these latter two studies separately also showed a small positive association ($ESr = .07$; 95% confidence interval [.04–.12]; $p < .001$).

Combined sexual behavior. Only four effect sizes examined the link between age at menarche and combined sexual behavior—these showed a significant small positive association ($ESr = .10$; no heterogeneity of effect sizes). Adolescents with a younger age at menarche were more likely to engage in combined sexual behavior.

Risky sexual behavior. Only six effect sizes examined the link between age at menarche and risky sexual behavior. We found a large positive association that showed that adolescents with a younger age at menarche were more likely to engage in risky sexual behavior ($ESr = .51$). This link was stronger for younger adolescents.

Discussion

With the present study, we show the first meta-analytical results of the relation between pubertal development and adolescent sexual behavior. Our results indicated that those

adolescents with an early pubertal timing engaged in earlier, more advanced, and more risky sexual behavior. Also, those adolescents with a more advanced pubertal status engaged in earlier and more advanced sexual behavior.

Moderation of the relation between puberty and (risky) sexual behavior

The present meta-analysis showed that the links of pubertal status and timing with nonrisky and risky sexual behavior were more pronounced in girls. The effect of pubertal status on combined sexual behavior showed a strong effect for girls but only a moderate effect for boys. The effect of pubertal timing on risky sexual behavior was moderate for girls and only small for boys. This suggests a different mechanism by which puberty is related to sexual development for boys and girls.

Overall, the results showed that, especially among young participants, (risky) sexual behavior was affected by a more advanced pubertal status, earlier pubertal timing, and a younger age at menarche. This may be because young adolescents are not as capable to handle potentially risky situations [68] or because they have a delay in the development of the cognitive control system of the brain [69,70]. In contrast, older adolescents are thought to have more opportunities to engage in sexual behavior, possibly because they experience fewer parental restrictions [71,72].

Moderation by ethnicity showed inconsistent findings. For pubertal status measures that reflect thelarche, andrenarche, and gonadarche, stronger links for white adolescents are found, whereas for the later-occurring menarche, stronger effects for black girls are found. The difference between pubertal status and age at menarche is important to consider because this indicates that pubertal status may show a combined effect of the development of several secondary sex characteristics, whereas menarche is the final stage of girls' pubertal development and an indicator of gonadarche. The present findings indicate ethnic differences in the magnitude of the link between pubertal development and sexual development, but especially, that research needs to disentangle the effects of thelarche, andrenarche, and gonadarche, and how these processes during adolescence may affect ethnic groups differently.

Finally, we examined whether including a stage-normative or peer-normative measure of pubertal timing moderated the links between pubertal timing and sexual behavior and sexual risk behavior. For the link between pubertal timing and sexual intercourse status, we found a small difference—the effect of pubertal timing on sexual intercourse status was stronger when a stage-normative measure of pubertal timing was used. In contrast, for the link between pubertal timing and risky sexual behavior, we found a larger difference, and here the effect was stronger when a peer-normative measure was used. Our findings suggest that in predicting sexual risk behavior, the perception of one's pubertal timing may be even more important than the assessment of certain physical characteristics. This may indicate that when adolescents *perceive* their own pubertal development as “early” relative to peers, they will also be psychologically geared toward more older, and/or more deviant social contexts [73], or this may make them more vulnerable to the influences of such contexts (contextual amplification; [68]), thereby increasing their chances of engaging in sexual risk behavior. Given that very few studies include both peer-normative and stage-normative perceptions of pubertal timing in the same

study, it is impossible to tease apart whether peer-normative puberty overrides stage-normative pubertal timing in predicting sexual behavior or whether two different mechanisms are operating as follows: a biological mechanism that promotes sexual debut and a psychological one that promotes behavioral risk.

Pubertal status versus pubertal timing

Three issues arise when comparing pubertal status to pubertal timing measures. First, several studies use a pubertal status measure in a sample of same-aged adolescents. Empirically speaking, if pubertal status is assessed in such a sample, this automatically reflects pubertal timing. Fortunately, we were able to account for this in the present meta-analysis by categorizing such studies as pubertal timing. However, it is clear that even among researchers, the distinction between pubertal status and pubertal timing is not always evident and, in addition to the assessment measure used, also depends on other factors. These include the age of the participants in the study, whether pubertal status scores are standardized, and whether age is controlled for in the analyses. Second, pubertal status and timing are confounded—those with an earlier pubertal timing have moved through more stages of pubertal development (which would indicate a more advanced pubertal status). In contrast, those with a later pubertal timing have not moved through as many stages, and are thus categorized as having a less advanced pubertal status. Considering these confounds, it is difficult to interpret unique effects of pubertal status and timing from general age-related changes [74]. Third, studies on pubertal development often combine several physical changes (such as pubic hair and breast development, or pubic hair and growth spurt) into one pubertal status or timing measure, regardless of their biological basis [75]. Finally, with this meta-analysis it becomes clear that the only way to distinguish pubertal status from timing is with a longitudinal study, accounting for individual differences in status, timing, and rate of development [76].

Strengths and limitations

With the present meta-analysis, we were able to quantify the effects of pubertal development on sexual behavior and sexual risk behavior with a large number of participants and across a wide range of ages. Although we were able to identify several gaps in the literature and provide a quantitative meta-analysis on the relation between pubertal development and sexual behavior, there are several limitations to this meta-analysis and the studies included to note. First, the measurement of pubertal development and sexual behavior was primarily by self-report and some were retrospective, which can be biased [5,77]. Second, we categorized studies on the basis of what they reported in the papers as their measures. Unfortunately, many studies do not clearly report the pubertal development measure, nor do many studies report whether they controlled for sex or age in their measure or analyses. In addition to these methodological limitations to the studies, the present meta-analysis is limited in its conclusions about ethnicity. We were unable to include moderation by ethnicity other than percentage of black/African American participants. Such a measure gets at an indirect measure of whether the link between pubertal developments varies when more or less members of an ethnic group are included in the sample, but the magnitude of the actual relation between pubertal development

and sexual behavior cannot be estimated. Our meta-analysis underscores two points as follows: (1) the need for investigators to report their analyses separately by ethnic group and (2) more research on pubertal and sexual development among different ethnic groups is needed and oversampling of these groups within stratification samples may be necessary to achieve sufficient power and reliability of the results.

Future research and implications

The present meta-analysis suggests that puberty affects boys and girls differently, or that the environment reacts differently to their physical changes. To extend these findings even further, both for girls and boys, studies need to incorporate the social context into their research. Pubertal and sexual development do not occur in a vacuum—reactions from peers concerning the adolescents' changing body, the relational context of sexual behavior, and availability of sexual health care all interact to affect adolescent sexuality. Further, our findings on sexual risk behavior among early maturing adolescents—strengthened by the idea that, when adolescents engage in sexual behavior at young ages, they tend to engage in more risky behaviors [78]—emphasize the need for early interventions to prevent pregnancy and STIs/HIV.

Our findings underline the important role of an early transition to reproductive maturity for the onset and timing of sexual and risky sexual behavior that is stronger for girls than boys. To study adolescent sexual development with a developmental systems approach, hormonal, genetic, and environmental factors need to be included.

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