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Aging US males with multiple sources of emotional social support have low testosterone

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ABSTRACT

Among species expressing bi-parental care, males' testosterone is often low when they cooperate with females to raise offspring. In humans, low testosterone men might have an advantage as nurturant partners and parents because they are less prone to anger and reactive aggression and are more empathetic. However, humans engage in cooperative, supportive relationships beyond the nuclear family, and these prosocial capacities were likely critical to our evolutionary success. Despite the diversity of human prosociality, no prior study has tested whether men's testosterone is also reduced when they participate in emotionally supportive relationships, beyond partnering and parenting. Here, we draw on testosterone and emotional social support data that were collected from older men ($n = 371$; mean: 61.2 years of age) enrolled in the National Health and Nutrition Examination Survey, a US nationally-representative study. Men who reported receiving emotional support from two or more sources had lower testosterone than men reporting zero support (all $p < 0.01$). Males with the most support (4+ sources) also had lower testosterone than those with one source of support ($p < 0.01$). Men who reported emotional support from diverse (kin + non-kin or multiple kin) sources had lower testosterone than those with no support ($p < 0.05$). Expanding on research on partnering and parenting, our findings are consistent with the notion that low testosterone is downstream of and/or facilitates an array of supportive social relationships. Our results contribute novel insights on the intersections between health, social support, and physiology.

Introduction

Evolutionary perspectives on vertebrate life histories often emphasize the importance of male–male competition and aggression as selective pressures that influence male somatic characteristics, neuroendocrine systems, and behavioral profiles. Testosterone (T), a steroid hormone produced by the hypothalamic–pituitary–gonadal axis (HPG), often takes on a central role in such models when they focus on physiological mechanisms that mediate life history trade-offs (Bribiescas, 2001; Gettler, 2014; Ketterson and Nolan, 1992; Muehlenbein and Bribiescas, 2005). T contributes to physical characteristics (e.g. skeletal musculature, ornamentation) and behavioral patterns (e.g. competition with conspecifics for territory, resources, dominance hierarchy status, interactions with females) that likely play a role in reproductive success for males of many mammalian species, including humans (Archer, 2006; Bribiescas, 2001; Ellison, 2001; Flinn et al., 2012; Puts et al., 2015). However, elevated T may also adversely impact survival, such as through increased exposure to injury due to male–male conflicts and reduced ability to stave off disease because of T's many immunosuppressive effects (Muehlenbein and Bribiescas, 2005). Moreover, T's behavioral and mood effects might negatively impact social relationships that are contingent on prosocial, empathic behavior among humans, though this has been little explored (Gettler, in press).

Men with high T express reduced empathy, show heightened tendencies towards anger, and are more keenly attentive to status-dominance threats, compared to individuals with low T (Carré and Olmstead, 2015; Gettler, 2014; van Anders et al., 2011; van Honk et al., 2010). Brain-imaging studies indicate that high T individuals show increased limbic (amygdala) activity and lower connectivity between limbic and executive cortical brain regions related to social behavior when their status is threatened (Carré and Olmstead, 2015; Gettler, 2014; van Honk et al., 2010). Thus, elevated T contributes to greater subcortical influence over behavior in response to challenge–competition–threat and less conscious processing of social stimuli under those conditions. These data suggest that men with high T might be more predisposed to reactive aggression when challenged or threatened (Carré and Olmstead, 2015; van Honk et al., 2010). Based on this growing body of literature, along with a large number of studies on T's responses during competition, van Anders and colleagues have proposed a new psychobiological theoretical framework that orients T along a nurturance–competition gradient. According to this model, humans' T production will be low in social contexts in which emotional

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warmth and empathic responses are paramount (van Anders et al., 2011; van Anders, 2013).

It is hypothesized that humans' capacity for downregulating T in such nurturant contexts may have emerged during human evolution in conjunction with selection pressures related to invested fatherhood and men's cooperation with mothers (Gettler, 2010; Gettler, 2014; Gray and Anderson, 2010). Consistent with this perspective, the notion that humans with low T engage in more nurturant behaviors is primarily supported by psychobiological studies of partnering and parenting. Building from Muller and colleagues' (2009) insightful cross-cultural research in Tanzania, which demonstrated the importance of cultural institutions related to fathers' involvement in direct childcare for men's T, studies in multiple cultural contexts have found that fathers with lower T engage in more direct care (Gettler, 2014). Findings consistent with this perspective have been found in studies of paternal behavior in the US, the Philippines, Israel, and Senegal (Alvergne et al., 2009; Gettler et al., 2012; Gettler et al., 2015; Mascaro et al., 2013; Weisman et al., 2014), and lab-based studies also support the notion that low T fathers are more sensitive and nurturant with children (Fleming et al., 2002; Storey et al., 2011; van Anders, 2013; Weisman et al., 2014). Meanwhile, in studies of heterosexual subjects, partnered men tend to have lower T than their single counterparts, though the pattern is not ubiquitous cross-culturally. Importantly, a variety of contextual factors, such as relationship commitment and interest in extra-pair sexual opportunities, or cultural institutions, such as levels of polygyny (Gray, 2003; Gray et al. 2007), moderate the relationship (Gray and Campbell, 2009; van Anders, 2013). While a recent study of nursing students (93% female) found no relationship between social network dimensions and T (Kornienko et al., 2014), it is unclear whether men have low T in the context of emotionally supportive relationships with other (non-partner, non-children) members of their social networks, such as extended kin, friends, and other community members. If such a pattern were observed, it could reflect the cooption of the neuroendocrine pathways related to partnering, fatherhood, and caregiving to social contexts with less explicit ties (evolutionarily) to reproductive fitness.

In most societies, individuals receive resources, support, and status and derive identity from diverse of types of family organization, including relatives traced through paternal and maternal ancestry as well as fictive kin (Murdock, 1949). While kin network support is of obvious importance in societies today and (likely) was during the evolutionary past (Gurven et al., 2012; Kramer and Ellison, 2010; Smith et al., 2010), relationships outside of formalized kinship structures are also fundamental sources of support and resources (Allen et al., 2011; Apicella et al., 2012; Hill and Hurtado, 2009; Jaeggi and Gurven, 2013). These non-kin support relationships, generated through location and membership-based ties (neighbors, church, work colleagues, and or social organizations), affective ties (friends and acquaintances), interaction ties (counselors, spiritual guides), and flow ties (exchange of information, resources), often carry an emotional salience equivalent to kin (Allen et al., 2011; Borgatti et al., 2009; Jordan-Marsh and Harden, 2005).

The effect of these relationships can be understood, in part, through developments in social network analysis whose "most fundamental axiom [suggests that] a node's position in a network determines in part the opportunities and constraints that it encounters, and in this way plays an important role in a node's outcomes" (Borgatti et al., 2009, pg. 894). Specifically, individuals with high status and influence within the network tend to have a greater number and diversity of links connecting them to the rest of the network (Barabasi and Albert, 1999; Borgatti et al., 2009). While status and influence are usually viewed as indicators of *power over other nodes*, they can also be used to evaluate the degree to which ego is able *to elicit*, *receive*, and *provision varied social support* (Wellman and Gulia, 1999). The maintenance of a range of intimate, supportive relationships with kin and non-kin sources likely requires qualitatively distinct, diffuse social and emotional skills and effort (Wellman and Gulia, 1999), and personal characteristics, such as empathic ability and emotional intelligence, affect the support individuals provide and receive in their networks (Austin et al., 2005; Trobst et al., 1994). We acknowledge that the data we analyze here do not allow for formal social network analysis. However, in addition to the evolutionary and psychobiological perspectives outlined above, we drew on network theory and kin/non-kin family studies to generate hypotheses regarding correlations between men's T and the type and number of emotionally supportive ties they have in their lives.

Here, using cross-sectional data from the National Health and Nutrition Examination Survey (NHANES) (1999–2004), which are representative of the US-population, we tested hypotheses regarding the relationship between men's T and their number/sources of emotional support ($n = 371$). Because NHANES social support data were only collected from older individuals, our subject pool is restricted to men who were 40 years of age or older. Drawing on recent psychobiological theory (van Anders et al., 2011; van Anders, 2013) and past longitudinal research showing the effects of social relationship transitions (i.e. becoming a father or becoming partnered) on T (Gettler et al., 2011), we predicted men's T from their total sources of emotional support. We hypothesized that men reporting a higher number of emotionally supportive relationships would have lower T. Drawing on theory and results from social network analysis (Allen et al., 2011; Borgatti et al., 2009; Jordan-Marsh and Harden, 2005), we then tested the hypothesis that men's T would be reduced when they received emotional support from diverse sources, e.g. related and unrelated individuals.

Methods

NHANES 1999–2004

NHANES is an ongoing series of studies conducted by the US government through the Center for Disease Control (CDC) whose principal aims are to characterize and assess health and nutritional status for a sample that is representative of the civilian, non-institutionalized US population. In order to select such a representative sample, NHANES recruits participants using a multi-stage, stratified, probability-cluster design and oversamples ethnic minority groups, low income individuals, adolescents, and older adults in order to ensure proper representation for sub-analyses. Here we analyze data from three cross-sectional waves (1999–2000, 2001–2002, 2003–2004) of NHANES continuous data collections, which are conducted in two-year cycles. The same participants are not followed up across multiple waves of NHANES continuous data collections. During the continuous surveys, approximately 7,000 participants are interviewed in their homes and then a majority of those participants ($n = 5{,}000$) undergo a medical examination that includes physiological and physical measurements as well as collection of blood samples, all conducted by trained professionals, at a mobile center. Detailed information on NHANES sampling design and methodologies, including the physical examinations and venipuncture collection protocols, as well as all the data we used for the present analysis are publicly available through the CDC website: http://www.cdc.gov/nchs/nhanes.htm.

Total testosterone (T) sub-sample selection and assay procedures

NHANES collects blood samples for the measurement of a predetermined set of biological markers, which does not include T. Following these measurements, scientists can apply to conduct supplementary laboratory analyses on the surplus samples. The total T data we analyzed here were derived from a secondary analysis of males' surplus sera. Nyante and colleagues (2012) previously published a detailed description of the sampling criteria that were used to identify surplus sera samples for reproductive hormone analyses among adult males (p. 457–458): There were 15,184 male participants in the 1999–2004