The Relationship between the Endocrine System and Aggression

The Endocrine System and Aggression: Key Hormonal Pathways

Aggression is shaped partly by hormones of the endocrine system, especially those from the **hypothalamic–pituitary–adrenal (HPA)** and **hypothalamic–pituitary–gonadal (HPG)** axes. Research across animals and humans links testosterone, cortisol, and several other hormones to aggressive and status-related behavior, but effects are generally small and strongly context-dependent (Mbiydzenyuy & Qulu, 2024; Montoya et al., 2011; Ramírez, 2003; Oliveira et al., 2024; Pante et al., 2022; Batrinos, 2012; Carré & Archer, 2018).

Core Hormonal Systems Involved

HPG axis: Testosterone and related signals

- Testosterone from the HPG axis shows a **small positive association** with aggression in men and women and rises during competitive or aggressive encounters (Denson et al., 2018; Montoya et al., 2011; Ramírez, 2003; Pante et al., 2022; Batrinos, 2012; Carré & Archer, 2018).
- Androgen receptors in aggression-related brain areas (amygdala, hypothalamus, prefrontal cortex) modulate aggressive output; local brain synthesis and conversion to dihydrotestosterone or estradiol further shape effects (Mbiydzenyuy & Qulu, 2024; Ramírez, 2003; Batrinos, 2012; Demas et al., 2006; Soma et al., 2008).
- In rodents, experimentally raising testosterone, GnRH activity, or LH can increase aggression; blocking these pathways often reduces it (Mbiydzenyuy & Qulu, 2024; Torma, 2025; Demas et al., 2006).

HPA axis: Cortisol and stress

- The HPA axis releases cortisol in response to stress. Animal work shows glucocorticoid manipulations can increase or decrease aggression, depending on dose and context (Mbiydzenyuy & Qulu, 2024; Mbiydzenyuy et al., 2024).
- In humans, findings are mixed, but many studies report **lower basal cortisol or blunted HPA activity** in chronically aggressive, antisocial, or bullying behavior, suggesting low stress reactivity may disinhibit aggression (Montoya et al., 2011; Ramírez, 2003; Pante et al., 2022; Babarro et al., 2024).

Dual-hormone (testosterone–cortisol) interaction

Pattern	Typical interpretation	Citations
High T + Low cortisol	Greater aggression / dominance tendency in some studies	(Montoya et al., 2011; Fragkaki et al., 2018; Calvete et al., 2025; Pante et al., 2022; Carré & Archer, 2018)
High T + High cortisol	Weaker or absent T–aggression link	(Fragkaki et al., 2018; Calvete et al., 2025; Pante et al., 2022)
Prenatal or chronic stress disturbing T–C coupling	Altered aggression in late childhood	(Nguyen et al., 2018)

FIGURE 1 How testosterone–cortisol balance is linked to aggression.

Evidence supports a **dual-hormone model**, but effect sizes are small and not always replicated, especially in females (Montoya et al., 2011; Fragkaki et al., 2018; Calvete et al., 2025; Pante et al., 2022; Oliveira & Bakker, 2022).

Other Endocrine and Neuropeptide Influences

- **Oxytocin and vasopressin**: Classically "social" hormones, but can increase territorial or provoked aggression; testosterone modulates their hypothalamic production (Mbiydzenyuy & Qulu, 2024; Denson et al., 2018; Mbiydzenyuy et al., 2024; Oliveira & Bakker, 2022).
- **Thyroid hormones (T3, T4)**: Dysregulation (hypo- or hyperthyroidism) is associated with irritability, impulsivity, and aggression, possibly via effects on monoamine systems and HPA coupling (Ramzan et al., 2025).
- **Adrenal androgens (DHEA, early adrenal androgens)** and locally synthesized brain steroids can sustain aggression when gonadal testosterone is low (e.g., non-breeding seasons) (Ramírez, 2003; Svare, 1983; Demas et al., 2006; Soma et al., 2008).

Development, Trauma, and Sex Differences

- During **childhood and adolescence**, rising gonadal and adrenal androgens, low HPA activity, and psychosocial stress together shape aggressive and antisocial trajectories; hormone–aggression links are typically indirect and bidirectional (hormones influence aggression, and aggression alters hormones) (Ramírez, 2003; Mbiydzenyuy et al., 2024; Nguyen et al., 2018).
- **Trauma timing** modifies the cortisol–testosterone–oxytocin interplay and is proposed as a key factor in adolescent aggression (Fragkaki et al., 2018; Nguyen et al., 2018).
- In women, testosterone–aggression links are similar but small; estradiol, progesterone, oxytocin, and fear of harm substantially shape when aggression is expressed (Denson et al., 2018; Oliveira & Bakker, 2022; Carré & Archer, 2018).

Conclusion

Overall, aggression is not controlled by a single "aggression hormone." Instead, it emerges from interacting endocrine systems—especially testosterone and related sex steroids, cortisol and the stress axis, and social neuropeptides—acting within specific brain circuits and social contexts. Hormonal effects are generally modest, often depend on testosterone–cortisol balance, life stress and trauma, sex, and learned beliefs about aggression.

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