AGGRESSIVE BEHAVIOR
Volume 29, pages 107–115 (2003)

Hormones and Competitive Aggression in Women

Elizabeth Cashdan*

Department of Anthropology, University of Utah, Salt Lake City, Utah

This study used diaries of competitive interactions to explore the relationship between hormones and competitive aggression in women. Thirty women completed approximately 10 diary entries each. In each entry, the women described a recent competitive interaction they had engaged in and noted whether it was expressed aggressively or through other tactics. Each woman received a score for the fraction of her competitive interactions that were expressed using physical aggression, verbal aggression, nothing overt, and so on. Hormones (total testosterone, free testosterone, androstenedione, estradiol, and cortisol) were measured in serum early in the follicular phase. Results indicate that women with low levels of androstenedione and total testosterone were less likely to express their competitive feelings overtly, while women with high levels of androstenedione were more likely than other women to express their competitive feelings through verbal aggression. Estradiol was unrelated to competitive tactics, but women with high estradiol levels reported fewer competitive interactions over athletics than did other women. Aggr. Behav. 29:107–115, 2003. © 2003 Wiley–Liss, Inc.

Key words: androgens; testosterone; androstenedione; aggression; competition; female aggression

An association between androgens and aggression in humans has been found frequently but not consistently, and meta-analyses have had difficulty finding patterns in the results [Archer et al., 1998]. The animal literature also shows this variation, but with more consensus about why it exists. This may be because aggression is construed less broadly; as Monaghan and Glickman [1992, p. 282] note, ''biologists, approaching the problem from an evolutionary perspective, have tended to focus on aggressive behaviors as one route to successful competition for limited resources.'' Correlations between aggression and androgens have been found most frequently in times of social instability, when males are actively competing for territory, dominance, or mating access. This has been referred to as the ''challenge'' hypothesis [Wingfield et al., 1987; Wingfield et al., 1990] since it predicts strong associations between hormones and aggression only when one animal is being directly challenged by another. The challenge hypothesis seems to work well for

*Correspondence to: Elizabeth Cashdan, Department of Anthropology, University of Utah, 270 S. 1400 E. Room 102, Salt Lake City, UT 84112-0060. E-mail: cashdan@anthro.utah.edu
Grant sponsor: National Center for Research Resources; Grant number MO1-RR00064.

Received 6 August 2001; amended version accepted 20 January 2002

Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/ab.10041

birds [Wingfield et al., 1987, 1990] and at least some primates [Cavigelli and Pereira, 2000; Sapolsky, 1987].

In the human literature, aggression is usually considered the intentional harming of one person by another [Monaghan and Glickman, 1992], a very broad definition that includes both competitive and non-competitive situations. If the arguments in the preceding paragraph apply to humans, we might expect stronger correlations when individuals are actively competing for resources or position. This expectation is consistent with the finding that testosterone (T) is most strongly associated with aggression in adolescent boys when the aggression is a response to a provocative challenge [Olweus et al., 1988; but see Christiansen and Knusmann, 1987]. Such challenges would, in the real world, often be generated by competition for a resource or position of power. This paper, therefore, focuses explicitly on competitive aggression, since it is anticipated that correlations with androgens will be strongest in such situations.

Although this type of aggression has been referred to as "inter-male" [Moyer, 1968], females of many species, including humans, are also competitive. Women feel as competitive as men do if they are asked about things that are salient to them [Cashdan, 1998], and they often compete aggressively [Burbank, 1987; Campbell, 1991, 1995; Cook, 1992; Eagly and Steffen, 1986; Glazer, 1992; Schuster 1983]. Yet the relationship between hormones and aggression in females is even less clear than in males. Some studies of women and girls have found positive correlations between circulating androgen levels and aggression [Dabbs et al., 1988; Dabbs and Hargrove, 1997; Harris et al., 1996; Inoff-Germaine et al., 1988; Van Goozen et al., 1995; see also van Honk et al., 1999, 2001], but often for some aggression variables and not others, and sometimes for only one androgen of several measured. Other studies have found no relationship between androgen levels and aggression [Cohen-Kettenis and Gooren, 1992], and at least one study found a negative correlation [Gladue, 1991]. Nearly all of these studies have focused on testosterone, but androstenedione is an important source of androgen for women and may have a stronger role to play. This study measured levels of testosterone (free and total), androstenedione, and estradiol in women, in order to see whether any of them are associated with the use of aggression in competitive interactions.

METHODS

Study Population

Thirty-four female University students enrolled in the study. The women were recruited through ads in the campus paper to stay in an on-campus residential facility, where students participate in research in exchange for reduced rent. They were told about the research, including the protocol for hormone collection, before agreeing to participate. All women included in this study were between 19 and 26 years of age (mean 21.5 years), had regular menstrual cycles, and were not taking birth control pills or other hormonal medication. Participants were also non-smokers and were neither hirsute nor obese.

Hormone Collection and Assay

Hormones were assayed from serum. Each participant came to the lab one time early in her follicular phase (6–8 days after the beginning of her menstrual period). Although androgen

levels are higher at midcycle, samples were taken in the early follicular phase for two reasons: (1) to get better control over cycle phase, since it is difficult to time ovulation without regular monitoring of temperature or other indicators, and (2) to more easily average over LH pulsations, which occur with higher frequency (about once an hour) in this phase of the cycle.

In order to average over LH pulsations, three blood samples were taken at 15–minute intervals and pooled for analysis. In order to control for diurnal variation in hormone levels, lab appointments were scheduled to take place approximately one hour after the participant's usual rising time (timing of blood draws ranged from 7:15 am to 9:45 am).

Blood draws and assays were done by the University of Utah Clinical Research Center. Serum levels of total testosterone (TT), free (unbound) testosterone (FT), estradiol (E) and cortisol (C) were measured with Coat–A–Count Radioimmunassay kits from Diagnostic Products Corp. (Los Angeles, CA) and serum androstenedione (A) levels were measured with a radioimmunoassay kit supplied by Diagnostics Systems Laboratories (Webster, TX). All assays were done according to kit protocol, and controls fell within accepted limits. Inter-assay and intra-assay coefficients of variation were less than 10%.

Competition Diaries

Data on how competition was expressed (i.e., aggressively or non-aggressively) were derived from diaries, which acted as a form of guided recall. Participants were asked to think about the day's events each evening and complete an entry each time they had something to report. They were asked to fill out a total of 10 forms each, which they did over the course of an academic term.

Participants were given the following written instructions:

Were there times today when you felt competitive with others, or when you sensed that they were competing with you? If so, please use this form to describe one of those times. Please review the instruction page to see how to fill out the questionnaire.

The instruction form defined competition very broadly, as follows:

What do we mean by competition? Typically, competition involves trying to improve one's position relative to someone else's, or trying to have something that someone else wants. The categories on the forms should clarify this further. For our purposes, competition is defined very broadly, and need not take place as a discrete event. If you are feeling competitive about something, it counts as competition.

The diary form asked what the competition was about, who the competition was with, how the competition was expressed, how it was resolved, and how strongly the person felt about the particular interaction. In order to make responses comparable, a series of options was listed, followed by a space for comments. The options were derived from earlier unstructured diaries and trial forms. The diary form listed eight options for the way competition was expressed:

1. physical aggression
2. verbal aggression (put-downs, barbed humor, sarcasm, being argumentative)
3. verbal assertiveness (non-aggressive comparisons or discussion)
4. showing-off
5. doing the activity faster or better
6. taking possession of desired object or space
7. nothing overt happened; I just felt competitive without expressing it
8. other

Participants were asked to check as many tactics as they wished for each interaction, and to indicate which tactics were taken by themselves and which by their competitors. Only the former are considered here.

Indirect aggression through social manipulation was not included in the diary form, because it was not volunteered by participants in the open-ended diaries and pretests that led to its development. This is unfortunate but not surprising; as Björkqvist et al. [1992] note, such manipulation is socially undesirable and hence is unlikely to be admitted or acknowledged through self-report.

Twelve options were listed for what the competitive interaction was about, and participants were told to indicate which option was most appropriate:

1. success at school (getting better grades than others, etc.)
2. success at work (promotion, recognition, more money)
3. athletic skill (winning at a sport, etc.)
4. success at another task or activity (please specify)
5. looking attractive
6. the attention of a man or men (state their relationship to you)
7. the attention of a woman or women (state their relationship to you)
8. popularity
9. prestige/status
10. a physical object, space, or territory (please specify)
11. getting one's way (getting one's opinion or course of action to prevail)
12. other (please specify).

The competition diaries are a method whose advantages and disadvantages complement those of more commonly-used approaches. Since they are not based on directly observed behavior, they are vulnerable to biases in participant awareness, recall, and accuracy in reporting. However, asking the participant to report on specific recent events should help to mitigate these biases and may make diaries more accurate than questionnaires that ask about customary behavior. The advantage of this method over laboratory studies is that it is able to tap competitive events that are salient to the individual, that occur naturally rather than in contrived situations, and whose outward manifestations may be difficult or impossible to observe.

Analysis

Because participants differed slightly in the number of diary entries they completed, I divided their behavioral scores (for example, the number of times they reported using aggression) by the number of diaries they completed. These numbers were then correlated with hormone levels.

RESULTS

Although participants were asked to complete ten diaries each, not everyone did so. Four participants completed fewer than eight diaries, and these women were dropped from the study. The final sample, therefore, consisted of 30 women. Their hormone levels are in Table I, and correlations between the hormones are in Table II. As noted above, I divided the number of times each participant reported a behavior by the number of diaries she completed. The unit of analysis, therefore, is the fraction of times each competitive behavior

Table I. Hormone Values

	TT	FT	A	E*	C
Mean	50	2.1	223	52	18.6
SD	19	1.2	82	39	6.8
Min	26	0.5	103	25	6.9
Max	109	4.9	382	222	29.6

TT = total testosterone in ng/dl; FT = free (unbound) testosterone in pg/ml; A = androstenedione in ng/dl; E = estradiol in pg/ml; C = cortisol in μg/dl.
*Two participants had E levels higher than would be expected from the protocol; the mean E of the remaining 28 participants was 43 (SD 11.8, range 25–75).

Table II. Correlations Between Hormones

	FT	A	E	C
TT	.64**	.82***	−.07	.18
FT		.56*	−.18	.01
A			−.04	.48*
E				.12

*$p < .01$, **$p < .001$, ***$p < .0001$; $n = 30$.

Table III. Fraction of Participants' Diaries Indicating Competition With Different Tactics

Tactic	*M*	*SD*
Physical aggression	.08	.08
Verbal aggression	.11	.13
Verbal assertiveness	.29	.17
Showing off	.08	.13
Doing activity better	.24	.21
Taking possession	.03	.05
Nothing overt	.31	.16

$n = 30$ women. Numbers sum to more than 1 because a given competitive interaction could involve more than one tactic.

(physical aggression, verbal aggression, showing off, etc.) was exhibited by each participant. As Table III shows, almost a third of the competitive interactions were not expressed overtly at all ("nothing overt happened; I just felt competitive without expressing it"). Verbal aggression was infrequent, being displayed in only 11% of interactions, on the average. Physical aggression was even less frequent, and often involved sports when it was mentioned.

There was no relationship between the fraction of diaries exhibiting physical aggression and hormone levels, but total testosterone (TT) and androstenedione (A) were somewhat higher in women whose diaries showed more verbal aggression (see Table IV). In addition to the active means of showing competition, participants were also given the opportunity to say that the competitive feelings they experienced and described were expressed by "nothing

Table IV. Correlations Between Hormone Levels and Competitive Behaviors

	Verbal Aggression	Nothing Overt
TT	.44*	−.46**
FT	.12	−.39*
A	.40*	−.49**
TT rank	.29	−.43*
FT rank	.08	−.30*
A rank	.41*	−.49**

*$p < .05$, **$p < .01$; $n = 30$.
TT = total testosterone.
FT = free (unbound) testosterone.
A = androstenedione.

overt.'' As table IV shows, women with lower levels of TT, FT, and A were less likely to act on their competitive feelings.

In order to minimize the statistical influence of the woman with the highest testosterone level, hormone values were converted into ranks. As Table IV shows, the correlation between verbal aggression and ranked TT is reduced below statistical significance, although the relationship with A remains as strong as before. The relationships of TT and A with ''nothing overt'' remain significant, and FT shows a trend in the same direction. In neither analysis did estradiol levels show any correlation with aggressive tactics, nor was there any relationship after removing from the sample the two women who had higher than expected E levels.

Although there was no relationship between hormones and physical aggression (there were few physically aggressive interactions), evidence for a possible indirect effect is suggested by differences in the object of competition. Of the 25 reported incidents of physical aggression, 9 involved athletic competition and 9 involved getting one's way (''trying to get one's opinion, plan, course of action, etc. to prevail''). Women with low levels of estradiol were significantly less likely to report athletic competitions than were other women ($r_s = -.60$, $P = .0006$, $n = 30$).

The relationship actually looks more like a step function: none of the 7 women with the highest E levels had any diaries indicating competition over athletics, whereas 78% of the remaining women, who had E levels lower than 50 pg/ml, reported such competition in at least some of their diaries. Since athletics is a domain where some physical aggression is often appropriate, and women with high E levels reported fewer such interactions, perhaps the physically aggressive component may make athletic competition less appealing to such women.

While aggression may be a route to success in certain competitive arenas, it is probably less useful when the object of competition involves success at school or work, attention from a prospective mate, or a host of other arenas in which human adults compete. I used the codings for the object of competition in order to subset the sample into various categories (for example, competition over social attention, attention from prospective mates, competition while engaging in athletics, etc.) in the hope that I would see a positive correlation between hormone levels and aggression in some arenas and not others. However, no clear patterns were detected, perhaps because the number of interactions in these subsets was too small.

DISCUSSION AND CONCLUSIONS

This study used diaries of competitive interactions to explore the relationship between hormones and competitive aggression. The strongest and most consistent result is that women with low levels of androstenedione and testosterone were less likely to express their competitive feelings overtly (i.e., they were more likely to report that "nothing overt happened; I just felt competitive without expressing it."). This suggests that these women were less assertive, a finding consistent with other reported data from this population [Cashdan, 1995]. Women with high levels of androstenedione were also more likely to express their competitive feelings through verbal aggression than were other women. There was no relationship between these hormones and physical aggression, perhaps because there were few instances of the latter in this dataset.

Women with high estradiol (E) levels reported fewer competitive interactions over athletics than did other women. One interpretation of this finding is that the physical aggression that is often useful in sports competition may be unappealing or aversive to women with high E levels. There was, however, no direct relationship between E and use of aggression (physical or verbal) in this dataset.

The validity of the results reported here are limited to the particular phase of the menstrual cycle during which samples were collected (6–8 days after beginning of menstruation). This caveat is obviously important for E but it may also be important for androgens; Dougherty et al. [1997] found that correlations between T and aggression differed markedly in different phases of the menstrual cycle.

What process might be giving rise to the patterns found here? The competition diaries were completed over a period of several weeks, which makes it unlikely that we are seeing the transient effects of a particular competitive interaction on hormone levels (or vice versa). Could chronic conditions nonetheless be driving changes in hormone levels? The clearest correlations found in this study were with androstenedione, which is as much an adrenal as an ovarian hormone. During the follicular phase, especially, there is little ovarian A [Yen and Jaffe, 1986], and it was during this phase that samples were collected for this study. The adrenals increase secretion of androgens (including A) in response to stress-induced secretions of ACTH [Batrinos et al., 1999; Odell and Parker, 1984]. It is therefore worth considering the hypothesis that aggressive competition during the several weeks of the study was stressful to the women who engaged in it, and the high A levels associated with verbal aggression were part of an adrenal stress response.

In order to test this hypothesis, cortisol (the chief adrenal stress hormone, often used as an indicator of stress) was assayed from the original serum samples. Cortisol and A were correlated in this population, as expected ($r = .48$, $P = .008$, $n = 30$), but cortisol levels were not associated with frequency of aggression, unexpressed competition ("nothing overt"), or the other competitive tactics measured in this study. This suggests that the correlation between androgens and aggression is probably not a response to the stress of competition. It seems more likely that differences in hormone levels are leading to differences in personal style and behavior.

Androstenedione is usually considered to be a "weak" androgen, based on its somatic effects, and it has been largely ignored in hormonal studies of aggression [but see Inoff-Germain et al., 1988, who found a relationship with aggression in adolescent girls]. Androstenedione is a major source of androgen for women, however, and the extreme aggressiveness of female hyenas has been attributed to high levels of this hormone [Glickman

et al., 1987]. The results of this study underscore the importance of measuring androstenedione in hormonal studies of female aggressive behavior.

ACKNOWLEDGMENTS

I am grateful to the University of Utah Clinical Research Center staff, particularly its director, J. Kushner, for help and support.

REFERENCES

Archer J, Birring SS, Wu FCW. 1998. The association between testosterone and aggression among young men: Empirical findings and a meta-analysis. Aggr Behav 24:411–420.

Batrinos ML, Panitsa-Faflia C, Koutsoumanis C, Vourlioti T, Koutsilieris M. 1999. Surgical stress induces a marked and sustained increase of adrenal androgen secretion in postmenopausal women. In Vivo 13:147–50.

Björkqvist K, Osterman K, Kaukiainen A. 1992. The development of direct and indirect aggressive strategies in males and females. In: Björkqvist K, Niemela P, editors "Of Mice and Women: Aspects of Female Aggression." San Diego:Academic Press. p 51–64.

Burbank VK. 1987. Female Aggression in Cross-Cultural Perspective. Behav Sci Res 21:70–100.

Campbell A. 1991. The Girls in the Gang. Oxford: Basil Blackwell.

Campbell A. 1995. A Few Good Men: Evolutionary psychology and female adolescent aggression. Ethol Sociobiol 16:99–123.

Cashdan E. 1995. Hormones, sex, and status in women. Horm Behav 29:354–366.

Cashdan E. 1998. Are men more competitive than women? Br J Soc Psychol 34:213–229.

Cavigelli SA, Pereira ME. 2000. Mating season aggression and fecal testoserone levels in male ring-tailed lemurs (*Lemur catta*). Horm Behav 37:246–255.

Christiansen K, Knussmann R. 1987. Androgen levels and components of aggressive behavior in men. Horm Behav 21: 170–180.

Cohen-Kettenis PT, Gooren LJ. 1992. The influence of hormone treatment on psychological functioning of transsexuals. J Psychol Hum Sex 5:55–67.

Cook HBK. 1992. Matrifocality and female aggression in Margariteno society. In: Björkqvist K, Niemela P, editors. "Of Mice and Women: Aspects of Female Aggression." San Diego:Academic Press. p 149–162.

Dabbs JM Jr, Ruback RB, Frady RL, Hopper CH, Sgoutas DS. 1988. Saliva testosterone and criminal violence among women. Pers Individ Diff 9:269–275.

Dabbs JM Jr, Hargrove MF. 1997. Age, testosterone, and behavior among female prison inmates. Psychosom Med 59:477–480.

Dougherty DM, Bjork JM, Moeller FG, Swann AC. 1997. The influence of menstrual-cycle phase on the relationship between testosterone and aggression. Physiol Behav 62:431–435.

Eagly AH, Steffen FJ. 1986. Gender and aggressive behavior: A meta-analytic review of the social psychological literature. Psychol Bull 100:309–330.

Gladue B. 1991. Aggressive behavioral characteristics, hormones, and sexual orientation in men and women. Aggr Behav 17:313–326.

Glazer IM. 1992. Interfemale aggression and resource scarcity in a cross-cultural perspective. In: Björkqvist K, Niemela P, editors. "Of Mice and Women: Aspects of Female Aggression." San Diego:Academic Press. p 163–171.

Glickman SE, Frank LG, Davidson JM, Smith ER. 1987. Androstenedione may organize or activate sex-reversed traits in female spotted hyenas. Proc Natl Acad Sci USA 84:3444–3447.

Harris JA, Rushton JP, Hampson E, Jackson DN. 1996. Salivary testosterone and self-report aggressive and pro-social personality characteristics in men and women. Aggr Behav 22:321–331.

Inoff-Germain G, Arnold G, Nottelmann E, Susman E, Cutler G Jr, Chrousos G. 1988. Relations between hormone levels and observational measures of aggressive behavior of young adolescents in family interactions. Dev Psychol 24:129–139.

Monaghan E, Glickman S. 1992. Hormones and aggressive behavior. In: Becker J, et al., editors. "Behavioral Endocrinology." Cambridge, MA:MIT Press. p 261–286.

Moyer KE. 1968. Kinds of aggression and their physiological basis. Communications in Behavioral Biology 2:65–87.

Odell WD, Parker LN. 1984. Control of adrenal androgen production. Endocr Res 10:617–30.

Olweus D, Mattsson Schalling D, Low H. 1988. Circulating testosterone levels and aggression in adolescent males: A causal analysis. Psychosom Med 50:261–272.

Sapolsky RM. 1987. Stress, social status, and reproductive physiology in free-living baboons. In: Crews D,

editor. "Psychobiology of Reproductive Behavior: An Evolutionary Perspective." Englewood Cliffs, NJ: Prentice Hall. Schuster I. 1983. Women's aggression: an African case study. Aggr Behav 9:319–331.

Van Goozen SHM, Cohen-Kettenis PT, Gooren LJG, Frijda NH. 1995. Gender differences in behavior: Activating effects of cross-sex hormones. Psychoneuroendocrinology 20:343–363.

van Honk J, Tuiten A, Verbaten R, Van den Hout M, Koppeschaar H, Thijssen J, De Haan E. 1999. Correlations among salivary testosterone, mood and selective attention to threat in humans. Horm Behav 36:17–24.

van Honk J, Tuiten A, Hermans E, Putnam P, Koppeschaar H, Thijssen J, Verbaten R, van Doornen L. 2001. A single administration of testosterone induces cardiac accelerative responess to angry faces in healthy young women. Behav Neurosci 115: 238–242.

Wingfield JC, Ball GF, Dufty AM Jr, Hegner, RE, Ramenofsky, M. 1987. Testosterone and aggression in birds. Am Sci 75:602–608.

Wingfield JC, Hegner RE, Dufty AM, Ball GF. 1990. The "challenge hypothesis": Theoretical implications for patterns of testosterone secretion, mating systems and breeding strategies of birds. Am Nat 136: 829–846.

Yen SSC, Jaffe RB. 1986. Reproductive Endrocrinology: Physiology, Pathophysiology and Clinical Management. (2nd ed.). Phladelphia:W.B. Saunders Co.