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Trait anxiety moderates the association between estradiol and dominance in women

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HIGHLIGHTS

- Dominance is negatively related to estradiol and estradiol to testosterone ratio
- Trait anxiety moderates the association between dominance and estradiol levels
- Testosterone levels do not predict dominance in reproductive age women
- Maintaining high dominance might be associated with significant costs to reproduction

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ABSTRACT

The aim of the study was to investigate the relationship between self-assessed social dominance trait and levels of free basal sex steroids: estradiol and testosterone, in reproductive age women. Polish urban women aged 24–35 (N = 72) filled in Trait Dominance–Submissiveness Scale (TDS) and State and Trait Anxiety Inventory (STAI). They also gave a single blood sample during the follicular phase of the following menstrual cycle. The blood sample was analyzed for concentration of free testosterone (T), estradiol (E_2) and cortisol (C).

We found that self-assessed social dominance was negatively associated with free E_2 and E_2 to T ratio. This general relationship was moderated by Trait Anxiety. Higher social dominance was associated with lower E_2 and lower E_2 to T ratio in moderate and highly anxious women. No such relationship was found in low anxious women.

Results of this study evidence important contribution of estradiol and question the independent role of testosterone in shaping dominance in women. They might also suggest important biological and psychological cost of maintaining high social dominance in reproductive age women.

1. Introduction

Accumulating evidence suggests that gonadal sex hormones are important modulators of social behavior in animals and humans. Testosterone levels are associated with social status, parenting behavior, aggression, risk taking, competition and social dominance [1]. Estradiol is similarly linked to behavior. Studies in women and non-human primates show that this hormone has potent prosocial and anxiolytic properties and thus may modulate aggression, anxiety, affiliative and parenting behavior which are all associated with dominance in females [2–4].

While numerous studies demonstrated the association of testosterone with dominance in males [5–9], the result of studies for females is equivocal. The strongest evidence for the effects of testosterone comes from primate studies where females are ranked based on the specific place in a despotic group hierarchy, and access to essential ecological resources depends on aggressive competition among females [10]. In such cases, where dominance has direct and immediate effect on female biological condition and reproductive success [11], testosterone, which triggers aggressive and dominant behavior, acts in a similar fashion as in males.

In contrast, in human females, the relationship between dominance hierarchy, reproductive success and testosterone is more elusive. Although studies showed that women defined as masculine based on their personality characteristics, and who have higher androgen levels, reach higher positions in society [12,13] than women defined as feminine and with lower androgen levels, it has also been demonstrated that these women tend to engage in reproduction later, declare the will

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to have fewer children and present neutral or negative attitude to maternity [14,15]. All of these factors are inversely associated with woman's parity and may have a negative impact on her reproductive success.

Thus, the biological function and consequences of social dominance in women, and its relationship to testosterone, are unclear. Nonetheless, Dabbs and Hargrove [16] showed that higher testosterone level is associated with aggressive dominant behavior in female prison inmates. Grant and France [17] demonstrated that higher self-assessed dominance is associated with higher levels of total testosterone in young female students. Edwards et al. [18] found that testosterone levels were associated with peer rated social status in female soccer players. Also, Mehta and Josephs [5] found that testosterone level is positively related to peer rated dominance both in young undergraduate men and women.

Other studies, however, failed to replicate testosterone association with dominance in women [18–21]. Instead, their results pointed to estradiol as the main modulator of behaviors associated with dominance in women. For instance, Cashdan [22] demonstrated a positive association between levels of estradiol and testosterone and self-assessed dominance and social status, but a negative association between these steroids and social status assessed by peers. Similarly, Stanton and colleagues [23,24] found no association between the level of testosterone and implicit power motivation, a preference for having impact and dominance over others. Instead, implicit power motivation correlated positively with basal levels of estradiol in the undergraduate participants of the study.

In addition, it was demonstrated that stress reactivity and anxiety might represent important modulators of the relationship between dominance and sex steroids. Rejeski and colleagues [25] found that young dominant women were much more reactive to stressors, as indicated by cardiovascular parameters, than those classified as submissive. Additionally, although there was no difference in testosterone levels between dominant and submissive groups, dominant women's baseline testosterone level was related to changes in systolic blood pressure during a stressful experimental task. Furthermore, Mehta and colleagues [6] demonstrated positive associations between testosterone levels and dominant behaviors in competitive situations but only in subjects with low cortisol levels. Based on that observation, they proposed the *dual-hormone hypothesis* of dominance regulation. They suggested that high cortisol levels block the positive influence of testosterone on dominance. Finally, Maner and colleagues [26] showed that socially anxious individuals responded to dominance threat with decreased testosterone level. Interestingly, while in the study by Mehta et al. [6] no gender effect was found, Maner et al. [26] reported that decreased testosterone levels in highly anxious subjects were only found in men.

1.1. The current study

As pointed out by Booth et al. [27] and Liening and Josephs [28] in their reviews on steroid hormones and dominance, there are too few studies on females to account for gender differences in testosterone-behavior associations. To fill this gap, we conducted a study aimed at investigating the relationship between social dominance and levels of free basal reproductive steroids: estradiol (E_2) and testosterone (T). In contrast to studies that explored dominance as the behavioral and physiological response to a situational challenge [5,6,23,24] we measured dominance as a stable personality characteristic self-assessed by participants [29]. Our previous work indicated that self-assessed personality/temperamental characteristics are associated with levels of ovarian hormones in women [30]. We hypothesized that in women, E_2 rather than T would be associated with self-reported social dominance. Experimental studies in non-human primates show that levels of this hormone are associated with anxiety, aggression, affiliation and parenting behavior and thus may modulate dominant behavior. These associations, however, are modified by female social rank and environmental context [31,3] so that low social rank decreases sensitivity to behavioral effect of E_2. Furthermore, social subordination in primate females is frequently associated with chronic stress that leads to decreased E_2 levels [32]. Our aim was thus to test the impact of stress related measures: basal cortisol (C) and state and trait anxiety, as the modulators of the association between dominance and reproductive hormones. Based on the observation that high social dominance is associated with higher reactivity to stressors [25] and that exposure to stressors and low social rank attenuates the behavioral effects of E_2 [33,34], we predicted that trait dominance would be negatively associated with E_2 levels in women with high stress related measures.

2. Methods

2.1. Study participants

A total of 92 women, aged 24 to 35 years, from the general population of the city of Wroclaw, Poland, participated in a larger study on the relationship between personality, stress and sex steroid hormone levels. They volunteered in response to the announcement published in local newspapers, Internet and at the University of Wroclaw. For the purpose of the current analysis, data from 72 premenopausal women who delivered a blood sample and completed psychological questionnaires were included (mean age 26.3 $\pm$ 2.40 years). These women were healthy, in the non-obese weight range ($19 < BMI < 30$) and did not use any form of hormonal medication or supplementation. They were not pregnant and not lactating for the last 3 months prior to the study. They had regular menstrual cycles in the range of 25 to 35 days.

Women who fit the inclusion criteria were invited for the meeting with a trained research assistant. At this meeting, the women were asked to fill in the general questionnaire, Trait Dominance–Submissiveness Scale (TDS) and Trait Anxiety Inventory. The anthropometric measurement of height, weight, body composition and body circumferences were also taken. Women were also asked to visit the Clinic of Endocrinology, Wroclaw Medical University, in the morning, during the follicular phase (days 6th to 10th) of their menstrual cycle. During this visit, a trained nurse from the Clinic drew a single blood sample from each woman. At the day of blood sampling, the participants also filled in the State Anxiety Inventory. All women gave the written consent for their participation in the study. As part of the larger project, the study protocol was reviewed by the appropriate committee of the Ministry of Science and Higher Education.

2.2. Anthropometric measurements

The following anthropometric measurements were taken: body height and sitting height (to the nearest 0.5 cm) using a stadiometer, waist, hip and chest circumferences (breast and under the breast — to the nearest 0.5 cm) using a measuring tape, body mass (to the nearest 0.1 kg) and body fat (to the nearest 0.1%) both using Tanita Inner Scan Body Composition Monitor (Model: BC-536). Waist to hip ratio (WHR) and Body Mass Index (BMI) were calculated based on the measurements taken.

2.3. Hormonal analysis

All serum samples were analyzed at the Laboratory of the Clinic of Endocrinology, Wroclaw Medical University. Samples were analyzed for the serum concentration of free T, free E_2 and C using a commercial radioimmunoassay kit (Siemens Medical Solution Diagnostics, Los Angeles, CA, USA). Concentrations of all hormones were assayed with Coat—a Count method. The sensitivity of the free T assay was 0.15 pg/mL and the intra-assay and inter-assay coefficient of variation were 4.9% and 8.3%, respectively. The free T concentration (median and central 95% range) for females in our sample was 1.11 pg/mL (0.484–2.45 pg/mL), which is in accordance with norms reported by the producer (for women between ages of 20 and 39 in this assay it is