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CLINICAL RESEARCH ARTICLE

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Salivary testosterone is associated with feelings of senselessness and self-dislike in women with borderline personality disorder

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ABSTRACT

Background: Women with borderline personality disorder (BPD) show increased basal levels of testosterone. We investigated whether salivary testosterone levels in women with BPD were indicative of specific symptoms associated with BPD. Based on the assumed link between testosterone and interpersonal dominance, we hypothesized a positive association between testosterone and externalising, i.e. aggressive or impulsive behaviour, potentially contributing to higher burden of interpersonal reactivity and conflict.

Methods: Saliva was collected from 98 women with BPD (average age in years: 28, range 18–46) between 1 and 2 pm. Self-rating scales were administered to assess severity of BPD (Borderline Symptom Checklist, BSL-23) and depressive symptoms (Beck's Depression Inventory, BDI-II). Regression analyses targeted associations between individual testosterone levels and BSL-23 and BDI-II total and by-item scores.

Results: Higher testosterone levels were associated with higher overall disease burden indicated by BSL-23 and BDI-II total scores. When analysed by item, higher testosterone levels were significantly associated with increased feelings of self-dislike, senselessness and pessimism, and the feeling of being a failure.

Conclusion: Our findings show that in women with BPD testosterone levels are positively associated with increased borderline and depressive symptomatology. Contrary to our expectations, rather than predicting externalising symptoms, higher testosterone is associated with a well-defined cluster of internalising symptoms characterized by a pessimistic and derogatory view towards oneself.

Testosterona en saliva se asocia con sentimientos de sin sentido y autodesprecio en mujeres con trastorno de personalidad limítrofe

Antecedentes: Las mujeres con trastorno de personalidad limítrofe (BPD por sus siglas en inglés) muestran niveles basales elevados de testosterona. Investigamos si los niveles de testosterona en saliva en mujeres con BPD eran indicativos de síntomas específicos asociados al BPD. Basándonos en el supuesto vínculo entre testosterona y dominancia interpersonal, hipotetizamos una asociación positiva entre testosterona y síntomas externalizantes, como conducta agresiva o impulsiva, que potencialmente contribuyera a la mayor carga de reactividad y conflicto interpersonal.

Métodos: Se recolectó saliva de 98 mujeres con BPD (edad promedio: 28 años, rangos 18–46) entre la 1 y 2 pm. Se administraron escalas de auto-reporte para evaluar la severidad del BPD (Lista de chequeo de síntomas limítrofes, BSL-23) y síntomas depresivos (Inventario de depresión de Beck, BDI-II). Los análisis de regresión se centraron en las asociaciones entre los niveles de testosterona individuales y las puntuaciones totales y por ítems de la BSL-23 y el BDI-II.

Resultados: Niveles de testosterona elevados se asociaron con mayor carga general de enfermedad, indicada por las puntuaciones totales del BSL-23 y del BDI-II. Cuando se analizó por ítem, los niveles de testosterona aumentados se asociaron significativamente con mayor sensación de auto desprecio, sin sentido y pesimismo, y sensación de ser un fracaso.

Conclusión: Nuestros hallazgos muestran que en mujeres con BPD los niveles de testosterona se asocian positivamente con mayor sintomatología limítrofe y depresiva. Contrariamente a nuestras expectativas, en lugar de predecir síntomas externalizantes, los niveles aumentados de testosterona se Vasociaron con un clúster bien definido de síntomas internalizantes caracterizados por una visión pesimista y despectiva de sí misma.

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PALABRAS CLAVE
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HIGHLIGHTS

- Salivary testosterone levels were measured in women with Borderline Personality Disorder.
- Higher testosterone levels were associated with higher borderline and depressive symptoms.
- Strongest associations with testosterone were found for internalising symptoms including feelings of senselessness and self-dislike.

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1. Introduction

Borderline Personality Disorder (BPD) is a debilitating mental illness that affects 1–2% of the general population. Central symptoms include instability of affect, identity and social interactions. Arising emotional tension can be overwhelming and lead to aggressive, self-harming or suicidal behaviour, as bottom-up intense affect interacts with dysfunctional negative beliefs about oneself and others. Multiple factors contribute to BPD aetiology, with early life adversity and dysregulation of the stress response interacting with neuro-endocrine development and functioning throughout life (Eck & Bangasser, 2020; Gunderson et al., 2018).

In contrast to stress hormones, the interplay of gonadal hormones and BPD symptomatology has only recently started to gain attention. Female patients with BPD show increased testosterone levels in saliva (Dyson et al., 2023; Rausch et al., 2015), serum (Bonfig et al., 2022; Roepke et al., 2010) and hair (Dettenborn et al., 2016), suggesting a disturbed androgen metabolism with higher incidence of hyperandrogenism (Tan et al., 2018). In premenopausal women, one quarter of testosterone is produced in the adrenal glands (Longcope, 1986). As such, deviant corticoid functioning and a chronically active adrenal system in BPD might lead to increased testosterone secretion, especially in women. Accordingly, baseline testosterone levels show a positive association with perceived life stress in healthy women (King et al., 2005).

Historically considered as the 'male' hormone, testosterone was associated with stereotypically male behaviour such as aggression, competition and dominance (Crespi, 2016; Eisenegger et al., 2011). Testosterone levels in females are 10% of those found in males. But also in women, baseline testosterone levels show positive correlations with aggression (Harris et al., 1996; Von der Pahlen et al., 2002), dominance (Grant & France, 2001) and competition (Cashdan, 2003), and testosterone supplementation can increase hostile behaviour in women (Sherwin & Gelfand 1985). However, data on the effects of gonadal hormones on premenopausal women is still scarce and the effects of testosterone on psychiatric symptomatology are poorly understood.

Interestingly, in a sample of female BPD patients, baseline salivary testosterone did not predict aggressive traits during adolescence (Cavelti et al., 2022) or motherhood (Rausch et al., 2015). Instead, testosterone levels were correlated with depressive and borderline symptoms (Roepke et al., 2010). Similar associations with depressive and anxiety symptoms were observed in adolescents with polycystic ovary syndrome (PCOS) (Donbaloğlu et al., 2022), a gynaecological condition linked to hyperandrogenism and a frequent comorbidity of BPD (Roepke et al., 2010). Notably, in MDD patients without BPD this association is usually reversed, with lower testosterone levels indicative of increased depressive symptoms (Flores-Ramos et al., 2019; Kumsar et al., 2014). Taken together, these findings raise the question which specific depressive and borderline symptoms are increased as a function of higher testosterone in female BPD patients.

1.1. Aim of the present study

In the present study, we investigated whether salivary testosterone in women with BPD was associated with increased symptom burden. Clinical symptoms were assessed with self-rating scales of borderline (BSL-23) and depressive symptoms (BDI-II), as well as clinician-rated presence of DSM-V criteria of BPD (SCID). We were particularly interested in identifying specific symptoms or symptom clusters associated with testosterone. Therefore, in addition to analysing questionnaire sum scores, by-item analyses were conducted. We hypothesized an association of higher testosterone levels with items indicative of externalising, i.e. aggressive or impulsive behaviour.

2. Methods

2.1. Participants

The sample consisted of 98 women (female sex assigned at birth assessed through self-report) with BPD which was a subsample of a larger study (Graumann et al., 2023). Diagnostic criteria for BPD were assessed with the Structured Clinical Interview for DSM-V (SCID) (Beesdo-Baum et al., 2019), exclusion criteria were acute major depressive episode (moderate or severe), current substance abuse, psychotic disorder and intake of more than three different psychotropic substances or benzodiazepines. All participants provided written informed consent and received monetary compensation (minimum 60€) for their participation as part of a larger study. The study was approved by the local ethical committee and in accordance with the Declaration of Helsinki.

2.2. Procedure

Participants underwent diagnostic interviews and filled out questionnaires on psychopathological symptoms using the web-based application REDCap on a tablet or computer, including the Beck Depression Inventory (BDI-II) and the Borderline Symptom List short version (BSL-23). Both scales are well established in clinical and research practice and offer good psychometric properties (Beck et al., 1996; Bohus et al., 2009; Kühner et al., 2007). The BDI-II is a 21-item, self-report rating that measures characteristic attitudes and symptoms of depression within the last 14 days

(Beck et al., 1996). The 21 items include (1) Sadness, (2) Pessimism, (3) Past failure, (4) Loss of pleasure, (5) Guilt feelings, (6) Punishment feelings, (7) Self-dislike, (8) Self-criticalness, (9) Suicidal thoughts or wishes, (10) Crying, (11) Agitation, (12) Loss of interest, (13) Indecisiveness, (14) Worthlessness, (15) Loss of energy, (16) Change in sleeping patterns, (17) Irritability, (18) Change in appetite, (19) Concentration difficulty, (20) Tiredness/fatigue, and (21) Loss of libido. Each item can be answered with a score from 0 to 3, with higher values corresponding to higher symptom load. The BSL-23 is a 23-item, self-report rating that measures BPD symptom severity within the last 7 days on a scale from 0 to 4 (Bohus et al., 2009). The 23 items include (1) Concentration difficulty, (2) Helplessness, (3) Absent-mindedness, (4) Disgust, (5) Thought of self-harm, (6) Distrust towards others, (7) Absent right to live, (8) Loneliness, (9) Stressful inner tension, (10) Fearful imagery, (11) Self-hatred, (12) Desire to punish self, (13) Shame, (14) Mood swings, (15) Voices inside/outside head, (16) Devastation by criticism (17) Vulnerability, (18) Fascination with death, (19) Senselessness, (20) Fear of loss of control, (21) Self-disgust, (22) Distance from oneself, and (23) Worthlessness. After the participant had filled out the questionnaires, around 1–2 pm in the afternoon, the saliva sample was collected and the experimental procedure proceeded as described elsewhere (Graumann et al., 2023).

Table 1. Regression analyses show the influence of baseline salivary testosterone levels on Borderline symptom checklist (BSL-23) scores. Individual item (sorted by β values) and BSL-23 total scores are reported.

BSL-23 Items	Regr.-coeff.	β	T	p_{uncorr}	(corr.$_{Bonf}$)
Senselessness (19)	.29	.32	3.26	.002	*
Self-disgust (21)	.31	.31	3.11	.003	
Disgust (4)	.25	.29	2.86	.005	
Worthlessness (23)	.27	.28	2.77	.007	
Distance from oneself (22)	.21	.25	2.48	.015	
Helplessness (2)	.19	.24	2.38	.019	
Self-hatred (11)	.21	.24	2.34	.021	
Absent right to live (7)	.21	.22	2.19	.031	
Desire to punish self (12)	.22	.22	2.15	.035	
Loneliness (8)	.17	.20	2.04	.045	
Shame (13)	.17	.19	1.91	.059	
Mood swings (14)	.16	.18	1.72	.088	
Thought of self-harm (5)	.15	.16	1.56	.112	
Vulnerability (17)	.12	.16	1.54	.127	
Fascination with death (18)	.14	.16	1.53	.130	
Concentration difficulty (1)	.12	.15	1.46	.147	
Absent-mindedness (3)	.16	.14	1.34	.184	
Fearful imagery (10)	.13	.14	1.38	.170	
Fear of loss of control (20)	.12	.13	1.31	.193	
Stressful inner tension (9)	.07	.10	0.92	.358	
Devastation by criticism (16)	.07	.07	0.72	.477	
Voices inside/outside head (15)	.02	.03	0.29	.775	
Distrust towards others (6)	.01	.01	0.12	.905	
BSL-23 total score	.16	.28	2.82	.003**	

Note: Results of regression analyses, significance is reported as uncorrected two-tailed p-value and additionally marked as significant with applied Bonferroni correction to control for multiple comparisons. Questionnaire item numbers are reported in brackets.

2.3. Testosterone assessment

Salivary testosterone was collected using SaliCap devices (1.5 ml polypropylene tubes; IBL, Hamburg, Germany) at baseline, e.g. before study intervention, and stored at -80° until further analyses. Participants were not allowed to drink, eat or chew gum until 30 min before saliva collection. Testosterone levels were determined using a competitive immunoassay (IBL/TECAN, Hamburg, Germany) following the manufacturer's recommendations. The detection limit was 2.1 pg/ml, precision parameters (coefficient of variation; CV) for medium concentrations at 50 pg/ml averaged below 5% CV for intra- and 10% CV for inter-assay variance.

2.4. Statistical analyses

Testosterone values were log transformed to fit normal distribution. Associations between testosterone levels and symptom severity were tested with regression analyses using SPSS 26. Because adipose tissue might influence the production of testosterone and affect depressive symptoms (Stanikova et al., 2019; Zhao et al., 2009), body-mass-index (BMI) was added as a predictor of no interest. To control for multiple comparisons in the by-item analyses, Bonferroni-correction was applied. Logistic regressions served to assess the influence of testosterone on presence/absence of BPD DSM-V criteria.

3. Results

3.1. Demographic

Participants' average age was $M = 28$ years ($SD = 7$, range 18-46). Average BMI was 23 kg/m^2 ($SD = 3$). Sixteen women reported the intake of hormonal contraception. In naturally cycling women, calendar-based assessment indicated that $n = 26$ were in their follicular and $n = 50$ in their luteal phase, while in four women a tractable cycle was absent. Neither hormonal contraception ($t(92) = 1.14$, $p = .31$) nor cycle phase ($F(2,89) = 0.59$, $p = .56$) affected average testosterone levels. Forty-two women were smokers. Fifty women reported intake of at least one psychotropic substance, while 48 patients were free of psychotropic medication. Average sum scores were $M = 27$ ($SD = 12$) for BDI-II and $M = 45$ ($SD = 20$) for BSL-23.

3.2. Associations between testosterone levels and symptom ratings

Testosterone scores are presented for 94 individuals, in four patients testosterone values were missing

because of measurement errors (e.g. the collected amount of saliva was too small for detection). The average testosterone levels of BPD patients were M = 30pg/ml (SD = 28pg/ml), ranging from 1 to 149pg/ml.

BSL-23: Higher testosterone levels were associated with higher overall borderline symptom burden indicated by the BSL-23 sum score. When analysed by item, higher testosterone levels were associated with increased feeling of senselessness. Further items associated with higher testosterone were and self-disgust, disgust, worthlessness, distance from oneself, helplessness, self-hatred, absence of right to live, desire to punish self, and loneliness, however, these items were not significant after Bonferroni-correction (See Table 1).

BDI-II: Higher testosterone levels were associated with overall higher BDI-II sum scores. By-item analysis revealed an association with higher sense of past failure, self-dislike and pessimism. Further items that showed a positive association but did not remain significant after Bonferroni-correction were suicidal thoughts or wishes, loss of pleasure, self-criticalness, worthlessness, guilt feelings, and indecisiveness (See Table 2).

DSM-V BPD criteria: No effects were significant after Bonferroni correction. On a trend level, higher testosterone was associated with a higher rate of meeting the DSM-V criterion of self-destructiveness. Interestingly, the association between testosterone levels and uncontrollable anger was negative: patients who met this this criterion showed a tendency towards lower testosterone levels (See Table 3).

Table 2. Regression analyses show the influence of baseline salivary testosterone levels on Beck's Depression Inventory II (BDI-II) scores. Individual item (sorted by β values) and BDI-II total scores are reported.

	Regr.-coeff.	β	T	p_{uncorr}	(corr.$_{Bonf}$)
BDI Items					
Past failure (3)	.23	.37	3.78	.001	*
Self-dislike (7)	.23	.34	3.45	.001	*
Pessimism (2)	.22	.33	3.26	.002	*
Suicidal thoughts or wishes (9)	.12	.27	2.67	.009	
Loss of pleasure (4)	.16	.26	2.52	.014	
Self-criticalness (8)	.16	.25	2.48	.015	
Worthlessness (14)	.16	.25	2.47	.015	
Guilt feelings (5)	.16	.24	2.32	.022	
Indecisiveness (13)	.17	.22	2.16	.033	
Tiredness/fatigue (20)	.11	.20	1.97	.052	
Punishment feelings (6)	.13	.19	1.81	.073	
Agitation (11)	.12	.19	1.84	.068	
Change in appetite (18)	.13	.18	1.74	.085	
Crying (10)	.12	.17	1.59	.115	
Loss of interest (12)	.10	.16	1.53	.110	
Sadness (1)	.06	.15	1.43	.156	
Change in sleeping patterns (16)	.10	.15	1.39	.167	
Loss of energy (15)	.06	.12	1.14	.256	
Concentration difficulty (19)	.07	.12	1.20	.235	
Loss of libido (21)	.07	.09	0.85	.398	
Irritability (17)	.04	.07	0.60	.549	
BDI total score	26.33	.34	3.40	.001***	

Note: Results of regression analyses, significance is reported as uncorrected two-tailed p-value and additionally marked as significant with applied Bonferroni correction to control for multiple comparisons. Questionnaire item numbers are reported in brackets.

Table 3. Logistic regression analyses of influence of basal testosterone levels on DSM-IV BPD criteria.

DSM-V BPD criteria	Regr.-coeff. B	Wald	p_{uncorr}	(corr.$_{Bonf}$)
Fear of abandonment	.247	2.22	.136	
Unstable relations	.161	0.71	.401	
Identity disturbance	.121	0.75	.386	
Impulsivity	-.071	0.24	.621	
Self-destructiveness	.720	6.20	.013	
Affective lability	-.723	2.21	.137	
Chronic emptiness	-.125	0.39	.533	
Uncontrolled anger	-.315	3.87	.049	
Paranoia/dissociation	-.109	0.52	.470	

4. Discussion

Our findings show a positive association between salivary testosterone levels and borderline and depressive symptoms in women with BPD. In particular, patients with higher testosterone levels showed higher ratings of self-dislike, senselessness and pessimism, and the feeling of being a failure. Results from both BSL-23 and BDI-II were highly consistent, which speak for a well-defined cluster of internalising symptoms that correlates with testosterone levels. In the clinician administered interview we found a non-significant trend towards stronger self-oriented destructiveness (self-harming and suicidal behaviour), whereas other-oriented anger and aggression showed a trend towards a negative association with baseline testosterone levels.

Our results do not support the hypothesis that testosterone in female BPD patients promotes externalising behaviour. Instead, the strongest associations were found for internalising symptoms characterized by a pessimistic and derogatory view of oneself. This symptom cluster overlaps between BPD and MDD symptomatology. In contrast, autonomous (sleep, appetite), motivational (apathy, agitation) or cognitive (concentration) symptoms of MDD were not significantly associated with testosterone levels. Taken together, higher salivary testosterone in female BPD patients is associated with a negative and pessimistic affect and cognition towards the self. This combination of negative affect and dysfunctional beliefs of worthlessness, to which BPD patients are prone, might further promote self-harm and suicidality. Consistently, higher testosterone levels have been associated with a higher number of previous suicide attempts in patients with bipolar disorder (Sher, 2012).

Androgen receptors, to which testosterone binds, show a high expression in the amygdala (Simerly et al., 1990), and testosterone administration increases amygdala reactivity in young and middle-aged women (Bos et al., 2013; Van Wingen et al., 2009). This might suggest a potential mechanism of action, as amygdala

hyperactivation is a stable finding in BPD patients (Donegan et al., 2003). More research is needed to understand the neuroendocrinological trajectories of BPD development that lead to increased testosterone levels in adulthood. Our findings suggest a link between testosterone and depressive and borderline symptomatology that is not primarily driven by patient BMI. Furthermore, in our sample oral contraception intake or cycle phase did not affect average testosterone levels. However, testosterone is known to fluctuate within the menstrual cycle, with an increase during ovulation (Al-Dujaili & Sharp, 2012). This calls for further investigations of dynamic changes of BPD symptoms across the menstrual cycle and the interplay with other gonadal hormones (Eisenlohr-Moul et al., 2018). Suicidal behaviour, which is common in BPD, changes throughout the menstrual cycle (Saunders & Hawton, 2006), and successful treatment and prevention requires a better understanding of potentially involved neuroendocrinological factors (Owens & Eisenlohr-Moul, 2018).

Identifying different phenotypes of androgen receptor sensitivity and circulating testosterone levels might also help to account for discrepant findings between MDD and BPD patients. In MDD, testosterone levels are reported to be reduced, and lower levels predict higher disease burden. While testosterone administration shows anti-depressive effects (Zito et al., 2023), age and, importantly, sex seem to be relevant mediators. In female samples, RCTs of testosterone administration did not significantly decrease depressive symptoms in MDD (Dichtel et al., 2020) or anorexia nervosa (Kimball et al., 2019). Delineating the specific symptoms that respond to external testosterone administration is relevant for these patient groups. In general, more research is needed to better understand potentially discrepant findings of MDD and BPD populations and the effect of biological sex. Furthermore, it would be interesting to know which specific depressive symptoms drove previously reported positive or negative associations with testosterone in MDD, and whether other clinical conditions such as PTSD and anxiety disorders show similar effects. So far, our findings do not allow the conclusion that the observed associations between testosterone and internalising symptoms are specific to women with BPD.

Another factor to consider in future research is stress, which constitutes both a cause for and a consequence of clinical symptom load. Testosterone increases after acute stress in patients with BPD and healthy controls (Deuter et al., 2021), as testosterone production is regulated by the hypothalamic-pituitary-gonadal which is bidirectionally connected with the hypothalamic–pituitary–adrenal axis (Acevedo-Rodriguez et al., 2018; Viau, 2002). Do BPD patients show higher testosterone levels due to higher daily stress that stems from symptom load? Or do higher testosterone levels precede borderline symptomatology and constitute a potential risk factor? Does borderline symptomatology remit when testosterone levels decrease, potentially pointing towards treatment approaches? Only longitudinal or interventional studies can answer these questions by targeting the causal direction of the association between testosterone and symptom load demonstrated by the present cross-sectional analysis. In contrast to increasing testosterone levels in MDD, our findings suggest that women with BPD might benefit from anti-androgen treatment which reduces testosterone levels. RCTs are lacking, however, a single case study reported that hyperandrogenism/PCOS treatment led to the remission of BPD symptoms in a young woman (Trisno et al., 2016). Reversely, our findings might invite more careful monitoring of psychiatric side effects of androgen treatment, especially in patients with known BPD symptoms.

4.1. Limitations

The present study only included women (female sex assigned at birth) with BPD, therefore, the association between testosterone on BPD symptoms in males remains unknown. Testosterone analyses were based on one sample. Some patients were smokers or taking psychiatric medication, which might influence endocrinological status.

5. Conclusion

Our findings suggest that salivary testosterone levels are associated with a relatively narrow cluster of internalising symptoms that overlap between BPD and MDD, including feelings of self-dislike, senselessness and pessimism, and the feeling of being a failure. More research is needed to better understand the influence of gonadal hormones on psychiatric symptomatology. In women, the influence of cycling hormones has been considered a nuisance factor and therefore symptomatically neglected for a long time. Elucidating the influence of (cycling) gonadal hormones can promote the development of cycle-sensitive female mental health approaches to improve prevention and treatment.

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References

Acevedo-Rodriguez, A., Kauffman, A. S., Cherrington, B. D., Borges, C. S., Roepke, T. A., & Laconi, M. (2018). Emerging insights into hypothalamic-pituitary-gonadal axis regulation and interaction with stress signalling. *Journal of Neuroendocrinology*, *30*(10), e12590. https://doi.org/10.1111/jne.12590

Al-Dujaili, E., & Sharp, M. (2012). Female salivary testosterone: Measurement, challenges and applications. In S. Ostojic (Ed.), *Steroids: From Physiology to Clinical Medicine* (pp. 129–167). IntechOpen Book Series.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory (BDI-II)* (Vol. 10). San Antonio, TX: Psychological Corporation.

Beesdo-Baum, K., Zaudig, M., & Wittchen, H.-U. (2019). *SCID-5-PD: strukturiertes Klinisches Interview für DSM-5-Persönlichkeitsstörungen: deutsche Bearbeitung des Structured Clinical Interview for DSM-5-personality disorders von Michael B. First, Janet BW Williams, Lorna Smith Benjamin, Robert L. Spitzer*. Hogrefe.

Bohus, M., Kleindienst, N., Limberger, M. F., Stieglitz, R. D., Domsalla, M., Chapman, A. L., Steil, R., Philipsen, A., & Wolf, M. (2009). The short version of the Borderline Symptom List (BSL-23): Development and initial data on psychometric properties. *Psychopathology*, *42*(1), 32–39. https://doi.org/10.1159/000173701

Bonfig, J., Herpertz, S. C., & Schneider, I. (2022). Altered hormonal patterns in borderline personality disorder mother-child interactions. *Psychoneuroendocrinology*, *143*, 105822. https://doi.org/10.1016/j.psyneuen.2022.105822

Bos, P. A., van Honk, J., Ramsey, N. F., Stein, D. J., & Hermans, E. J. (2013). Testosterone administration in women increases amygdala responses to fearful and happy faces. *Psychoneuroendocrinology*, *38*(6), 808–817. https://doi.org/10.1016/j.psyneuen.2012.09.005

Cashdan, E. (2003). Hormones and competitive aggression in women. *Aggressive Behavior*, *29*(2), 107–115. https://doi.org/10.1002/ab.10041

Cavelti, M., Rinnewitz, L., Walter, M., van der Venne, P., Parzer, P., Josi, J., Bertsch, K., Brunner, R., Resch, F., & Koenig, J. (2022). Psychobiological correlates of aggression in female adolescents with borderline personality disorder. *Psychopathology*, *55*(1), 37–48. https://doi.org/10.1159/000520228

Crespi, B. J. (2016). Oxytocin, testosterone, and human social cognition. *Biological Reviews*, *91*(2), 390–408. https://doi.org/10.1111/brv.12175

Dettenborn, L., Kirschbaum, C., Gao, W., Spitzer, C., Roepke, S., Otte, C., & Wingenfeld, K. (2016). Increased hair testosterone but unaltered hair cortisol in female patients with borderline personality disorder. *Psychoneuroendocrinology*, *71*, 176–179. https://doi.org/10.1016/j.psyneuen.2016.05.026

Deuter, C. E., Duesenberg, M., Hellmann-Regen, J., Metz, S., Roepke, S., Wolf, O. T., Otte, C., & Wingenfeld, K. (2021). Psychosocial stress increases testosterone in patients with borderline personality disorder, post-traumatic stress disorder and healthy participants. *Borderline Personality Disorder and Emotion Dysregulation*, *8*(1), 1–9. https://doi.org/10.1186/s40479-021-00145-x

Dichtel, L. E., Carpenter, L. L., Nyer, M., Mischoulon, D., Kimball, A., Deckersbach, T., Dougherty, D. D., Schoenfeld, D. A., Fisher, L., & Cusin, C. (2020). Low-dose testosterone augmentation for antidepressant-resistant major depressive disorder in women: An 8-week randomized placebo-controlled study. *American Journal of Psychiatry*, *177*(10), 965–973. https://doi.org/10.1176/appi.ajp.2020.19080844

Donbaloğlu, Z., Tuhan, H., Çoban, ÖG, Kızılay, DÖ, İsmailoğlu, E., Önder, A., Acar, S., Bedel, A., Çetiner, E. B., & Singin, B. (2022). Hyperandrogenism correlates with psychological symptoms in adolescents with polycystic ovary syndrome. *Clinical Pediatric Endocrinology*, *31*(2), 68–76. https://doi.org/10.1297/cpe.2022-0010

Donegan, N. H., Sanislow, C. A., Blumberg, H. P., Fulbright, R. K., Lacadie, C., Skudlarski, P., Gore, J. C., Olson, I. R., McGlashan, T. H., & Wexler, B. E. (2003). Amygdala hyperreactivity in borderline personality disorder: Implications for emotional dysregulation. *Biological Psychiatry*, *54*(11), 1284–1293. https://doi.org/10.1016/S0006-3223(03)00636-X

Dyson, T., Thomas, S. J., Townsend, M. L., Finch, A., South, A., Barkus, E., Walter, E., Mendonca, C., Grenyer, B. F., & Pickard, J. A. (2023). Salivary testosterone and cortisol levels in borderline personality disorder before and after a 12-week group dialectical behavior therapy intervention. *Frontiers in Psychology*, *14*, 1–10. https://doi.org/10.3389/fpsyg.2023.1195187

Eck, S. R., & Bangasser, D. A. (2020). The effects of early life stress on motivated behaviors: A role for gonadal hormones. *Neuroscience & Biobehavioral Reviews*, *119*, 86–100. https://doi.org/10.1016/j.neubiorev.2020.09.014

Eisenegger, C., Haushofer, J., & Fehr, E. (2011). The role of testosterone in social interaction. *Trends in Cognitive Sciences*, *15*(6), 263–271. https://doi.org/10.1016/j.tics.2011.04.008

Eisenlohr-Moul, T. A., Schmalenberger, K. M., Owens, S. A., Peters, J. R., Dawson, D. N., & Girdler, S. S. (2018). Perimenstrual exacerbation of symptoms in borderline personality disorder: Evidence from multilevel models and the Carolina Premenstrual Assessment Scoring System. *Psychological Medicine*, *48*(12), 2085–2095. https://doi.org/10.1017/S0033291718001253

Flores-Ramos, M., Alcauter, S., Lopez-Titla, M., Bernal-Santamaria, N., Calva-Coraza, E., & Edden, R. (2019). Testosterone is related to GABA+ levels in the posterior-cingulate in unmedicated depressed women during reproductive life. *Journal of Affective Disorders*, *242*, 143–149. https://doi.org/10.1016/j.jad.2018.08.033

Grant, V. J., & France, J. T. (2001). Dominance and testosterone in women. *Biological Psychology*, *58*(1), 41–47. https://doi.org/10.1016/S0301-0511(01)00100-4

Graumann, L., Cho, A. B., Kulakova, E., Deuter, C. E., Wolf, O. T., Roepke, S., Hellmann-Regen, J., Otte, C., & Wingenfeld, K. (2023). Impact of social exclusion on empathy in women with borderline personality disorder. *European Archives of Psychiatry and Clinical*

Neuroscience, *273*(4), 865–874. https://doi.org/10.1007/s00406-022-01535-0

Gunderson, J. G., Herpertz, S. C., Skodol, A. E., Torgersen, S., & Zanarini, M. C. (2018). Borderline personality disorder. *Nature Reviews Disease Primers*, *4*(1), 1–20. https://doi.org/10.1038/nrdp.2018.29

Harris, J. A., Rushton, J. P., Hampson, E., & Jackson, D. N. (1996). Salivary testosterone and self-report aggressive and pro-social personality characteristics in men and women. *Aggressive Behavior*, *22*(5), 321–331. https://doi.org/10.1002/(SICI)1098-2337(1996)22:5<321::AID-AB1>3.0.CO;2-M

Kimball, A., Schorr, M., Meenaghan, E., Bachmann, K. N., Eddy, K. T., Misra, M., Lawson, E. A., Kreiger-Benson, E., Herzog, D. B., & Koman, S. (2019). A randomized placebo-controlled trial of low-dose testosterone therapy in women with anorexia nervosa. *The Journal of Clinical Endocrinology & Metabolism*, *104*(10), 4347–4355. https://doi.org/10.1210/jc.2019-00828

King, J. A., Rosal, M. C., Ma, Y., & Reed, G. W. (2005). Association of stress, hostility and plasma testosterone levels. *Neuroendocrinology Letters*, *26*(4), 355–360.

Kumsar, Ş, Kumsar, N. A., Sağlam, H. S., Köse, O., Budak, S., & Adsan, Ö. (2014). Testosterone levels and sexual function disorders in depressive female patients: Effects of antidepressant treatment. *The Journal of Sexual Medicine*, *11*(2), 529–535. https://doi.org/10.1111/jsm.12394

Kühner, C., Bürger, C., Keller, F., & Hautzinger, M. (2007). Reliabilität und Validität des revidierten Beck-Depressionsinventars (BDI-II). *Der Nervenarzt*, *78*(6), 651–656. https://doi.org/10.1007/s00115-006-2098-7

Longcope, C. (1986). 1 Adrenal and gonadal androgen secretion in normal females. *Clinics in Endocrinology and Metabolism*, *15*(2), 213–228. https://doi.org/10.1016/S0300-595X(86)80021-4

Owens, S. A., & Eisenlohr-Moul, T. (2018). Suicide risk and the menstrual cycle: A review of candidate RDoC mechanisms. *Current Psychiatry Reports*, *20*(11), 1–11. https://doi.org/10.1007/s11920-018-0962-3

Rausch, J., Gäbel, A., Nagy, K., Kleindienst, N., Herpertz, S. C., & Bertsch, K. (2015). Increased testosterone levels and cortisol awakening responses in patients with borderline personality disorder: Gender and trait aggressiveness matter. *Psychoneuroendocrinology*, *55*, 116–127. https://doi.org/10.1016/j.psyneuen.2015.02.002

Roepke, S., Ziegenhorn, A., Kronsbein, J., Merkl, A., Bahri, S., Lange, J., Lübbert, H., Schweiger, U., Heuser, I., & Lammers, C.-H. (2010). Incidence of polycystic ovaries and androgen serum levels in women with borderline personality disorder. *Journal of Psychiatric Research*, *44*(13), 847–852. https://doi.org/10.1016/j.jpsychires.2010.01.007

Saunders, K. E., & Hawton, K. (2006). Suicidal behaviour and the menstrual cycle. *Psychological Medicine*, *36*(7), 901–912. https://doi.org/10.1017/S0033291706007392

Sher, L., Grunebaum, M. F., Sullivan, G. M., Burke, A. K., Cooper, T. B., Mann, J. J., & Oquendo, M. A. (2012). Testosterone levels in suicide attempters with bipolar disorder. *Journal of Psychiatric Research*, *46*(10), 1267–1271.

Sherwin, B. B., Gelfand, M. M., & Brender, W. (1985). Androgen enhances sexual motivation in females: a prospective, crossover study of sex steroid administration in the surgical menopause. *Psychosomatic Medicine*, *47*(4), 339–351.

Simerly, R., Swanson, L., Chang, C., & Muramatsu, M. (1990). Distribution of androgen and estrogen receptor mRNA-containing cells in the rat brain: An in situ hybridization study. *Journal of Comparative Neurology*, *294*(1), 76–95. https://doi.org/10.1002/cne.902940107

Stanikova, D., Zsido, R. G., Luck, T., Pabst, A., Enzenbach, C., Bae, Y. J., Thiery, J., Ceglarek, U., Engel, C., & Wirkner, K. (2019). Testosterone imbalance may link depression and increased body weight in premenopausal women. *Translational Psychiatry*, *9*(1), 160. https://doi.org/10.1038/s41398-019-0487-5

Tan, R. Y., Grigg, J., & Kulkarni, J. (2018). Borderline personality disorder and polycystic ovary syndrome: A review of the literature. *Australian & New Zealand Journal of Psychiatry*, *52*(2), 117–128. https://doi.org/10.1177/0004867417730650

Trisno, R., Worsley, R., & Kulkarni, J. (2016). Borderline personality disorder and polycystic ovary syndrome. *Australian & New Zealand Journal of Psychiatry*, *50*(4), 385. https://doi.org/10.1177/0004867415615950

Van Wingen, G. A., Zylicz, S. A., Pieters, S., Mattern, C., Verkes, R. J., Buitelaar, J. K., & Fernández, G. (2009). Testosterone increases amygdala reactivity in middle-aged women to a young adulthood level. *Neuropsychopharmacology*, *34*(3), 539–547. https://doi.org/10.1038/npp.2008.2

Viau, V. (2002). Functional cross-talk between the hypothalamic-pituitary-gonadal and -adrenal axes. *Journal of Neuroendocrinology*, *14*(6), 506–513. https://doi.org/10.1046/j.1365-2826.2002.00798.x

Von der Pahlen, B., Lindman, R., Sarkola, T., Mäkisalo, H., & Eriksson, C. P. (2002). An exploratory study on self-evaluated aggression and androgens in women. *Aggressive Behavior*, *28*(4), 273–280. https://doi.org/10.1002/ab.80005

Zhao, G., Ford, E. S., Dhingra, S., Li, C., Strine, T. W., & Mokdad, A. (2009). Depression and anxiety among US adults: Associations with body mass index. *International Journal of Obesity*, *33*(2), 257–266. https://doi.org/10.1038/ijo.2008.268

Zito, S., Nosari, G., Pigoni, A., Moltrasio, C., & Delvecchio, G. (2023). Association between testosterone levels and mood disorders: A minireview. *Journal of Affective Disorders*, *330*, 48–56. https://doi.org/10.1016/j.jad.2023.02.108