



Review article

Testosterone, cortisol, and human competition



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ABSTRACT

Testosterone and cortisol figure prominently in the research literature having to do with human competition. In this review, we track the history of this literature, concentrating particularly on major theoretical and empirical contributions, and provide commentary on what we see as important unresolved issues. In men and women, athletic competition is typically associated with an increase in testosterone (T) and cortisol (C). Hormone changes in response to non-athletic competition are less predictable. *Person* (e.g., power motivation, mood, aggressiveness, social anxiety, sex, and baseline levels of T and C) and *context* (e.g., whether a competition is won or lost, the closeness of the competition, whether the outcome is perceived as being influenced by ability vs. chance, provocations) factors can influence hormone responses to competition. From early on, studies pointed to a positive relationship between T and dominance motivation/status striving. Recent research, however, suggests that this relationship only holds for individuals with low levels of C – this is the core idea of the *dual-hormone hypothesis*, and it is certain that the broadest applications of the hypothesis have not yet been realized. Individuals differ with respect to the extent to which they embrace competition, but the hormonal correlates of competitiveness remain largely unexplored. Although rapid increases in both T and C associated with competition are likely adaptive, we still know very little about the psychological benefits of these hormonal changes. Administration studies have and will continue to contribute to this inquiry. We close with a discussion of what, we think, are important methodological and mechanistic issues for future research.

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“Ever to be the best and to surpass others”

[–Achilles in *The Odyssey* by Homer]

Introduction

A competition is a social interaction in which access to something valued is contested between individuals and groups. Both (or all) parties must be motivated to gain access to the object of desire, which is in limited supply. But the object itself may be no more than the feeling (e.g., pride, superiority) that comes from victory, and we take as given that, at least for some people, the act of competing itself is its own reward. True to its Latin roots (*-competere*: to meet, come together), a competition is a social encounter. Some evolutionary theorists suggest that it was the emergence of social competition that resulted in the evolution of human intelligence – one mark of intelligence being the ability choose, in uncertain circumstances, the proper strategy for success in competitive contexts (Alexander, 1989; Flinn et al., 2005). Modern humans compete for many things, foremost among them social status and/or desired resources such as money and sexual partners, each of which may be a proxy for status. Some people compete just to be a “winner,” to be better than someone else, smarter, faster, stronger, and happier, have more friends, more influence, more power. As evolutionary and social/developmental psychologist Patricia Hawley writes, “the natural asymmetries among individuals in their ability to prevail in competition result in social dominance” (Hawley, 1999, p. 97–98). Formal contests add structure and, at least on the surface, simplify the social aspects of competing. This is one reason why competitions, naturally occurring or contrived for special purpose, have been used to study the related psychologies of dominance, power-motivation, and status-seeking. Additionally, the psychological and sometimes physical challenges of competing make competition a useful paradigm for exploring the psychobiological correlates of social stress (Salvador, 2005).

Although subject to individual differences, the drive for status, power, and social influence is a pervasive determinant of human behavior. And, it's literally in our blood. Early studies of relationships between testosterone, cortisol, and dominance hierarchies in non-human primates (e.g., Mazur, 1976; Rose et al., 1975), studies relating testosterone and career status in humans, (Purifoy and Koopmans, 1979), and research on aggressive dominance in men (for review, Archer, 2006) prompted the start, beginning more than three decades ago, of research on the hormonal correlates of human competition.

Testosterone (T) is an androgenic steroid hormone secreted from the testes in men and the ovaries in women. Additional amounts of T in both men and women are contributed by the adrenal cortex and by peripheral conversion of adrenocortical precursor hormones (e.g., Stewart, 2003). Cortisol (C) is a glucocorticoid hormone secreted from the adrenal cortex in response to physical and psychological stress (Dickerson and Kemeny, 2004). Certainly, the established association between T and aggressive behavior (see Archer, 1991, 2006; Carré and Olmstead, 2015 for reviews), social status, status striving, and stress, made the measurement of T and C a popular choice for social scientists interested in the psychology of human competition. It was a great help that, beginning in the mid-1980s, radioimmunoassay and, later, enzyme assays were sufficiently developed so that T and C could be assayed from human saliva (e.g., Riad-Fahmy et al., 1982; Riad-Fahmy et al.,

1987; Vining and McGinley, 1987) which could be easily collected from willing participants. And so it is that, with few exceptions (e.g., Casto and Edwards, 2016a; Filaire et al., 1999; McHale et al., 2016; Suay et al., 1999) the research literature on hormones and human competition has mostly to do with T and C. We review here the history and major contributions, theoretical and empirical, to this literature. We intend this review to be comprehensive, but not exhaustive, and along the way we'll highlight what we think are major unresolved issues in the field.

Beginnings

The publication of two studies, one in 1980 and the other shortly thereafter in early 1981, would, in retrospect, usher in more than three decades of research intended to reveal the hormonal correlates and underpinnings of human competition. Drawing partly on work with male rhesus monkeys showing that changes in social status are reflected in changes in blood levels of T (Rose et al., 1975), Allan Mazur and Theodore Lamb (1980) and Michael Elias (1981) reported the results of research designed to determine the effect of athletic competition in human males on blood levels of T and, in the Elias study, T and C. Mazur and Lamb (1980) paired up twelve experienced male tennis players for a total of three doubles matches. Men gave blood 3–4 h before the start of the match and additional samples were given at 1, 2, 3 and 4 h after match completion. Two doubles matches were won “decisively,” and three of the four winning players showed an increase in T 2 h after match completion, while all four losers showed a decrease. In the Elias study, 15 male wrestlers contributed blood samples before and at two intervals after a single match. T increased during the course of the match but had returned to baseline within 35 min of match completion. C levels also increased during competition and remained elevated relative to baseline for at least 35 min after match completion. Percent change in T from before to 10 min after match completion was significantly higher in winners than losers. And, at both 10 and 35 min after match completion, C values in winners were, on average, significantly higher than C values in losers.

Despite novel results, because these studies had relatively few participants, each would have been difficult to publish in today's climate of concern for replicability. But they were then, and still are, widely cited as evidence that T and C increase in response to athletic competition and, a point emphasized in both studies, the response is higher in winners than losers. But, the endocrine results of the two studies were, in fact, conspicuously different. For the tennis players, the increase in T level was not apparent within 1 h after the end of the match, but only became evident 2 h after match completion and only for decisive winners. For the wrestlers, elevated T levels were apparent at 10 min after the match but T levels returned to, or fell below, baseline within 35 min after match completion. To sum up, in the Elias study, T and C increased *during* the course of athletic competition; in the Mazur and Lamb study, an increase in T was only evident more than an hour *after* the end of competition. The matter of timing is not a trivial one. As it turns out, T and C levels can change in advance of, during, and after the end of a competition, and an elevated level of T and/or C at one moment may have a cause or psychological meaning that is quite different from an elevated level of either hormone at some other moment in relation to the competition.

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