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## Next Steps in Puberty Research: Broadening the Lens Toward Understudied Populations

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### Abstract

Decades of puberty research have yielded key scientific discoveries. Building on the field's rich history, we highlight four understudied populations: youth of color, boys, sexual minority youth, and gender minority youth. We explore why scientific study has been slow to evolve in these groups and propose paths forward for exciting new work. For ethnically racially diverse youth, we discuss the need to incorporate culture and context. For boys, we highlight methodological issues and challenges of mapping existing conceptual models onto boys. For sexual and gender minority youth, we discuss unique challenges during puberty and suggest ways to better capture their experiences. With an eye toward a new era, we make recommendations for next steps and underscore the importance of transdisciplinary research.

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Puberty has been a topic of investigation since the mid-20th century (Greulich, Dorfman, Catchpole, Solomon, & Culotta, 1942; Marshall & Tanner, 1969, 1970; Reynolds & Wines, 1948, 1951; Tanner, 1962), and soon thereafter the study of puberty emerged as an inherently transdisciplinary field. Scientific discoveries from medicine, psychology, animal biology, and epidemiology have been critical to understanding the onset and normative progression of puberty, its hormonal underpinnings, and the potential short- and long-term effects of off-time maturation (Grumbach, 1980; Knobil, Plant, Wildt, Belchetz, & Marshall, 1980; Parent et al., 2003; Petersen & Taylor, 1980; Plant, 2008; Styne & Grumbach, 2002). Understanding normative pubertal processes has provided important foundational knowledge for the field. However, existing scholarship largely has focused on girls and on individuals of European descent (see Marceau, Hottle, & Yacilla, 2019, in this issue). Inadequately addressing certain populations in sufficient depth limits our understanding of the broad range of experiences associated with puberty, across individuals, and within certain populations. As the field matures, fully exploring the different implications that puberty may

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hold will be critically important for expanding and integrating our existing knowledge of puberty across contexts and subgroups.

To understand why the field is just now broadening the lens of our understanding of puberty and its implications, it is helpful to examine historic precursors in the study of pubertal development, which has largely focused on White youth of European descent. Nearly 50 years ago, Marshall and Tanner described the stages of puberty (Marshall & Tanner, 1968, 1969, 1970) and provided the field with a useful metric for understanding sexual maturation and individual variation in the timing and tempo of sexual maturation (see Mendle, Beltz, Carter, & Dorn, 2019, this issue). However, the original Tanner stages were based on a sample of 228 White British boys (Marshall & Tanner, 1970) and 192 White British girls (Marshall & Tanner, 1969) housed in an orphanage. Subsequent measures of puberty were designed largely to map onto the Tanner stages (Dorn, Dahl, Woodward, & Biro, 2006; Dorn & Susman, 2004; Hua-mei, 2010; Juul et al., 2006; Morris & Udry, 1980), thus creating a system of tracking sexual maturation that originated from a very select sample (orphans) within a specific population (White British children), which now is being used on increasingly diverse cohorts of youth. The irony of Marshall and Tanner's contribution is that a method designed to understand normative variation has, in some ways, laid the foundation for the field to under appreciate the breadth of individual variation in puberty and its effects. Below, we examine understudied populations as a call to action for the field to re-engage with Marshall and Tanner's original goal of describing variation in the process of puberty and to urge researchers to consider aspects of puberty that have received inadequate attention.

In considering why these groups remain understudied, we offer two main reasons for this dearth of information. One, pubertal variation across subgroups may lack the scientific appeal of exciting or provocative research questions. Ultimately, puberty is a normative process that everyone experiences and more thoroughly describing that normative process in understudied groups might seem incremental given the cost and challenges of research. Obtaining adequate sample sizes, particularly in hard-to-reach groups, and retaining individuals in longitudinal research are difficult and costly undertakings that may be hard to justify if insights are deemed incremental. However, many of the persistent unanswered and important questions are specific to fairly basic, descriptive processes around normative variation in puberty and related outcomes. These basic studies are still needed to understand the breadth of individual differences related to race, ethnicity, and sex across various contexts (Owen, Goldstein, Clayton, & Segars, 2013; Ramnitz & Lodish, 2013). While research on intricate endocrine (Finkelstein et al., 1998; Matchock, Dorn, & Susman, 2007; Shirtcliff, Dahl, & Pollak, 2009; Susman, 1985; Van Hulle, Moore, Shirtcliff, Lemery-Chalfant, & Goldsmith, 2015) or neuroimaging (Goddings, Burnett Heyes, Bird, Viner, & Blakemore, 2012; Koolschijn, Peper, & Crone, 2014; Ladouceur, Peper, Crone, & Dahl, 2012; Peper et al., 2010) protocols add appeal and mechanistic understanding to the process of puberty (al-Attia, Bakir, & Butt, 1993; Bomberg et al., 2015; Charmandari, Brook, & Hindmarsh, 2004; Ibanez, de Zegher, & Potau, 1998), it is also important to extend the foundational perspective of Marshall and Tanner and explore individual variation in puberty as we broaden the description of normative development to include more than a sample of 420 White British youth as the de facto reference group.

Two, it is important to admit that extending pubertal research to deepen our understanding of puberty within certain subgroups may make many researchers uncomfortable. Puberty is a complex and multifaceted process that involves vast changes beyond physical growth and maturation of secondary sexual characteristics. It intersects with identity formation, increases in sexual desire, and increasingly complex social interactions. Addressing issues related to ethnicity–race and culture, for instance, may not seem consistent when describing biological processes related to growth and maturation. Yet, how puberty is viewed by the adolescent experiencing this transition, and by the outside world, likely depends on subgroup characteristics and cultural and contextual norms. With notable exceptions (Biro & Dorn, 2005; Bramen et al., 2012; Finkelstein et al., 1998; Halpern, Udry, & Suchindran, 1998; Manzini, 2001; Suleiman, Galvan, Harden, & Dahl, 2016), we, as adults, tend to distance ourselves from aspects of studying a developmental stage characterized by sexual maturation and increases in sexual desire, often shrouding puberty in a cloud of euphemisms (Dorn & Susman, 2004). There are many components of typical development, such as sexual intimacy, spermarche, and gender identity, for example, that, as adults, we would rather ignore than confront in research with youth; this avoidance is magnified further when sexually marginalized or gender minority youth are under investigation.

To broaden the lens of our understanding of puberty, it is necessary to both describe the full range of the pubertal experience across diverse youth and also to confront the variability in pubertal changes and experiences. To that end, we focus here on four understudied groups, selected because they help address mechanistic points about the scientific study of the process of puberty and its implications for adolescent health and well-being. In addition, they illustrate the expansive variation in pubertal experiences across youth. First, we discuss culture and ethnicity–race and explain why a deeper examination of these issues is critical to the study of puberty because the timing of puberty, as well as related health and mental health implications, may be fundamentally different for ethnic–racial minority youth. Second, we address boys' puberty, because contemporary psychosocial models of pubertal risk (developed for girls) may not apply to boys, for whom the timing, progression, neural and hormonal underpinnings, and relevant physical changes of puberty differ from girls. Third, we highlight sexual minority youth (lesbian, gay, bisexual, queer; LGBTQ) as an understudied population that forces the field to confront a potentially uncomfortable aspect of the pubertal process—that, at its core, puberty is the attainment of sexual maturation and involves sexual feelings and desires. Last, we talk about gender minority (e.g., transgender) youth, who face unique issues related to the pubertal transition and experience some of the highest levels of stress and mental health challenges during puberty. We summarize individual differences in puberty across these populations, discuss conceptual issues and methodological barriers that have limited research within these groups, and offer approaches to advance scientific inquiry.

## Puberty Among Racially and Ethnically Diverse Groups

Research on puberty has advanced rapidly over the past several decades, and individual differences in the timing of pubertal development have been increasingly identified as an important risk factor for internalizing and externalizing problems during adolescence (see Mendle, Harden, Brooks-Gunn, & Graber, 2012). However, much of the extant puberty

research has not established an adequate empirical base to understand the effects of pubertal development among racially and ethnically diverse youth. To illustrate this in the field of psychology, we conducted a literature search (1996–2016), using PsycINFO, with the keywords *puberty* or *pubertal timing* or *pubertal status* in age groups that spanned childhood and adolescence. The search yielded 707 articles that met the selection criteria. We specified the search by also selecting PsycINFO abstracts that included *race*, *ethnicity*, or specific racial–ethnic groups (i.e., *African American/Black*, *Latino/Hispanic*, *Asian American*, *American Indian*). Of the 707 abstracts, only 24 (or 3%), addressed race or ethnicity by mention of these key words in the study abstract; for specific ethnic groups, *African American/Black* was mentioned in 38 abstracts (5%), which was more frequent than other groups.

This is disappointing for a number of reasons. First, data from the United States shows that puberty is starting earlier than in past decades and that the timing of pubertal onset varies markedly depending on ethnic–racial group membership, with African Americans entering puberty at the youngest ages, followed by Latinos, and then non-Latino Whites and Asians (Biro et al., 2013; Chumlea et al., 2003; Euling et al., 2008). Secular trends toward earlier pubertal timing and ethnic and racial disparities in pubertal onset have also been observed in countries outside of the United States (Aksglaede, Sorensen, Petersen, Skakkebaek, & Juul, 2009; Cameron, Grieve, Kruger, & Leschner, 1993; Lum et al., 2015; Parent et al., 2003; Simon, Wardle, Jarvis, Steggle, & Cartwright, 2003; Song et al., 2015). For example, in the United Kingdom, among both boys and girls, Black youth were more likely to be in more advanced pubertal stages compared to same-aged youth from White and Asian backgrounds (Simon et al., 2003). Notably, these effects appear to be driven by girls' environments in addition to their race. Among Black South African girls, for example, those living in urban areas were more advanced pubertally than those living rurally, indicating that aspects of the urban environment (e.g., diet, exercise) contribute to earlier development (Cameron et al., 1993). Longitudinal data confirms that early puberty is associated with numerous deleterious mental health outcomes for girls and boys (see Mendle & Ferrero, 2012; Mendle, Turkheimer, & Emery, 2007 for reviews), yet we still know very little about whether and how early pubertal timing, and other pubertal factors such as tempo (i.e., the pace at which youth progress through puberty), influence mental health differentially across ethnic–racial groups.

Second, youth from different ethnic and cultural backgrounds differ from each other not only in the age at which they physically mature, but potentially vary in their psychological responses to maturation. For example, menstruation is a biological milestone associated with puberty in girls. In some cultures and contexts, menarche may be accompanied by feelings of shame and the need to conceal it from others (Lahme, Stern, & Cooper, 2016; Stubbs, 2008), whereas in other cultures, menarche is celebrated (Weisfeld, 1997). The arrival of a girl's first menstrual cycle therefore may be accompanied by shame or pride. As such, the health and psychological implications of puberty, a biological process that unfolds in context, can be augmented or ameliorated by cultural and contextual factors, social norms, behaviors, and values (Morales-Chicas & Graham, 2015; Seaton & Carter, 2017; White, Deardorff, & Gonzales, 2012; White, Deardorff, Liu, & Gonzales, 2013).

Third, due to the social implications of puberty, youth from racially and ethnically diverse populations face unique challenges during puberty, which can stem from the emerging salience of ethnic and racial identity (ERI) in processes of self-understanding (Hill & Lynch, 1983; Quintana, 2007; Sellers, Rowley, Chavous, Shelton, & Smith, 1997; Umaña-Taylor et al., 2014), increased exposure to adults and peers of differing racial and ethnic backgrounds (Morales-Chicas & Graham, 2015), and concerns related to different pubertal trajectories and timing (Carter, Jaccard, Silverman, & Pina, 2009). Despite these complexities, the puberty field often takes a simple comparative approach, in which ethnicity–race is treated as an independent variable and different groups are then contrasted on the puberty variable of interest (see Mendle et al., 2019, in this issue). All too often, social class or nativity is not accounted for and within-group variability is ignored. As such, a deeper examination of the pubertal process among youth of color—one that incorporates strong theory related to their individual experiences within their contexts—is crucial.

One way to better understand the risks associated with early pubertal development among racially and ethnically diverse youth is to examine parallel developmental processes like identity development (Carter, Seaton, & Rivas-Drake, 2017; Seaton & Carter, 2017; Townsend, 2002). During the pubertal transition, adolescents construct individual identities (“Who am I?”) as well as social identities (“Who are we?”), including identities relating to ethnicity and race (cf. Umaña-Taylor et al., 2014). A positive ERI has been found to be associated with better adjustment among youth of color (see Umaña-Taylor et al., 2014). It is possible that, as racially and ethnically diverse youth mature, they develop their ERI by assimilating salient puberty-related experiences into their existing self-concept, which is shaped by context and cultural norms, and then interpret the physical changes associated with puberty in a manner that has the potential to cultivate a positive ERI. However, research examining whether positive ERI can buffer against potential negative effects of early pubertal timing among racially and ethnically diverse youth remains scant (Carter et al., 2017; Seaton & Carter, 2017; Townsend, 2002). The few studies published to date focused on U.S. populations and specifically on African American girls. Townsend (2002) found that early developing girls who reported less-developed ERI endorsed risky sexual behavior attitudes, but there were no associations among later developing girls (Townsend, 2002). In a more recent study, Seaton and Carter (2017) found that early-maturing Black adolescent girls who perceived lower public regard for their race (i.e., the belief that the broader society views African Americans negatively) and attended non-majority Black schools reported more depressive symptoms. Conversely, girls with higher public regard were less affected by early puberty. This study suggests socialization efforts that lead to a more positive perception of one’s race may protect against the negative effects of early puberty.

Early development may be particularly challenging for youth of color as they simultaneously cope with stressors linked to being a member of an ethnic–racial group. Exposure to prejudice or discrimination based on ethnicity–race is associated with mental health problems and could have unique implications for early developers (Hamlat, Stange, Abramson, & Alloy, 2014; Hamlat et al., 2015). In general, early puberty leads to some youth being perceived as older than they actually are, which can result in higher status (positive) or, alternatively, to unrealistic expectations and punitive actions by adults and peers (negative). For youth of color, the combination of negative ethnic–racial stereotypes

and early development might further exacerbate risk for negative outcomes. While no studies to date have examined the adjustment implications of ethnic-racial discrimination experiences at varying levels of development, theory posits that stereotypes, which likely drive ethnic-racial discrimination experiences, shape individual-contextual interactions during key developmental transitions (Spencer, 2006).

Most of the ethnic-racial stereotype literature has focused on African Americans, and there is strong evidence that the cultural stereotypes of that group remain largely negative (Blaine & McClure Brenchley, 2007). For example, research has shown that adults and youth associate being Black (and male) with low intelligence, hostility, aggressiveness, and violence (Blaine & McClure Brenchley, 2007). This stereotype is illustrated in the media coverage of the recent deaths of unarmed African American boys shot by police in the United States (Schultz, 2015; Wilson, Hugenberg, & Rule, 2017). In 2014, Tamir Rice, a 12 year-old African American boy, was shot and killed by police in Cleveland, Ohio. In the contentious aftermath, the Cleveland Police Patrolman's Association president said, "Tamir Rice is in the wrong. He's menacing. He's 5-feet-7, 191 pounds. He wasn't that little kid you're seeing in pictures. He's a 12-year-old in an adult body" (Schultz, 2015). This comment exemplifies how pubertal development and stereotypes/discrimination intersect among youth of color and underscores the complexity that is currently missing from puberty research.

Some limited research, focused on U.S. populations, has examined how ethnic and cultural context, which likely drives social comparisons, influences associations between pubertal timing and adjustment (Morales-Chicas & Graham, 2015; Seaton & Carter, 2017; White et al., 2012, 2013). White et al. (2012) found that early maturing Mexican-origin fifth grade girls living in neighborhoods with less Latino representation experienced more depression in seventh grade compared to those in ethnically dense Latino neighborhoods. A similar pattern was found for early maturing Mexican-origin boys and externalizing behaviors (White et al., 2013). These findings emerged even when neighborhood socioeconomic differences were considered. In the school context, Morales-Chicas and Graham (2015) demonstrated that both perceived ethnic group representation and deviation from the Latina body mass index (BMI) norm moderated the effect of pubertal status on school connectedness. On-time developers (compared to early and late) who deviated from the Latina BMI norm toward being underweight and who attended schools where there were relatively few Latinas reported the most school connectedness. Thus, Latinas who develop on time and are relatively underweight feel more connected to their schools when they are surrounded by non-Latina peers who are likely similarly developed. Combined, these findings suggest that during the pubertal transition, ethnic minority youth look to their social environments to gauge how they feel about their developing bodies (Blanton, 2001; Festinger, 1954). Including pubertal timing measures that directly ask adolescents to compare themselves to their peers and assessing the context (e.g., racial-ethnic composition of schools or neighborhoods; same-race friendships) could enhance our understanding of early pubertal effects in racially and ethnically diverse youth.

Lastly, our understanding of pubertal development among racially and ethnically diverse youth can be improved further by examining within-ethnic-racial group variation (see

Mendle et al., 2019, in this issue) within the United States and globally. Most U.S. studies of ethnic minority samples combine several ethnic subgroups into broad categories (e.g., Asians, Latinos) despite important cultural and historical differences that exist among these ethnic subgroups (Pew Research Center, 2016). These differences argue for the necessity of studying distinct subgroups rather than mixed origin samples to improve validity of results.

To deepen our understanding of distinct cultural norms within subgroups, some limited work has focused specifically on within-ethnic-racial group variation and this work has focused on U.S. samples (e.g., Carter, Caldwell, Matusko, Antonucci, & Jackson, 2010; Deardorff et al., 2013). For example, research on Mexican-origin youth living in the United States found that maternal parenting behaviors mediated the association between girls' pubertal timing and internalizing and externalizing outcomes, but these associations varied depending on mothers' country of origin (United States vs. Mexico) (Deardorff et al., 2013). Such results speak to the importance of understanding culture-specific norms when studying puberty. Similarly, neurodevelopmental research on Mexican American youths' family obligation values and behavior sheds light on important cultural and neurological mechanisms during puberty that influence this group's mental health (Telzer, Tsai, Gonzales, & Fuligni, 2015).

Given emerging cultural research, a stronger focus on culture-specific mechanisms, along with a deeper understanding of the challenges uniquely faced by ethnically and racially diverse youth during the pubertal transition, is warranted. Also, it is critical to extend this work to adolescents from other cultures and ethnic backgrounds globally (Patton et al., 2016; Sawyer et al., 2012), as well as to ethnic minority youth in countries outside the United States, including indigenous youth and immigrants. With waves of immigration across Europe and in many parts of the world, we need to understand how nonmajority youth differentially experience pubertal development and which contextual and cultural factors are most salient in predicting health and well-being. There are important opportunities to investigate these processes among new immigrants and to examine the intersection of immigration-related stress and pubertal maturation for youth experiencing these vast biological, social, and geographical transitions simultaneously.

## Boys' Puberty

Within some disciplines, boys' puberty is well described (see Mendle et al., 2019, in this issue). For example, the field of endocrinology has shown that maturation of the adrenal gland is one of the first signs of puberty in boys (Byrne et al., 2017; Mundy et al., 2015); then gonadarche commences when there is a dramatic rise in testosterone and other androgens (Braams, van Duijvenvoorde, Peper, & Crone, 2015), which stimulate genital development and other hallmark physical signs of puberty (Biro, Lucky, Huster, & Morrison, 1995). The field of neuroscience is generating emerging data that the physical changes that accompany puberty extend upward into the brain as pubertal hormones impact neural development (Goddings et al., 2012; Vijayakumar, Shirtcliff, op de Macks, & Pfeifer, under review). The growing biological data about boys, however, has not sufficiently bridged disciplinary boundaries (e.g., public health, social sciences, developmental sciences with neuroscience and physiology) so that researchers can fully explore mechanisms underlying the psychosocial risks that often accompany puberty. Here, we explore three measurement

reasons for why this information is lost in translation, and then consider whether and how current psychosocial models for puberty can apply to boys' development.

The developmental salience of puberty, and pubertal timing, is much less clearly understood in boys than girls. This is partially due to three intertwined measurement issues. The first measurement issue is related to a shortage of visible markers of boys' maturation, particularly of the earliest stages of development (Patton & Viner, 2007). For girls, there are clear outward pubertal signs that appear relatively early and can often be observed over clothing: breast development is visible by Tanner stage 2 and peak height velocity is typically achieved by Tanner stage 3, with most growth completed by Tanner stage 4 (Marshall & Tanner, 1969). As such, self- or parent-report measures have ample utility for girls (Dorn et al., 2006). For boys, by contrast, the onset and progression of puberty is typically marked by increases in testicular volume. Parents are not equipped to assess their child's testicular development, and most would be hesitant to even discuss these physical changes with their sons (Dorn, Susman, Nottelmann, Inoff-Germain, & Chrousos, 1990). Consequently, both parent-report and self-report measures do not adequately capture early maturational events in boys (Petersen, Crockett, Richards, & Boxer, 1988; Shirtcliff et al., 2009). By the time boys begin to show visible signs of puberty (e.g., peak height velocity, voice changes, and facial hair), they have already been undergoing the pubertal process for months to years, including all the neural and hormonal maturational events that accompany puberty (Vijayakumar et al., under review). Thus, by the time visible signs of development are apparent among boys, the concept of "early maturation" may no longer seem applicable, or may be difficult to apply, if a primary mechanism for psychosocial risk of early puberty relies on others' noticing physical development.

A second related measurement issue is that many pubertal events among boys lack a single gold standard measurement tool. For more developed boys, the widely-used Pubertal Development Scale adequately captures late occurring events but may miss earlier stages (Petersen et al., 1988). Tanner stages, on the other hand, attempt to place a framework around measuring aspects of puberty but are certainly not ideal. Tanner staging may miss late-occurring events given that the most visible signs of puberty, including peak height velocity and voice changes, are typically achieved around Tanner stage 4, but pivotal changes such as beard growth typically occur around Tanner stage 5 or even later—described as "stage 6," which may not occur until the early 20s (Marshall & Tanner, 1970). Moreover, pubertal hormones continue to rise long after boys achieve Tanner stage 5 (Braams et al., 2015; Hiort, 2002), providing further evidence that boys' maturation continues long after their genital and pubic hair maturation is adult-like. Increasingly, research settings are using direct measures of pubertal hormones for describing the process of puberty (Goddings et al., 2012; J. G. Simmons et al., 2014), and this methodology is promising as a single biomarker (or panel of hormones) may be able to span the full range of pubertal maturation within and across boys, from age 8 years through the early 20s, including adrenarche (Byrne et al., 2017). Moreover, new assay techniques (e.g., measuring pubertal hormones in hair samples) add feasibility for longitudinal projects (Mundy et al., 2013; Wang, Moody, & Shirtcliff, 2016). Nonetheless, hormone concentrations do not distinctly map onto stages of puberty (Shirtcliff et al., 2009) and effects of hormones are often different from puberty effects (Herting et al., 2014; Van Hulle et al., 2015), suggesting



that hormones complement but do not replace pubertal status measures (Dorn et al., 2006). As such, the “gold standard” may not be a single tool, but rather a combination of puberty measures, including hormones, with acknowledgment that the “best” measure may shift as youth progress through the process of puberty.

Third, while there is a large body of established work for girls that uses menarche (i.e., a discrete, measurable event which occurs toward the end of puberty, signaling the female capacity to reproduce) as a proxy for pubertal timing, there is no analogous, “objective” event in boys’ lives. The closest pubertal marker, spermarche, is not easily measured (Gaddis & Brooks-Gunn, 1985; Jorgensen, Keiding, & Skakkebaek, 1991; Kulin, Frontera, Demers, Bartholomew, & Lloyd, 1989; Laron, 2010) because boys may not be aware of their first ejaculate, they may be too embarrassed to tell parents, and clinic-based first morning urine assays are unlikely to capture this adequately and have a high false-negative rate (Hirsch, Lunenfeld, Modan, Ovadia, & Shemesh, 1985). As such, puberty must be viewed as a process and not an event, requiring multimethod longitudinal investigations spanning many years. For boys, this potentially means continuing assessment long after Tanner stage 5 is attained.

Together, these three measurement issues—hidden early development, absence of late maturation metrics, and lack of salient event markers—have contributed, in part, to a poorer understanding of boys’ puberty compared to girls. Adding to these issues, boys’ development is initiated much later than girls’ on average. Therefore, it is difficult to understand potential risks associated with “early” puberty among boys, given that most study designs are based on girls’ trajectories and do not cover the full age span necessary to measure boys’ puberty. Furthermore, it is extremely challenging to make comparisons between the sexes, given age differences in social, cognitive, and emotional factors that may confound the relationship between “early pubertal timing” and outcomes.

This leads to another shortcoming: conceptual models of the effects of pubertal development tend to be underdeveloped for boys. To understand whether pubertal timing and tempo convey risk for mental health problems, psychosocial puberty models that were developed for girls have been applied to boys, often with mixed success. Historically, there was a prevailing view that early maturation had psychosocial benefits for boys, in large part due to the athletic advantages that come with advanced physical growth (e.g., height, muscle composition) compared to same-aged peers. Research dating back to the 1950s suggested that early pubertal development in boys was associated with higher self-esteem, better body image, and a host of other positive outcomes, while late maturation was associated with greater feelings of inadequacy, dependency, and social rejection (Blyth, 1981; Clausen, 1975; Crockett & Petersen, 1987; Jones & Bayley, 1950; Mussen & Jones, 1957; R. G. Simmons, Blyth, Van Cleave, & Bush, 1979).

Accumulating evidence, however, questions whether early maturation is advantageous for boys. A growing number of studies show that early puberty carries risk for internalizing symptoms, including depression and anxiety, and externalizing symptoms including attention deficit disorder, conduct disorder, aggression, delinquency, and risk-taking behavior (Huddleston & Ge, 2003; Mendle & Ferrero, 2012). Research with African

American boys described above (Hamlat et al., 2014) also illustrates potential drawbacks of early development for mental health and well-being. Additionally, one compelling longitudinal study found that advanced pubertal status in early adolescence was a stronger predictor of boys' depression and anxiety 4 years later than baseline mental health or stressful life events (Ge, Conger, & Elder, 2001). Overall, this work challenges popular assumptions that boys' early maturation is positive, which is based in traditional (and perhaps outdated) notions of masculinity, suggesting that the social meaning of puberty may be distinct for boys versus girls. This begs for stronger models to be developed specifically for boys.

To date, three rival hypotheses (initially developed for girls) have been advanced to explain the link between the pubertal transition and the observed risk for poor psychological outcomes (Caspi & Moffitt, 1991; Petersen & Taylor, 1980), with moderate success in explaining risk for boys. The *early-timing hypothesis* posits that early-maturing youth find pubertal adjustment especially challenging and are more likely to experience adverse outcomes throughout adolescence and early adulthood (Huddleston & Ge, 2003; Mendle & Ferrero, 2012). The recent empirical evidence described above suggests that early pubertal timing may be detrimental for boys, yet the mechanism for boys is unclear. That is, early pubertal onset is thought to carry risk for girls because they are developing earlier than same-age peers, may have less knowledge and experience with puberty, and move away from the preferred body type (e.g., weight gain, unwelcome breast development). This is not the case for boys who typically develop later than girls, experience substantial maturation before others notice, and whose maturation is thought to move them toward a preferred body type. Given this, it is important for the early-timing hypothesis to generate theories for underlying mechanisms that are applicable for the pathways of development experienced by boys.

*The off-time hypothesis* suggests that adolescents who develop off-time in either direction might be at risk because they are different from their same-sex peers, and therefore this model may provide a better conceptual fit for boys. There is some evidence that both early and late timing are associated with depressive symptoms (Conley & Rudolph, 2009; Graber, Lewinsohn, Seeley, & Brooks-Gunn, 1997). One large population sample of 15,922 boys aged 14–16 found that both very early and late puberty were associated with depressive symptoms (Weichold, Silbereisen, & Schmitt-Rodermund, 2003).

Finally, more research is needed with regard to the *stressful change hypothesis*, which posits that, regardless of timing, adolescents in the midst of pubertal changes will manifest higher levels of risk than pre- or postpubertal youth because the physical and neural changes during puberty are rapidly occurring and dramatic, making it difficult for youth to adjust. This hypothesis is challenging to test given that, methodologically, it requires longitudinal data collection that adequately captures development from onset to completion of puberty (Bundak et al., 2007; Castellanos-Ryan, Parent, Vitaro, Tremblay, & Seguin, 2013; Marceau, Ram, Houts, Grimm, & Susman, 2011; Mendle, Harden, Brooks-Gunn, & Graber, 2010). In a longitudinal study designed to examine these three rival hypotheses about the pubertal transition's effects on symptoms of depression, results supported the early-timing hypothesis

for girls and the stressful change hypothesis for boys (Ge et al., 2003), suggesting that longitudinal designs are necessary to test competing theoretical models of puberty for boys.

Although it has empirical support, the stressful change hypothesis implies that difficulties occur temporarily during pubertal maturation; however, risk for mental health problems may persist long after puberty commences and concludes. Psychobiological models can accommodate longer-term effects given that puberty encompasses a period of reorganization as well as activation (Romeo, 2003). It may be that the intersection of puberty and other events, such as stressful peer relations (Mendle et al., 2012), allows risk to persist after the pubertal transition. Some research has examined the confluence of puberty and life stress (Conley & Rudolph, 2009; Conley, Rudolph, & Bryant, 2012; Rudolph & Flynn, 2007; Rudolph, Troop-Gordon, Lambert, & Natsuaki, 2014), but generally found more support for such effects for girls than boys. A missing component in the stressful change hypothesis is a systematic exploration of gender-specific stressors and challenges that may confer longer-term risk for mental health problems.

Taken together, pubertal development and psychosocial outcomes have been examined in boys, but with moderate success, such that boys are not necessarily “understudied” but rather “unknown.” To advance the field, models for boys must take into account the fundamental differences in the appearance and meaning of puberty for boys compared to girls. The underlying mechanism for mental health risk in early adolescence is unlikely to be based on social comparison among young boys, given that their maturation is hidden. However, social comparisons may become more salient among relatively older boys when height, voice changes, muscle mass and facial hair are more prevalent and apparent to others, yet research with older males is scarce. Moreover, among younger boys, proposed mechanisms may need to focus more on psychobiological processes that influence emotions, mood, and brain development (Buchanan, Eccles, & Becker, 1992; Marceau, Dorn, & Susman, 2012). Because early puberty is largely hidden in boys, parents, teachers, and peers may not attribute emotions or mood changes to puberty or normative aspects of growing up. For instance, puberty is thought to contribute to major shifts in parent–child relationships, including increased conflict and distance as adolescents seek greater autonomy. Therefore, early-developing boys may face increased social challenges or more strict behavioral repercussions in their homes, schools, and neighborhoods, as their puberty-related changes are not realized or understood.

Going forward, transdisciplinary research is needed to better understand the interaction between biological, social, and cultural aspects of puberty, and the distinctive ways in which these processes affect boys and girls. Emerging research is already examining the pubertal transition as a time in which childhood problems can become exacerbated by neural and physical changes (Auyeung, Lombardo, & Baron-Cohen, 2013). However, the role of the sociocultural factors in these associations has not been considered in depth. For instance, gender-based expectations may cause parents, teachers, or other adults to elicit or reinforce expected responses from youth, thus shaping their behavior. Further work on the role of the environment and how it interacts with physical maturation, hormone levels, and behavior is greatly needed.

It may also be necessary for research to differentiate mechanisms for risk by using specific domains of development to better understand sex differences in the effects of puberty. For instance, some pubertal growth may be positive for boys (e.g., muscle mass), but other changes may carry negative social consequences (e.g., acne, body odor). The opposing effects of negatively and positively valenced pubertal events may be missed in summative measures that under appreciate the timing of these respective events. That is, it may be important to further distinguish *when* boys experience negative or positive social consequences of development. For example, a deepening voice may eventually be positively valenced (Harries, Walker, Williams, Hawkins, & Hughes, 1997; Hodges-Simeon, Gurven, Cardenas, & Gaulin, 2013; Juul, Magnusdottir, Scheike, Prytz, & Skakkebaek, 2007), yet a source of peer stress when it awkwardly cracks. This level of specificity would be important to consider in research with girls as well.

Questions also remain as to whether the pubertal transition differs for boys based on ethnicity–race, culture, and gender identity. Traditionally positive signs of development may not be positively valenced for some youth who do not want to engage in hegemonic masculinities or for whom height and muscle mass may not be desirable. For example, African American boys (as described earlier) or transgender youth (as discussed later) may not experience such changes favorably. Moreover, there is growing evidence for contextual amplification of pubertal transition effects among boys, including neighborhood ethnic–racial and socioeconomic concentration (Ge, Brody, Conger, Simons, & Murry, 2002; White et al., 2013) as reviewed in the previous section.

Lastly, it is critical to consider the context for putatively positive puberty events. At the onset of puberty, there is a period of structural reorganization and plasticity in the brain, which leads to important changes in social and affective processing (see al-Attia, Beltz, Peper, Crone, & Braams, 2019, in this issue). While these changes are thought to underlie adolescent vulnerabilities (e.g., risk-taking and substance use), they may also confer adaptive advantages, such as greater motivational flexibility and cognitive control in a rapidly changing social world (Crone & Dahl, 2012). There has also been increasing interest in the role of puberty hormones, particularly testosterone, in the regulation of reward and social-affective motivation (e.g., see Eisenegger, Haushofer, & Fehr, 2011). Overall, the capacity for greater social and emotional engagement that emerges around puberty may provide adaptive advantages in positive social contexts, which may also differ by sex.

## Puberty Among Sexual Minority Youth

Before turning to the implications of puberty for sexual minority youth, we consider limitations in measurement, which partially explain why sexual orientation remains understudied in the puberty literature. Pubertal development is commonly assessed based on anthropomorphic changes that describe either physical maturation or certain salient biological events, such as menarche (see Mendle et al., 2019, in this issue). However, an important psychosocial marker of pubertal development that is commonly ignored is increases in sexual interest or sexual desire (McClintock & Herdt, 1996). The hormonal and physical changes of puberty promote increases in sexual feelings, thoughts, behaviors, and activities (D’Augelli, 2001). This raises a challenge of studying puberty among sexual

minority youth as that process of sexual awareness unfolds throughout the pubertal period, is influenced by contextual factors due to the target of their desire, and can be critical to the developing adolescent's identity and adjustment during this time (see Mendle et al., 2019, in this issue).

Puberty can be a particularly daunting time for sexual minority youth or youth who are questioning their sexual identities. Many LGBQ adolescents and adults report that awareness of their sexual orientation and same-sex sexuality occurred during early adolescence (Bell, Weinberg, & Hammersmith, 1981; D'Augelli & Hershberger, 1993; Gibson, 1989; Herdt & Boxer, 1993; Strommen, 1989a, 1989b). For many adolescents, the pubertal transition serves as a staging ground for sexual orientation exploration and affirmation; however, there has been little investigation of the implications of these normative developmental processes for LGBQ adolescent development. This is an important concern for at least two reasons.

First, the stigma attached to same-sex sexual orientation may lead LGBQ youth to experience shame and discrimination (Meyer, 2003), and this stigma can be experienced at all levels of an individual's ecological system (e.g., families, schools, political systems or cultural values and beliefs) (Kosciw, Greytak, Diaz, & Bartkiewicz, 2010; G. M. Russell, Bohan, McCarroll, & Smith, 2011; Ryan, Huebner, Diaz, & Sanchez, 2009). LGBQ youth who experience stigma may inhibit the expression of their same-sex attraction, and, for some of these youth, suppression of their sexual feelings may be channeled into alternate affective expressions, such as depression and anxiety or more serious risk behavior such self-harm (e.g., cutting) and suicidality (suicidal thoughts, plans, and attempts) (Hatzenbuehler, 2011; S.T. Russell, 2003; Savin-Williams, 1994).

Second, LGBQ youth who experience stigma may adapt by presenting themselves as heterosexual or asexual and, as such, youth with same-sex attractions become indistinguishable in research from other youths. On average, self-disclosure among LGBQ youth tends to occur before high school graduation and disclosure to others tends to occur just after high school graduation (Savin-Williams & Diamond, 2000). Thus, during the pubertal period and particularly in early adolescence, researchers may miss or misclassify many of those who will eventually identify as either LGBQ (Saewyc, 2011).

It is important to note, however, that not all LGBQ youth are stigmatized. LGBQ youth who are growing up in countries where same-sex marriage is legally recognized (currently 26 countries around the world; Pew Research Center, 2017) or in cities or school communities that socially sanction same-sex relationships, may be less likely to experience discrimination and more likely to find supportive contexts to explore their sexual identities. Also, youth who are members of an ethnic-racial group in which same-sex behaviors are more widely accepted (e.g., certain Native American tribes) may report less shame or discrimination linked to their sexual orientation. For example, *two spirit* refers to Native American individuals who may engage in same-sex sexual behavior or follow alternate gender roles (Adams & Phillips, 2009; Lang, 2016). Conversely, in many countries, same-sex behaviors remain illegal and punishable by jail or death. Even in countries where same-sex relationships are legally sanctioned, they may be highly stigmatized in certain regions of those countries (e.g., rural areas in the United States) and same-sex individuals may

experience violence as a result. Thus, the challenges associated with puberty among LGBQ youth are inherently culturally and contextually specific.

With this in mind, how do we capture the normative developmental experiences of LGBQ youth either independent of or in comparison to their heterosexual counterparts? Biologically based puberty processes are similar across these groups and pubertal experiences most likely depend on context (Hines, Constantinescu, & Spencer, 2015; Martin & Nguyen, 2004). We offer several approaches to increasing scientific inquiry within this population with appropriate sensitivity and nuance.

First, researchers should avoid defining their samples using sexual identity labels (e.g., *lesbian, gay*) and instead rely on descriptions of behaviors, desires, or attractions (Savin-Williams, 2001). Researchers may need to ask questions about the existence, number, or proportion of sexual feelings, behaviors, and attractions that an adolescent has with males and females. LGBQ youth may be emotionally and cognitively unprepared for feelings of sexual arousal and desire for same-sex peers, particularly given the stigma attached to same-sex sexual orientation. As such, some adolescents might not be ready to describe their sexual identity but may be able to define their sexual attractions when given options that allow for variability (e.g., “I’m mostly attracted to girls,” “I’m attracted to both boys and girls,” “I’m mostly attracted to boys”). Moreover, how LGBQ youth choose to self-identify may also differ from how others perceive them or how researchers categorize them (see Mendle et al., 2019, in this issue).

Second, researchers should approach LGBQ identities with a focus on the nuances across and within L, G, B, and Q identities (Worthen, 2012). Like ethnic–racial identities, LGBQ identities are typically conceptualized in research as sociodemographic categories, resulting in a binary focus on heterosexual versus homosexual status, rather than on the range of LGBQ identities per se. By taking a multifaceted approach to examining sexual identity, researchers may be able to identify groups of youth who have different sexual desires and feelings at varying levels of pubertal development.

Stressors related to sexual orientation may exert either a positive or negative influence on corresponding aspects of personal identity in early adolescence. Same-sex attraction may make some youth susceptible to feelings of shame and hence lead them to dis-identify when they have negative experiences relating to group membership. While LGBQ youth share many developmental experiences (e.g., identity development) and challenges (e.g., peer relations) with their heterosexual counterparts that often go unrecognized (Savin-Williams, 2001), the stigma attached to same-sex desires may lead LGBQ youth to experience additional shame and discrimination (Cahill, Battle, & Meyer, 2003). Consequently, youth with same-sex attractions may experience emotional distress, evaluate themselves negatively, or socially withdraw in an effort to avoid others’ disapproval and rejection (Troiden, 1989). On the other hand, unfavorable experiences relevant to sexual orientation ultimately may lead to a stronger sense of identity, in part because these experiences provide opportunities for reconsideration of an identity in which being LGBQ is devalued. This line of reasoning stems from research on racial identity, which suggests that negative experiences can lead some people to have a stronger identity because their experiences may drive them to

embrace who they are and seek support from others who are similar. Puberty research with LGBTQ youth requires consideration of linkages between stressful experiences and processes of identity and self-esteem.

Drawing on heteronormative work that addresses sexual development in a positive light is a promising start for thinking about identity among sexual minority groups. For example, Rosenthal and colleagues (Buzwell & Rosenthal, 1996; Moore & Rosenthal, 1993) proposed that sexual identity is composed of three components: sexual self-esteem, sexual self-efficacy, and sexual attitudes. These researchers identified distinct groups of youth who reacted differently to sexual situations and had different sexual desires and feelings. Given that puberty unfolds over several years, employing an approach that assesses a range of processes that capture sexual behaviors and attractions that are inclusive of all youth will allow researchers to understand better how puberty and feelings about one's sexuality develop over the course of early adolescence. To date, however, scarce literature focuses on desires and sexual feelings during puberty (see Suleiman et al., 2016; Suleiman & Harden, 2016 for exceptions), with extant studies typically limited to sexual risk-taking behaviors and outcomes (i.e., age at sexual initiation, pregnancy, contraception).

## Puberty Among Transgender Youth

Like sexual minority youth, transgender youth face high levels of stigma and discrimination and are perhaps the most underrepresented subgroup in the psychological literature examining normative variation in puberty (Grant et al., 2011; Greytak, Kosciw, & Diaz, 2009). Transgender individuals are those whose gender identity is different from that of their assigned sex at birth, also known as natal sex. Gender identity begins to develop in very early childhood but continues to be shaped throughout the pubertal period, and there is wide individual variability in terms of gender identification (see Rosenthal, 2016; Vance, Ehrensaft, & Rosenthal, 2014; for reviews). Many individuals do not fully identify as transgender until late adolescence or early adulthood, while others may never adopt a binary gender identity (i.e., nonbinary, gender-fluid) (Ristori & Steensma, 2016; Rosenthal, 2016). Moreover, gender dysphoria in childhood has been shown to persist for some and desist for others over time (Ristori & Steensma, 2016; Rosenthal, 2016). Although there have been advances in understanding trajectories of gender identity, prospective research starting at younger ages with longer-term follow up is needed (K. R. Olson, 2016).

For puberty researchers, recognizing the fluidity of gender during adolescence is critical, and currently there is no universally accepted comprehensive term to describe nonbinary youth: those who do not identify as male or female, including gender questioning, gender nonconforming, gender variant, or genderqueer. Therefore, although we use the term transgender here, we acknowledge the heterogeneity and fluidity of gender identity, particularly during puberty, which demands flexibility and the acceptance of continuums around gender. This raises methodological challenges when assessing transgender identity in puberty studies, because assigning gender identity labels risks misclassifying youth (see Mendle et al., 2019, in this issue). This is particularly true given that the terminology in this area is rapidly changing among adolescents and also varies regionally and within countries. Qualitative work that seeks to understand how youth view and describe themselves appears

critical to inform better assessment in future quantitative studies. Moreover, some of this work may need to be regionally specific and culturally grounded to best capture gender identity among youth from different contexts and settings.

As a group, transgender individuals experience elevated distress during adolescence and are at risk for discrimination and numerous mental health problems, including self-harm, depression, anxiety, suicidality, and victimization (Clark et al., 2014; Nahata, Quinn, Caltabellotta, & Tishelman, 2017; J. Olson, Schrager, Belzer, Simons, & Clark, 2015; Olson-Kennedy, 2016; Veale, Peter, Travers, & Saewyc, 2017; Veale, Saewyc, Frohard-Dourlent, Dobson, & Clark, 2015). These challenges are further exacerbated at pubertal onset, when many transgender youth experience even more marked distress (Vance et al., 2014). Internal conflicts around gender identity, exacerbated by societal pressure to conform to binary gender standards, escalate once the physical changes associated with puberty begin (Vance et al., 2014). Moreover, mental health problems are likely augmented in countries and regions where transgender identity is not accepted and may be met with discrimination and violence.

The context within which transgender youth develop is strongly predictive of how well they are able to navigate puberty. Not surprisingly, research suggests that youths' experiences of discrimination and intolerance largely predict their emotional functioning (Ristori & Steensma, 2016). Prior to puberty, youth who have socially transitioned (i.e., those who are supported to live openly as the gender that they identify with) show similar levels of depression as cisgender (nontransgender) youth and only slightly elevated levels of anxiety (K. R. Olson, Durwood, DeMeules, & McLaughlin, 2016), suggesting that safe and accepting settings are protective for transgender children. In adolescence, transgender youth with supportive parents exhibit higher life satisfaction, lower burden associated with being transgender, and less depression (Simons, Schrager, Clark, Belzer, & Olson, 2013). Thus, poor mental health among transgender individuals is not inevitable, but the collective research speaks to their vulnerability to discrimination and underscores the need for early intervention and social support to mitigate challenges prior to the start of puberty.

Changing social norms have led to an increasing willingness on the part of families to seek out help from providers when their transgender children are going through puberty. This has sparked a great deal of recent pediatric research, much of which transcends the typically siloed approach to studying puberty and draws on the transdisciplinary strengths of these pediatric settings (Tishelman et al., 2015). In turn, gender specialty clinics have experienced an increasing demand for medication to delay pubertal onset and have been studying the implications of delaying puberty for transgender youths' adjustment and well-being (Turban, Winer, Boulware, VanDeusen, & Encandela, 2017). Puberty suppressors or blockers (GnRH agonists) are a group of medications prescribed by endocrinologists to suppress sex hormones and thereby inhibit puberty. A number of studies have shown puberty blockers to be safe and effective (Schagen, Cohen-Kettenis, Delemarre-van de Waal, & Hannema, 2016) and associated with positive mental health outcomes among transgender youth (de Vries, Steensma, Doreleijers, & Cohen-Kettenis, 2011; de Vries et al., 2014). In 2008, the Endocrine Society approved endocrine suppressors to treat transgender youth as young as 12 years old, and declared them safe and effective (Hembree et al., 2009). The process is



completely reversible, which theoretically allows youth to experience early adolescence with reduced anxiety and stress, to develop better coping skills, and to delay challenging decisions about more invasive medical procedures, such as cross-sex hormonal treatment and surgical interventions, until they are older (Vance et al., 2014).

In addition to intervention at the biological level, psychosocial interventions have been on the rise both in combination with medical intervention and on their own. In the psychosocial domain, endocrinologists and primary care providers are collaborating with psychologists and social workers to help families support prepubertal children to socially transition, and these interventions show strong promise for maintaining psychological health and well-being (Durwood, McLaughlin, & Olson, 2017; K. R. Olson et al., 2016; Turban, 2017). As such, this is an exciting time for transdisciplinary endeavors focused on promoting well-being among transgender youth before and during puberty. Clinical research is making great strides toward documenting the efficacy of bio–psycho–social interventions that transcend typical disciplinary siloes (Tishelman et al., 2015).

Despite recent successes, interventions for transgender youth are still not widely available for everyone (Shumer & Spack, 2013). In a recent qualitative study, youth and their parents reported numerous barriers to accessing gender-affirming care, including access to pubertal suppression, illuminating the limited availability of appropriate and consistent medical care (Gridley et al., 2016). In higher income areas, there has been a marked increase in families and youth engaging with practitioners and clinics to discuss gender identity, often with an eye toward medical intervention. However, these resources remain inaccessible to youth from lower income backgrounds, or for those who live in countries or regions where there is intolerance for nontraditional gender identities or a lack of gender-affirming health care (Winter et al., 2016). As such, a limitation of clinical research is that studies often depend on convenience samples of youth and families who are more resourced and educated and who are more likely to be tolerant of gender identity issues, thus potentially biasing results.

Outside of the clinical research setting, the study of transgender youth is limited by insufficient data (e.g., small samples of transgender youth in existing data sets). In most large, public health or epidemiologic studies, gender identification was not assessed directly, making it impossible to draw conclusions about normative development, pubertal maturation, and psychosocial issues in this group. Until recently, studies lumped transgender youth together with LGBQ youth (i.e., the “T” in LGBTQ), and thus gender identity often became erroneously conflated with sexual identity. However, better assessment of transgender status is increasing in population health studies, which will increase our understanding of the prevalence and experiences of this important subgroup.

For example, the New Zealand Adolescent Health Study (Youth’12), a nationally representative high school health survey, revealed that among the 8,166 youth assessed, 1.2% identified as transgender, 2.5% reported being not sure about their gender, and 1.7% did not understand the question (Clark et al., 2014). Compared to their cisgender peers (i.e., those whose gender identity matches their natal sex), these students reported markedly higher depressive symptoms and suicidality, lower personal safety, and poorer access to health care. In addition to its representative sample, another strength of this study was its

ethnic diversity, including New Zealand European, Maori, and Pacific/Asian Islanders. An examination of how intersectionality between ethnic-racial identity and transgender identity, particularly during puberty, predicts health and well-being represents an important future area of inquiry.

A second study, the 2015 Canadian Transgender Youth Health Study, focused specifically on transgender individuals, and included 923 youth between the ages of 14 and 25 years (Veale et al., 2015, 2017). Findings showed that only about half of transgender youth lived “in their felt gender” all of the time. Similar to the Youth’12 results, many transgender youth reported safety concerns and discrimination, including sexual harassment (70%), inconsistent health care, and high levels of self-harm and suicide. Family and other adult support was identified as a particularly important protective factor, yet 70% of youth reported that their families did not understand them and 25% had run away from home in the past year.

Cross-sectional studies of transgender youth lend insight into the special needs and uniquely vulnerable situations of this group; however, in order to better understand trajectories of health and mental health across puberty, investigation needs to start at younger ages and follow youth for adequate periods of time. Almost 50% of transgender youth identify as such before age 12, and studies show that many youth report knowing they were transgender before age 8 or as early as preschool (Clark et al., 2014; Fast & Olson, 2017; K. R. Olson, 2016). Research needs to include sufficiently large prospective studies that track transgender youths’ experiences over the course of puberty.

As indicated earlier, research and intervention in clinical settings have recently exploded, as practitioners respond to urgent needs for medical and/or psychosocial interventions to support developing transgender youth and their families. This underscores the urgent need for strong developmental theory in this area. With the advent and expansion of pediatric gender clinics worldwide, gains have been made to provide individualized multidisciplinary and comprehensive care to transgender youth (de Graaf et al., 2017; Hsieh & Leininger, 2014; Leibowitz & Spack, 2011; Shumer, Nokoff, & Spack, 2016; Tishelman et al., 2015; Vance et al., 2014; de Vries & Cohen-Kettenis, 2012). In the United States, the launch of a \$5.7 million NIH-funded effort to study transgender adolescents provides the basis for hope that this area of research will continue to grow rapidly (Reardon, 2016). This work is inherently transdisciplinary and fields are already coming together to investigate medical approaches, adjunctive psychosocial interventions to minimize stress and increase support, and interventions at the school, community, and policy levels to improve the lives of transgender youth as they navigate puberty.

## DISCUSSION

Fifty years ago, Tanner staging provided established metrics to capture the process of physical maturation and, over time, scientific inquiry has expanded from thinking about puberty as a basic anthropometric research tool (Tanner staging) into an entire transdisciplinary field of study. As this field has matured, it has converged on the notion that puberty is not simply captured in one measure but represents a developmental process that encompasses social, biological, neurological, cultural, sexual, and identity development. As

such, the pubertal process is not a simple progression from one stage to the next but instead marks the onset of a new developmental period in the life of a child, involves a process that takes years to unfold, and which will impact the life of the individual across the entire lifespan (see Mendle et al., 2019, in this issue). The study of puberty is complex; every individual progresses through puberty in his/her own way, and we need to embrace that complexity to advance the science.

By highlighting four understudied groups in this article, we have begun to identify clear areas where limitations exist and highlighted specific areas for further and deeper scientific inquiry. Although we could not cover an exhaustive list of specific populations with unique pubertal experiences and needs (e.g., medically challenged youth, youth in foster care, and youth experiencing puberty in lower and middle income countries where pubertal education is scarce), the field is well-poised to stretch beyond its current limits to expand and augment research and develop stronger models that deepen our understanding of puberty among all of these understudied groups.

As signaled throughout this special issue, a particular challenge in bringing disciplines together lies in the measurement of puberty. There is vast potential for transformative impact as we accept that the assessment of puberty must capture a complex developmental process which spans years and whose tendrils stretch into many other processes in the lives of youth. Answers to the most important questions about the pubertal period will not be attained by searching for a single gold standard puberty metric, as the prior 50 years of research show. Grasping for a gold standard in Tanner staging in which pubertal changes are considered “complete” once youth appear “adult-like” doesn’t capture the vast array of physical, neural, and hormonal changes and therefore is not biologically accurate, even if it accurately describes the physical attributes of youth (Braams et al., 2015; Goddings et al., 2012; Koolschijn et al., 2014). Rather than search for such a metric, the understudied populations presented here illustrate the importance of asking *when* and *for whom* a particular assessment of puberty is best (Dorn et al., 2006), and when a proposed underlying mechanism may (or may not) be applicable to individuals or their contexts (Hamlat et al., 2014). Our call to action is for scholars to broaden and advance the study of puberty, and to do so requires an appreciation of the complexity of pubertal maturation for boys, as well as girls, and across diverse populations. As we move toward more nuanced developmental research, it will be important to pursue cutting-edge inquiries with a deeper understanding of the basic developmental processes of how diverse youth mature. This may be underappreciated, grinding work, yet it is critical for providing depth and longevity to the exciting and provocative research questions that remain unanswered in the lives of youth.

In tackling these challenges, it is important to recognize that current pubertal research resides in silos across fields such as medicine, genetics, psychology, anthropology, neuroscience, public health, and epidemiology (see Marceau et al., 2018, in press), each with its own focus. Discipline-specific foci drive diverging theoretical models, definitions, terminology, and research designs, which create large and often impenetrable divides between fields, and in turn prevent them from coming together to answer cross-cutting questions about pubertal development. As reflected at several points in this article, it is critical to support interdisciplinary teams and transdisciplinary research in order to bridge

these chasms and build a more integrated picture of how the process of puberty unfolds for a diversity of youth and outcomes.

The puberty field is currently at an important nexus whereby the synergy among leading-edge research on developmental and cultural-contextual factors could drive more complex models and unleash compelling and innovative research opportunities. For example, the intersection between ethnicity–race, cultural norms, and sexual identity during the pubertal period is a largely unexplored but potentially important area of study to help explain disparities in adolescent health outcomes. Including hard-to-reach populations in longitudinal research and unpacking developmental processes can be complex, costly, and time-consuming, which explains why certain research areas remain under-appreciated and understudied to date. However, as we become more comfortable tackling complicated (and sometime controversial) questions, doors will open to allow us to examine a multitude of intersecting phenomena—including inquiries around ethnicity–race, sex, sexual orientation, and gender. To reach this goal, we need to answer some basic developmental questions, which, in turn, may challenge our long-standing conceptual models of puberty and shape the narrative about adolescent development in new and exciting ways. When we, as a field, can both tackle seemingly tedious questions (e.g., variations in puberty within and across groups) and simultaneously be bold enough to ask about uncomfortable topics (e.g., ethnicity–race, sexual desire, gender norms, identity), then the field of puberty will finally have the opportunity to “mature” in new and exciting ways.

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