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Warm Parenting Throughout Adolescence Predicts Basal Parasympathetic Activity Among Mexican-Origin Youths

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ABSTRACT

Parenting that is warm and supportive has been consistently linked to better emotion regulation in children, but less is known about this association in adolescents. Adolescence is thought to be an important period for emotion regulation development given that it coincides with the emergence of mental health issues. Respiratory sinus arrhythmia (RSA) is a measure of parasympathetic regulation linked to emotion and behavior regulation. Despite the well-documented links between parenting practices and emotion regulation, and between RSA and emotion regulation, few studies have focused on the association between positive parenting and adolescent RSA or included both mothers and fathers. The current study analyzed the influence of warm parenting throughout adolescence (ages 10–16) on basal RSA at age 17 in 229 Mexican-origin youths. Latent-growth curve models were used to analyze associations between maternal and paternal warmth and baseline RSA. Changes in maternal, but not paternal, warmth from age 10 to 16 were related to youths' basal RSA at age 17. Specifically, youths who perceived increasing (or less decreasing) maternal warmth across adolescence had higher basal RSA. This finding suggests that positive maternal parenting experiences during adolescence "get under the skin" to enhance parasympathetic functioning that supports youths' emotion regulation capacities.

1 | Introduction

Emotion regulation can be defined as "the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features to accomplish one's goals" (Thompson 1994, 27–28). Throughout development, emotion regulation is scaffolded by interactions with parents, and parenting that is warmer and more supportive, and less cold and hostile, has been linked to more effective emotion regulation in adolescents (Berona et al. 2023; Morris et al. 2017). Baseline respiratory sinus arrhythmia (RSA), a measure of parasympathetic control over cardiac activity in a wakeful relaxed state, is thought to reflect the capacity for flexible physiological regulation that underlies emotional and behavioral regulation (Hastings and Kahle 2019; Porges 2007).

Parenting behaviors such as warmth and hostility have been linked to adaptive RSA functioning, that is, RSA that supports positive emotion regulation processes and outcomes (Alen et al. 2022; Bell et al. 2018; Graham, Scott, and Weems 2017). However,

studies focusing on the association between parenting and RSA among adolescents remain limited; most of the existing literature is focused on infancy and childhood (Bell et al. 2018; Hastings et al. 2019). Identifying predictors of physiological indicators of emotion regulation, such as basal RSA, in adolescence is important because the pubertal period may act as a sensitive window for heightened impact of the caregiving environment on neurobiological maturation (Gunnar et al. 2019). Furthermore, it is important to expand this research beyond WEIRD (Western, Educated, Industrialized, Rich, and Democratic) samples (Henrich et al.2010), which have been the usual focus of developmental studies of parenting and RSA. Latinos are one of the fastest-growing ethnic groups in the United States (Funk and Lopez 2022) and Mexican-origin Latinos make up the largest share (61.5%) of this group, but remain understudied in neurobiological research (Parra and Hastings 2018). Thus, the purpose of this study is to examine the influence of warm parenting on basal RSA throughout adolescence in Mexican-origin youth.

1.1 | RSA and Emotion Regulation

The autonomic nervous system (ANS) has been extensively studied in relation to emotion reactivity and regulation (Hastings and Kahle 2019; Nock and Berry Mendes 2008; Porges 2007). The parasympathetic nervous system (PNS), a branch of the ANS, often referred to as the "rest and digest" system, acts to maintain efficient metabolism by downregulating arousal and promoting restorative processes in the body. RSA is a measure of heart rate variability that corresponds with respiration and serves as an index of PNS activity. In a restful waking state, greater parasympathetic influence, reflected by higher basal RSA, increases inhibitory vagal control of the heart, lowering heart rate and blood pressure, and supporting an individual's ability to respond and adapt to their environment appropriately (Porges 2007). Thus, variation in basal RSA may reflect individual differences in the capacity to regulate arousal (Hastings and Kahle 2019), including controlling emotional responses.

Basal RSA exhibits a pattern of growth until the age of 18, followed by a continuous decline thereafter (Silvetti, Drago, and Ragonese 2001). Basal RSA is moderately stable, such that children with higher resting RSA relative to others tend to continue having higher resting RSA over time (Dollar et al. 2020; El-Sheikh 2005). However, there is also some evidence that suggests malleability in basal RSA from childhood to early adolescence, particularly in response to negative environmental influences, such as family conflict or stress (El-Sheikh and Erath 2011; Hinnant, Erath, and El-Sheikh 2015). Notably, there remains a gap in the literature concerning changes in basal RSA beyond early adolescence in response to positive environmental factors, such as parental warmth.

Higher basal RSA in adolescence is considered adaptive, as it has been consistently linked to greater emotion regulation skills and various aspects of positive functioning. For example, Vasilev et al. (2009) found that increases in basal RSA from late childhood to early adolescence predicted fewer self-reported difficulties in emotion regulation (see also Williams et al. 2015). Higher basal RSA also has been linked to higher effortful control, inhibitory control, and improved performance on cognitive assessments, and less depressed mood, in youths (Chapman et al. 2010; Gillie, Vasey, and Thayer 2014; Koenig et al. 2016; Staton et al.2009). Given the connections between RSA and youth emotion regulation and positive functioning, it is valuable to understand whether modifiable environmental factors, such as parenting, influence RSA development during adolescence.

1.2 | Parenting and RSA

Despite the established links between parenting and emotion regulation during adolescence (Brenning et al. 2015; Dwairy 2010; Ratliff et al. 2023) and between adolescents' RSA and emotion regulation (Chapman et al. 2010), notable gaps exist in the literature regarding the relation between parenting and adolescent RSA, and particularly whether parental warmth and supportiveness contribute to individual differences in RSA. Warm and supportive parenting is characterized by affectionate, consistent, and responsive behavior that attends to a child's needs (Zhou et al. 2002). Such parenting practices have the potential to boost adolescents' sense of acceptance, safety, and positive self-regard, fostering their emotion regulation skills and encouraging their adaptive functioning (Morris et al. 2017). Warm and supportive parenting has been linked to greater effortful control in childhood and fewer externalizing problems in adolescence (Atherton, Lawson, and Robins 2020; Eisenberg et al. 2005). Conversely, hostile and unsupportive parenting has been linked to lower effortful control (Atherton, Lawson, and Robins 2020) and more emotional and behavioral problems in adolescence (Chang et al. 2003; Klimes-Dougan et al. 2007).

Most studies examining concomitant changes in positive parenting and basal RSA have focused on the earlier childhood years. Although some studies have observed nonsignificant associations between warm and supportive parenting and basal RSA in toddlers and preschoolers (Hastings et al. 2019; Kennedy et al. 2004; Perry et al. 2013), a number of studies suggest that the association is robust in childhood. For example, with a Mexican-origin sample of families with kindergarten-aged children, Johnson et al. (2017) found that higher maternal responsivity predicted greater increases in resting RSA over 5 years. Further, higher maternal responsivity also buffered the negative effects of poverty on resting RSA. In a 12-week emotion coaching intervention administered among a fairly diverse sample of mothers (42.9% European American, 22.4% Hispanic/Latino, and 16.7% African American) and their 9-year-old children, Katz et al. (2020) reported that children of mothers who received the intervention showed greater increases in baseline RSA, compared to children of mothers who did not receive the intervention. In another intervention study conducted with predominantly European American families of children with ADHD, Bell et al. (2018) observed that decreases in negative parenting, but not increases in positive parenting, were associated with increased basal RSA from pre- to postintervention in preschoolers. These intervention studies are indicative of a potential causal contribution of parenting to RSA (Bell et al. 2018; Katz et al. 2020).

The more limited research on associations between parental socialization and adolescents' RSA has been inconsistent. For example, whereas Hastings et al. (2014) found no significant associations between supportive or punitive parenting and basal RSA

in a predominantly European American sample of 11- to 16-year olds, Graham, Scott, and Weems (2017) found greater parent-reported positive parenting (e.g., praise) and involvement (e.g., help with homework) to be associated with higher resting HRV in a majority ethnically/racially minoritized sample of adolescents. In a recent meta-analysis, Alen et al. (2022) revealed overall nonsignificant associations between parenting and children's and adolescents' basal HRV measures, but this was moderated by study design and sample characteristics. Within experimental studies and studies with clinical samples, more positive parenting was robustly associated with higher basal PNS activity. These findings are consistent with a causal contribution of more positive parenting to better PNS functioning, and with stronger parenting influences on basal PNS activity in more vulnerable youth (Alen et al. 2022).

The Johnson et al. (2017), Katz et al. (2020), and Graham, Scott, and Weems (2017) studies are notable for their examinations of PNS activity in ethnically/racially diverse samples, which are underrepresented in developmental psychophysiology research (Hastings, Guyer, and Parra 2022). To our knowledge, as of yet, there have been no studies focused on parenting and PNS activity in Mexican-origin adolescents. In addition, the literature on parenting and children's PNS activity is notably lacking in its consideration of potential paternal influences (Alen et al. 2022). Most studies have been conducted with exclusively mother–child dyads, illustrating the need for greater research with fathers.

RSA and emotion regulation capabilities remain relevant in adolescence, as adolescents seek novel social situations and thus are exposed to new circumstances that may challenge their emotion regulation capabilities. Given the significance of RSA and its implications for emotion regulation in adolescence, it is important to investigate whether parental influence extends into this developmental phase. As children move into adolescence, there is often a decline in emotional closeness and time spent with parents, accompanied by an amplified reliance on peer support and exposure to external media and activities outside the home (Wigfield, Byrnes, and Eccles 2006). Adolescence is also a time of increased youth–parent conflict, often stemming from youths' desire for greater autonomy and the renegotiation of parental expectations (McGue et al. 2005). The confluence of these factors may contribute to a general decrease in parental warmth throughout the course of adolescence. Yet, adolescents continue to value family connectedness and benefit from the receipt of warmer and more supportive parenting (Smetana and Rote 2019). Whether changes in the quality of parenting throughout adolescence influence youths' basal RSA has yet to be determined, yet it clearly warrants empirical attention. Further, it is critical to broaden the scope of the research of parenting and RSA to encompass more diverse samples such as Mexican-origin youths, an understudied population in developmental psychobiology (Carlo et al. 2022).

1.3 | Differential Effects of Mothers and Fathers

Despite increasing involvement in child rearing by fathers in recent years (Parker 2013) and evidence linking increased paternal involvement with positive child outcomes (Cabrera, Shannon, and Tamis-LeMonda 2007; Yogman et al. 2016), few studies in developmental psychobiology include fathers (Parent et al. 2017; W. Schulz, Hahlweg, and Su 2023). Across a set of three analyses of a study conducted with young children, Hastings and colleagues (Hastings and De 2008; Hastings, Nuselovici et al. 2008; Hastings, Sullivan et al. 2008) reported no significant associations between children's basal RSA and multiple aspects of paternal parenting. There is a lack of comparable research with fathers and adolescents' RSA. Mothers and fathers may display warmth to different extents (Brand and Klimes-Dougan 2010; Cheung et al. 2018), and fathers and mothers often fulfill distinct socialization roles within Mexican-origin and other Latino families (Carlo et al. 2022), such that maternal and paternal warmth might be expected to be associated differently with adolescents' RSA. Yet, Nair et al. (2020) found that both greater maternal and greater paternal positive parenting were associated with greater effortful control in Latino early adolescents, suggesting that the influences of fathers and mothers may be more similar than different. To our knowledge, there have been no studies examining the contributions of maternal *and* paternal warmth to youths' baseline RSA. It may be especially relevant to consider both mothers' and fathers' contributions when looking at the psychobiological development of Mexican American youths, since most are raised in two-parent households where fathers often have some involvement in the day-to-day care of their children (Aragao et al. 2023; Carlo et al. 2022).

1.4 | Gender and Nativity of Youths as Potential Moderators

Some studies have reported that girls report higher average levels of parental support than boys (De Goede, Branje, and Meeus 2009; McGue et al. 2005). Further, mother–adolescent relationships often are characterized as having greater connectedness and involvement than father–adolescent relationships (Hossain, Lee, and Martin-Cuellar 2015; Updegraff, Delgado, and Wheeler 2009). A recent meta-analysis did not find that the gender of the child moderated associations between basal PNS activity and multiple aspects of parenting, including warmth (Alen et al. 2022). Therefore, differences in the average levels of paternal or maternal warmth may not be expected to influence the prospective associations between warmth and male and female youths' basal RSA, but this possibility was explored.

Additionally, whether the nativity of Mexican-origin youths moderated the relations between parental warmth and adolescents' basal RSA was explored. Youths born in Mexico may identify more strongly with Mexican cultural values compared to youths born in the United States (Calderón-Tena, Knight, and Carlo 2011; Perez and Padilla 2000). One key cultural value is *familismo*, which emphasizes interdependence and family relationships to be warm, close, and supportive (Campos et al. 2014). Consequently, youths who identify more with Mexican cultural values may feel more connected to their parents and report higher levels of warmth. To our knowledge, whether the nativity of Mexican-origin youths also may affect the prospective relations of parental warmth with basal RSA has yet to be considered in the literature.

1.5 | The Current Study

The purpose of this study was to examine how changes in maternal and paternal warm and supportive parenting throughout adolescence were related to basal RSA in Mexican-origin youths. We hypothesized that (1) warm parenting would exhibit a decline over the course of adolescence and (2) higher levels of warm parenting throughout adolescence would be positively associated with adolescent basal RSA at age 17. Moreover, we tested whether changes in maternal and paternal warmth had unique and additive effects on adolescent basal RSA, when both were included in the same model. Given the dearth of research examining the joint influences of mothers' and fathers' positive parenting on adolescent RSA, this latter aim remained exploratory. Similarly, analyses of youth gender and nativity as moderators of associations of parental warmth with basal RSA also were exploratory.

2 | Methods

2.1 | Participants

Data were obtained from the California Families Project (CFP), an ongoing longitudinal study examining 674 Mexican-origin youths in Northern California. The study utilized data from participants in the neurobiology substudy with 229 youths (Mage = 17.16, SD = 0.43, 49.34% females, 26.20% born in Mexico [first generation], 73.80% born in the United States [second or third generation]) and their parents (76.24% two-parent households). Maternal and paternal parenting data were obtained from Waves 1, 3, 5, and 7, corresponding to ages 10, 12, 14, and 16, respectively, of the original study, and RSA data came from Time 1 of the neurobiology substudy, assessed at age 17. The substudy was designed to examine neurobiological contributors to the etiology of depression. Thus, youths were oversampled for depressive symptoms based on self-reported symptoms at 14–15 years assessed with the Computerized Diagnostic Interview Schedule for Children-IV (C-DISC; Shaffer et al. 2000) and General Distress and Anhedonic Depression Items of the Mood and Anxiety Symptom Questionnaire (MASQ; Watson et al. 1995). The substudy sample included 75% of youths with scores above the sample median on any of these three measures and 25% of youths with scores below the mean on all three measures. Hence, a bivariate score for depression risk (0 = No, 1 = Yes) was included in all analyses. At the time of sample selection, no participants met the diagnostic criteria for major depressive disorder.

2.2 | Procedure

2.2.1 | Main CFP Study Procedure

Beginning when youths were 10 years old (Wave 1), CFP assessments with youths and their parents were completed annually in each family's home. Parental warmth data were collected from youth reports biennially (Waves 1, 3, 5, and 7). Measures were translated from English to Spanish by bilingual staff and then back-translated to ensure accuracy. Youths were interviewed in their homes in Spanish or English, depending on their preference. Figure 1 shows a visualization of the complete study timeline from Waves 1 to 7 (ages 10 to 16) of the main CFP protocol and the assessment of basal RSA at Time 1 (age 17) of the neurobiology substudy.

2.2.2 | Neurobiological Substudy Procedure

During the period of the Wave 7 data collection, youths were asked to participate in the neurobiology substudy on the basis of their Wave 5 depression scores. Approximately 15.5 weeks after their Wave 7 visit, on average, youths visited an imaging research center at a university medical center, where they participated in a 3-h protocol involving multifaceted neurobiological and behavioral assessments. Basal RSA was measured approximately 1 h after arrival. The study site's Institutional Review Board approved the main CFP study and neurobiological substudy. Participants' parents provided informed consent and adolescents provided assent; both were compensated monetarily for their participation.

2.3 | Measures

2.3.1 | Parental Warmth

Parental warmth for mothers and fathers was measured with youth reports using the Behavioral Affect Rating Scale (BARS; Kim et al.2003). The BARS consisted of 22 items with subscales for warmth (9 items) and hostility (13 items). An example item from the warmth subscale is: "During the past three months when you and your [parent] have spent time talking or doing things together, how often did your [parent] act loving and affectionate toward you?". An example item from the hostility subscale is: "During the past 3 months when you and your [parent] have spent time talking or doing things together, how often did your [parent] argue with you whenever you disagreed about something?". Adolescents rated items using a 4-point scale, with 1 indicating "almost never or never" and 4 indicating "almost always or always". Warmth and hostility scores were negatively correlated within each wave (mean $r = -0.26$, $p < 0.001$). Therefore, hostility values were reverse scored and then averaged with warmth values to create one composite score at each wave, such that higher scores reflected high warmth and low hostility, whereas lower scores reflected low warmth and high hostility. Adolescent reports of mother and father warmth and hostility across all waves had good reliability (range $a = 0.77$–0.93), except father hostility at Wave 3 ($a = 0.65$). Across all waves, youths' reports of mother warmth and hostility were available for more than 96% of the sample, and youths' reports of father warmth and hostility were available for more than 84% of the sample.

2.3.2 | Respiratory Sinus Arrhythmia

Electrocardiogram (ECG) data were collected from youths at age 17 using three electrodes on the chest connected with Biopac fMRI compatible wireless signal recording (Biopac Systems, USA) via Siemens' telnet MPCU at 400 Hz. Youths' ECG was recorded throughout a 3-min reclining resting baseline, obtained several minutes after the electrodes were attached, and before the youths

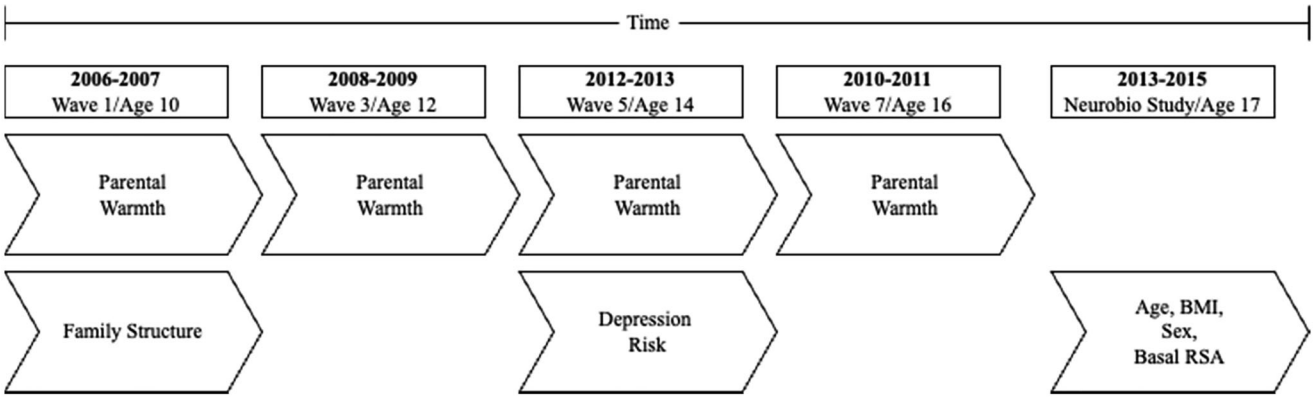

FIGURE 1 | Timeline of data collection.

entered a fMRI scanner. The data were transformed into an ASCII-formatted string of amplitude values, which was then input into the Mindware HRV program (Mindware Technologies, Gahanna, OH) for editing. RSA was calculated using the inter-beat interval sequence. The delay time between consecutive local maxima in the QRS complex (R-spikes) was used to calculate inter-beat intervals (Berntson et al. 1997). Trained research assistants visually inspected ECG data for accurate identification of R-spikes and edited the data when the automated software misinterpreted the R-spikes. The frequency band utilized to measure RSA was 0.12–0.40, reflecting the age-normative respiratory frequency band (Dollar et al. 2020). RSA is calculated by Mindware as the natural log of spectral power in this frequency range. Basal RSA was calculated in 30-s epochs, which were averaged across the 3-min baseline. RSA data for 10 individuals during baseline were missing due to human error or equipment errors during sample collection.

2.3.3 | Covariates

The following covariates were included in analyses: Child age at scan, sex-assigned-at-birth, body-mass index (BMI), depression risk, and family structure (single- or two-parent household) at Wave 1. Prior work has shown that individual differences in age, sex, BMI, and depression risk all impact autonomic nervous system function (Harteveld et al. 2021; Hollenstein et al. 2012; Koenig et al. 2014; Nelson et al. 2021).

2.4 | Analytic Strategy

This study examined prospective associations of maternal and paternal warm parenting throughout adolescence (ages 10–16) with adolescents' basal RSA at age 17. To address the first study's aim, no-growth, linear-growth, and latent-growth curve models (LGCM) were estimated using the lavaan (Rosseel 2012) package in Rstudio (R version 4.1.1) to model the trajectory of warm parenting across adolescence, using warm parenting scale scores at each wave as observed indicators of the latent intercept and slope factors. The latent basis model is similar to a linear model in the sense that the rate of change is represented by one latent slope factor. However, the latent basis model is more flexible and can be nonlinear because the basis coefficients at each time point are not equal (Grimm, Nilam, and Hamagami 2011). The chi-square (χ^2) goodness of fit statistic, comparative fit index (CFI; Bentler 1990), Tucker–Lewis Index (TLI; Tucker and Lewis 1973), root-mean-square error of approximation (RMSEA; Browne and Cudeck 1992), and standardized root-mean-square residual (SRMR; Hu and Bentler 1999) were used to evaluate fit of each model. Model fit was considered acceptable if RMSEA and SRMR were < 0.08 and CFI and TFI were > 0.90. First, a univariate maternal warmth LGCM was fitted to calculate the intercept and slope, in which Wave 1 warmth was fixed at 0, Wave 7 warmth was fixed at 1, and Waves 3 and 5 warmth were freely estimated. Next, a paternal warmth model was fitted, with the same fixed and freely estimated loadings as the maternal warmth model. Lastly, a bivariate LGCM including maternal and paternal warmth was fitted, with the same fixed and freely estimated loadings. To address the second aim, baseline RSA was regressed onto each model's intercept and slope, along with the relevant covariates. All covariates were mean-centered prior to analyses. Full information maximum likelihood (FIML) estimation was used to account for missing data. FIML has been shown to produce unbiased estimates, as well as lower rates of convergence failures and Type 1 error rates compared to other missing data methods (Enders and Bandalos 2001).

3 | Results

3.1 | Preliminary Analyses

Table 1 provides descriptive statistics and correlations for all study variables. Of the covariates, sex and BMI were both significantly correlated with adolescent basal RSA; female youths had higher RSA than male youths, and youths with higher BMI had lower RSA. Maternal warmth at Wave 1 and paternal warmth at Wave 3 were significantly, positively correlated with adolescent basal RSA. A two-way (2 target parents × 4 time points) within-subjects ANOVA was run to test for differences in warmth within and between parents across 4 time points throughout adolescence. A borderline main effect of time was found, $F(2.8, 476.34) = 29.576$, $p = 0.053$, moderated by a significant interaction between parent and time, $F(3, 510) = 13.245$, $p < 0.001$. Parental warmth decreased over time, and maternal warmth was higher than paternal warmth at Waves 1, 5, and 7. Maternal and paternal warmth did not differ at Wave 3.

TABLE 1 | Descriptive statistics and zero-order correlations of study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Sex of adolescent	—													
2 Age of adolescent	−0.01	—												
3 BMI	**0.17****	0.04	—											
4 Depression risk	**−0.16***	−0.12	−0.01	—										
5 Family structure	−0.03	0.04	−0.09	−0.04	—									
6 Maternal Warmth Wave 1	**−0.14***	0.00	0.00	−0.02	0.09	—								
7 Maternal Warmth Wave 3	−0.09	0.03	−0.04	**−0.18****	0.11	**0.42*****	—							
8 Maternal Warmth Wave 5	0.01	0.10	0.11	**−0.34*****	**0.14***	**0.35*****	**0.55*****	—						
9 Maternal Warmth Wave 7	0.02	0.12	**0.16***	**−0.28*****	0.02	**0.25*****	**0.46*****	**0.60*****	—					
10 Paternal Warmth Wave 1	−0.11	−0.01	0.02	0.04	**0.24*****	**0.46*****	**0.42*****	**0.24*****	**0.24*****	—				
11 Paternal Warmth Wave 3	−0.06	0.07	**−0.17***	**−0.21****	**0.16***	0.11	**0.52*****	**0.29*****	**0.23****	**0.29*****	—			
12 Paternal Warmth Wave 5	−0.13	0.00	−0.05	**−0.27*****	**0.15***	0.17	**0.41*****	**0.50*****	**0.40*****	**0.34*****	**0.62*****	—		
13 Paternal Warmth Wave 7	−0.10	0.11	0.03	**−0.21****	0.05	0.10	**0.26*****	**0.27*****	**0.49*****	**0.34*****	**0.50*****	**0.61*****	—	
14 Baseline RSA at age 17	**−0.20****	0.04	**−0.23*****	0.01	−0.09	**−0.14***	0.10	0.09	0.05	−0.08	**0.16***	0.05	−0.01	—
Mean	—	17.16	25.35	—	—	3.33	3.32	3.24	3.16	3.38	3.29	3.17	3.01	6.82
SD	—	0.43	5.65	—	—	0.34	0.38	0.46	0.46	0.34	0.46	0.47	0.53	0.98
Min	—	16.24	15.75	—	—	2.09	1.89	1.47	1.68	1.85	1.12	1.41	1.32	4.04
Max	—	18.84	44.87	—	—	4.00	4.00	4.00	4.00	3.96	3.96	4.00	4.00	9.09

Note: For sex of adolescent, 0 = female, 1 = male. For depression risk, 0 = Absent, 1 = Present. For family structure, 0 = single-parent family, 1 = two-parent family. BMI = body mass index. RSA = respiratory sinus arrhythmia.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

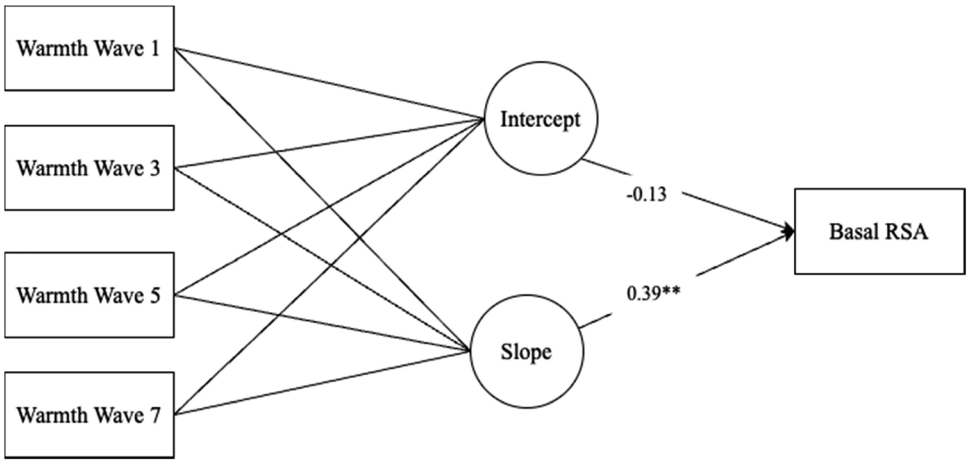

FIGURE 2 | Path model of maternal warmth from 10 to 16 years predicting adolescent basal respiratory sinus arrhythmia at 17 years. ** $p < 0.01$. RSA = respiratory sinus arrhythmia. Covariates were included in the model (see Table 2) but are not included in the figure to enhance clarity.

We compared model fit between no-growth, linear-growth, and latent-growth curve models for mothers and fathers separately. The no-growth model ($\chi^2 = 137.72$, $df = 46$, $p < .001$) and linear-growth model ($\chi^2 = 6.22$, $df = 40$, $p = 0.013$) for maternal warmth showed significantly worse fit than the latent-growth curve model and were therefore rejected. Likewise, the no-growth model ($\chi^2 = 46$, $df = 205.23$, $p < .001$) and linear-growth model ($\chi^2 = 16.90$, $df = 40$, $p = 0.005$) for paternal warmth showed significantly worse fit than the latent-growth curve model and also were rejected. Given that the LCGM was a significantly better fit for mothers and fathers we did not test no-growth or linear-growth models for the bivariate model; we only tested a bivariate LGCM.

3.2 | Latent-Growth Curve Analyses Predicting Adolescent Basal RSA

3.2.1 | Mother LGCM

We regressed basal RSA at age 17, along with all the covariates, onto the level and slope factors from the maternal LGCM (see Figure 2). Fit for this model was good, *CFI* = 0.961, *TLI* = 0.955, *RMSEA* = 0.037, *SRMR* = 0.056. With Wave 1 fixed to 0 and Wave 7 fixed to 1, the model assigned factor loadings of 0.343 and 0.861 to Waves 3 and 5, respectively. The latent average maternal warmth at age 10 was 3.35 (equivalent to "a lot of the time"). The latent slope was negative ($\beta = -0.518$, $p < 0.001$), indicating that maternal warmth decreased from age 10 to 16. The covariance between intercept and slope was not significant; therefore, this covariance was set to zero for model parsimony.

Maternal warmth at intercept (age 10) was not significantly related to baseline RSA ($\beta = -0.133$, $p = 0.192$). However, the slope of maternal warmth was significantly related to baseline RSA ($\beta = 0.392$, $p = 0.005$), such that youths who reported smaller decreases, or increases, in maternal warmth from age 10 to 16 had higher baseline RSA at age 17 (see Table 2 and Figure 3). Sex and BMI were both significantly correlated with adolescent basal RSA. Females had greater basal RSA than males ($\beta = -0.171$, $p = 0.013$), and youths with lower BMI had greater basal RSA ($\beta = -0.294$, $p < 0.001$).

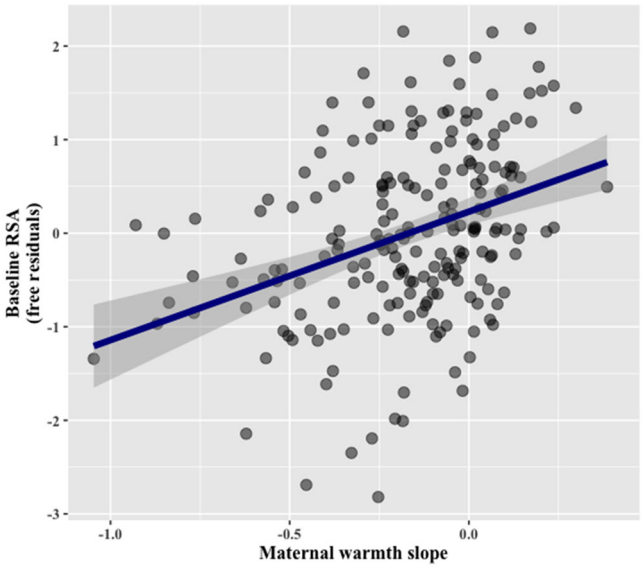

FIGURE 3 | Slope of maternal warmth across adolescence significantly and positively predicts youths' basal respiratory sinus arrhythmia (RSA). Latent average intercepts and slopes for maternal warmth were estimated and extracted for each participant from the latent-growth models. Basal RSA was regressed on all covariates, and the residual values were plotted against the latent maternal warmth slope factor for illustrative purposes.

3.2.2 | Father LGCM

We regressed basal RSA at age 17, along with all the covariates, onto the level and slope factors from the paternal LGCM. Fit for this model was acceptable, *CFI* = 0.92, *TLI* = 0.90, *RMSEA* = 0.05, *SRMR* = 0.06. With Wave 1 fixed to 0 and Wave 7 fixed to 1, the model assigned factor loadings of 0.400 and 0.669 to Waves 3 and 5, respectively. The latent average paternal warmth at age 10 was 3.39. The latent slope was negative ($\beta = -1.275$, $p < 0.001$), indicating that paternal warmth decreased from age 10 to 16. The covariance between intercept and slope was not significant; therefore, this covariance was set to zero. Neither paternal warmth at the intercept ($\beta = 0.108$, $p = 0.929$) nor the

TABLE 2 | Predictions of youths' basal respiratory sinus arrhythmia and covariates from intercepts and slopes of maternal and paternal warmth across adolescence.

	Maternal warmth			Paternal warmth			Maternal and paternal warmth		
	B	***SE***	***p***	***β***	***SE***	***p***	***β***	***SE***	***p***
Age	0.02	0.45	0.757	0.04	0.20	0.661	0.02	0.15	0.756
Sex	−0.17	0.13	**0.013****	−0.15	0.30	0.331	−0.18	0.15	0.013
BMI	−0.29	0.01	**0.000*****	−0.21	0.01	**0.010****	−0.30	0.01	**0.000*****
Depression risk	0.15	0.21	0.093	−0.05	1.19	0.923	0.15	0.28	0.206
Family structure	−0.11	0.15	0.077	−0.18	1.97	0.832	−0.10	0.30	0.425
Maternal intercept	−0.13	0.45	0.192	—	—	—	−0.13	0.83	0.502
Maternal slope	0.39	0.45	**0.005****	—	—	—	0.42	0.47	**0.004****
Paternal intercept	—	—	—	0.11	6.31	0.929	−0.02	1.20	0.911
Paternal slope	—	—	—	−0.07	4.10	0.951	−0.04	0.65	0.840

Note: BMI = body mass index. ** $p < 0.01$, *** $p < 0.001$.

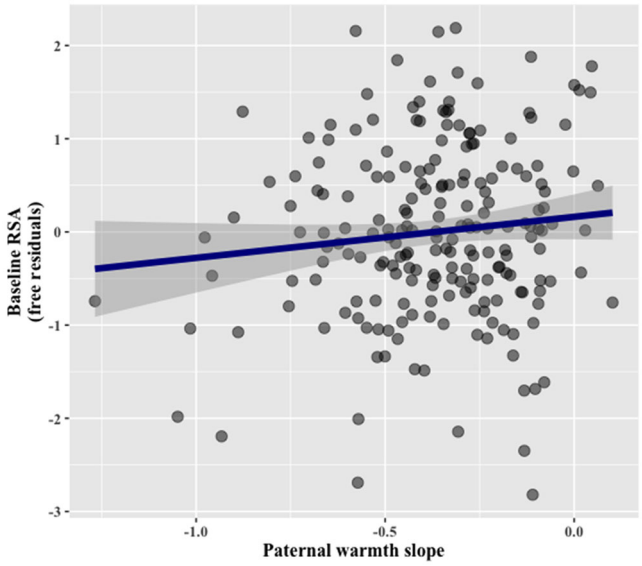

FIGURE 4 | Slope of paternal warmth across adolescence does not significantly predict youths' basal respiratory sinus arrhythmia (RSA). Latent average intercepts and slopes for paternal warmth were estimated and extracted for each participant from the latent-growth models. Basal RSA was regressed on all covariates, and the residual values were plotted against the latent paternal warmth slope factor for illustrative purposes.

slope of paternal warmth ($\beta = -0.074$, $p = 0.951$) were significantly related to baseline RSA (see Table 2 and Figure 4).

3.2.3 | Mother and Father LGCM

We regressed basal RSA at age 17, along with all the covariates, onto the level and slope factors from the maternal and paternal LGCM to confirm that maternal warmth was still significant with paternal warmth included in the same model. Fit for this model was acceptable, *CFI* = 0.946, *TLI* = 0.935, *RMSEA* = 0.049, *SRMR* = 0.062. Including both maternal and paternal warmth did not change any of the preceding findings; the slope of maternal warmth continued to be the only significant predictor of adolescents' baseline RSA at age 17.

3.3 | Post Hoc Analyses: Moderation by Gender and Nativity

We conducted multigroup analyses within the maternal, paternal, and bivariate LCGMs to examine whether the association between changes in maternal warmth and basal RSA at age 17 differed between females and males and/or depending on whether youths were born in Mexico or in the United States. In the unconstrained models, factor loadings, intercepts, and covariances were free to vary, whereas in the constrained models, only the regression paths were constrained to be equal. Unconstrained models did not fit the data better than the constrained models for either youth gender or nativity (all $p > 0.05$). Therefore, we found no evidence of significant group differences by either youth gender or nativity.

3.4 | Post Hoc Analyses: Considering Parental Warmth and Hostility Separately

Recognizing that some past studies have indicated that either increases in positive parenting or decreases in negative parenting could predict children's higher basal RSA (Bell et al. 2018; Johnson et al. 2017), we re-ran the models for mothers and fathers with warmth and hostility entered as separate predictors. In the model for mothers, neither the intercept for warmth nor the intercept for hostility predicted adolescents' basal RSA, but both slope effects were significant. Specifically, more positive slopes for maternal warmth predicted higher basal RSA ($\beta = 0.321$, $p = 0.016$), whereas more positive slopes for maternal hostility predicted lower basal RSA ($\beta = -0.359$, $p = 0.031$). Conversely, in the model for fathers, there were no significant associations of the intercepts and slopes of warmth and hostility with adolescents' basal RSA.

4 | Discussion

This study analyzed the effects of mothers' and fathers' warm parenting throughout adolescence on Mexican-origin youths' basal RSA. Our findings extend prior work focusing on childhood (Bell et al. 2018; Katz et al. 2020), demonstrating that parasympathetic plasticity to caregiving continues into adolescence. We found that changes in mothers', but not fathers', warmth from age 10 to 16, as reported by youths, predicted Mexican-origin youths' basal RSA at age 17. More specifically, although on average youths reported that mothers' and fathers' warmth decreased across adolescence, when youths reported smaller decreases or even increases in maternal warmth from ages 10 to 16, they evinced higher basal RSA at age 17. Notably, when considered as separate aspects of parenting, both increases in maternal warmth and decreases in maternal hostility made incremental and additive contributions to the prediction of higher basal RSA. Neither maternal nor paternal warmth at age 10 (i.e., the intercept of the model) predicted basal RSA. Rather, it was the trajectory of maternal warmth across adolescence that predicted higher basal RSA, and equally so for female and male youths, and for youths born in Mexico and in the United States. These results show that the maintenance of maternal warmth is important throughout adolescence; warm mother–adolescent relationships appear to "get under the skin" to enhance parasympathetic functioning, potentially supporting youths' ER capacities (Hastings and Kahle 2019).

Adolescence represents a period of important developmental changes across biological, cognitive, and social domains. During adolescence, there is rapid maturation of the brain (Casey, Jones, and Hare 2008), including regions in the prefrontal cortex related to affect processing (Somerville, Jones, and Casey 2010). The release of pubertal hormones has organizational effects on many neurobiological systems, demarcating a period of biological plasticity that may make adolescents more sensitive to the effects of affective and social stimuli (Vijayakumara et al. 2018), such as parental warmth. It should be recognized that this study did not measure RSA prior to adolescence, and therefore we cannot show that RSA changed over the experience of parenting during adolescence, nor rule out the possibility that associations may have emerged earlier in development. Nonetheless, our findings support the idea that adolescence is a period of plasticity in which mother–adolescent relationships that emphasize warmth and acceptance and diminish hostility may "get under the skin" to scaffold youths' enhanced physiological capacities for regulation.

In addition to these biological changes, adolescents begin to explore new environments and form new peer and romantic attachments. This increased individuation can be accompanied by increased parent–child conflict, decreased dependency on parental support, and increased saliency of peer support (Furman and Buhrmester 1992; Hostinar, Johnson, and Gunnar 2015). Despite this shift, parental support remains relevant for youths, as parental attachment is argued to provide the foundation, or secure base, from which adolescents feel safe to explore and engage in novel social situations (Bowlby 1969; Cooper, Shaver, and Collins 1998). A recent meta-analysis demonstrated robust support for supportive parent–adolescent relationships predicting more positive peer and romantic relationships (S. Schulz et al. 2023). It is possible that influences on adolescent emotion regulation capacities, including parasympathetic regulation, may serve as mechanisms by which parental warmth and support benefit youths' abilities to establish positive relationships with their age-mates.

A parenting profile that is high in warmth and low in hostility may foster an environment in which youth feel safe to express their emotions, reducing stress and promoting better parasympathetic functioning. Adolescence is a developmental period that tends to be marked by a rise in parent–child tension and conflict (McGue et al. 2005), as evidenced in this sample by the negative slopes of maternal and paternal warmth from 10 to 16 years. However, adolescents continue to value closeness with their parents (Smetana and Rote 2019), and strong family connections are central to the cultural values of Mexican-origin communities (Campos et al. 2014). Hence, parents' ability to regulate their anger and respond to their children with positive affect, especially during disputes, may serve to provide a safe "training ground" for youth to practice effective emotion regulation strategies. Youth also may be more inclined to emulate the effective emotion regulation modeled by their parents, as the positive climate of their relationship could serve to make youth more attentive and receptive to the socialization efforts of their parents (Grusec and Goodnow 1994). Thus, by establishing a relationship context of safety, affection, and connection, parents could promote stronger tonic parasympathetic activity for youths (Porges and Furman 2011).

Maintaining parental connection may be especially important for Mexican-origin youths, given that Mexican culture has been characterized as collectivist and interdependent (Campos et al. 2014; Harrison et al. 1990; Keefe, Padilla, and Carlos 1979). Even as Mexican-origin families assimilate to majority U.S. values, perceived family support continues to be a stable and essential dimension of familismo (Sabogal et al. 1987), which may be why associations of maternal warmth with basal RSA did not vary by youth nativity. Yet, further research on how cultural values and acculturation processes may contribute to psychobiological functioning is warranted (Carlo et al. 2022).

One explanation for the unique association of maternal warmth with youths' basal RSA may be the higher level of caregiving responsibilities by mothers in Mexican American families. Mexican American mothers report spending more time with their children (Hossain, Lee, and Martin-Cuellar 2015) and having higher levels of warmth/acceptance, involvement, and knowledge of adolescents' daily activities (Updegraff, Delgado, and Wheeler 2009), compared to fathers. This increased involvement may also lead to stronger mother–youth attachments compared to father–youth attachments (Doyle, Lawford, and Markiewicz 2009; Rosenthal and Koback 2010). Altogether, mothers' greater caregiving responsibilities and involvement may result in increased significance for the socio-emotional relationship between mother and child compared to the relationship between father and child.

In addition, some research has indicated that Latino fathers employ both high warmth and strictness in their parenting practices, a style referred to as "no-nonsense parenting" (Brody and Flor 1998; White et al. 2013). Carlo et al. (2018) found that no-nonsense Mexican American fathers were no less likely

than traditionally authoritative Mexican American fathers to have adolescents with higher levels of prosocial behaviors, academic self-efficacy, and academic achievement; hence, no-nonsense paternal parenting may be effective for promoting positive adjustment in Mexican American youths. It is possible that our definition of parental warmth, in which high warmth also reflected low hostility, overlooked an important profile of parenting by Mexican fathers. In other words, perhaps a paternal parenting profile characterized by high warmth with some hostility (or strictness with negative affect) may have predicted adolescents' adaptive high basal RSA. This would suggest that traditional frameworks for conceptualizing the relations between parenting and child outcomes, including RSA, that are largely based on European American samples do not fully capture the range of parenting in Mexican American families. Altogether, this emphasizes the importance of considering culture-specific aspects of socialization that may contribute to adolescent emotion regulation and RSA development.

4.1 | Limitations

Findings from the present study should be interpreted in the context of several research limitations. First, this study only utilized youth reports of warm parenting. Single-informant reports may be biased due to subjective individual experiences. Various studies have demonstrated low levels of agreement on how parents and their children rate their relationships with one another (Korelitz and Garber 2016; Leung and Shek 2014; Tein, Roosa, and Michaels 1994). Conversely, adolescent reports may reflect how youths have experienced and internalized their relationship quality with their parents (Human et al. 2016), which could be more relevant for the development of their physiological regulatory capacities, such that the degree of parent–youth agreement may not be critical.

Whether it is considered a limitation or a study feature, it is also important to recognize the context in which basal RSA was measured. Basal RSA is often treated as a "trait-like" measure of parasympathetic capacity for well-regulated responses to the environment (Hastings and Kahle 2019). In this study, basal RSA was recorded once in a medical fMRI facility, a potentially unfamiliar and unsettling environment. Thus, another interpretation of our findings may be that Mexican-origin youths with warmer, less hostile relationships with their mothers perceived this environment as safe, physiologically reflected in higher basal RSA during their visit.

Due to the study timeline, we could not compare the magnitude of the effects of parenting during adolescence to the effects of parenting in childhood. The first wave of data collected occurred when youths were age 10; no measures of parenting were collected before this. Thus, we cannot know whether the associations of maternal warmth with adolescent RSA were reflective of, or perhaps built upon, the promotive influences of earlier positive caregiving, such as facial expressiveness and touch that have associated with RSA during infancy and early childhood (Feldman 2006; Feldman et al. 2010). Similarly, as RSA was first measured in late adolescence, we cannot rule out the possibility that children's earlier basal RSA may have contributed to the parenting they experienced in adolescence, as has been documented in some studies of younger children and their parents (Hastings et al. 2019; Kennedy et al. 2004). In other words, some youths may have entered their adolescence with higher resting RSA, conferring greater capacity for emotion regulation, and thereby behaved in well-regulated ways that could have evoked warmer maternal parenting. Lacking an earlier measure of RSA, we also could not measure change in basal RSA; thus, our findings do not show that parenting predicts the development of RSA over time. In addition, as this study did not utilize an experimental design, we cannot infer that maternal warmth was causally influential on adolescents' basal RSA.

5 | Conclusion

Overall, this study found significant evidence for the prospective relation between maternal warm parenting across adolescence and youths' basal RSA in late adolescence, but not for similar influences of paternal warmth. These findings are consistent with research showing that sensitive, warm maternal caregiving is critical to children and youths' positive emotion regulation and adjustment. To our knowledge, this is the first study to examine parental warmth in relation to basal RSA among Mexican-origin youths. Efforts to replicate these findings, and potentially using intervention or other experimental procedures to assess potential causal mechanisms of maternal warmth shaping PNS development, are strongly encouraged. Given the growing population of Mexican-origin families in the United States, it is critical to conduct more neurobiological research with this community. Continuing to investigate relations between parenting and youth parasympathetic regulation will help to inform the development of family-based intervention programs for Mexican-origin youths and to advance our understanding of their healthy biobehavioral development such as adaptive emotion regulation.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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