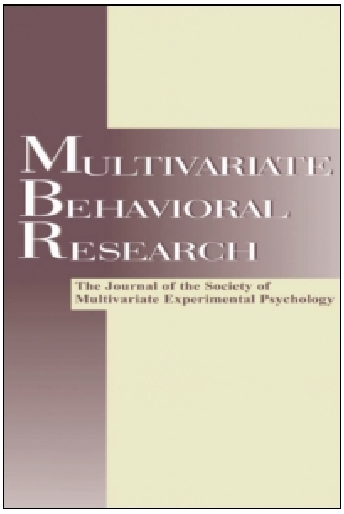

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The Longitudinal Interplay of Adolescents' Self-Esteem and Body Image: A Conditional Autoregressive Latent Trajectory Analysis

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Self-esteem and body image are central to coping successfully with the developmental challenges of adolescence. However, the current knowledge surrounding self-esteem and body image is fraught with controversy. This study attempts to clarify some of them by addressing three questions: (1) Are the intraindividual developmental trajectories of self-esteem and body image stable across adolescence? (2) What is the direction of the relations between body image and self-esteem over time? (3) What is the role of gender, ethnicity, and pubertal development on those trajectories? This study relies on Autoregressive Latent Trajectory analyses based on data from a 4-year, 6-wave, prospective longitudinal study of 1,001 adolescents. Self-esteem and body image levels remained high and stable over time, although body image levels also tended to increase slightly. The results show that levels of self-esteem were positively influenced by levels of body image. However, these effects remained small and most of the observed associations were cross-sectional. Finally, the effects of pubertal development on body image and self-esteem levels were mostly limited to non-Caucasian females who appeared to benefit from more advanced pubertal development. Conversely, Caucasian females presented the lowest self-esteem and body image levels of all, although for them more advanced pubertal development levels were associated with a slight rise in body image over time.

In a review of self-concept research, Craven and Marsh (2008) emphasized that self-concept history was fraught with controversy. Complex and controversial issues often require sophisticated methodologies—this is the essence of substantive-methodological synergies (Marsh & Hau, 2007). Substantively, this study attempts to clarify three controversial issues: (1) How stable are the intraindividual trajectories of self-esteem and body image in adolescence? (2) What is the direction of the relations between self-esteem and body image? (3) What is the role of gender, ethnicity, and pubertal development on those trajectories? Methodologically, this study demonstrates the usefulness of Autoregressive Latent Trajectories (ALTs; Bollen & Curran, 2006) in addressing these issues.

SUBSTANTIVES ISSUES: THE LONGITUDINAL INTERPLAY OF ADOLESCENTS' SELF-ESTEEM AND BODY IMAGE

Secondary school[1] years play a crucial role in the development of adolescents

[1] This study uses data collected in Quebec (Canada). In Quebec, children start elementary school around the age of 6 and usually remain in the same school until Grade 6, after which they transition to secondary schools (close to the age of 12), where they remain 5 years (Grades 7 to 11). Quebec secondary schools thus combine North American middle, junior high, and high schools.

because during this period they evolve in a context in which they implicitly and explicitly learn about themselves and relationships and at the same time experience the major physical changes associated with puberty, which in turn exert a determining impact on how they perceive themselves and interact with others (Eccles et al., 1993; Steinberg & Morris, 2001). Today, there is considerable evidence (Roeser, Eccles, & Sameroff, 2000; Smolak, 2004) that the secondary school years (from Grade 7 or 12 years of age) are characterized by multiple transformations that can be stressful for adolescents and drastically impact the way they define themselves in general (i.e., self-esteem) or physically (i.e., body image). Self-esteem and body image are considered interrelated key indicators of successful coping with the developmental challenges of adolescence (Craven & Marsh, 2008) because they (a) are at the core of the various biopsychosocial transformations of adolescence (Clark & Tiggemann, 2008; Eccles et al., 1993) and (b) are strongly and positively interrelated during this period, at least in Western societies (Davison & McCabe, 2006; Frost & McKelvie, 2004; Harter, 1999). Not surprisingly, body image occupies a central position in the self-concept system because the body, through its appearance, attributes, and abilities, represents a preeminent interface in social interactions (Fox & Corbin, 1989). Self-esteem refers to the positive or negative way people feel about themselves as a whole, which is also often called global self-esteem or global self-worth (Brown, Dutton, & Cook, 2001). Body image refers to people's self-evaluations of their physical attractiveness, which is also often called body image satisfaction or perceived physical appearance (Marsh, 1990b). Persons with high levels of self-esteem and body image feel good about themselves generally (self-esteem) and physically (body image).

Most studies investigating the transition from the elementary to the secondary school noted that it is often accompanied by a decrease in self-esteem and body image (Eccles et al., 1993; Twenge & Campbell, 2001) and is often interpreted as meaning that secondary school years are accompanied by such a decrease. However, the results from studies focusing specifically on secondary school, after the transition, are more confusing. For instance, some studies found significant average (intraindividual) increases in students' self-esteem (e.g., Greene & Way, 2005; Moneta, Schneider, & Csikszentmihalyi, 2001), whereas other found significant decreases (e.g., Greene, Way, & Pahl, 2006; Reddy, Rhodes, & Mulhall, 2003) or identified stable intraindividual trajectories (Young & Mroczeck, 2003). To our knowledge, only two studies verified the intraindividual evolution of body image during the secondary school years. The first showed that levels of body image remained stable between Grades 7 and 8 and increased between Grades 9 and 11 (Cole et al., 2001). The second, however, showed a constant increase over time (Young & Mroczeck, 2003). However, these studies are still few, especially for body image, and need to be replicated with more diversified methods and samples.

One of the promising ways to clarify this question is through the reliance on a multidimensional hierarchical self-concept perspective (Shavelson, Hubner, & Stanton, 1976). In their classic review of self-concept research Shavelson et al. represented the self-concept as a pyramid, with self-esteem at the apex and more specific constructs at the next lower level, such as the academic self, the social self, and the physical self. Specificity increases downward with the most situation-specific self-perceptions at the base. Within this model, self-esteem is seen as relatively stable compared with specific self-perceptions, which are more transient (Shavelson et al., 1976). This conception assumes that within-person changes in specific components affect the higher order constructs (i.e., bottom-up hypothesis; Byrne & Gavin, 1996; Shavelson et al., 1976). In contrast, Brown (1993) proposed that a sudden drop in self-esteem may radiate downward to specific components (i.e., top-down hypothesis). Some also noted the possibility of simultaneous bottom-up and top-down relations, proposing reciprocal or bidirectional hypotheses (Marsh, 1990a). In the few longitudinal studies designed to compare those models directly (but not focusing on the self-esteem–body image relationships), Marsh and Yeung (1998) and Kowalski, Crocker, Kowalski, Chad, and Humbert (2003) provided little support for top-down, bottom-up, or reciprocal models but for stable "horizontal" effects, with each construct mostly related to itself over time.

Although self-esteem and body image are known to be strongly interrelated (Davison & McCabe, 2006; Frost & McKelvie, 2004; O'Dea, 2006; Stice, 2002), the results from studies focusing on the directionality of these relations are mixed and inconclusive (Harter, 1999). On the one hand, researchers advocating multidimensional self-concept theories, in which self-esteem is seen as a composite of numerous domains central to an individual (Harter, 1999; Tiggemann, 2005), obtained results conforming to a bottom-up hypothesis, with relations going upward from body image to self-esteem (e.g., Clay, Vignoles, & Dittmar, 2005; Dubois, Tevendale, Burk-Braxton, Swenson, & Hardesty, 2000; Keery, van den Berg, & Thompson, 2004; Shroff & Thompson, 2006). On the other hand, scholars investigating etiological theories of eating disorders, in which body image plays a central role (Button, 1990; Tiggemann, 2005), obtained results conforming to a top-down hypothesis, with relationships going downward from self-esteem to body image (e.g., O'Dea & Abraham, 2000; Paxton, Eisenberg, & Neumark-Sztainer, 2006; Ricciardelli & McCabe, 2001). The lack of clear results regarding the direction of these relations may be attributed to the fact that most studies were driven by unidirectional theories and failed to confront alternative hypotheses (as did Marsh & Yeung, 1998, or Kowalski et al., 2003). Recently, Tiggemann (2005) did so and noted that when initial levels of self-esteem were controlled, body image positively predicted later levels of self-esteem, whereas no evidence of the reverse was found. However, this study relied on a small sample of girls and on two widely spaced measurement points, reinforcing the need to replicate these results on a mixed-gender sample and to verify whether this directionality is stable or changes during adolescence.

Predictors of Self-Esteem and Body Image Across Adolescence

To obtain a clear picture of self-esteem and body image across adolescence, it is also important to understand how they develop. A range of individual factors appear to be involved in the development of self-esteem and body image. Among these, gender, ethnicity, and puberty appear particularly important (e.g., Dubois, Burk-Braxton, Swenson, Tevendale, & Hardesty, 2002; Williams & Currie, 2000). First, several studies showed that girls, relative to boys, had lower initial levels and a greater decrease in self-esteem and body image (Feingold & Mazzella, 1998; Kling, Hyde, Showers, & Buswell, 1999; Twenge & Campbell, 2001). Second, many studies showed that youths from ethnic minority groups tended to present lower levels of self-esteem, more marked increases in self-esteem, and higher levels of body image than youths from Caucasians majority groups (Gray-Little & Hafdahl, 2000; Greene & Way, 2005; Roberts, Cash, Feingold, & Johnson, 2006; Ricciardelli, McCabe, Williams, & Thompson, 2007) although the results remain unclear (Rhodes, Roffman, Reddy, & Fredriksen, 2004; Young & Mroczeck, 2003). Besides, two meta-analyses (Kling et al., 1999; Twenge & Crocker, 2002) showed that gender moderated the influence of ethnicity on self-esteem: gender differences were more pronounced among majority than minority groups. No such studies are available yet for body image.

Finally, inconsistent associations were also observed between pubertal development and self-esteem/body image. Indeed, some results showed that advanced pubertal development was associated with lower levels of self-esteem and body image (Lackovic-Grgin, Dekovic, & Opacic, 1994; Wichstrøm, 1998), whereas others indicated that it is during early puberty that the lowest levels of self-esteem and body image are observed (e.g., Alsaker, 1995; Wade, Thompson, Tashakkori, & Valente, 1989). One possible explanation for this discrepancy involves gender as a moderator (O'Dea & Abraham, 1999; Steinberg & Morris, 2001). Indeed, because girls usually start pubertal development earlier than boys, they also tend to experience more often the simultaneous occurrence of pubertal development and of the secondary school transition, which can potentially interrupt unfinished developmental tasks (such as coming to terms with new social roles associated with the emergence of adultlike bodies or dealing with the higher autonomy and freedom characteristic of secondary schools) and increase the stressfulness of both experiences (Alsaker, 1995; Angold & Worthman, 1993). In addition, puberty often results in body fat accumulation in girls, an often undesired change, whereas for boys it usually results in muscle increase and the emergence of other culturally valued attributes (Alsaker, 1995; Angold & Worthman, 1993; Stice & Bearman, 2001). Indeed, studies showed that early pubertal development is associated with lower self-esteem/body image than more advanced pubertal development in females, whereas the opposite is observed in males (Folk, Pedersen, & Cullari, 1993; Ge, Conger, & Elder, 1996; O'Dea & Abraham, 1999; Siegel, Aneshensel, Tabù, Cantwell, & Driscoll, 1998). Gender and ethnicity may even simultaneously moderate the effects of puberty on self-esteem and body image. Indeed, some studies revealed that the deleterious effects of early puberty could be limited to, or stronger for, girls of Caucasian European/North American origin (Halpern, Udry, Campbell, & Suchindran, 1999; Siegel, Yancey, Aneshensel, & Schuler, 1999), suggesting that social factors may moderate these relations. For instance, whereas the Caucasian European/North American culture emphasizes lean "prepubertal" looks for girls, African American/Black and Hispanic American/Latin cultures put less emphasis on leanness and more on the fuller forms emerging with puberty (Siegel et al., 1999; Stice & Bearman, 2001). Clearly, the existence of such a three-way interaction between gender, ethnicity, and pubertal development, which was observed only in Siegel et al.'s (1999) cross-sectional study for body image, should be replicated.

METHODOLOGICAL ISSUES: STATISTICAL APPROACHES TO THE STUDY OF DEVELOPMENTAL STABILITY AND CHANGE

To investigate questions related to the stability of developmental processes and to the longitudinal interplay between two developmental processes, multiple analytical tools can be used. Classically, correlational analyses have been used to investigate the stability of interindividual rank order differences as well as the interrelationships between variables. However, these analyses are limited because (a) they completely exclude mean-level information (being based on z scores) and information regarding intraindividual stability of interest to this study and (b) they remain univariate. They thus cannot be used to describe the overall shape of developmental trajectories, also of interest in this study. Conversely, repeated measures analysis of variance (ANOVAs) have been used to study the longitudinal stability of mean-levels in a single developmental process at a time. In ANOVAs, polynomial contrasts can also be included to model the shape of the time-related evolution (i.e., linear, curvilinear, etc.). However, ANOVAs cannot easily be used to study the intra- or interindividual stability of developmental processes or the interplay between developmental processes.

To answer those limitations, autoregressive models were proposed (Bollen & Curran, 2006; Jöreskog, 1979; Marsh & Grayson, 1994). The nature and direction of the interplay between multiple processes may be directly estimated by adding cross-lagged parameters between them. In multivariate autoregressive models, each time point on a variable is thus defined as an additive function of the prior time point on this variable, plus the prior time point on the second variable, plus a random disturbance (with the first time point treated as predetermined, i.e., as an exogenous variable that is not influenced by the other variables included in the model). In those models, it is also possible to correlate the residuals from similar time points on both processes. This method is illustrated in Figure 1. However, autoregressive models remain based on covariance stability and thus cannot take into account the full, traitlike trajectory of the developmental processes and their overall "holistic" interplay, which may often present a substantive interest in their own right. Although mean-structure information can be incorporated in these models to define the shape of the longitudinal mean-level trajectories through polynomial ANOVA-like contrasts (Marsh & Grayson, 1994), they remain unable to take into account the pattern of intraindividual stability and change of interest to this study, being more focused on rank order interindividual stability.

Marsh and Grayson (1994) illustrated the biases resulting from the study of developmental processes through these classical approaches and Rogosa (1995; also see Meredith & Tisak, 1990) proposed Latent Curve Models (LCMs) as a solution. LCMs are a mean and covariance-based extension of structural equation models in which the repeated measures on a variable are related to latent variables through a restricted factor structure allowing for the separate estimation of the intercepts and slopes of intraindividual trajectories (nonlinear terms may also be estimated). Those latent variables may then be directly predicted from other variables, and the overall "holistic" interplay of these parameters in different developmental processes may also be estimated (Bollen & Curran, 2006; MacCallum, Kim, Malarkey, & Kiecolt-Glaser, 1997; McArdle, 1989). LCMs

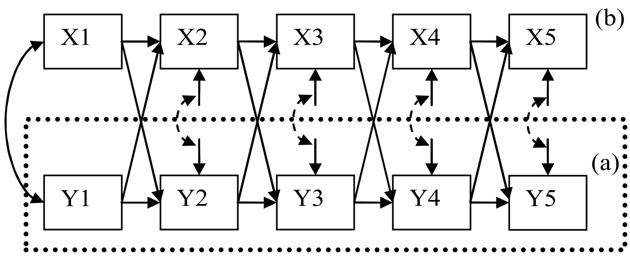

FIGURE 1 Univariate (a) and bivariate (b) autoregressive cross-lagged model.

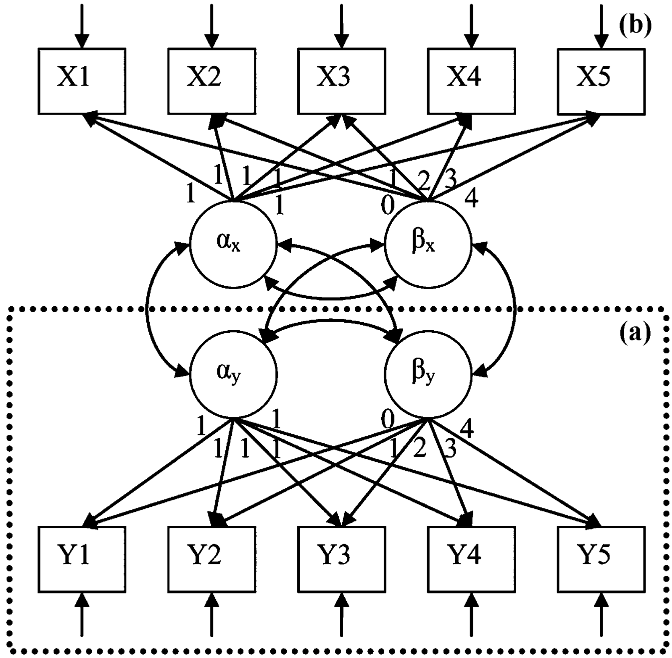

FIGURE 2 Unconditional univariate (a) and bivariate (b) Latent Curve Model.

are perfectly suited to the study of intraindividual stability and change and are specifically designed to portray the overall shape of developmental trajectories. An LCM is depicted in Figure 2.

However, LCMs do not allow for the estimation of autoregressive and time-specific relations among the repeated measures. This may represent a seriously biasing factor in self-concept research. Indeed, self-concept components are known to possess state-trait properties (Butler, Hokanson, & Flynn, 1994)—that is, of being best represented by stable (trait) and reactive (state) components—but these state-trait properties have yet to be specifically investigated in a comprehensive manner. In LCM, only overall intraindividual trajectories are usually estimated, corresponding to the trait component of self-concept dimensions, without taking into account the—sometimes strong—autocorrelations that influence adjacent, statelike time points in individuals' trajectories. More precisely, LCMs consider that time-specific deviations from the overall trajectories (e.g., deviation from a straight line in linear models) only represent random "errors" to be controlled rather than substantively meaningful deviations from the generic trajectory. Such deviations may indeed represent statelike "shocks" to the overall trajectories. These "shocks" may result from meaningful situation-specific perturbations (e.g., the death of a loved one) or successes (e.g., admission into a highly competitive program) and even exert a lasting influence on individual trajectories. Such time-specific, statelike relations may indeed be quite strong and/or vary across time and thus potentially bias the estimation of the full trajectories by causing them to be "absorbed" by the remaining parameters of the model (Sivo, Fan, & Witta, 2005). Indeed, the imposition of an autoregressive structure on the residual variances of specific time points has often been recommended as a way to avoid such biases (e.g., Singer & Willett, 2003) and has long been considered a central component of econometric time series analyses (e.g., Box & Jenkins, 1976). Biases resulting from the failure to take into account these autoregressive statelike components may potentially explain the aforementioned contradictory findings regarding the stability of self-esteem and body image trajectories.

From the presentation of the previous models, one is left with the impression that a "trait-or-state" choice should be made between studying overall trajectories and their interrelationships or time-specific influences between repeated measures when in fact both questions may present a substantive and complementary interest. For these specific cases, Bollen and Curran (2004, 2006) proposed Autoregressive Latent Trajectories (ALTs) as a way to combine both types of analyses and to avoid the potential biases inherent in both autoregressive and LCM models. Although the ALT is highly similar to alternative latent state-trait models (e.g., Cole, Martin, & Steiger, 2005; Hamaker, Nesselroade, & Molenaar, 2007; Steyer, Schmitt, & Eid, 1999), these models traditionally did not impose a developmental LCM-like structure on their trait components and thus are unable to directly portray the shape of the developmental trajectories of interest to this study (Tisak & Tisak, 2000). Similarly, although ALTs might in some specific cases be mathematically equivalent to LCMs with autoregressive error structures, they represent a more flexible and generic expression of these models (Hamaker, 2005). In ALTs, as in autoregressive models, the first measurement point is treated as predetermined (i.e., as an exogenous variable not influenced by the estimated trajectory factors or the other measurement points) but is correlated with the latent intercept and slope parameters. An ALT is presented in Figure 3. It is important to note that ALTs allow for the inclusion of predictors. Although ALTs incorporate autoregressive structures to LCMs, these structures take another meaning in ALTs, being based on the statelike residuals of the LCM part, and thus do not directly reflect interindividual rank-order stability. Rather, we argue that the state-trait analogy, in which the autoregressive structure is seen as reflecting the impact of individual statelike deviations from the overall trajectories on the remaining time points, represents a more exact description of the autoregressive part of ALTs. Thus, although this was not the case in this study, ALT results may reflect more than the simple combination of results obtained from separate LCMs and autoregressive models.

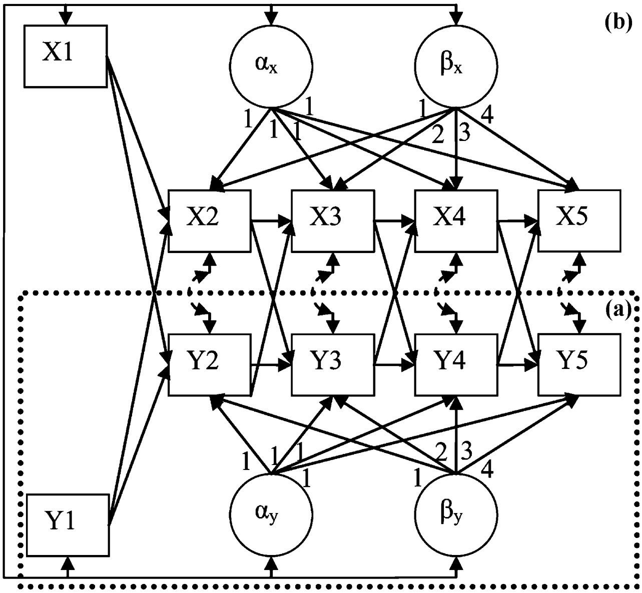

FIGURE 3 Unconditional univariate (a) and bivariate (b) Autoregressive Latent Trajectory model.

THIS STUDY

While illustrating the usefulness and flexibility of the newly developed ALT, this study attempts to clarify three issues. First, the intraindividual stability of the developmental trajectories of self-esteem and body image across adolescence is evaluated. Second, the nature and direction of the relationships between self-esteem and body image are investigated. Finally, the role of gender, ethnicity, and pubertal development and their interaction in the development of self-esteem and body image are tested. Following Siegel et al. (1999), we postulate a significant three-way interaction.

METHOD

Participants and Procedure

The Montreal Adolescent Depression Development Project (MADDP; Morin, Janosz, & Larivée, 2009) is a 4-year prospective longitudinal study of over

1,000 adolescents measured six times over this period. This project was initially designed as a 1-year intensive follow-up study with three measurement points. All seventh-grade students from five Montreal-area secondary schools were asked to participate in the project in September 2000, right after the secondary school transition. Parents of the 1,553 eligible participants were informed of the project through a letter that was accompanied by a consent form that described the initial three measurement points (across one school year): September/October 2000 (Time 1), February 2001 (Time 2), and May/June 2001 (Time 3). Only 10 parents refused to let their children participate in the initial part of the study. It should be noted that self-esteem and body image were not measured at Time 3. The remaining 1,543 students were asked to sign a consent form similar to the parental one. A total of 1,370 agreed to participate (66 refused) and completed Time 1 measures (104 were either sick or absent or could not be reached in time and thus could not consent) and at least one of the remaining two measurement points. Only 3 more were lost due to chronic absenteeism during the 1st year of the study. For more details see Morin et al. (2009).

These 1,370 participants were then contacted, during their 2nd year of secondary school (eighth grade: 2001–2002), to participate in a longer term follow-up study comprising 3 additional years, with one measurement period per year (Time 4, 5, and 6, with Time 4 being close to 1 year after Time 2). From those participants, 1,034 were included in the longer term follow-up study: (a) 58 refused to sign the consent form in Year 2, (b) 142 were absent or had changed schools and were impossible to locate during Year 2, and (c) 136 were excluded due to parental refusal. Of those, 1,001 were included in this study. The remaining 33 failed to complete at least three (out of five) valid measurements on both self-esteem and body image. In addition, these 33 students' answers were inconsistent or extreme (e.g., choosing an elevated number of the first or last answering point notwithstanding reversed score items) and characterized by multiple skipped answers on most of the completed questionnaires, leading us to question the trustworthiness of their answers.

This sample was predominantly of a French Canadian Caucasian background (79.30%) and almost equally split across genders (53.85% males). At Time 1, the mean age of the participants was 12.62 years (SD = 0.63). Of these students, (a) 48.55% attended public schools, 30.47% attended private schools, and 20.98% attended a public school for gifted students; and (b) 20.68% were in a regular program, 29.67% in an enriched program, 30.67% in a program for gifted students, and 18.98% in a special education program. Attrition analyses were conducted to compare this sample with the 1,370 students who were part of Year 1 initial follow-up (see Morin et al., 2009). These analyses rejected the null hypothesis of no differences between groups and thus revealed that, when compared with the participants, lost students were older

($t = -2.82, df = 1060, p \leq .01$) and came more often from special education programs ($\chi^2 = 30.16, df = 3, p \leq .01$), public schools ($\chi^2 = 35.17, df = 4, p \leq .01$), and ethnic minority groups ($\chi^2 = 14.75, df = 1, p \leq .01$). However, the statistical tests also failed to reject the null hypothesis of no differences between the retained and lost participants on gender ($\chi^2 = 0.05, df = 1, p \geq .01$), self-esteem ($t = 0.56, df = 1307, p \geq .01$), body image ($t = -0.16, df = 1303, p \geq .01$), and pubertal development ($t = 0.27, df = 1322, p \geq .01$).

Measures

Demographic information. Gender and nationality of the participants were obtained from school records. Gender was coded 0 for males and 1 for females. Nationality was used as a proxy of ethnicity and was coded 0 for students of North American decent and whose maternal language was either French or English ($n = 892$; 89.1%) and 1 for students with other nationalities ($n = 109$; 10.9%). These two groups are hereafter referred to as Caucasian and non-Caucasian. Non-Caucasian youths were almost equally from African/Arabic descent, Asian descent, and South American descent, but there were insufficient numbers to consider each group separately. Overall, the sample comprised 470 Caucasian boys, 477 Caucasian girls, 69 non-Caucasian boys, and 40 non-Caucasian girls.

Pubertal development. The adolescents' levels of pubertal development were measured with the French adaptation (Héroux, 1997; Verlaan, Cantin, & Boivin, 2001) of Petersen, Crockett, Richards, and Boxer's (1988) Pubertal Development Scale. This self-reported instrument comprises seven items rated on a 4-point scale reflecting incremental pubertal changes. Of those, three items are generic (body hair, skin change, and growth spurt), two are reserved for boys (voice change and facial hair), and two are reserved for girls (breast change and menarche). This questionnaire was used in the 1st year of the study across the first three measurement points. A composite measure of pubertal development was constructed by averaging students' levels of pubertal development across the three measurement points taken in the 1st year of the study to better reflect the fact that pubertal development is a developmental process rather than a static state (Alsaker, 1995; Angold & Worthman, 1993). Validation studies of this questionnaire revealed adequate psychometric properties and convergent validity with Tanner stage evaluations (e.g., Petersen et al., 1988; Verlaan et al., 2001). In the present study, internal consistency (α) coefficients varied from .70 to .74 across the three measurement points, which were also highly correlated with one another ($r = .80$ to .81).

Self-esteem. The French adaptation (Vallières & Vallerand, 1990) of the Rosenberg Self-Esteem Inventory (Rosenberg, 1965) was used to assess adolescents' self-esteem at Times 1, 2, 4, 5, and 6. The 10 items (e.g., I feel that I have a number of good qualities) from this instrument are rated on a 4-point Likert scale ranging from *strongly agree* (4) to *strongly disagree* (1). Validation studies revealed adequate psychometric properties (e.g., Byrne, 1996; Vallières & Vallerand, 1990). In the present study, internal consistency (α) coefficients vary from .77 to .89 across the five yearly measurement points, which are also significantly correlated with one another ($r = .38$ to .58).

Body image. The French adaptation (Guerin, Marsh, & Famose, 2003) of the perceived physical appearance scale from Marsh's (1990b) Self-Description Questionnaire-II (SDQ-II) was used at Times 1, 2, 4, 5, and 6. The eight items (e.g., I am good-looking) from this scale are rated on a 4-point Likert scale ranging from *strongly agree* (4) to *strongly disagree* (1) rather than on the original 6-point scale from the SDQ-II to ensure a minimal level of consistency across the multiple-rating scales used in the MADDP and thus to limit the cognitive toll on the participants. Validation studies of this questionnaire revealed adequate psychometric properties (e.g., Guerin et al., 2003; Marsh, 1990b). In this study, internal consistency (α) coefficients vary from .88 to .90 across the five yearly measurement points, which are also significantly correlated with one another ($r = .41$ to .69).

Analytical Strategy

Models were estimated with the Full Information Maximum Likelihood Estimator from Mplus 5.1 (L. Muthén & Muthén, 2008). Full Information Maximum Likelihood estimation has been repeatedly confirmed as an efficient method of dealing with even large proportions of missing data under missing-at-random assumptions by estimating the full model using all of the available information from all cases (Enders, 2010; Enders & Bandalos, 2001; Graham, 2009). For additional details on the technical implementation of Full Information Maximum Likelihood estimation in Mplus, interested readers are referred to Chapter 6 of the Mplus technical appendix (B. O. Muthén, 1998–2004). The fit of all models was estimated with multiple indices: the χ^2 likelihood ratio test, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA). Values greater than .90 for CFI and TLI are considered indicative of adequate fit, although values greater than .95 are preferable (e.g., Bollen, 1989; Hu & Bentler, 1999). Values smaller than .08 or .06 for the RMSEA and smaller than .10 and .08 for the SRMR support, respectively, acceptable and good fit (e.g., Bollen, 1989; Hu & Bentler, 1999). Nested models were compared through χ^2 difference tests ($\Delta\chi^2$; Bollen, 1989).[2]

The analytical strategy followed Bollen and Curran's (2004, 2006) recommendations.[3,4] First, univariate unconditional autoregressive models, LCMs, and ALT models were estimated on one developmental process (self-esteem or body image) at a time. However, because these models yielded conclusions identical to those from the multivariate models, they are not reported here for the sake of parsimony but are presented in supplemental materials available on the Mplus website (http://www.statmodel.com/papers.shtml). Multivariate LCMs, autoregressive models, and ALTs were estimated and compared to determine which model provided the most complete and parsimonious representation of the data. Indeed, ALTs are complex models that should always be built up carefully from simpler models to ensure that their complexity really improves the representation of the data (Bollen & Curran, 2004, 2006). Although those models are not nested, it is possible to specify an ALT in which autoregressive and cross-lagged parameters are fixed to zero, which is equivalent to an LCM and nested within the ALT. The multivariate autoregressive and ALT models included cross-lagged regression parameters going from each construct (self-esteem, body image) to the other. In the multivariate LCM, correlations were added between the intercept and slope factors of both processes. Finally, the multivariate ALT also included correlations between the first measurement point and the intercept and slope factors of both processes. Bollen and Curran (2004,

[2]Given the sample size dependency of $\Delta\chi^2$, some suggest that changes in fit indices should also be considered in nested model comparisons (e.g., Cheung & Rensvold, 2002). In the present study, these additional verifications did not change the conclusions from the $\Delta\chi^2$.

[3]Models were estimated with manifest variable indicators (mean scale scores) to avoid unnecessary complexity. Still, longitudinal models based on manifest indicators may present problems because they rely on an often untested assumption of measurement invariance and may confound unstable reliability with stability/instability of the construct (Marsh, Muthén et al., 2009). In addition, in ALTs, the autoregressions are estimated on the time-specific uniquenesses of each process, which in manifest variables combines measurement errors (that are partialled out in latent models) and state deviations. This could lead to an underestimation of the autoregressive parameters. Fortunately, our decision to rely on manifest indicators did not affect the results because (a) we found evidence of longitudinal measurement invariance for self-esteem and body image and (b) key fully latent models were estimated and yielded highly similar results, confirming the absence of bias in the reported results.

[4]All models were estimated while ignoring the clustering of students within schools. This did not affect the results because (a) the estimated intraclass correlations coefficients on the study variables were all very low (0.004 to 0.067; $M = 0{,}023$, $SD = 0.018$); (b) key models were estimated while considering this clustering with Mplus "Type = Complex" feature, a method that has been shown to be as effective as full multilevel models (Marsh, Lüdtke et al., 2009; Marsh & O'Mara, 2010) and converged on highly similar results, although these models were never fully proper (negative variance estimates, warnings, etc.) potentially due to the low number of Level 2 units ($n = 5$ schools).

2006) recommended that additional constraints should be progressively added to the ALT to ensure that the final model represents the most parsimonious representation of the data: (a) fixing the slope factor's variance to zero, (b) excluding the slope factor, (c) excluding the time-specific uniquenesses' correlations, (d) constraining the time-specific uniquenesses' correlations to equality, (e) constraining the autoregressive parameters to equality across time periods, and (f) imposing equality constraints on the cross-lagged parameters.[5] The first three of these modifications were added on one process (self-esteem or body image) at a time.

Finally, the predictors and their interactions were added to the final model and the significant interactions were interpreted following Bollen and Curran's (2006) recommendations. More precisely, the intercept and slope factors of both developmental processes as well as their first predetermined measurement point were regressed on each predictor and on their two- and three-way interactions. For significant interactions, the simple effects of pubertal development in different subgroups (males and females; Caucasian or non-Caucasian students) were first estimated by recoding gender and/or ethnicity by subtracting one from these variables. Indeed, when an interaction term is included in the model, the regression coefficient associated with each predictor forming the interaction reflects the effect of this predictor when the other predictor(s) forming the interaction are equal to zero. Subtracting one from gender or ethnicity (initially coded zero for males or Caucasian students and one for females or non-Caucasian students) ensure that zero now represent the other subgroup.[6]

For additional details on the mathematical representation of these models on the time codes used in this study and on the assumptions underlying them, readers are referred to the Appendix and to Bollen and Curan (2004, 2006). Mplus codes for the main models tested in this study are also presented in supplemental materials available on the Mplus website (http://www.statmodel.com/papers.shtml).

[5]In LCMs and ALTs, only linear trajectories were estimated (intercepts and slopes). The exclusion of quadratic trends is based on substantive and statistical reasons. Substantively, three of the preceding LCM studies estimated quadratic trends and found that they did not significantly contribute to the models (Greene & Way, 2005), were too small to be meaningful (Greene, Way, & Pahl, 2006), or were significant only in specific subgroups (Moneta et al., 2001). In this study, model comparisons of preliminary quadratic and latent basis models (McArdle & Epstein, 1987; Meredith & Tisak, 1990; Ram & Grimm, 2007) with linear models revealed that the former did not provide a better representation of the data than linear models. For these reasons, and because adding nonlinearity in ALTs involves constraining meaningful parameters, linear ALTs were estimated.

[6]A reviewer noted that the group comparisons implicit in these interactions effects rely on assumption of strict measurement invariance of the body image and self-esteem constructs in gender, ethnicity, and gender X ethnicity groups. Upon verification, these assumptions were reasonably met in this study.

RESULTS

Descriptive Statistics

The descriptive statistics and correlations of all variables are reported in Table 1. These results show that the various measurement points of both self-esteem and body image are moderately related to one another and quite stable over time. Gender and pubertal development are also significantly related to some of the measurement points of body image and self-esteem, which show fewer significant relations with ethnicity. Gender is also significantly and positively related to pubertal development, confirming that girls tend to have more advanced pubertal development than boys.

Unconditional Multivariate Models

The results from the various multivariate models are reported in Table 2. These results parallel those from the univariate ALT (see the supplemental materials available on the Mplus website at http://www.statmodel.com/papers.shtml) as well as those from the multivariate autoregressive and LCM results, showing the complementarity of these various models in this study. These results reveal that neither the autoregressive model nor the LCM provide a satisfactory fit to the data, whereas the ALT provides an adequate fit to the data according to all fit indices and is superior to the nested ALT-LCM according the $\Delta\chi^2$ statistics. The parameter estimates from the retained final ALT model (Model 14) are presented in Figure 4, with the exemption of the variance-covariance estimates, which are reported in Table 3.

These results show that the slope factor for self-esteem can be removed (Model 6) without significantly changing the overall fit of the model. A closer look at the estimated parameters shows that adolescents' average levels of self-esteem have an initial mean of 31.76 on a 10 to 40 scale (corresponding to 3.2 on the 1 to 4 answering scale, and thus apparently they feel very good about themselves generally), present significant interindividual variability (see Table 3), and show intraindividual stability (i.e., no slope) over time. The observed difference between the estimated intercept factor and the first measurement point ($\mu_{t1} = 31.76$ vs. $\mu_{\alpha} = 23.66$) reflects the fact that in ALTs, the intercept represents the portion of the Time 2 variable remaining unexplained by the Time 1 variable. Regarding body image, it appeared necessary to model both the variance of the slope factor (Model 7) and the slope factor itself (Model 8). However, because the estimated variance for the slope factor proved small and nonsignificant ($\psi_{\beta\beta} = 0.43$, $SE = 0.39$), an observation that is convergent with the preliminary results from the univariate ALT for body image (see the supplemental materials available on the Mplus website at http://www.

TABLE 1
Descriptive Statistics and Correlations for the Study Variables

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1. Time 1 SE	1.00												
2. Time 2 SE	.551*	1.00											
3. Time 4 SE	.386*	.478*	1.00										
4. Time 5 SE	.404*	.520*	.564*	1.00									
5. Time 6 SE	.377*	.390*	.434*	.581*	1.00								
6. Time 1 BI	.454*	.460*	.306*	.302*	.268	1.00							
7. Time 2 BI	.370*	.588*	.335*	.354*	.228	.686	1.00						
8. Time 4 BI	.275*	.383*	.507*	.407*	.282	.512	.573*	1.00					
9. Time 5 BI	.273*	.402*	.379*	.552*	.374	.491	.538*	.662*	1.00				
10. Time 6 BI	.242*	.352*	.346*	.380*	.482	.413	.448*	.553*	.654*	1.00			
11. Gender (dummy)	−.118*	−.097*	−.216*	−.188*	−.154*	−.014	−.036	−.146*	−.117*	−.117*	1.00		
12. Nationality (dummy)	−.011	−.006	.025	.022	−.002	.049	.063	.057	.026	.019	−.066*	1.00	
13. PD	−.077*	−.073*	−.118*	−.065*	−.065	.025	−.011	−.037	−.016	.018	.456*	−.001	1.00
Mean	31.71	31.72	31.86	32.61	32.90	23.40	23.13	23.53	23.56	24.14	0.46	0.11	2.47
Variance	30.60	35.85	36.68	34.43	35.84	32.83	31.24	28.00	26.57	23.25	0.25	0.10	0.39
Standard deviation	5.53	5.99	6.06	5.87	5.99	5.73	5.59	5.29	5.15	4.82	0.50	0.31	0.62
Minimum	10	10	10	11	10	8	8	8	8	8	0	0	1
Maximum	40	40	40	40	40	32	32	32	32	32	1	1	3.93
Cronbach's alpha (α)	.77	.84	.85	.87	.89	.88	.90	.90	.90	.89	—	—	.70–.74

Note. SE = self-esteem; BI = body image; PD = pubertal development.
$^*p \leq .05$.

TABLE 2
Results From the Multivariate Latent Curve Models (LCM), Autoregressive Models, and Autoregressive Latent Trajectory (ALT) Models

Models	χ^2 *(df)*	*CM*	$\Delta\chi^2$ *(df)*	*CFI*	*TLI*	*RMSEA*	*SRMR*
1. LCM, full model	534.00 (41)*	—	—	0.891	0.880	0.110	0.095
2. Autoregressive, full model	313.40 (24)*	—	—	0.932	0.876	0.110	0.093
3. ALT, full model	40.77 (10)*	—	—	0.993	0.968	0.055	0.042
4. ALT, nested LCM model	377.63 (28)*	3	336.86 (18)*	0.918	0.872	0.112	0.060
5. ALT, no slope variance on SE	48.69 (16)*	3	7.92 (6)	0.992	0.979	0.045	0.043
6. ALT, no slope on SE	51.83 (17)*	5	3.14 (1)	0.992	0.979	0.045	0.045
7. ALT-6 + no slope variance on BI	77.05 (22)*	6	25.22 (5)*^{EP}	0.987	0.974	0.050	0.047
8. ALT-6 + no slope on BI	87.20 (23)*	6	35.37 (6)*	0.985	0.971	0.053	0.052
9. ALT-7 + no time-specific uniquenesses correlations	295.13 (26)*	7	218.08 (4)*	0.937	0.894	0.102	0.066
10. ALT-7 + fixed time-specific uniquenesses correlations	82.53 (25)*	7	5.48 (3)	0.987	0.976	0.048	0.049
11. ALT-10 + fixed autoregressions for SE	96.30 (28)*	10	13.77 (3)*	0.984	0.975	0.049	0.054
12. ALT-10 + fixed autoregressions for BI	90.67 (28)*	10	8.14 (3)	0.985	0.977	0.047	0.056
13. ALT-12 + fixed BI > SE regressions	96.97 (31)	12	6.3 (3)	0.984	0.978	0.046	0.061
14. ALT-13 + fixed SE > BI regressions	105.16 (34)	13	8.19 (3)	0.983	0.979	0.046	0.061
Final conditional multivariate ALT	151.48 (69)*	—	—	0.982	0.970	0.035	0.039

Note. SE = self-esteem; BI = body image; χ^2 = chi-square test of model fit; *df* = degrees of freedom; $\Delta\chi^2$ = chi-square difference test; CM = comparison model in the $\Delta\chi^2$; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; ^{EP} = model retained given estimation problems (negative or nonsignificant variances) in the previous one.

$*p \leq .01$.

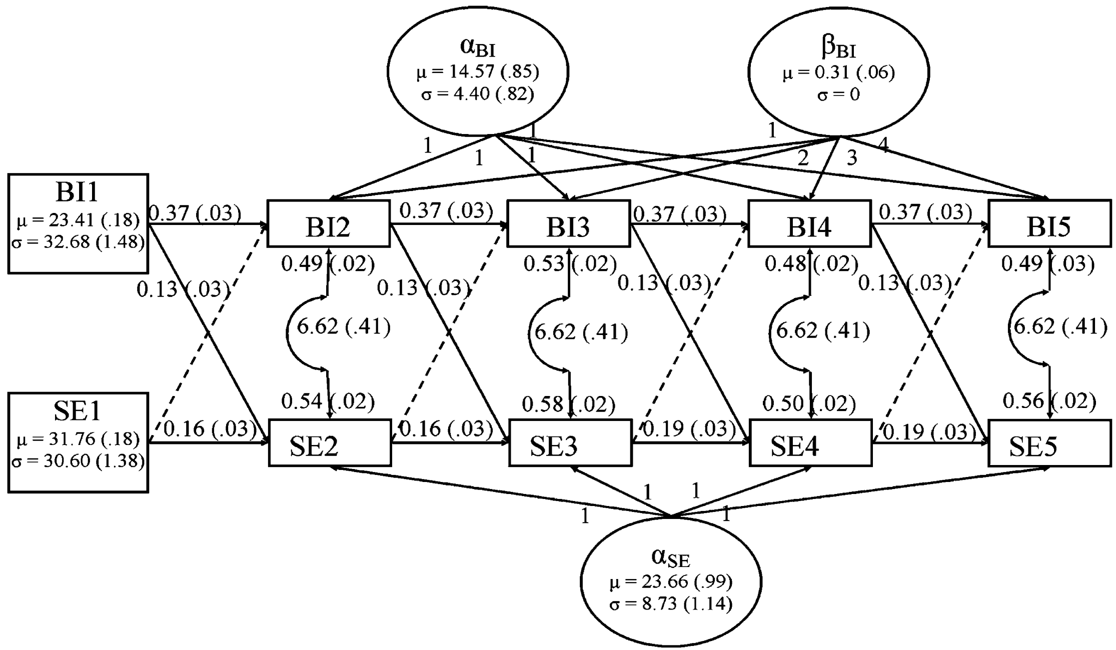

FIGURE 4 Parameter estimates from the final unconditional multivariate ALT model.

Note. ALT = autoregressive latent trajectory; BI = body image; SE = self-esteem. The correlations between the first time points, intercepts, and slope of both processes are excluded from the figure and reported in Table 3. Dotted lines represent nonsignificant paths and the standard errors of the estimates are reported in parentheses. To ease in the interpretation of the results, we report the standardized uniquenesses (which corresponds to $1 - R^2$) but the unstandardized estimates for the other parameters.

TABLE 3
Variances, Covariances, and Correlations Between the Estimated Parameters of the Final Unconditional Multivariate ALT

	Time 1 SE	*Time 1 BI*	*Intercept Factor SE*	*Intercept Factor BI*
Time 1 SE	30.60 (1.38)	14.36 (1.11)	9.82 (.92)	4.56 (.68)
Time 1 BI	0.45 (.03)	32.68 (1.48)	6.57 (.97)	8.00 (.86)
Intercept factor SE	0.60 (.03)	0.39 (.05)	8.73 (1.14)	3.58 (.78)
Intercept factor BI	0.39 (.04)	0.67 (.03)	0.58 (.07)	4.40 (.82)

Note. Variances are reported in the diagonal, covariances over the diagonal, correlations under the diagonal, and standard errors in parentheses. ALT = autoregressive latent trajectory; SE = self-esteem; BI = body image.

All estimates are significant ($p \leq .001$).

statmodel.com/papers.shtml), this parameter was fixed to zero in the following analyses. The estimated parameters showed that adolescents' average levels of body image have an initial mean of 23.41 on an 8 to 32 scale (corresponding to 2.9 on the 1 to 4 answering scale, and thus apparently they feel very good about themselves physically), present significant interindividual variability (see Table 3), and slightly increase over time, although this intraindividual increase is common to all participants (i.e., interindividual variability on the developmental changes in body image across adolescence was negligible and fixed to zero in Model 7 and the remaining models). It is also noteworthy that the correlations between the first measurement points and the intercept factors from both developmental processes are all significant and elevated (see Table 3), suggesting strong associations between self-esteem and body image trajectories. Furthermore, the results reveal that the inclusion of time-specific covariances between the uniquenesses of both developmental processes is necessary (Model 9) and that these covariances should be constrained to equality (Model 10), indicating a strong level of covariation between self-esteem and body image within each wave, which remain stable over time.

Finally, the results show that the body image autoregressions, as well as the self-esteem-on-body image and body image-on-self-esteem cross-lagged regressions can all be constrained to equality (Models 12-13-14), although the self-esteem statelike autoregressions cannot (Model 11). More precisely, these results show that (a) the ability of statelike deviations in self-esteem levels to predict later levels of self-esteem is small but significant and appears to increase slightly over time; (b) the ability of statelike deviations in body image levels to predict later levels of body image is moderate, significant, and stable over time; and (c) the ability of statelike deviations in self-esteem levels to predict later levels of body image is nonsignificant at all time points, whereas the ability of statelike deviations in body image levels to predict later levels of self-esteem is small but significant and stable over time, suggesting the presence of bottom-up relationships between self-esteem and body image. This final model (Model 14) still provides a satisfactory fit to the data according to all fit indices.

Role of Gender, Ethnicity, Pubertal Development, and Their Interactions

The predictors were directly added to the final ALT. These results are reported in the last row of Table 2 and in Table 4. This final model provides an adequate fit to the data according to all indices. Because the variance of the body image slope factor was fixed to zero in the unconditional ALT, this final model was estimated with the residual variance of the body image slope factor fixed to zero.

The results show that only gender influenced the first self-esteem measurement point, with girls presenting lower initial levels than boys (see Table 4). Although this main effect is even more significant on the intercept factor of self-esteem trajectories, it should be interpreted cautiously because the effect of the three-way interaction on the intercept of the self-esteem trajectories is also significant. The simple slopes of pubertal development on the self-esteem intercept factor were thus calculated in the different subgroups and are reported in Table 5. The simple effect of pubertal development on the self-esteem intercept is significant only for non-Caucasian females and nonsignificant for the other students (Caucasian males, Caucasian females, and non-Caucasian males). Thus, for non-Caucasian females, more advanced pubertal development is associated with a higher level of self-esteem. Interestingly, among non-Caucasian females, those with a low level of pubertal development appear to present the lowest level of self-esteem of all participants whereas those with an average or high level of pubertal development appear to present levels of self-esteem that are indistinguishable from male levels. For Caucasian females, levels of self-esteem appeared unaffected by pubertal development and consistently lower than males' levels.

The results show that no predictor influenced the first body image measurement point but that the effect of gender is significant on the body image intercept factor, with girls presenting lower levels than boys across adolescence. However, this main effect should be interpreted cautiously as the effects of the three-way interaction on the intercept and slope factors of the body image trajectories are significant or very close to being so ($p = .051$ for the intercept). Because the effect of the three-way interaction on the body image slope factor is significant and because the results from the simple slope analyses of the three-way interaction effects on the intercept factor of body image trajectories parallel those of the self-esteem trajectories, this marginally significant effect should still be interpreted. Regarding the body image intercept factor, the simple slopes of pubertal development parallel those from the self-esteem analyses and are

TABLE 4

Results From the Regression of the Final Multivariate Conditional ALT Parameters on the Predictors and Their Interactions

	SE (Time 1)			*SE (Intercept Factor)*			*BI (Time 1)*			*BI (Intercept Factor)*			*BI (Slope Factor)*		
Predictors	*b*	*s.e.*	*p*	*b*	*s.e.*	*p*	*b*	*s.e.*	*p*	*b*	*s.e.*	*p*	*b*	*s.e.*	*p*
Intercept	32.32	0.29	0.000	24.62	1.02	0.000	23.47	0.30	0.000	15.22	0.87	0.000	0.34	0.09	0.000
Gender	−1.05	0.42	0.012	−1.56	0.28	0.000	−0.26	0.44	0.548	−0.89	0.28	0.002	−0.13	0.12	0.277
Nationality	0.02	0.75	0.982	−0.51	0.50	0.315	0.98	0.79	0.210	0.39	0.51	0.443	−0.29	0.22	0.191
PD	−0.24	0.49	0.631	0.11	0.33	0.736	0.29	0.51	0.567	0.54	0.33	0.103	−0.11	0.14	0.444
Gender * PD	−0.33	0.66	0.622	−0.57	0.44	0.200	−0.28	0.69	0.685	−0.84	0.45	0.061	0.45	0.19	0.018
Nationality * PD	1.31	1.53	0.392	0.07	1.02	0.947	2.07	1.58	0.190	−0.62	1.02	0.548	0.63	0.44	0.146
Gender * Nationality	−1.10	1.25	0.381	0.19	0.83	0.822	−0.13	1.30	0.920	−0.07	0.84	0.929	0.58	0.36	0.101
Gender * Nationality * PD	0.91	2.24	0.685	3.12	1.48	0.035	−0.27	2.32	0.909	2.91	1.50	0.051	−1.70	0.63	0.007

Note. ALT = autoregressive latent trajectory; SE = self-esteem; BI = body image; PD = pubertal development; * = interaction; b = regression coefficient; s.e. = standard error of the coefficient; p = statistical significance.

TABLE 5
Simple Slopes of Pubertal Development in the Subgroups of Students (Males and Females From Caucasian and non-Caucasian Subgroups) on the Intercepts and Slopes of the SE and BI Trajectories

Subgroups of Students	*SE (Intercept Factor)*				*BI (Intercept Factor)*				*BI (Slope Factor)*			
	μ_α	*b*	*s.e.*	*p*	μ_α	*b*	*s.e.*	*p*	μ_α	*b*	*s.e.*	*p*
Caucasian females	23.06	−0.46	0.30	0.12	14.33	−0.30	0.30	0.32	0.21	0.34	0.13	0.01
Non-Caucasian females	22.73	2.73	1.03	0.01	14.64	2.00	1.05	0.06	0.51	−0.73	0.44	0.10
Caucasian males	24.62	0.11	0.33	0.74	15.22	0.54	0.33	0.10	0.34	0.11	0.14	0.44
Non-Caucasian males	24.11	0.18	0.96	0.85	15.61	−0.08	0.97	0.94	0.05	0.52	0.41	0.20

Note. SE = global self esteem; BI = body image; μ_α = intercept of the regression predicting the trajectory's intercept factor; μ_β = intercept of the regression predicting the trajectory's slope factor; *b* = regression coefficient; s.e. = standard error of the coefficient; *p* = statistical significance.

only marginally significant for non-Caucasian females and nonsignificant for the other students (Caucasian males, Caucasian females, and non-Caucasian males). However, regarding the body image slope factor, the simple effect of pubertal development is present only for Caucasian females and non-significant for the other students (Caucasian males, non-Caucasian females, and non-Caucasian males). These results show that advanced pubertal development is associated with higher levels of body image in non-Caucasian females but also predict more pronounced increases in body image in Caucasian females. This seemingly complex three-way interaction on body image trajectories is also illustrated in Figure 5, which suggests that males generally tend to present stable levels of body image that are higher than those from Caucasian females. However, Caucasian females with more advanced pubertal development also recover from their initially low levels of body image over time but without ever reaching males' levels. Indeed, higher levels of pubertal development are characterized by more pronounced increases in body image levels over time for Caucasian females. Finally, non-Caucasian females present an interesting profile. Indeed, at average or advanced levels of pubertal development, they present elevated body image levels that are indistinguishable from male levels. However, in contrast to Caucasian females, non-Caucasian females experience negative effects from low levels of pubertal development and, in this case, their body image levels are the lowest of those observed in this study. However, they recover from these initially low levels of body image and reach male levels by the end of the study.

DISCUSSION

This study aimed to answer three questions. First, it sought to verify the intra-

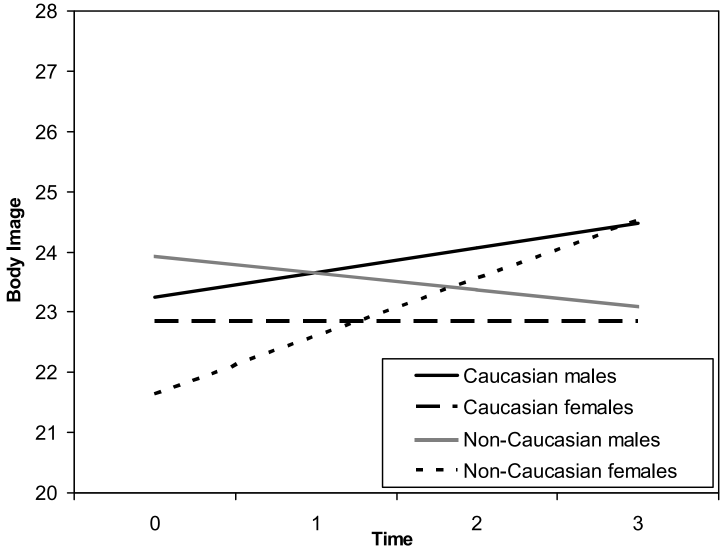

FIGURE 5a Body image trajectories for the low pubertal development students.

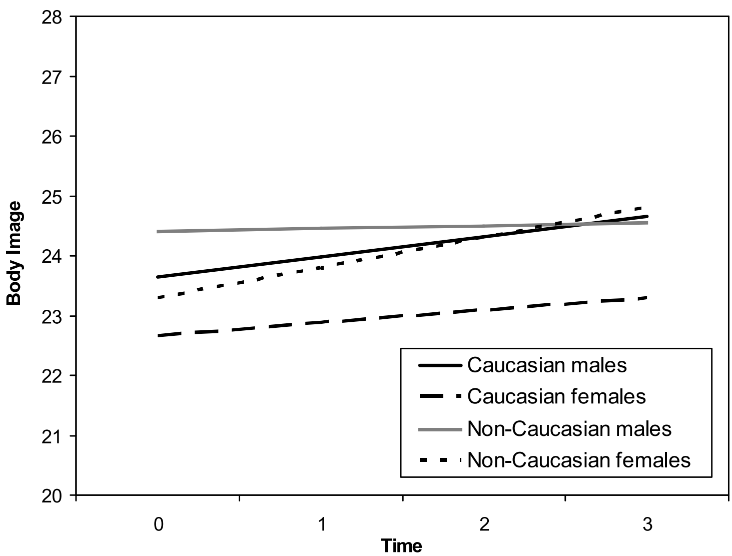

FIGURE 5b Body image trajectories for the average pubertal development students.

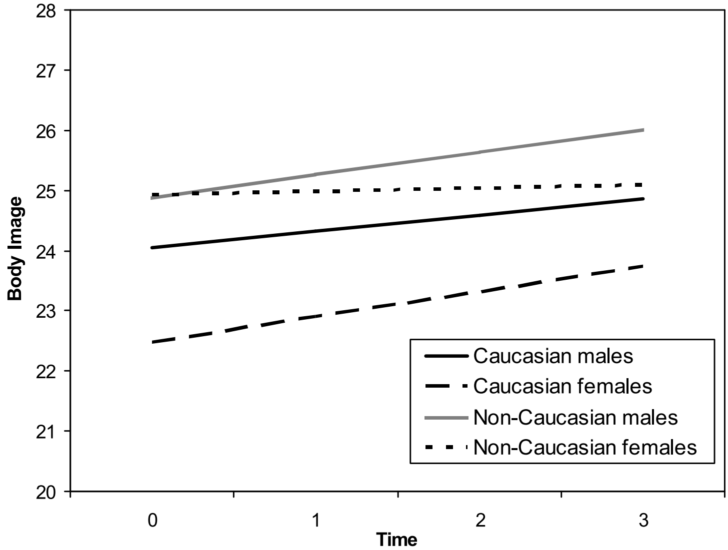

FIGURE 5c Body image trajectories for the high pubertal development students.

individual stability and overall shape of the developmental trajectories of self-esteem and body image in adolescence following the secondary school transition. The results are clear in showing that on the average levels of self-esteem remain high (participants feel very good about themselves) and stable (no slope factor was retained) across adolescence. Additionally, the autoregressions identified between adjacent time points, which were found to increase over time, suggest that the temporal stability of self-esteem may increase with age with deviations from the latent trait trajectories being integrated into the model through increasingly strong regulatory autoregressive mechanisms. These results are consistent with some of the previous studies in which the developmental stability of self-esteem was investigated (e.g., Young & Mroczeck, 2003) and thus contribute an additional piece of evidence toward the resolution of this issue by suggesting that the increases or decreases identified in previous studies (e.g., Greene & Way, 2005; Greene et al., 2006; Moneta et al., 2001; Rhodes et al., 2004) may have been an artifact of ignoring the autoregressive statelike influences between adjacent time points.

Regarding body image, the results converge on similar conclusions. Indeed, although a slope factor could be identified to describe body image trajectories, it remained small and showed no interindividual variability, suggesting that the observed intraindividual rise was common to all participants or at least showed negligible interindividual variability. Furthermore, even though significant group-based variability was identified regarding the magnitude and direction of the slopes of adolescents' body image trajectories, these slopes all remained small. Even in the group with the most pronounced slope (non-Caucasian females with low pubertal development; see Figure 4A), it represents a variation of only around 3 points (on a scale of 8 to 32 or a shift of approximately half a standard deviation from the initial level) over the study period. Similarly, the estimated autoregressive parameters between adjacent time points are higher than those estimated for self-esteem and stable over time, showing that even statelike deviations from the overall traitlike trajectories exert a lasting impact on the model through significant autoregressions. The greater state- and traitlike stability of low-order self-components (such as body image) is consistent with Marsh (2007; see also Marsh, Richards, & Barnes, 1986a, 1986b) results but contradicts Shavelson et al.'s (1976) proposition of a greater rigidity at the top of the hierarchy. In summary, the results show that adolescents' levels of body image are elevated (i.e., they generally feel good about their physical appearance) and intraindividually stable across adolescence but also marked by a slight increase over time that varies across observed subgroups but otherwise shows negligible interindividual variability. These results are again consistent with those from some of the previous studies (Cole et al., 2001; Young & Mroczeck, 2003) and suggest that, with time, adolescents become slightly more satisfied with their body image.

These results, regarding the intraindividual developmental stability of elevated levels of self-esteem and body image in adolescence, illustrate that most adolescents appear to cope well with the adolescent transition and its associated physiological, emotional, and social changes. Those results represent a further disconfirmation of Hall's (1904) "Storm and Stress" theory, depicting adolescence as a period of crisis characterized by many inherent developmental difficulties. This study is clearly not the first to disconfirm this bleak vision of adolescence by showing that, at least in North America or Europe, normative development tends to be quite adaptive and that most adolescents possess the inherent ability to face its developmental challenges with stables levels of self-esteem and body image (e.g., Arnett, 1999; Moneta et al., 2001; Rutter, Graham, Chadwick, & Yule, 1976; Steinberg & Morris, 2001). However, care should be taken not to use this result to justify lessening the attention devoted to adolescence as a keystone developmental period. Indeed, although most adolescents possess the resources (e.g., family, peer, and teacher support, academic competencies, positive school experiences, etc.) to face the many developmental challenges of adolescence, these challenges remain, and adolescence is still a key period in which development may go awry (Arnett, 1999).

Second, this study aimed to clarify the nature and directions of the interrelations between body image and self-esteem trajectories over time at both the trait and state levels. Once again, the results were clear and confirmed that both processes were deeply intertwined. Indeed, the estimated intercepts and first measurement points of individual self-esteem and body image trajectories were correlated with each other, and equal time-specific correlations between each measurement point were needed to provide an adequate representation of the data. Not only were all the estimated correlations significant but they were also substantial. However, when cross-lagged regressions were added to the model, the results show that the temporal directionality of these effects went from body image to self-esteem (because the reverse effects were nonsignificant). These effects remained stable but quite small, over time, suggesting that real "influence" between self-esteem and body image is due to changes in body image statelike levels. This is not surprising given the observed intraindividual stability of both developmental processes at the trait level. These results confirm and complete those from some previous studies (Clay et al., 2005; Dubois et al., 2000; Tiggemann, 2005) and show that during the secondary school years, adolescents' statelike levels of self-esteem are positively and significantly influenced by their statelike levels of body image. This confirms the aforementioned bottom-up hypothesis (Byrne & Gavin, 1996; Shavelson et al., 1976) and contradicts both the top-down (Brown, 1993) and reciprocal hypotheses (Marsh, 1990a). However, because these state-level effects remained small, it would be legitimate to say that the close associations between self-esteem and body image at the trait level are mostly due to covariation rather than to the "influence" of one variable over the other, forming a new "covariation" hypothesis while at the same time showing that all of these alternative hypotheses may in fact be complementary rather than contradictory. Indeed, horizontal effects (Kowalski et al., 2003; Marsh & Yeung, 1998), in which a construct predicts itself over time, are also apparent from the intraindividual developmental stability of both constructs.

Finally, this study aimed to verify the specific role of gender, ethnicity, and pubertal development and their interactions in the development of self-esteem and body image. The results might appear somewhat complex to interpret but yield strong support to the hypothesized three-way interaction between those three predictors. First, it is interesting to note that none of these variables predicted the first (predetermined) measurement point of body image and that only gender predicted the first self-esteem measurement point, with girls presenting lower initial levels than boys. This is not surprising because this first measurement point was taken right at the beginning of the school year, following the secondary school transition, at a time when social comparisons based on ethnicity, gender, pubertal development (especially), or their combination have seldom started in the new school (Marsh, Köller, & Baumert, 2001). Although such social comparison processes may have been present in the preceding school, pubertal development is very seldom advanced enough to result in visible changes before the 1st year of secondary school (at least in the majority of students), precluding social comparisons based on pubertal development (and interactions of pubertal development with additional variables) in elementary schools. However, the effect of the three-way interaction between those predictors proved significant on the intercepts of the self-esteem and body image trajectories and on the slopes of the body image trajectories. This is consistent with the current body of knowledge (Ge et al., 1996; Halpern et al., 1999; O'Dea & Abraham, 1999; Siegel et al., 1999) and with our a priori hypothesis. First, it should be noted that, even though this interaction was observed, it did not suffice to completely offset the main effect of gender in which girls compared with boys tend to present lower levels of body image and self-esteem across the adolescent years. Again, this is consistent with the results from previous studies (e.g., Cole et al., 2001; Moneta et al., 2001).

More precisely, the results from this three-way interaction show that the effects of pubertal development on the average levels of body image and self-esteem across adolescence (the intercept factor) were limited to non-Caucasian females, for whom more advanced pubertal development appeared beneficial. Lower levels of pubertal development were even associated with lower levels of body image and self-esteem for them. Moreover, an examination of the figures depicting the trajectories of body image in the different subgroups of students also showed that non-Caucasian females with initially low levels of pubertal development also present a steeper rise in body image and reach the level observed in the other subgroups by the end of the study. Although not verified in this study, it is likely that the detrimental effects of initially low pubertal development levels would tend to disappear once pubertal development follows its normal course. Conversely, Caucasian females presented the lowest self-esteem and body image levels of all, although for them more advanced pubertal development levels were associated with a significant slight rise in body image over time in manner similar to what was observed in non-Caucasian females with low pubertal development. This suggests that the initially low body image levels rise when peers' levels of pubertal development reach the target adolescent's level. Thus, it appears that the initially low levels of body image observed in both subgroups of females (Caucasians with high pubertal development and non-Caucasians with low pubertal development) were only transitory. Clearly, social comparison processes are at play here (Halpern et al., 1999; Siegel et al., 1999), with the most favorable situation being either when the target non-Caucasian girl corresponds to her cultural group's physical stereotype or when the target majority girl's observable differences disappear due to increasing similarity to her peers. Those observations confirm the fact that the majority of youths follow an adaptive developmental trajectory and possess the resources required to face normative developmental challenges (Arnett, 1999; Cole et al., 2001; Steinberg & Morris, 2001; Young & Mroczeck, 2003).

Limitations and Directions for Future Research

Although promising, the results from this study are plagued by at least four important limitations, which should be addressed in future studies. First, the research design used in this study limits the generalizability of the findings. Indeed, results from the MADDP are exclusively based on a short-term follow-up (i.e., 4-year) of a convenience sample of a single cohort of students following the secondary school transition. In addition, the observed attrition rate, although in line with the rates generally reported in such studies, remain elevated and its impact on the generalizability of the results remains unknown. In addition, because the MADDP was first designed as a 1-year project to which a longer term follow-up was added, participants and their parents needed to consent again to their inclusion in the longer term component and ethical rules precluded the inclusion of nonconsenting students in the longitudinal analyses (e.g., those who completed Year 1 questionnaires but failed to consent to the longer term study). This situation precluded us from using modern missing data imputation techniques (Enders, 2010; Graham, 2009) for part of the total sample, which may have biased the obtained results. Overall, questions as to whether (a) these results are similar to those found in childhood or just before secondary school transition, (b) whether they can be generalized to late adolescence and adulthood, and (c) whether they can be generalized to representative samples of youths from other countries remain unanswered and should be a future research priority. It would be interesting to start a study earlier, before the secondary school transition, or to continue it later, after the next transition, to estimate whether (a) the observed intraindividual stability of self-esteem starts in childhood and is maintained in later years, (b) the observed slight increase in body image level was already started in childhood or if it represents a compensatory mechanism designed to regain losses due to the adolescent transition, and (c) the directionality of influences between both processes remains similar or changes across time. Similarly, as it is the case in psychological sciences in general, these results should be replicated on diversified samples before they can be used in practice.

Although the longitudinal design of the study is an important strength, it relied on widely spaced measurements. Thus, although we relied on state-trait analogies to explain the added value of ALTs, an in-depth examination of state-trait models would require multiple time points taken at shorter intervals. Indeed, state-trait models imply a general point of equilibrium (trait) around which occasion-specific (state) variations occurs, and previous studies did indeed show that a similar pattern characterized by significant day-to-day variations occur in self-esteem and body image levels (Fortes, Delignières, & Ninot, 2004). The fact that the measurement points used in the present study were so widely spaced could have hidden this day-to-day reactivity and specific top-down or bottom-up effects, thus wrongly leading us to conclude that covariation effects might be stronger than top-down, bottom-up, or reciprocal relations. This shorter term variability in self-concept dimensions and their interrelationships should be examined in future studies. Another aspect that could have induced some biases in the observed parameters estimates regarding the stability and interrelationships of body image and self-esteem is linked to our decision to rely on time-specific manifest, rather than latent, indicators of both constructs. The "statelike" uniquenesses of each process from which the autoregressions and cross-lagged regressions are estimated thus combine measurement errors (that are partialled out in latent models) and statelike deviations. This could have lead to an underestimation of the autoregressive parameters or to a confusion of unstable reliability with stability/instability of the constructs. In this study, this decision was anchored in preliminary tests that confirmed the measurement invariance of both constructs over time and the absence of biases (Footnote 3). Thus, future applications of ALTs should either directly rely on fully latent variable methodologies or conduct a similar series of preliminary tests before deciding to rely on manifests indicators.

Second, the great majority of the sample used in this study was of Caucasian origin, leaving few students to form the non-Caucasian group. More precisely, the reader should keep in mind that the observed three-way interaction, although interesting and consistent with the theoretical bases presented in the introduction, rely on only 109 non-Caucasian students, a number that is then halved by gender. This clearly affects the generalizability of the results, especially because previous studies (e.g., Twenge & Crocker, 2002) showed that the effects of ethnicity on self-esteem and body image varied according to specific ethnic groups (e.g., African Americans, Hispanics, Asians), meaning that our interpretation involving cultural stereotypes may not apply to all of the students forming the non-Caucasian subgroup. However, such detailed distinctions could not be made in this study because of the relatively low sample size of specific ethnic groups but should be more systematically explored in the future. However, it should be noted that because interaction effects are computed on the full sample, the low sample size in the non-Caucasian subgroups may only have affected the results by decreasing the power of the analysis to detect significant interactions. The fact that the three-way interaction came out as statistically significant suggests that it was also substantial.

Third, although youths from this study appeared to follow adaptive developmental trajectories, a result which confirms that the majority of today's adolescents are well equipped to face the developmental tasks of adolescence, this does not mean that a significant level of scientific attention should not be devoted to the smaller number of youths who really do fare poorly in the face of those challenges (Arnett, 1999). Indeed, the fact that low levels of body image and self-esteem represent risk factors for a wide array of psychopathologies such as eating disorders or depression (e.g., Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004; Lewinsohn & Essau, 2002; Stice, 2002; Stice, Hayward, Cameron, Killen, & Taylor, 2000; Stice, Presnell, & Bearman, 2001) has been recognized for a long time and similar three-way interactions hypotheses between ethnicity, gender, and pubertal development in the development of depressive disorders have been previously proposed and purported to be mediated through body image disturbances (Stice & Bearman, 2001). Clearly, any community sample such as the one used in this study potentially comprises a significant number of youths suffering from diverse psychopathologies (Lewinsohn, Hops, Roberts, Seeley, & Andrews, 1993; Newman et al., 1996). Thus, although the overall self-concepts trajectories observed in the present sample remained quite high and increasing, it would be logical to assume that a subgroup of students probably present very low self-concepts. In studies focusing on either mental health from a positive psychology perspective (such as this one), as in study of psychopathologies, the extent to which the observed relationships are biased by the aggregation of healthy and unhealthy youths remains unknown. To this end, one interesting complement to this study would be to rely on growth mixture models to extract otherwise nonobservable subgroups of adolescents presenting more maladaptive trajectories of self-esteem and body image (e.g., B. O. Muthén, 2002). The extraction of those subgroups of adolescents would provide the scientific community with a clearer anchoring in the understanding of those developmental processes. Indeed, growth mixture modeling methods allow for the direct incorporation of predictors of class membership in the estimated model and for the verification of possible predictors-to-outcomes relationships variation in different subgroups.

Finally, the state-trait analogy used in the context of this study is limited by the fact that, although predictors of the trait component of self-esteem and body image were included and examined, no attempt was made to clarify the multiple sources of influence that could play a role in the deviation from this trait, that is, the state components. Indeed, although multiple factors (e.g., familial, peer, school, and romantic conflicts or support; victimization; academic achievement; etc.) may influence adolescents' self-esteem and body image occasion-specific states, or more precisely may "impact" them sufficiently to generate a deviation from their usual stable traitlike trajectory, these factors were not considered in this study and should be more thoroughly investigated in future studies. This brings into question the issue of the causal inferences that could reasonably be made from the present results. Here, as with all social science research, it is appropriate to propose causal relations, but researchers should fully interrogate support for these hypotheses based on the accumulation of results from multiple methods, designs, time points, and settings. This study only represents one step toward causal inference. Although stronger causal inferences are possible in longitudinal designs such as this one, or in quasiexperimental or true experimental studies, "proving" causality is a precarious undertaking based on assumptions that are typically untested or untestable and related to the consideration of all of the "relevant" variables. Thus, although this study shows that there is some form of influence going from ethnicity, puberty, and gender to the self concept components considered here, these relationships cannot be fully interpreted as causal as they only met one condition for causality, that is, temporal precedence. Indeed, although we know that gender, ethnicity, and pubertal development are unlikely to be influenced by self-concept, the observed relationships can still be explained by many unobserved variables that might in fact represent the underlying causal mechanism. For instance, membership in specific ethnic groups is known to be associated with different body image stereotypes (e.g., Siegel et al., 1999; Stice & Bearman, 2001), which can potentially explain the observed relationships or negate them in specific adolescents who do not share in these stereotypes. The same comment applies to the observed directionality of the relationships between the statelike components of body image and self-esteem. The results clearly show that, when temporal precedence is taken into account, as well as common causes of both processes (controlled through time-specific correlated uniquenesses between self-esteem and body image; Widaman, Dogan, Stockdale, & Conger, 2010), the relationships conform to a bottom-up hypothesis. However, the mechanisms underlying these relationships remain unknown. As an extended discussion of causal inferences in social sciences is beyond the scope of this study, we refer interested readers to recent publications and debates on these issues (Foster, 2010a, 2010b; Markus, 2010; Morgan & Winship, 2007; Pearl, 2009a, 2009b; Widaman et al., 2010).

CONCLUSION

This study was a substantive methodological synergy designed to illustrate the usefulness of ALT models, a combination of autoregressive models and LCM, in addressing controversial issues in self-concept research. It is important to note that this study demonstrated that both the traitlike developmental processes and the time-specific statelike influences were needed to adequately represent the evolution of both self-concept components over time. Because this study represents the first attempt to apply the ALT method to self-concept research, the observed results suggest that all of the preceding studies, which relied either on LCM (to answer questions regarding the stability of self-concept) or on autoregressive models (to answer questions regarding the interrelations between self-concept components) may have been biased by their failure to take into account the full state-trait picture. Indeed, the integration of both form of state- and traitlike influences within the ALT model used in this study even allowed us to formulate a new "covariation" hypothesis to illustrate the developmental association between body image and self-esteem and to show that more than one of the preceding hypotheses (i.e., bottom-up, top-down, reciprocal, horizontal, covariation) may coexist. This supports Bollen and Curran's (2004) description of ALTs as the "synthesis of two traditions" and indicates that future research on self-concept should from now on consider the possibility that ALT may represent a viable representation of the data. However, care should be taken to avoid relying indiscriminately on ALTs. Although ALTs did provide the best representation of the data in this study, this conclusion was supported by the careful examination of multiple alternative models. ALTs are complex models that should be built up from simpler models to ensure that their complexity really adds to the understanding of the question under investigation. Voelkle (2008) showed that ALTs rely on the assumption that both the LCM and autoregressive part of the ALT contain no misspecifications. A common violation of these assumptions comes from unmodeled nonlinearity in the LCM part of the ALT (see Footnote 5). However, this warning should not be taken as a reason to avoid ALTs as studies also showed that excluding significant autoregressive effects from an LCM could also result in biased estimates (e.g., Singer & Willett, 2003; Sivo et al., 2005).

McArdle (2009, p. 601) urged scholars to begin longitudinal analyses by asking, "What is your model for change?" In the present study, we argued that the required model for studying change in the context of the present study was the ALT as this model allowed us to clearly and simultaneously consider (a) the state-trait properties of self-concept components, (b) the overall and potentially evolving shape of the trait component of self-concept trajectories, and (c) the autoregressive cross-lagged effects of the state components of self-concept. Preliminary analyses also suggested that we did not need to consider nonlinearity in the estimation of the overall trajectories (see Footnote 5) and that the ALT provided a better representation of the data than alternative LCM and autoregressive models. However, the results also showed that a classical state-trait model (without growth structure in the trait component; Cole et al., 2005; Hamaker et al., 2007; Steyer et al., 1999) was sufficient to represent self-esteem but that a complete ALT was required for body image. However, researchers should not make such assumptions without prior verifications. For instance, it has now been shown that multiple forms of nonlinear trajectories (latent basis, logistic, exponential, multiphase, etc.) can be estimated in common statistical packages (e.g., Grimm & Ram, 2009; Ram & Grimm, 2007). In addition, the ALT is just one of the multiple frameworks that can be used to study change. Rovine and Molenaar (2005) clearly showed how the autoregressive, LCM, and ALT models considered here were in fact special cases of a global nonstationary autoregressive moving average (NARMA) framework and thus linked to the even larger family of time series models and dynamic factor analysis (e.g., Boker

& Wenger, 2007; Nesselroade, McArdle, Aggen, & Meyers, 2002). Closer to developmental psychology, McArdle (2009; see also Ferrer & McArdle, 2003, 2010) proposed the Latent Difference Score (LDS) model as an alternative global framework for the study of change in longitudinal study and recently extended it for an even greater level of flexibility (Hamagami & McArdle, 2007). Of particular interest, the LDS model is specifically built to allow for a clear differentiation of between reliability of the measures and stability/instability of the developmental processes. We thus urge researchers not to consider the ALT the ultimate alternative for the study of change but rather to clearly define their a priori model for change and the multiple alternatives that are currently available.

At a more practical level, these results once again confirm that the majority of youths do follow adaptive developmental trajectories and that interventions could be more specifically targeted at the minority of youths with low self-esteem or body image levels. Particular attention should be devoted to Caucasian girls who systematically presented the lowest levels of self-esteem and body image. Although non-Caucasian girls were also found to be significantly affected by lower levels of pubertal maturation, they were also found to recover over time from these initially low levels. Finally, the new covariation hypothesis as well as the observation that complementary hypotheses may simultaneously describe the developmental relations between self-esteem and body image suggest that multiple pathways of influence might be at play during adolescence. In this study, horizontal effects are present and indicate the overall stability of the traitlike component of self-esteem and body image, which were found to covary over time. This suggests that intensive interventions targeting either one of these processes may influence both if they manage to modify their trait components. Conversely, because statelike components of self-esteem and body image appear mostly related through bottom-up relations, punctual intervention targeting state-like components of self-esteem and body image, in a crisis state, for instance, should target body image rather than self-esteem.

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APPENDIX

Formal Algebraic Specifications for the Autoregressive Models, the Latent Curve Models (LCM), and the Autoregressive Latent Trajectory (ALT) Models Used in the Study

Two variables, Y (e.g., self-esteem) and W (e.g., body image), have been measured repeatedly over time (t) on i participants. For this demonstration, let's say that each variable was measured five times (thus $t = 1, 2, 3, 4,$ or 5) and that the time intervals were all 1 year apart. The formulas presented in this section are taken from Bollen & Curran (2004, 2006).

In *univariate autoregressive models*, each variable is expressed as an additive function of the preceding value and of a random error term. Thus, for $t > 1$, the equation for y_{it} is

$$y_{it} = \alpha_{yt} + \rho_{y_t,y_{t-1}} y_{i,t-1} + \varepsilon_{yit}. \tag{1}$$

In this equation, y_{it} is the dependent variable for participant i at time t ($t = 1, 2, 3, 4,$ or 5 in this example); α_{yt} is the fixed intercept for the equation at time t; $\rho_{y_t,y_{t-1}}$ is the regression weight representing the autoregressive effects of y_{it} on y_{it-1}, which may change over time; and ε_{yit} is the error term. This model assumes that errors have a mean of 0 and are not correlated over time, across cases, or with the ys. In this model, because no predictor is available for the first measurement point, the equation for y_{i1} is

$$y_{i1} = \alpha_{y1} + \varepsilon_{yi1}. \tag{2}$$

Because it is possible to model autoregressive functions for multiple variables, it is also possible to specify relationships between those variables. In *multivariate autoregressive cross-lagged models*, each variable is expressed as an additive function of the preceding values of both variables (Y and W) and a random error term. More precisely, for $t > 1$, the equations for y_{it} and w_{it} are

$$y_{it} = \alpha_{yt} + \rho_{y_t,y_{t-1}} y_{i,t-1} + \rho_{y_t,w_{t-1}} w_{i,t-1} + \varepsilon_{yit}, \tag{3}$$

$$w_{it} = \alpha_{wt} + \rho_{w_t,y_{t-1}} y_{i,t-1} + \rho_{w_t,w_{t-1}} w_{i,t-1} + \varepsilon_{wit}. \tag{4}$$

In these equations $\rho_{y_t,w_{t-1}}$ and $\rho_{w_t,y_{t-1}} y_{i,t-1}$ are, respectively, the regression weights representing the cross-lagged effects of y_{it} on w_{it-1} and of w_{it} on y_{it-1}.

Multivariate models assume that errors have a mean of 0 and are not correlated over time, across cases, across processes, with the ys or with the ws, although in some cases the errors might be allowed to correlate across process at similar time points to reflect the fact that what caused a disturbance at a specific time point on a variable may also have caused a similar disturbance on the other variable (i.e., ε_{yit} may correlate with ε_{wit}). In this model, y and w are treated as predetermined as in Equation (2) for the first measurement point because no predictor is available for y_{i1} or for w_{i1}.

In *univariate Latent Curve Models* (*LCMs*), individual trajectories are estimated for each case according to the following equation for y_{it}:

$$y_{it} = \alpha_{iy} + \beta_{iy}\lambda_t + \varepsilon_{yit}. \tag{5}$$

In this equation, α_{iy} and β_{iy}, respectively, represent the random intercept and slopes for participant i and ε_{yit} represents the time- and individual-specific error term. LCMs assume that errors have a mean of 0 and are not correlated over time, across cases, or with the ys. Most LCM models also assume that all cases have the same error variance for each time period but allow these errors to vary across periods. Finally, λ_t represents the passage of time and is coded to reflect the time intervals between measurement points. For instance, in a model including five measurement points equally spaced 1 year apart where one wants to estimate the intercepts of linear trajectories at Time 1 [$E(\alpha_{iy}) = \mu_{y1}$], λ_t will be coded $\lambda_1 = 0, \lambda_2 = 1, \lambda_3 = 2, \lambda_4 = 3$, and $\lambda_5 = 4$. The time codes used in this study are –0.4, 0, 1, 2, 3 to reflect the fact that (a) Time 1 occurred 5 months before Time 2, (b) the remaining measurement points were taken 1 year apart, and (c) Time 1 was conceptualized as the MADDP baseline control measurement point. This also allows for greater level of consistency with the ALT models in which the Time 1 measurement point is specified as in the autoregressive models and taken out of the trajectory equation (so that the time codes for the remaining measurement points were 0, 1, 2, and 3). Therefore, the intercept of the trajectories was estimated at Time 2 in both the LCMs and the ALTs (for more details on time codes, see Biesanz, Deeb-Sossa, Papadakis, Bollen, & Curran, 2004). When study participants differ in age, Metha and West (2000) show that relying on uniform time codes for all participants, versus individual-specific codes, may result in estimation bias. In the present study, this limitation is partly offset because all participants are quite close in age and of the same grade level. Moreover, Metha and West add that uniform time coding could still be appropriate when (a) the regression of the intercept factor of the LCM on participants' age at Time 1 is equal to the slope factor and (b) the regression of the slope factor on age at Time 1 is equal to zero (for a mathematical demonstration of these conditions, readers are referred to Metha & West, 2000). Both conditions were met in the context of the present study.

Because the intercepts and slopes of these trajectories are specified as random factors, they can vary across cases and are represented by the following equations:

$$\alpha_{iy} = \mu_{\alpha y} + \zeta_{\alpha yi}, \tag{6}$$

$$\beta_{iy} = \mu_{\beta y} + \zeta_{\beta yi}, \tag{7}$$

where $\mu_{\alpha y}$ and $\mu_{\beta y}$ represent the average intercept and slope across all cases, and $\zeta_{\alpha yi}$ and $\zeta_{\beta yi}$ represent disturbances (with a mean of zero) around these average estimates that reflect the variability of the estimated intercepts and slopes across cases. Linear LCMs can finally be represented by integrating Equations (6) and (7) into Equation (5) as

$$y_{it} = (\mu_{\alpha y} + \lambda_t \mu_{\beta y}) + (\zeta_{\alpha yi} + \lambda_t \zeta_{\beta yi} + \varepsilon_{yit}). \tag{8}$$

It should be noted that, for them to be fully identified, linear LCMs models require a minimum of three measurement points. LCMs can be estimated through various analytical frameworks. In this study, they were estimated through the Structural Equation Modeling framework described in Bollen and Curran (2004, 2006). In these models, the measurement points are represented as being determined by correlated intercept (with loadings all fixed to 1) and slope (with loadings corresponding to λ_t) factors, at least for the estimation of linear trajectories, as in the present study. In the case of *multivariate LCMs*, an identical model is also estimated for W (i.e., Equations (5–7) in which the ys subscript would be replaced by ws subscript). The only addition would come from the fact that in multivariate LCMs, the intercepts and slope factors from both processes (Y and W) are also allowed to correlate (for more complex multivariate LCMs, see Bollen & Curran, 2004, 2006).

Univariate Autoregressive Latent Trajectory models (ALT) combine both of the preceding models by allowing the inclusion of autoregressive parameters within LCMs thus leading to the following equations for $t > 1$:

$$y_{it} = \alpha_{iy} + \lambda_t \beta_{iy} + \rho_{y_t, y_{t-1}} y_{i,t-1} + \varepsilon_{yit}, \tag{9}$$

$$\alpha_{iy} = \mu_{\alpha y} + \zeta_{\alpha yi}, \tag{10}$$

$$\beta_{iy} = \mu_{\beta y} + \zeta_{\beta yi}, \tag{11}$$

and, for $t = 1$,

$$y_{i1} = \mu_{y1} + \varepsilon_{yi1}. \tag{12}$$

In ALTs, the first measurement point, the intercept factor, and the slope factors are always specified as correlated. The remaining model specifications are similar to LCM model specifications. It should be noted that in ALT, the estimated intercept factor ($\mu_{\alpha y}$) generally appears much lower than the first measurement point (μ_{y1}). This should not be interpreted as reflecting developmental instability or decrease because it simply reflects the fact that in ALTs, the intercept represents the portion of the Time 2 variable remaining unexplained by the Time 1 variable (also see Figure 3). Indeed, in ALTs the first measurement point is taken out of the LCM part of the model and treated as predetermined as in autoregressive models to avoid problems of infinite regress (for additional discussions of this issue, see Bollen & Curran, 2004, 2006). Finally, for them to be identified, linear ALTs require at least five measurement points, although additional constraints can be added to identify models with three or four measurement points (for the mathematical specifications of models with fewer than five measurements points, see Bollen & Curran, 2004, 2006).

In multivariate ALTs, an identical model is also estimated for W (i.e., Equations (9–12) in which the ys subscript would be replaced by ws subscript) and the first measurement points, intercept factors, and slope factors are allowed to correlate. As in multivariate autoregressive models ε_{yit} may be allowed to correlate with ε_{wit}. The inclusion of cross-lagged parameters also involves modifying Equation (9) in the following manner:

$$y_{it} = \alpha_{iy} + \lambda_t \beta_{iy} + \rho_{y_t, y_{t-1}} y_{i,t-1} + \rho_{y_t, w_{t-1}} w_{i,t-1} + \varepsilon_{yit}. \tag{13}$$

All of the previous models were specified as unconditional, meaning that no variables were used to predict either the intercepts and slope factors (time-invariant covariate) or the time-specific measurement points (time-varying covariates). In this study, three time-invariant predictors (gender, ethnicity, and pubertal development, referred to here as M, N, and P) as well as their two- and three-way interactions are added to the final ALT model estimated for self-esteem and body image. These models involve modifying Equations (10–12) to incorporate the effects of these predictors (specified as γs) on Y as well as on W. For Y $(t > 1)$,

$$\begin{aligned}\alpha_{iy} = \mu_{\alpha y} &+ \gamma_{\alpha yM} M_i + \gamma_{\alpha yN} N_i + \gamma_{\alpha yP} P_i + \gamma_{\alpha yMN} M_i N_i \\ &+ \gamma_{\alpha yMP} M_i P_i + \gamma_{\alpha yNP} N_i P_i + \gamma_{\alpha yMNP} M_i N_i P_i + \zeta_{\alpha yi},\end{aligned} \tag{14}$$

$$\begin{aligned}\beta_{iy} = \mu_{\beta y} &+ \gamma_{\beta yM} M_i + \gamma_{\beta yN} N_i + \gamma_{\beta yP} P_i + \gamma_{\beta yMN} M_i N_i \\ &+ \gamma_{\beta yMP} M_i P_i + \gamma_{\beta yNP} N_i P_i + \gamma_{\beta yMNP} M_i N_i P_i + \zeta_{\beta yi},\end{aligned} \tag{15}$$

and, for $t = 1$,

$$\begin{aligned}y_{i1} = \mu_{y1} &+ \gamma_{y1M} M_i + \gamma_{y1N} N_i + \gamma_{y1P} P_i + \gamma_{y1MN} M_i N_i \\ &+ \gamma_{y1MP} M_i P_i + \gamma_{y1NP} N_i P_i + \gamma_{y1MNP} M_i N_i P + \varepsilon_{yi1}.\end{aligned} \tag{16}$$

In conditional ALTs models, it is important to keep in mind that (a) the estimated intercepts of the growth trajectories (i.e., initial levels) are in fact the disturbances of the intercept factors remaining unexplained by the first predetermined measurement points of both variables and (b) the estimated intercepts and slope factors of the growth trajectories represent their levels when all predictors take a value of zero.

For additional details on these models, on their matrix algebra representations, on the assumptions underlying them, and for additional types of conditional models, interested readers are referred to Bollen and Curran (2004, 2006).