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Testosterone Associations with Parents' Child Abuse Risk and At-Risk Parenting: A Multimethod Longitudinal Examination

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Abstract

The current investigation considered salivary testosterone as a potential biomarker of physical child abuse risk. Parents enrolled in a prospective, longitudinal, multimethod study beginning prenatally provided saliva when their toddlers were 18 months old. Mothers and fathers self-reported on their empathy, frustration tolerance, and child abuse risk, as well as completing analog tasks of frustration intolerance and child abuse risk and participating in structured parent-child interactions. In contrast to mothers, fathers' higher testosterone levels were associated with increased child abuse risk, less observed positive parenting, more observed negative parenting, and an analog task of frustration intolerance; such findings were reflected across time. Further, fathers' socioeconomic status moderated the association between testosterone levels and abuse risk. No evidence of partner effects was observed in dyadic analyses. The current findings suggest that higher testosterone levels reflect an increased likelihood that paternal physically abusive behavior may be expressed.

Keywords

physical child abuse risk; child abuse potential; harsh parenting; salivary testosterone; multimethod

Since 2013, protective services has witnessed an increase in maltreatment referrals, investigations, and substantiated cases, with nearly 4.3 million reports in 2017 (U.S. Department of Health and Human Services [DHHS], 2019). Yet statistics underscore that most maltreatment cases—particularly physical abuse—are never reported to protective services (Fallon et al., 2010; Sedlak et al., 2010). Because child protective services identify only a fraction of parents engaged in physical abuse, prevention efforts strive to decrease the

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likelihood a parent will abuse their children, termed *child abuse potential* (Milner, 1994). Parents' child abuse potential has been linked to harsh parenting (Conners, Whiteside-Mansell, Deere, Ledet, & Edwards, 2006; Margolin, Gordis, Medina, & Oliver, 2003; Rodriguez, Smith, & Silvia, 2016a, 2016b) as well as physically abusive discipline tactics (Rodriguez, 2010). To reduce parents' child abuse risk, abuse prevention programs often prioritize pregnant and perinatal mothers (e.g., Pajer et al., 2014), consistent with early identification and prevention goals (Eckenrode, 2011), although few programs are directed at new fathers. The current study aligns with this early prevention priority, following new parents' abuse risk across the transition to parenthood.

A range of risk factors has been identified in physical abuse, including demographic qualities of the parent that are descriptive and epidemiological in nature. For example, younger parents are considered at increased risk to abuse their children (Hoffman & Maynard, 2008; MacMillan, Tanaka, Duku, Vaillancourt, & Boyle, 2013) and lower socioeconomic status (SES) is consistently a strong predictor of child abuse risk (Akmatov, 2011; DHHS, 2019; Doidge et al., 2017; MacMillan et al., 2013; Sedlak et al., 2010). Furthermore, despite persistent calls to study paternal abuse risk (Lee, Bellamy, & Guterman, 2009), mothers remain a central focus of inquiry in investigations of child abuse risk. Yet fathers perpetrate nearly half of physical maltreatment (Sedlak et al., 2010) and often some of the most severe physical abuse (Pittman & Buckley, 2006; Starling, Sirotnak, Heisler, & Barnes-Ely, 2007).

Although research has advanced our knowledge of sociocognitive processes leading to abuse risk (see Rodriguez, Silvia, & Gaskin, 2019), considerably less empirical attention has focused on the role of physiological processes that may contribute to abuse risk. A growing appreciation of the importance of physiological processes in complex behaviors has emerged in the behavioral sciences, with specific interest in the correlates and concomitants of individual differences in testosterone levels (e.g., Stoff & Susman, 2005; Svare, 2013). Hormones are widely seen as not directly causing behavior but rather increasing the probability that existing behavioral tendencies will be expressed given contextual demands (e.g., Sapolsky, 2017). For example, individual differences in testosterone levels have been implicated in the expression of social dominance, competition, aggression, and antisocial behavior (Archer, 2006; Yildirim & Derksen, 2012a), but these effects are moderated by social contextual forces and factors (such as socioeconomic conditions, family relationships, and mental health; e.g., Chen, Dariotis, & Granger, 2018). Surprisingly, empirical work examining the role of individual differences in testosterone in relation to child abuse risk is absent. Testosterone levels tend to be relatively stable within an individual such that, despite variations by time of day, or declines in levels by age, the relative rank ordering between individuals is maintained across time (i.e., those with highest levels within a group at one point will likely retain that relative status later on; Granger, Shirtcliff, Booth, Kivlighan, & Schwartz, 2004). Thus, parents' testosterone levels could provide a glimpse into parental abuse risk across time.

Although research has not considered links between testosterone levels and abuse risk specifically, higher testosterone levels are associated with lower impulse control and lower empathy (Yildirim & Derksen, 2012b). Interestingly, apart from the previously discussed demographic qualities that characterize abusive parents, prior research has observed that parents with lower empathy also demonstrate greater child abuse risk (de Paúl, Pérez-Albéniz, Guibert, Asla, & Ormaechea, 2008; Francis & Wolfe, 2008; Rodriguez, 2013). Furthermore, parents who are more impulsive (Rodriguez, Gracia, & Lila, 2016) and express lower frustration tolerance also exhibit greater child abuse risk (McElroy & Rodriguez, 2008; Rodriguez, Baker, Pu, & Tucker, 2017; Rodriguez, Russa, & Kircher, 2015). Thus, considering all the evidence, the observed links between personality characteristics like low empathy and frustration tolerance with child abuse risk could be associated with higher testosterone levels.

Some limited work has explored testosterone levels in relation to parenting quality. A recent meta-analysis reports that men who are more inclined toward, and invested in, parenting tend to have lower testosterone levels (Grebe, Sarafin, Strenth, & Zilioli, 2019). Among new fathers transitioning into parenthood, lower testosterone levels have been detected in men with greater paternal involvement and investment (Gettler, McDade, Agustin, Feranil, & Kuzawa, 2013; Saxbe, Edelstein et al., 2017; Weisman, Zagoory-Sharon, & Feldman, 2014). Fathers with lower testosterone levels display more positive parenting during father-child interactions and report greater empathy (Kuo et al., 2016). Among women, lower testosterone levels have been observed in mothers relative to childless women (Kuzawa, Gettler, Huang, & McDade, 2010), particularly in mothers of young children (Barrett et al., 2013). Lower maternal engagement has been associated with higher levels of testosterone in mothers (Clowtis et al., 2016). Such findings suggest that, similar to fathers, mothers' parenting behavior may also be linked to testosterone levels. Nonetheless, relative to fathers, considerably less empirical work has evaluated testosterone levels in new mothers in relation to their parenting behavior.

Other research has noted that testosterone exerts its effects within the wider social context (Booth, Johnson, & Granger, 1999)—for example, against the backdrop of socioeconomic conditions. Early work suggested that higher testosterone levels are linked to lower occupational attainment (Dabbs, 1992) and unemployment (Booth et al., 1999). Others, however, have not observed this link with SES (Hughes & Kumari, 2019). More nuanced work has identified interaction effects, in which college educated males with more children had lower testosterone whereas below-college educated males with more children had higher testosterone levels (Jasienska, Jasienska, & Ellison, 2012); this interaction may reflect the greater stress fathers experience in raising more children under adverse socioeconomic conditions. Contemporary theorists speculate that socioeconomic influences can moderate associations between testosterone and antisocial behavior (Yildirim & Derksen, 2012a) wherein aggressive behavior may be expressed when higher testosterone levels interact with lower, rather than higher, SES.

Studies also demonstrate that fathers of young children who experience their paternal role as constraining evidence higher testosterone (Waldvogel & Ehrlert, 2018). Indeed, fathers' testosterone levels across the transition to parenthood related to later parenting stress (Saxbe, Dunkel Schetter, Simon, Adam, & Shalowitz, 2017). Moreover, those with high testosterone levels and aggressive tendencies did not modulate their emotions (Kaldewaij et al., 2019), suggesting that those with higher testosterone levels and poor emotion regulation may be more inclined to react aggressively. Notably, greater stress from the parenting role (Lowell & Renk, 2017; Miragoli, Balzarotti, Camisasca, & Di Blasio, 2018) and poorer emotion regulation skills are also both connected to greater child abuse risk (Hiraoka et al., 2016; Lowell & Renk, 2017; Rodriguez et al., 2017; Rodriguez, Silvia, & Pu, 2018). Potentially, socioeconomic status, stress from the restrictiveness of the parenting role, and emotion regulation abilities may interact with testosterone levels to affect parents' child abuse risk.

The measurement of testosterone levels in parents—an objective assessment strategy—in combination with previously identified risk factors may clarify our understanding of child abuse risk. Yet conventional approaches to assess risk factors routinely depend upon explicit assessment methods, primarily via self-report questionnaires that are more subjective and susceptible to participant distortion. In contrast, indirect assessment approaches like analog tasks are designed to estimate the construct of interest in intentionally ambiguous ways so that the participant is unaware of the intent and/or scoring of the task (Fazio & Olson, 2003). Such indirect approaches use implicit processes or behavioral simulations to approximate the construct of interest. Given the sensitive nature of child abuse risk, utilizing indirect assessment methods can be particularly critical (Camilo, Garrido, & Calheiros, 2016; DeGarmo, Reid, & Knutson, 2006; Rodriguez, Bower-Russa, & Harmon, 2011). Direct observations of structured parent-child interactions can be viewed as an analog strategy, aiming to approximate typical daily parent-child interactions (DeGarmo et al., 2006; Haynes, 2001). In the current study, we employed a multimethod approach, including explicit self-report measures, analog tasks, and parent-child interactions.

Current Study

In an effort to identify biobehavioral indicators of physical abuse risk, the current study examined mothers' and fathers' salivary testosterone levels collected when their children were 18 months old as part of a prospective, longitudinal, multimethod study. A number of research questions (RQs) guided this investigation: (1) We investigated whether higher salivary testosterone levels would be concurrently associated with parents' dispositional personality characteristics of lower empathy and poorer frustration tolerance (cf. Yildirim & Derksen, 2012b). Given the stability in inter-individual differences in testosterone levels (Granger et al., 2004), we also considered whether earlier assessments of empathy and frustration tolerance would prospectively predict parents' later testosterone levels when their toddlers were 18 months and whether testosterone levels at 18 months would predict parents' later empathy. (2) We further examined whether higher salivary testosterone levels would be concurrently associated with measures of child abuse risk as well as with less observed positive parenting and more observed negative parenting. (3) We considered longitudinal relations between testosterone levels and abuse risk, evaluating whether abuse risk would prospectively predict parents' later testosterone levels when their toddlers were 18 months old and whether testosterone levels at 18 months would predict parents' later child abuse risk. (4) Based on prior work that has implicated that one's testosterone level may relate to their partner's functioning (e.g., Saxbe, Edelstein et al., 2017), we also explored potential "partner" effects—namely, whether testosterone levels in one member of a couple would predict abuse risk in their partner. (5) Finally, we considered potential moderators of the association between parents' testosterone levels and their concurrent abuse risk. Given prior research, we anticipated main effects for lower SES, higher stress from the parenting role, and lower emotion regulation to relate to abuse risk. We also considered whether SES interacts with testosterone levels to affect abuse risk; whether stress from the parenting role exacerbates the effects of testosterone levels with abuse risk; and whether better emotion regulation reduces the association of testosterone levels with abuse risk.

Method

Participants

Data are drawn from the Following First Families (Triple-F) study, a prospective longitudinal study in a large Southeastern US urban city tracking abuse risk. Primiparous mothers (n = 201) and their male partners (n = 151) enrolled in a three-wave longitudinal study, with the first wave beginning the last trimester of their pregnancy (Time 1, T1). Parents (186 mothers, 146 fathers) were reassessed when their infants were 6 months old (± 2 weeks) for Time 2 (T2) and when their toddlers were 18 months old (± 3 weeks) for Time 3 (T3). At Time 3, parents (180 mothers, 144 fathers) were invited to contribute saliva for this adjunct study module. Then, in an unplanned extension of the Triple-F study, parents were re-invited to participate in a fourth wave (Time 4, T4) when their children had turned four years old (4 years, 0 months to 4 years, 4 months).

At T3, 209 parents contributed saliva for this module of the Triple-F study. Compared to parents for whom saliva was not collected, parents who provided saliva were comparable in age, $t(322) = .05$, $p > .05$, but had marginally higher income levels, $t(322) = -1.87$, $p = .06$, and higher educational levels, $t(322) = -2.60$, $p \leq .05$. However, those who provided saliva did not significantly differ from those who did not on any outcome measures in this investigation (all $p > .10$). Of the 209 parents who contributed saliva, 188 (n = 108 mothers, n = 80 fathers) provided sufficient quantity and quality of saliva to assay testosterone levels. Of these, T4 data were available for 70 mothers and 49 fathers.

Mothers who contributed saliva at T3 were on average 27.86 years old (SD = 5.50). In terms of racial identity, 54.6% self-identified as White, 42.6% as African-American, 1.9% as Native-American, and 0.9% as Asian; of these, 3.7% also identified as Hispanic/Latina and 8.3% identified as biracial. Half of these mothers reported their combined annual household income was under $50,000 and their highest educational level attained as some college or technical school; 36% reported they received public assistance. Fathers who provided saliva were on average 30.56 years old (SD = 5.82). For fathers, 63.7% were White and 36.3% identified as African-American; 5% also self-identified as biracial and 2.5% as Hispanic/Latino. Half of these fathers reported a combined annual household income of under $60,000 and their highest educational level attained as some college or technical school.

Procedure

Expectant parents were recruited for the Triple-F study with flyers distributed at local hospital obstetric/gynecological clinics and childbirth classes. Interested mothers contacted the lab to schedule their initial 2½ hour session for themselves and, when available, their partner. Enrolled families were re-contacted at Time 2 and Time 3 for a 3-hour session and at Time 4 for a 2-hour session. At each time point, mothers and fathers independently provided consent and completed the study protocol in separate rooms. Self-report and analog measures were administered electronically on laptop computers with headphones. All study procedures were approved by the university's Institutional Review Board.

Saliva Collection and Testosterone Determination

A single sample of saliva (later assayed for testosterone) was collected from parents before beginning a parent-child interaction task. Following Granger and colleagues' procedures (2012), saliva was collected using a 6.5 × 90 mm absorbent swab (Salimetrics, Carlsbad, CA). Parents were asked to place the swab under their tongue for a minimum of 1 minute and then transfer the swab into a swab storage tube. Collected samples were placed in a freezer and stored frozen at -80°C until assay. Samples were assayed in duplicate at the Institute for Interdisciplinary Salivary Bioscience Research using commercially available enzyme immunoassays without modifications to the manufacturer's recommended protocols (Salimetrics, Carlsbad, CA). The test volume was 50 μL, and range of sensitivity was from 1.0 to 600 pg/mL. Inter-assay and intraassay precision (coefficient of variation) were, on average, less than 15% and 10%, respectively.

Measures

Internal consistencies for the measures below appear in Table 1.

Empathy (T1-T4).—The *Interpersonal Reactivity Index* (IRI; Davis, 1983) is a self-report measure of dispositional empathy administered at all four time points. The Empathic Concern and Perspective Taking subscales were administered, reflecting affective and cognitive dimensions of empathic ability, respectively. Each subscale includes 7 items, rated on a 5-point scale rated from 1 (*does not describe me well*) to 5 (*describes me very well*). Items across both scales were summed to create a total score, with higher scores indicating greater empathy. The IRI demonstrates convergent validity with comparable measures of empathy (Davis, 1983).

Frustration Tolerance (T1-T3).—The *Frustration Discomfort Scale* (FDS; Harrington, 2005) is a 7-item self-report measure of one's dispositional ability to tolerate discomfort and frustration. The FDS was administered at T1, T2, and T3. Using a 5-point scale, participants indicate their level of agreement from 1 (*strongly disagree*) to 5 (*strongly agree*). Summing across items, the total score is oriented so that higher scores suggest greater frustration tolerance. The FDS demonstrates acceptable internal consistency (α = .90) and discriminant validity in differentiating clinical from comparison samples (Harrington, 2005).

The *Paced Auditory Serial Addition Task* (PASAT) is a cognitive task adapted as a computerized analog task of frustration tolerance (Schloss & Haaga, 2011), administered at T1 only. Participants are presented a series of numbers individually for 3.5 seconds; they are instructed to add each new number to the previous number and select the correct sum displayed on the monitor. They then must forget that sum and add the next number to the previously displayed number. Responses that are incorrect or slow result in an aversive sound blast. After practice trials, participants received 172 trials unless they select a large

"QUIT" button displayed on the screen to discontinue this cognitively challenging task. PASAT scores thus reflect the number of completed trials, with lower scores suggesting poorer frustration tolerance. Scores are associated with another behavioral intolerance analog task (Schloss & Haaga, 2011).

Child Abuse Risk (T1-T4).—The *Child Abuse Potential Inventory* (CAPI; Milner, 1986) is the most widely utilized measure designed to screen for child abuse risk. The CAPI contains 160 *Agree/Disagree* items, with only 77 items scored and variably weighted to contribute to the Abuse Scale score; the Abuse Scale includes factors of Distress, Rigidity, Unhappiness, Problems with Child and Self, Problems with Family, and Problems with Others (however, the Abuse Scale items do not directly address parenting). Higher CAPI Abuse Scale scores indicate greater abuse risk. Prior research indicates that CAPI Abuse Scale scores demonstrate predictive validity, correctly classifying 89.2% of confirmed child abusers and 99% of controls (Milner, 1994).

The *Adult Adolescent Parenting Inventory-2* (AAPI-2; Bavolek & Keene, 2001) is an additional self-report measure of child abuse risk specifically designed to assess parenting beliefs and behaviors considered to reflect abusive parenting. Forty items are rated on a 5-point Likert scale from 1 (s*trongly disagree*) to 5 (*strongly agree*). Total scores are derived from the sum across items, oriented to align with the CAPI such that higher total scores suggest higher abuse risk. AAPI-2 items were selected to distinguish between maltreating and non-maltreating samples (Bavolek & Keene, 2001), with evidence of reliability and validity (Conners et al., 2006).

The *Response Analog to Child Compliance Task* (ReACCT; Rodriguez, 2016) is a computerized analog task to assess child abuse risk, administered at all four time points. An introductory scene is described to parents wherein they are asked to imagine they are running late to get their child to preschool. Following that instruction, a series of 12 successive scenes describe steps that would be needed to leave for the preschool quickly (e.g., getting out of bed, getting dressed). In each scene, the parent is told they provided an instruction to the child to get ready to leave home and the child is reported to be either compliant or noncompliant. Parents are asked to select from 16 possible options how they would respond to the child's compliance or noncompliance; some parent responses are adaptive (receiving positive weights) versus maladaptive (receiving negative weights)—e.g., physical and psychological aggression. Because the child may have been noncompliant, the parent can remain "stuck" in a scene until the child complies; thus, the parent provides 20 total discipline responses across the 12 scenes. During the task, parents hear and see a ticking clock of how late they are to induce time urgency. For each apparent success in securing compliance, the parent earns a game bonus of 50 cents. ReACCT scores in this analysis include parental responses for noncompliance (12 responses), in which higher scores suggest harsher responding. Across several samples of varying risk, ReACCT Noncompliance scores demonstrated reliability and correlated with measures of abuse risk (CAPI, AAPI-2) and harsh and abusive physical discipline (Rodriguez, 2016).

Observed Parenting (T2, T3).—At Time 2, each parent engaged in a structured parent-child interaction with three tasks adapted from Haltigan and colleagues (2014): a 4-min caregiving, a 7-min free play, and a 4-min task to frustrate the child. During caregiving, parents were asked to undress the infant, change the infants' diaper, and redress the infant. During free play, parents and infants were seated on a blanket on the floor; parents were instructed to play with their infant as they normally would but using only the standard set of provided age-appropriate toys while completing a brief form about their infant, which competed for their attention. During the frustration-eliciting task, the infant was belted in an infant seat with the parent seated to their side; from behind, the experimenter gently restrained the infant's arms so they were immobile; after the first minute, parents were instructed to interact with the child as they pleased, with the same age-appropriate toys still available to them. For two-parent families, the order of which parent engaged the infant in the parent-child interaction first was counterbalanced.

At Time 3, parents participated in another parent-child interaction session with four tasks adapted from Leerkes and Wong (2012): an 8-min free play, a 4-min clean-up, a 4-min task to induce frustration in the child, and a 4-min novelty task. Free play was comparable to above but with a different set of toys. For the clean-up task, the assistant: emptied all toys onto the floor; introduced a new, attractive musical toy to the child; instructed the parent to get the child to pick up all the toys into a provided container; and advised the parent they had four minutes to complete the clean-up while involving the child, with a countdown clock placed within sight of the parent. During the frustration-inducing task, the assistant presented the child with a musical phone that lit up, allowing the child to handle the toy briefly. Then, the assistant took the phone away and placed it in a clear plastic jar with a lid that the child could not open and repeatedly prompted the child to retrieve the phone from the jar. During the novelty task, an assistant wearing a costume (e.g., "Shrek," first parent-child interaction, "Sulley" from Monsters, Inc., second interaction) entered the room and gradually approached the child within 2 feet while delivering a standard script. Again for two-parent families, parent-child interaction order was counterbalanced.

At both time points, two trained coders rated the videotaped parent-child interactions based on dimensions of parental behavior, adapted from the behavioral codes used in the NICHD Study of Early Child Care and Youth Development (NICHD ECCRN, 1999). Dimensions used in this report include: *sensitivity to distress* (prompt, appropriate responses to infants cries, fusses and other distress signals); *sensitivity to non-distress* (prompt, consistent, and infant-centered responses to infant social signals other than distress); *detachment* (uninvolved, disengaged behaviors reflecting little awareness of the infant's needs); *positive regard* (warm, affectionate, approving behavior toward child) and *negative regard* (negative, hostile, harsh, and disapproving behaviors toward child). Each dimension was rated on a 7-point scale ranging from 1 (*very low*) to 7 (*very high*). Positive and negative regard were rated once after watching all tasks within a time point; all other dimensions were rated separately for each task. Inter-rater reliability between coders was calculated for each dimension and each time point for the parent study using intraclass correlation coefficients (ICC) based on double-coded cases (T2, n = 44 mothers, n = 37 fathers; T3, n = 39 mothers, n = 52 fathers). For mothers, ICCs ranged from .88-.96 at T2 and .82-.90 at T3; for fathers, .91-.99 at T2 and .86-.93 at T3. Separately for T2 and T3, scores for sensitivity to distress and sensitivity to non-distress across tasks and positive regard were averaged for a total Observed Positive Parenting score. Likewise, scores for detachment across tasks were averaged with observed negative regard scores for total T2 and T3 Observed Negative Parenting scores.

T3 Moderators

Socioeconomic Status.—Because income and educational level were collinear ($r = .66$, $p < .001$), these values were standardized, combined, and then standardized for a composite socioeconomic status (SES) indicator, for mothers and fathers separately.

Parenting Stress Role Restriction.—The *Parenting Stress Index* (PSI; Abidin, 2012) Role Restriction is a subscale of the PSI, a self-report measure of perceived stress from parenting. On this 7-item scale, parents report on the extent to which they experience stress from their role as a parent from perceived burden and restriction on freedom. Parents rate each item from 1 (*strongly agree*) to 5 (*strongly disagree*), which was summed for a total subscale score in which higher scores suggest greater perceived stress from their parenting role. This scale demonstrates adequate reliability ($\alpha = .81$) and validity across a variety of samples (Abidin, 2012).

Emotion Regulation.—The *Negative Mood Regulation Scale* (NMRS; Catanzaro & Mearns, 1990) asks participants how well they manage their emotions and recover emotional balance following distress. Thirty items are rated on a 5-point scale from 1 (*strongly agree*) to 5 (*strongly disagree*). Items are summed for a total score in which higher scores indicate poorer emotion regulation ability. The NMRS has demonstrated internal consistency across samples ($\alpha > .86$), stability, and concurrent and predictive validity (Catanzaro & Mearns, 1990).

Analytic Plan

For the first three RQs, correlations were examined between the personality characteristics (empathy and frustration tolerance), abuse risk, and observed parenting with testosterone levels, at all time points. To further test the third, longitudinal RQ pertaining to abuse risk, we utilized MPlus 8.1 to examine testosterone levels in relation to abuse risk (CAPI, AAPI-2, ReACCT) across the four time points (path models that estimate lagged effects of stability in abuse risk across time). These path models use maximum likelihood estimation with robust standard errors in which missing values across time were accommodated using full-information maximum likelihood methods. Also using MPlus, we tested RQ4 using actor-partner independence models (APIM; Cook & Kenny, 2006; Kenny, Kashy, & Cook, 2006) which nest parents within a couple. These APIMs simultaneously considered both “actor” effects on abuse risk (i.e., a parent’s testosterone level direct effects on their T3 abuse risk [CAPI, AAPI-2, ReACCT]) as well as “partner” effects (i.e., effects of a parent’s testosterone levels on their partner’s abuse risk). To judge model fit for these MPlus models, we deemed fit to be acceptable via values on the comparative fit index (CFI), root mean square error of approximation (RMSEA), as well as standardized root mean square residual (SRMR). CFI values above .90 and SRMR values under .08 suggest adequate model fit; RMSEA values below .08, with an upper bound of its confidence interval (CI) below .10 suggest good fit (Kline, 2011). Finally, to test moderation for RQ5, interaction effects were examined utilizing hierarchical multiple regression. Interaction terms were created with standardized multiplicative terms of testosterone with each potential moderator (SES, PSI Role Restriction, NMRS Total). After covariates were entered first, main effects of testosterone with all moderator variables were entered simultaneously in the second step, followed by inclusion of all interaction terms. Using simple slopes analysis, any significant interaction effect was probed by testing the association between testosterone levels and abuse risk at two levels of the moderator: one standard deviation below the mean ("low") and one standard deviation above ("high").

Results

Preliminary Analyses

Means, standard deviations, and internal consistencies per measure for each time point, for mothers and fathers separately, appear in Table 1. Note that SES was significantly positively correlated with higher testosterone levels for both mothers and fathers. Consistent with existing research on robust demographic indicators of abuse risk, parents' abuse risk was also negatively correlated with SES (mothers, $r = -.36$ to $-.52$; fathers, $r = -.33$ to $-.53$, all $p \leq .001$) and parental age (mothers, $r = -.36$ to $-.55$; fathers, $r = -.36$ to $-.55$, all $p \leq .001$). Because controlling for age or SES would imply testosterone would need to account for incremental variance (which was not the intent of this study), neither was considered a covariate. However, time of day of saliva collection was unrelated to the abuse risk measures (e.g., all $p \geq .10$) but was related to testosterone (fathers, $r = -.31$, $p \leq .01$; mothers, $r = -.18$, $p = .07$), and was included as a covariate in the main analyses.

Research Questions 1–3: Bivariate Analyses across Time

Bivariate associations (controlling for time of day) between testosterone level and all measures across time appear in Table 1. Overall, mothers' testosterone levels did not evidence significant associations across measures. Mothers' testosterone levels were not significantly related to empathy scores across time, with modest indications of concurrent (T3) and prospective lower frustration tolerance relating to their higher testosterone levels. With regard to abuse risk, mothers' testosterone levels were not significantly correlated with any measures concurrently (T3), nor were those measures prospectively (T1, T2) related to their T3 testosterone levels, nor did their testosterone levels predict later (T4) scores on those measures. Moreover, mothers' testosterone levels were unrelated to observed parenting at T2 or T3.

In contrast, several significant bivariate associations were observed with fathers' testosterone levels[1] (see Table 1). For RQ1, although the association between self-reported lower frustration tolerance and fathers' testosterone levels were only in the expected direction concurrently (T3) and prospectively (at T1), the more objective PASAT analog task indicated that lower frustration tolerance prenatally (T1) was significantly related to fathers' higher testosterone levels when their children were toddlers ($r = -.38$, $p \leq .01$). Fathers' self-

[1]Analyses including SES in addition to time since waking as a covariate reduced the significant correlations for father reported in Table 1 to be statistically non-significant.

reported dispositional empathy was not significantly related to their testosterone levels (in which only the association with T4 IRI scores were in the expected direction).

With regard to abuse risk (RQ2), several associations were observed concurrently: higher paternal testosterone levels were significantly associated with higher scores on both questionnaire measures of abuse risk (the AAPI-2 and CAPI) as well as the analog ReACCT task. Furthermore, for RQ3, fathers' higher abuse risk on the AAPI-2 and the ReACCT task at T1 and the CAPI Abuse Scale and the ReACCT Noncompliance analog scores at T2 predicted higher testosterone levels at T3. Finally, fathers' higher testosterone levels at T3 also predicted significantly higher abuse risk on the CAPI Abuse Scale at T4. For observed parent-child interactions, fathers' higher testosterone levels were significantly concurrently (RQ2) associated with less observed positive parenting and more observed negative parenting. Additionally, less positive parenting and more negative parenting observed during interactions when their children were infants at T2 prospectively related to fathers' higher testosterone levels at T3.

Research Question 3: Longitudinal Analyses for Abuse Risk

A path model for CAPI Abuse Scale scores from T1-T4 linked to fathers' testosterone levels appears in Table 2. This path analysis pointed to a theoretically meaningful modification index from T1 to T3 CAPI, after which the model demonstrated better fit (CFI = .95, SRMR = .07, RMSEA = .16 [.07, .26]). With all CAPI scores controlled across time, fathers' testosterone levels at T3 still predicted subsequent CAPI Abuse scale scores. The path analysis for the AAPI-2 scores similarly identified a modification index from T1 to T3 AAPI-2; this model demonstrated good fit (CFI = 1.00, SRMR = .03, RMSEA = .00 [.00, .14]). As noted for the CAPI, fathers' testosterone levels at T3 significantly predicted T4 AAPI-2 total scores even controlling for stability in AAPI-2 scores; further, AAPI-2 scores assessed prenatally predicted fathers' T3 testosterone levels. For the ReACCT scores, the path model instead indicated a modification index linking T2 to T4 ReACCT scores; the subsequent model fit was then strong (CFI = 1.00, SRMR = .05, RMSEA = .00 [.00, .12]). With these controls for stability in ReACCT scores, fathers' testosterone levels were not significantly related to ReACCT Noncompliance scores.

Research Question 4: Dyadic Analyses

APIM models for the dyadic analyses for T3 CAPI Abuse Scale, AAPI-2, and ReACCT scores were all just identified and thus demonstrate perfect model fit. Across analyses, women's testosterone levels covaried with their partners ($\beta = .31$, $p \leq .01$). However, there were no statistically significant partner effects across the three abuse risk scores (all $p > .05$). Only fathers' testosterone predicting mothers' AAPI-2 total scores approached significance ($\beta = .20$, $p = .087$).

Research Question 5: Interaction Effects

Multiple regression analyses examined interaction effects at T3. Similar to the null direct effects for mothers, no significant interaction effects were observed for the three proposed moderators (all $p > .05$). For fathers, results of moderation analyses appear in Table 3. Consistent with the substantial literature documenting strong relations between SES and child abuse risk, fathers' lower SES demonstrated significant associations with all three measures of abuse risk, which are apparent in their main effects. Of the moderators, SES significantly interacted ($\beta = -.31$, $p \leq .01$) with testosterone levels for CAPI Abuse Scale scores (but not the other two abuse risk measures). The simple slopes analysis for SES moderation specifically is depicted in Suppl. Fig 1. Note that for fathers with low SES, the simple slopes analysis indicated abuse potential did not differ regardless of testosterone level ($\beta = .05$, $p > .05$); but for fathers with high SES, those with higher testosterone levels had marginally lower abuse potential ($\beta = -.27$, $p = .07$). When considered in conjunction with SES, no significant moderation effects were observed for either emotion regulation or parenting stress from role restriction (both of which covary with SES).

Discussion

The present study evaluated mothers' and fathers' testosterone levels in relation to personality characteristics of empathy and frustration tolerance as well as child abuse risk and observed parenting in a multimethod, longitudinal investigation. Although the limited prior work on parenting suggested mothers' higher testosterone levels might be associated with abuse risk, our study did not find evidence for that hypothesis, nor did we find evidence that one member of a couple predicted their partner's abuse risk. In contrast, effects were observed for fathers, wherein higher testosterone levels when their children were toddlers was concurrently associated with their elevated abuse risk as well as predicting later abuse risk; we also saw some indications that earlier abuse risk prospectively predicted fathers' testosterone levels. Fathers with higher testosterone levels were also observed to engage in less positive and more negative parenting. Although fathers' testosterone levels were not significantly related to self-reported empathy or frustration tolerance across time, the analog task of frustration intolerance obtained prenatally was significantly associated with fathers' higher testosterone levels nearly two years later. We also noted that fathers' socioeconomic status, but not stress from the restrictiveness of the paternal role nor emotion regulation, moderated the link between abuse risk and testosterone levels.

Elevated testosterone levels were proposed to relate to both mothers' and fathers' abuse risk given research linking testosterone to parenting, although less work had examined mothers. Our findings that higher testosterone levels in fathers was associated with less positive and more negative parenting echo prior evidence that fathers with lower testosterone levels are more invested in parenting (Grebe et al., 2019) and display more positive parenting (Kuo et al., 2016). Our findings extend earlier research by demonstrating that the higher testosterone levels connected to more aggressive behavior in general (Archer, 2006; Yildirim & Derksen, 2012a; Chen et al., 2018) also applies to fathers' child abuse risk. The associations identified between fathers' higher testosterone levels and child abuse risk as well as observed parenting behavior were not only apparent concurrently—these patterns were evident from earlier assessments using questionnaires, analog tasks, and parent-child interactions, and further supported by its association with later child abuse risk. These findings appear particularly robust given replication across time, the significant effects identified in the longitudinal analyses that controlled for stability in child abuse risk, and the patterns that emerged across different methods. However, it is important to recognize that fathers' testosterone levels do not demonstrate incremental variance in predicting abuse risk beyond what is attributable to their socioeconomic status (also apparent in the main effects in the interaction analyses). Thus, elevated testosterone levels contribute to understanding the processes involved in abuse risk, but not as a substitute for sociodemographic contributors.

Given that prior work has observed greater impulsivity and lower empathy in relation to both testosterone (Yildirim & Derksen, 2012b) and child abuse risk (e.g., Francis & Wolfe, 2008; Rodriguez et al., 2015), we also hypothesized that higher testosterone levels would be related to lower self-reported empathy and frustration tolerance. Fathers' self-reported empathy was not significantly associated with their testosterone levels at any time point, in contrast to one study suggesting a modest association between testosterone and empathy in one of three saliva samples, involving a considerably less diverse sample than the present study (Kuo et al., 2015). We also did not observe a significant association between fathers' testosterone levels and self-reported frustration tolerance (albeit the associations observed were in the expected direction); instead, we identified a significant negative association between the analog task of frustration tolerance administered to expectant fathers and their testosterone levels when their children were toddlers. Together, these findings raise questions about the value of self-report measures to assess such personality dimensions given that both empathy and frustration tolerance are susceptible to participant distortion from social desirability responding. Future research should expand the assessment tools for such qualities to clarify how paternal hormones such as testosterone might relate to dispositional qualities like empathy and frustration tolerance.

Notably, no significant associations were identified for mothers' testosterone levels. Although mothers with higher testosterone levels demonstrate less engagement with their children (Clowtis et al., 2016) and are more likely to be childless (Kuzawa et al., 2010), no known studies have considered whether mothers' testosterone levels relate to their child abuse risk. Other than possible weak associations with self-reported frustration tolerance, our findings suggest mothers' testosterone levels do not appear to activate tendencies that translate into elevated child abuse risk. Others have detected testosterone-cortisol interactions in relation to paternal, but not maternal, caregiving (Bos et al., 2018). We further did not find significant effects of males predicting the abuse risk of their partner, although some have observed partner effects of fathers' testosterone levels on mothers' functioning (e.g., Saxbe, Edelstein et al., 2017). Observed gender differences in such findings may reflect the disparate processes for testosterone production between men and women (i.e., produced directly in the testes in males versus peripheral conversion from DHEA for females), which underlies gender differences in absolute testosterone levels; further, measurement of salivary testosterone is less precise in women (Shirtcliff et al., 2002). Thus, alternative testosterone measurement for women may be needed but it may be that testosterone does not cultivate the conditions for mothers that exacerbates their abuse risk. One could speculate that, for women, individual differences in other hormones such as estrogens or oxytocin may be more relevant in biopsychosocial models of their abuse risk but such speculations await further study.

We also considered potential interaction effects to evaluate factors that may intersect with testosterone levels to influence abuse risk. First, our findings demonstrated a negative association between SES and testosterone levels (discernible even among mothers)—which aligns with early work on the association between SES and testosterone (Dabbs, 1992; Booth et al., 1999) but conflicts with more recent work (Hughes & Kumari, 2019). Others have speculated on potential interaction effects (Yildirim & Derksen, 2012a), which we considered in this investigation. Beyond the robust main effects of SES, a significant interaction effect was observed (with the most frequently utilized measure of abuse risk, the CAPI) for fathers. Specifically, abuse potential was equivalent irrespective of testosterone level for fathers with lower SES. However, higher SES fathers with higher testosterone levels demonstrated marginally lower child abuse potential. These findings suggest higher SES conditions may reduce abuse risk despite higher testosterone levels. Thus, in contrast to earlier speculation that higher testosterone levels may interact to exacerbate lower SES to adversely affect behavior (Yildirim & Derksen, 2012a), we observed higher SES as a potential protective factor for fathers. Clearly future investigations with larger samples and multiple measures of child abuse risk are needed to replicate such findings. We further considered interaction effects with fathers' stress from experiencing their parenting role as restrictive as well as their emotion regulation. Earlier work indicated that stressors relate to fathers' higher testosterone levels (Waldvogel & Ehrlert, 2018), and that those with both high testosterone levels and aggressive tendencies may not demonstrate effective emotion regulation (Kaldewaij et al., 2019). However, in concert with SES, we could not identify significant interaction effects with emotion regulation ability or parenting stress. Given that we considered these interactions simultaneously with SES, it is possible that neither parenting stress nor emotion regulation uniquely interact with fathers' testosterone levels. Further, although perceived stress may be appropriate to assess via self-report, estimating one's emotion regulation abilities could be biased in self-reports. Other than perhaps pursuing multi-informant reports of emotion regulation ability (Rodriguez, Tucker, & Palmer, 2016; Pu, Rodriguez, & Baker, 2019), analog approaches to assessing emotion regulation are also worth considering in relation to testosterone levels as well as potential experimental paradigms that induce stress that may interact with testosterone levels.

Strengths, Limitations, and Additional Future Directions

Several limitations should be considered. Because participants initially enrolled in the Triple-F study before the adjunct project evaluating biomarkers began, not all participants provided saliva, decreasing the available sample size. A larger sample size would thus be ideal, although no significant differences from those who did not provide saliva on any outcome measures were observed. Further, few participants in the current sample identified as Hispanic/Latinx, primarily identifying as White or African American; thus our findings may not generalize beyond the latter two groups. Future work with a larger, more ethnically diverse sample would offer an opportunity to not only replicate the current findings but permit study of additional interaction effects as well.

The current study benefits from the longitudinal design to evaluate whether cross-sectional associations are replicated at other time points and whether relations with testosterone hold controlling for stability in abuse risk. Although testosterone status is relatively stable across time (Granger et al., 2004), additional assays of testosterone at multiple times (cf. Dariotis, Chen, & Granger, 2016) would be useful to bolster the longitudinal findings we observed given that testosterone was assayed from a single saliva collection. The current project was strengthened by its multimethod design; nonetheless, we relied on self-reports for constructs like empathy and emotion regulation (for which there were not available analog tasks). Notable among our findings was a robust relation between the analog task of frustration tolerance and fathers' testosterone levels nearly two years later, underscoring that constructs of interest in this field should develop additional indirect assessment approaches (Camilo et al., 2016).

Testosterone levels were associated with observed paternal positive and negative parenting, suggesting that testosterone levels may not only relate to aggressive behavior but also withdrawn and disengaged parenting behavior—a potential area for further inquiry as such parenting may also predict subsequent abuse risk. Another potential direction for research pertains to intergenerational cycles of aggressive behavior, namely how parental testosterone levels may contribute to abuse risk that translates into more aggressive behavior in the next generation. For example, children experiencing harsh discipline with higher testosterone levels were more likely to engage in aggressive behavior (Chen, Raine, & Granger, 2018). Conceivably, testosterone levels may play a role in aggressive patterns across generations.

In sum, the current findings suggest that testosterone levels may be relevant in understanding how traditional predictors of abuse risk culminate in aggressive behavior, although only for fathers. Salivary biomarkers can add value as objective indicators in biopsychosocial models of parents' abuse risk, which may more holistically capture the complex interplay of mechanisms involved in abusive behavior (Sapolsky, 2017). As front-line professionals and policy-makers consider the array of influences that may amplify the abuse risk of the parents they work with, an appreciation of that wider biopsychosocial picture may encourage less reductionistic characterizations of what collectively contributes to parent-child aggression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

Abidin RR (2012). Parenting Stress Index (4th Edition). Lutz, FL: Psychological Assessment Resources.

Akmatov MK (2011). Child abuse in 28 developing and transitional countries—results from the Multiple Indicator Cluster Surveys. International Journal of Epidemiology, 40, 219–227. [PubMed: 20943933]

Archer J (2006). Testosterone and human aggression: An evaluation of the challenge hypothesis. Neuroscience and Biobehavioral Reviews, 30, 319–345. [PubMed: 16483890]

Barrett ES, Tran V, Thurston S, Jasienska G, Furberg A Ellison PT, & Thune I (2013). Marriage and motherhood are associated with lower testosterone concentrations in women. Hormones and Behavior, 63, 72–79. [PubMed: 23123222]

Bos PA, Hechler C, Beijers R, Shinohara K, Esposito G, & de Weerth C (2018). Prenatal and postnatal cortisol and testosterone are related to parental caregiving quality in fathers, but not in mothers. Psychoneuroendocrinology, 97, 94–103. [PubMed: 30015010]

Bavolek SJ, & Keene RG (2001). Adult-Adolescent Parenting Inventory (AAPI-2): Administration and development handbook. Park City, UT: Family Development Resources, Inc.

Booth A, Johnson DR, & Granger DA (1999). Testosterone and men's health. Journal of Behavioral Medicine, 22, 1–19. [PubMed: 10196726]

Camilo C, Garrido MV, Calheiros MM (2016). Implicit measures of child abuse and neglect: A systematic review. Aggression and Violent Behavior, 29, 43–54.

Catanzaro SJ, & Mearns J (1990). Measuring generalized expectancies for negative mood regulation: Initial scale development and implications. Journal of Personality Assessment, 54, 546–563. [PubMed: 2348341]

Chen FR, Dariotis JK, & Granger DA (2018). Linking testosterone and antisocial behavior in at-risk transitional aged youth: Contextual effects of parentification. Psychoneuroendocrinology, 91, 1–10. [PubMed: 29505951]

Chen FR, Raine A, & Granger DA (2018). Testosterone and proactive-reactive aggression in youth: The moderating role of harsh discipline. Journal of Abnormal Child Psychology, 46, 1599–1612. [PubMed: 29353364]

Clowtis LM, Hang D, Padhye NS, Rozmus C, & Barratt MS (2016). Biobehavioral factors in child health outcomes: The roles of maternal stress, maternal-child engagement, salivary cortisol, and salivary testosterone. Nursing Research, 65, 340–351. [PubMed: 27579502]

Conners NA, Whiteside-Mansell L, Deere D, Ledet T, & Edwards MC (2006). Measuring the potential for child maltreatment: The reliability and validity of the Adult Adolescent Parenting Inventory-2. Child Abuse & Neglect, 30, 39–53. [PubMed: 16406026]

Cook WL, & Kenny DA (2006). The actor–partner interdependence model: A model of bidirectional effects in developmental studies. International Journal of Behavioral Development, 29, 101–109.

Dariotis JK, Chen FR, & Granger DA (2016). Latent trait testosterone among 18–24 year olds: Methodological considerations and risk associations. Psychoneuroendocrinology, 67, 1–9. [PubMed: 26852415]

Davis MH (1983). The effects of dispositional empathy on emotional reactions and helping: A multidimensional approach. Journal of Personality, 51, 167–184.

DeGarmo DS, Reid JB, & Knutson JF (2006). Direct laboratory observations and analog measures in research definitions of child maltreatment In Feerick M, Knutson JF, Trickett P, & Flanzier S (Eds.), Child abuse and neglect: Definitions, classifications, and a framework for research (pp. 293–328). Baltimore, MD: Brooks.

de Paúl J, Pérez-Albéniz A, Guibert M, Asla N, & Ormaechea A (2008). Dispositional empathy in neglectful mothers and mothers at high risk for child physical abuse. Journal of Interpersonal Violence, 23, 670–684. [PubMed: 18263864]

Doidge JC, Higgins DJ, Delfabbro P, Edwards B Vassallo S, Tournbourou JW, & Segal L (2017). Economic predictors of child maltreatment in an Australian population-based birth cohort. Children and Youth Services Review, 72, 14–25.

Eckenrode J (2011). Primary prevention of child abuse and maltreatment In Koss MP, White JW, & Kazdin AE (Eds). Violence against women and children, Vol. 2: Navigating solutions (pp. 71–91). Washington, DC: American Psychological Association.

Fallon B, Trocmé N, Fluke J, MacLaurin B, Tonmyr L, & Yuan Y (2010). Methodological challenges in measuring child maltreatment. Child Abuse & Neglect, 34, 70–79. [PubMed: 20053453]

Fazio RH, & Olson MA (2003). Implicit measures in social cognition research: Their meaning and use. Annual Review of Psychology, 54, 297–327.

Francis KJ, & Wolfe DA (2008). Cognitive and emotional differences between abusive and non-abusive fathers. Child Abuse & Neglect, 32, 1127–1137. [PubMed: 19036447]

Gettler LT, McDade TW, Agustin SS, Feranil AB, & Kuzawa CW (2013). Do testosterone declines during the transition to marriage and fatherhood relate to men's sexual behavior? Evidence from the Philliplines. Hormones and Behavior, 64, 755–763. [PubMed: 24018138]

Granger DA, Fortunato CK, Beltzer EK, Virag M, Bright MA, & Out D (2012). Focus on methodology: Salivary bioscience and research on adolescence: An integrated perspective. Journal of Adolescence, 35, 1081–1095. [PubMed: 22401843]

Granger DA, Shirtcliff EA, Booth A, Kavlighan KT, & Schwartz EB (2004). The “trouble” with salivary testosterone. Psychoneuroendocrinology, 29, 1229–1240. [PubMed: 15288702]

Grebe NM, Sarafin RE, Strenth CR, & Zilioli S (2019). Pair-bonding, fatherhood, and the role of testosterone: A meta-analytic review. Neuroscience & Biobehavioral Reviews, 98, 221–233. [PubMed: 30639674]

Haltigan JD, Leerkes EM, Wong MS, Fortuna K, Roisman GI, Supple AJ, … Plamondon A (2014). Adult attachment states of mind: Measurement invariance across ethnicity and associations with maternal sensitivity. Child Development, 85, 1019–1035. [PubMed: 24936609]

Harrington N (2005). The Frustration Discomfort Scale: Development and psychometric properties. Clinical Psychology and Psychotherapy, 12, 374–387.

Haynes SN (2001). Clinical applications of analogue behavioral observation: Dimensions of psychometric evaluation. Psychological Assessment, 13, 73–85. [PubMed: 11281041]

Hiraoka R, Crouch JL, Reo G, Wagner MF, Milner JS, & Skowronski JJ (2016). Borderline personality features and emotion regulation deficits are associated with child physical abuse potential. Child Abuse & Neglect, 52, 177–184. [PubMed: 26754570]

Hoffman SD, & Maynard RA (2008). Kids having kids: Economic costs and social consequences of teen pregnancy. Washington, DC: Urban Institute Press.

Hughes A, & Kumari M (2019). Testosterone, risk, and socioeconomic position in British men: Exploring causal directionality. Social Science & Medicine, 220, 129–140. [PubMed: 30423482]

Jasienska G, Jasienska M, & Ellison PT (2012). Testosterone levels correlate with the number of children in human males, but the direction of the relationship depends on paternal education. Evolution and Human Behavior, 33, 665–671.

Kaldewaij R, Koch SBJ, Zhang W, Hashemi MM, Klumpers F, Roelofs K (2019). High endogenous testosterone levels are associated with diminished neural emotional control in aggressive police recruits. Psychological Science, 30, 1161–1173. [PubMed: 31251695]

Kenny DA, Kashy DA, & Cook WL (2006). Dyadic Data Analysis. New York: Guilford Press.

Kline RB (2011). Principles and practice of structural equation modeling. New York: Guilford.

Kuo PX Saini EK, Thomason E, Schultheiss OC Gonzalez R, & Voling BL (2016). Individual variation in fathers’ testosterone reactivity to infant distress predicts parenting behaviors with their 1-year-old infants. Developmental Psychobiology, 58, 303–314. [PubMed: 26497119]

Kuzawa CW, Gettler LT, Huang Y, & McDade TW (2010). Mothers have lower testosterone than non-mothers: Evidence from the Philippines. Hormones and Behavior, 57, 441–447. [PubMed: 20122934]

Lee SJ, Bellamy JL, & Guterman NB (2009). Fathers, physical child abuse, and neglect: Advancing the knowledge base. Child Maltreatment, 14, 227–231. [PubMed: 19581429]

Leerkes EM, & Wong MS (2012). Infant distress and regulatory behaviors vary as a function of attachment security regardless of emotion context and maternal involvement. Infancy, 17, 455–478. [PubMed: 22919285]

Lowell A, & Renk K (2017). Predictors of child maltreatment potential in a national sample of mothers of young children. Journal of Aggression, Maltreatment, and Trauma, 26, 335–353.

MacMillan HL, Tanaka M, Duku E, Vaillancourt T, & Boyle MH (2013). Child physical and sexual abuse in a community sample of young adults: Results from the Ontario Child Health Study. Child Abuse & Neglect, 37, 14–21. [PubMed: 23290623]

Margolin G, Gordis EB, Medina AM, & Oliver PH (2003). The co-occurrence of husband-to-wife aggression, family-of-origin aggression, and child abuse potential in a community sample. Journal of Interpersonal Violence, 18, 413–440.

McElroy EM, & Rodriguez CM (2008). Mothers of children with externalizing behavior problems: Cognitive risk factors for abuse potential and discipline style and practices. Child Abuse & Neglect, 32, 774–784. [PubMed: 18760476]

Milner JS (1986). The Child Abuse Potential Inventory: Manual (2nd ed.). Webster, NC: Psyctec.

Milner JS (1994). Assessing physical child abuse risk: The Child Abuse Potential Inventory. Clinical Psychology Review, 14, 547–583.

Miragoli S, Balzarotti S, Camisasca E, & Di Blasio P (2018). Parents' perception of child behavior, parenting stress, and child abuse potential: Individual and partner influences. Child Abuse & Neglect, 84, 146–156. [PubMed: 30099228]

NICHD ECCRN (1999). Child care and mother–child interaction in the first three years of life. Developmental Psychology, 35, 1399–1413. [PubMed: 10563730]

Pajer KA, Gardner W, Lourie A, Chang C Wang W, & Currie L (2014). Physical child abuse potential in adolescent girls: Associations with psychopathology, maltreatment, and attitudes toward child-bearing. Canadian Journal of Psychiatry, 59, 98–106. [PubMed: 24881128]

Pittman JF, & Buckley RR (2006). Comparing maltreating fathers and mothers in terms of personal distress, interpersonal functioning, and perceptions of family climate. Child Abuse & Neglect, 30, 481–496. [PubMed: 16698080]

Pu DF, Rodriguez CM, & Baker LR (2019). When couples disagree: Predicting informant differences in adults' emotion regulation. Journal of Child and Family Studies, 28, 1548–1557.

Rodriguez CM (2010). Parent-child aggression: Association with child abuse potential and parenting styles. Violence and Victims, 25, 728–741. [PubMed: 21287963]

Rodriguez CM (2013). Analog of parental empathy: Association with physical child abuse risk and punishment intentions. Child Abuse & Neglect, 37, 493–499. [PubMed: 23294605]

Rodriguez CM (2016). Parental discipline reactions to child noncompliance and compliance: Association with parent-child aggression indicators. Journal of Child & Family Studies, 25, 1363–1374.

Rodriguez CM, Baker LR, Pu DF, & Tucker MC (2017). Predicting parent-child aggression risk in mothers and fathers: Role of emotion regulation and frustration tolerance. Journal of Child and Family Studies, 26, 2629–2538.

Rodriguez CM, Bower-Russa M, Harmon N (2011). Assessing abuse risk beyond self-report: Analog task of acceptability of parent-child aggression. Child Abuse & Neglect, 35, 199–209. [PubMed: 21481929]

Rodriguez CM, Gracia E, & Lila M (2016). Multimethod prediction of child abuse risk in an at-risk sample of male intimate partner violence offenders. Child Abuse & Neglect, 60, 27–35. [PubMed: 27676366]

Rodriguez CM, Russa MB, & Kircher JC (2015). Analog assessment of frustration tolerance: Association with self-reported child abuse risk and physiological reactivity. Child Abuse & Neglect, 46, 121–131. [PubMed: 25796290]

Rodriguez CM, Silvia PJ, & Pu DF (2018). Predictors of change in mothers' and fathers' parent-child aggression risk. Child Abuse & Neglect, 86, 247–256. [PubMed: 30388708]

Rodriguez CM, Silvia PJ, & Gaskin RE (2019). Predicting maternal and paternal parent-child aggression risk: Longitudinal multimethod investigation using Social Information Processing theory. Psychology of Violence, 9, 370–382. [PubMed: 31131149]

Rodriguez CM, Smith TL, & Silvia PJ (2016a). Multimethod prediction of physical parent-child aggression risk in expectant mothers and fathers with Social Information Processing Theory. Child Abuse & Neglect, 51, 106–119. [PubMed: 26631420]

Rodriguez CM, Smith TL, & Silvia PJ (2016b). Parent-child aggression risk in expectant mothers and fathers: A multimethod theoretical approach. Journal of Child and Family Studies, 25, 3220–3235. [PubMed: 28082826]

Rodriguez CM, Tucker MC, & Palmer K (2016). Emotion regulation in relation to emerging adults' mental health and delinquency: A multi-informant approach. Journal of Child and Family Studies, 25, 1916–1925.

Sapolsky RM (2017). Behave: The biology of humans at our best and worst. New York: Penguin.

Saxbe DE, Dunkel Schetter C, Simon CD, Adam EK, & Shalowitz MU (2017). High paternal testosterone may protect against postpartum depressive symptoms but confer risk to mothers and children. Hormones and Behavior, 95, 103–112. [PubMed: 28757312]

Saxbe DE, Edeltstein RS, Lyden HM, Wardecker BM, Chopik WJ, & Moors AC (2017). Fathers' decline in testosterone and synchrony with partner testosterone during pregnancy predicts greater postpartum relationship investment. Hormones and Behavior, 90, 39–47. [PubMed: 27469070]

Schloss HM, & Haaga DAF (2011). Interrelating behavioral measures of distress tolerance with self-reported experiential avoidance. Journal of Rational-Emotive & Cognitive-Behavioral Therapy, 29, 53–63.

Sedlak AJ, Mettenburg J, Basena M, Petta I, McPherson K, Greene A, & Li S (2010). Fourth National Incidence Study of Child Abuse and Neglect (NIS–4): Report to Congress, Executive Summary. Washington, DC: U.S. Department of Health and Human Services, Retrieved from http://www.acf.hhs.gov/sites/default/files/opre/nis4_report_congress_full_pdf_jan2010.pdf

Shirtcliff EA, Granger DA, & Likos A (2002). Gender differences in the validity of testosterone in saliva by immunoassay. Hormones and Behavior, 42, 62–69. [PubMed: 12191648]

Starling SP, Sirotnak AP, Heisler KW, & Barnes-Eley ML (2007). Inflicted skeletal trauma: The relationship of perpetrators to their victims. Child Abuse & Neglect, 31, 993–999. [PubMed: 17870159]

Stoff DM, & Susman EJ (2005). Developmental psychobiology of aggression. Cambridge: Cambridge University Press.

Svare BB (2013). Hormones and aggressive behavior. New York: Plenum Press.

United States Department of Health and Human Services. (2019). Child Maltreatment 2017. Retrieved from https://www.acf.hhs.gov/cb/resource/child-maltreatment-2017

Weisman O, Zagoory-Sharon O, Feldman R (2014). Oxytocin administration, salivary testosterone, and father-infant social behavior. Progress in Neuro-Psychopharmacology & Biological Psychiatry, 49, 47–52. [PubMed: 24252717]

Waldvogel P, & Ehlert U (2018). Testosterone is associated with perceived constraint in early fatherhood. Adaptive Human Behavior and Physiology, 4, 69–90.

Yildirim BO, & Derksen JJL (2012a). A review on the relationship between testosterone and life-course persistent antisocial behavior. Psychiatry Research, 200, 984–1010. [PubMed: 22925371]

Yildirim BO, & Derksen JJL (2012b). A review on the relationship between testosterone and the interpersonal/affective facet of psychopathy. Psychiatry Research, 197, 181–198. [PubMed: 22342179]

Table 1

Means, Standard Deviations, Internal Consistencies and Partial Correlations with Testosterone Levels for Mothers and Fathers

	Mothers			Fathers		
	α[a]	*M(SD)*	Testo (*r*)[b]	α	*M(SD)*	Testo (*r*)[b]
T1 IRI Empathy	.82	55.61 (8.46)	.13	.82	54.08 (8.13)	−.04
T1 FDS Frustration	.82	18.32 (5.35)	−.20*	.86	18.18 (5.61)	−.19
T1 PASAT (Frustration)		86.30 (70.99)	−.16		101.85 (71.96)	−.38***
T1 AAPI-2 Total	.87	102.31 (19.27)	.00	.89	104.05 (18.78)	.25*
T1 CAPI Abuse Scale Total		93.03 (72.91)	.16		81.85 (59.25)	.14
T1 ReACCT Noncompliance	.76	1.09 (12.86)	.01	.76	−0.71 (12.47)	.23*
T2 IRI Empathy	.84	55.91 (9.08)	.04	.81	54.20 (8.45)	−.06
T2 FDS Frustration	.87	18.33 (5.80)	−.24*	.86	18.63 (5.70)	−.08
T2 AAPI-2 Total	.91	100.24 (21.65)	−.04	.89	101.21 (18.81)	.20
T2 CAPI Abuse Scale Total		83.70 (69.18)	.08		72.29 (62.22)	.29*
T2 ReACCT Noncompliance	.83	0.12 (15.22)	−.03	.78	−1.18 (12.56)	.26*
T2 Observed Positive Parenting	.88	5.25 (1.08)	−.08	.89	4.42 (0.92)	−.27*
T2 Observed Negative Parenting	.83	1.57 (0.99)	.10	.70	1.48 (0.59)	.44***
T3 IRI Empathy	.82	55.59 (8.70)	.02	.77	53.82 (7.66)	.04
T3 FDS Frustration	.90	18.27 (5.94)	−.18‡	.89	17.74 (6.08)	−.20‡
T3 AAPI-2 Total	.91	97.72 (20.50)	.02	.89	101.16 (19.94)	.31**
T3 CAPI Abuse Scale Total		89.95 (81.82)	.07		68.32 (58.44)	.27*
T3 ReACCT Noncompliance	.81	−0.24(14.12)	.02	.79	0.96 (14.03)	.24*
T3 Observed Positive Parenting	.86	4.89 (0.62)	−.08	.82	4.51 (0.86)	−.39***
T3 Observed Negative Parenting	.80	1.53 (0.63)	.12	.70	2.03 (0.73)	.34**
T4 IRI Empathy	.86	58.19 (8.57)	−.05	.85	54.78 (9.81)	.17
T4 AAPI-2 Total	.90	89.39 (21.43)	.06	.89	92.31 (19.70)	.11
T4 CAPI Abuse Scale Total		80.60 (76.89)	.09		60.92 (47.82)	.32*
T4 ReACCT Noncompliance	.82	−3.13 (13.15)	.18	.78	−4.43 (10.86)	.06
Moderators						
T3 SES Composite		0.00 (1.00)	−.27**		0.00 (1.00)	−.58***
T3 PSI Role Restriction	.73	20.54 (6.21)	−.09	.73	18.04 (4.97)	−.17
T3 NMRS Emotion Regulation	.92	66.16 (18.14)	−.01	.91	65.58 (17.27)	−.01
T3 Testosterone Level		72.95 (35.75)			165.24 (62.59)	

Note. IRI = Interpersonal Reactivity Index; FDS = Frustration Discomfort Scale; PASAT = Paced Auditory Serial Addition Test; AAPI-2 = Adult-Adolescent Parenting Inventory-2; CAPI = Child Abuse Potential Inventory; ReACCT = Response Analog to Child Compliance Task; PSI = Parenting Stress Index; NMRS = Negative Mood Regulation Scale.

[a]Alpha not computed for: PASAT is a single value; Child Abuse Potential Inventory items are variably weighted; SES is a standardized composite of income and educational level.

[b]Partial correlations controlling for time of day

$^{*}p \leq .05$,

$^{**}p \leq .01$,

$^{***}p \leq .001$;

$^{‡}p = .07$

Table 2

Longitudinal Analysis of Fathers' Testosterone Levels in Relation to Abuse Risk across Time

	CAPI		AAPI-2		ReACCT	
	β	*p*	β	*p*	β	*p*
T1[a] Abuse Risk → Testo	.12	.622	.27	**.048**	.12	.313
T2 Abuse Risk → Testo	.24	.422	−.04	.857	.12	.456
T3 Abuse Risk ↔ Testo	.24	*.063*	.04	.685	.09	.383
Testo → T4 Abuse Risk	.29	**.008**	−.39	**.000**	.16	.219
Lagged Effects						
T1 Abuse Risk → T2 Abuse Risk	.75	**.000**	.77	**.000**	.57	**.000**
T1 Abuse Risk → T3 Abuse Risk[b]	.37	**.014**	.47	**.000**	.56	**.002**
T2 Abuse Risk → T3 Abuse Risk	.49	**.004**	.49	**.000**	.72	**.000**
T3 Abuse Risk → T4 Abuse Risk	.94	**.000**	.62	**.000**	.27	.110

Note. Analyses control for time since waking. CAPI = Child Abuse Potential Inventory Abuse Scale; AAPI-2 = Adult-Adolescent Parenting Inventory-2; ReACCT = Response Analog to Child Compliance Task Noncompliance scale. Bolded p-values are statistically significant; italics reflect marginal significance.

[a]Time points (T1, T2, T3, T4) in first column refer to measures of abuse risk (CAPI, AAPI-2, ReACCT in columns) at those time points

[b]Instead of T1→T3, ReACCT path T2→T4.

Table 3

Multiple Regression Analyses of Interaction Effects of T3 Moderators of Testosterone Levels with T3 Child Abuse Risk Measures

	CAPI			AAPI-2			ReACCT		
	β (*t*)	β (*t*)	β (*t*)	β (*t*)	β (*t*)	β (*t*)	β (*t*)	β (*t*)	β (*t*)
Time of Day	−.04 (−.37)	.04 (.39)	.00 (.04)	.04 (.31)	.15 (1.44)	.13 (1.26)	.07 (.61)	.12 (1.08)	.16 (1.34)
Testosterone		.03 (.24)	−.03 (−.25)		.14 (1.06)	.14 (.94)		.04 (.27)	.13 (.83)
SES		−.48 (−4.10)***	−.44 (−3.70)***		−.34 (2.67)**	−.30 (−2.22)*		−.32 (−2.28)*	−.30 (−2.00)*
PSI Role Restriction		.19 (2.05)*	.25 (2.63)**		−.03 (.32)	−.02 (−.15)		−.06 (−.52)	−.05 (−.45)
NMRS Emot Reg		.30 (3.08)***	.29 (3.07)**		.33 (3.18)**	.32 (3.00)**		−.02 (−.21)	−.03 (−.26)
Testosterone x SES			−.31 (−2.73)**			−.08 (−.63)			.13 (.90)
Testosterone x PSI			.10 (.87)			−.03 (−.23)			−.05 (−.36)
Testosterone x NMRS			.06 (.58)			.03 (.24)			.13 (1.01)
F (R^2)	.14 (.00)	10.68 (.42)***	8.10 (.48)***	.10 (.00)	6.75 (.32)***	4.19 (.32)***	.37 (.00)	2.18 (.13)	1.66 (.16)

Note. Standardized beta and t-tests. CAPI = Child Abuse Potential Inventory; AAPI-2 = Adult-Adolescent Parenting Inventory-2; ReACCT = Response Analog to Child Compliance Task; PSI = Parenting Stress Index; NMRS = Negative Mood Regulation Scale.

* $p \leq .05$,

** $p \leq .01$;

*** $p \leq .001$