Hormones and Behavior 56 (2009) 206–213

Contents lists available at ScienceDirect

Hormones and Behavior

journal homepage: www.elsevier.com/locate/yhbeh

Are gonadal steroids linked with orgasm perceptions and sexual assertiveness in women and men?

Sari M. van Anders [a,*], Emily J. Dunn [b]

[a] Departments of Psychology and Women's Studies, Program in Neuroscience, Reproductive Sciences Program, University of Michigan, Mail: 530 Church Street, Ann Arbor, MI 48105, USA
[b] Human Biology Program, Indiana University, 1165 E. Third St., Morrison Hall 101, Bloomington, IN 47405, USA

ARTICLE INFO

Article history:
Received 25 February 2009
Revised 28 March 2009
Accepted 24 April 2009
Available online 3 May 2009

Keywords:
Estradiol
Testosterone
Orgasm
Sexuality
Gender
Sex
Hormone
Perception
Relaxation
Assertiveness

ABSTRACT

Past findings suggest links between orgasms and testosterone (T), as well as sexuality and estradiol (E), and we examined hormone–orgasm links in this study via two hypotheses (below). Participants were 86 women and 91 men who provided a saliva sample and completed a demographics questionnaire, the Orgasm Checklist (Mah and Binik, 2002), the Hurlbert (1991) Index of Sexual Assertiveness, and the Sexual Desire Inventory (Spector and Fremeth, 1996). Results supported the first hypothesis of correlations between T and positive orgasm experience in women, specifically with the relaxation, soothing, and peaceful items in both partnered and solitary orgasm contexts. Results also indicated correlations between E and flooding and spreading items in a solitary orgasm context. There were no associations between hormones and men's perceptions of their orgasm experiences. There was no support for the second hypothesis of associations between higher T and more sexual assertiveness. Post hoc analyses showed associations between E and women's sexual desire, and T and men's sexual desire. We discuss implications of these findings including that solitary vs. partnered orgasm experiences may differ, and suggest that T might be associated with perceptions of psychological experiences of orgasms, and E might be associated with perceptions of physical experiences of orgasms.

Researchers have examined links between sexuality and hormones in both healthy and clinical populations (for a review, see Bancroft, 2005). Hormone–sexuality studies often focus on testosterone (T) and clinical populations, though some have addressed sexual questions in healthy populations. For example, sexual activity increases women's T (van Anders et al., 2007a) and perhaps men's T (Dabbs and Mohammed, 1992; cf. e.g. Lee et al., 1974), and viewing erotic stimuli increases men's T (e.g. Rowland et al., 1987) but perhaps not women's T (Heiman et al., 1991; van Anders et al., 2009). Others have included cortisol (C) (e.g. Exton et al., 2000) and estradiol (E) showing that sexual arousal decreases C and increases E (e.g. van Anders et al., 2009). Though much of sex research is conducted with steroids, researchers have found that peptides like prolactin and oxytocin appear to be higher around orgasm in women and men (e.g. Carmichael et al., 1987; Blaicher et al., 1999; Exton et al., 2001; Krüger et al., 2003).

Orgasm studies have largely been conducted with peptide rather than steroid hormones, so rather less is known about associations between steroids and orgasms. Still, some studies have examined T and orgasms in healthy individuals. Mantzoros et al. (1995) found correlations between DHT (a T metabolite) but not T itself and reported frequency of orgasms in men. Bancroft et al. (1983) found significant positive correlations between T and orgasm frequency over menstrual cycles. van Anders et al. (2007a) found evidence of trait-like associations between women's T and presence of orgasms. Exton et al. (1999) found a statistical trend for orgasm to increase T, and though van Anders et al. (2007a) did not find evidence of this, means were in the expected direction. As such, evidence links orgasms and T but in ways that have not been clearly characterized.

There are several possibilities for conceptualizing proximate mechanisms that underscore, and ultimate theories that address, orgasm–hormone associations and we test two of these in this paper. The first hypothesis is that individuals with higher T might experience orgasms in ways that are more positive in some way (e.g. more pleasurable, rewarding, etc.). There is evidence that androgens have reinforcing properties (Wood, 2004), and perhaps higher T women experience more frequent orgasms because they experience more rewarding orgasms. Further, there are correlations between T and interest in sexual stimuli (Rupp and Wallen, 2007) as well as sexual excitement (van Anders et al., 2009). And, Traish et al. (2007) found that T increased vaginal vasocongestion in rats, and van Anders et al. (2009) found that women's T was correlated with reports of past genital wetness. Women with higher T may experience more vaginal vasocongestion, and thus a heightened and more positive physiological/genital experience of orgasm, or they may pay more attention to sexual cues during sexual activity,

* Corresponding author. Fax: +1 734 763 7480.
E-mail addresses: smva@umich.edu (S.M. van Anders), emdunn@indiana.edu (E.J. Dunn).

0018-506X/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.yhbeh.2009.04.007

which may enhance or increase attention to the positives of orgasm experiences.

The second hypothesis for orgasm–T links is that women with higher T might be more sexually assertive, as past evidence shows links between sexual assertiveness and orgasm frequency (Hurlbert, 1991). And, some evidence, though mixed, does link T with characteristics that might be described as related to assertiveness or confidence (e.g. Udry and Talbert, 1988; Mazur and Booth, 1998; Grant and France, 2001; Cashdan, 1995; van Bokhoven et al., 2006). Accordingly, T may be linked with assertiveness more generally, but with specific ramifications for partnered orgasm experiences. Here, we test for associations, but directionality could be such that higher T leads to more sexual assertiveness, more sexual assertiveness leads to higher T, or a more interactive effect.

Evidence also points to associations between E and sexuality, though few studies have been conducted with men. In many if not most relevant species, E facilitates estrus behaviors (e.g. Giraldi et al., 2004). E and sexual behaviors have also been strongly linked in non-human primates (e.g. Wallen and Zehr, 2004). In women, E is associated with vaginal processes like vasocongestion and lubrication (e.g. Sarrel, 2000), which are likely to be relevant to orgasm experiences. Research with postmenopausal women tends to show that lower levels of E are associated with lower vaginal lubrication (Alexander et al., 2004), and that E administration increases vaginal lubrication (e.g. Alexander et al., 2004; Cayan et al., 2008) as well as neural responses to erotic stimuli (Archer et al., 2006). Fewer studies have included premenopausal women, but findings do indicate E–sexuality links. For example, van Anders et al. (2009) found that women's E increased upon viewing erotic stimuli and predicted genital sexual arousal, and was also correlated with the Orgasm Subscale of the Female Sexual Function Index (FSFI: Rosen et al., 2000). Since there is less research with healthy premenopausal women's sexuality and E (and very little with men's), analyses with E were exploratory.

The majority of sexuality–hormone research is conducted within men or within women, and this decreases the ability to ask the same questions while taking gender into account. Further, the majority of sexuality research with men and premenopausal women includes T but not E, and few studies with men have included E at all. As such, we attempt to examine orgasm associations in men as well as women, including T and E. We hope to extend our limited knowledge about hormone–sexuality associations, and more specifically provide a foundation for future research on links between gonadal steroid hormones and orgasms in healthy men and women.

Methods

Participants

Participants ($N = 177$, mean age = 21 yrs, SD = 3 yrs) were recruited via advertisements posted in the community and via the Psychology Subject Pool, receiving $10 or class credit respectively for their participation. Participants included 91 men and 86 women, and the majority ($n = 162$) were students. Participants were diverse by employment status[1], self-identified ethnicity[2], religion[3], and had mostly resided in the U.S. for their entire lives[4].

Participants mostly self-identified as heterosexual ($n = 151$), with three participants identifying as bisexual, one as pansexual, four as gay, one as queer, one as lesbian, and one as homosexual, with 15 nonresponders. The Kinsey questions of sexual orientation via fantasy and behavior (Kinsey et al., 1948) produced a similar number of heterosexual individuals ($n = 152$) and GLQ (gay, lesbian, queer) individuals ($n = 6$), but a higher number of bisexual individuals ($n = 19$).

Participants were varied by relationship status: single ($n = 69$), dating one person ($n = 20$), dating more than one person ($n = 9$), in a long-term relationship of less than a year ($n = 35$), married, common-law, or in a long-term relationship greater than one year ($n = 34$), in a committed relationship and having other partners ($n = 6$), with four nonresponders.

The data from those women using hormonal contraceptives who volunteered despite selection criteria and two women who reported being menopausal were not analyzed as IRB approval was for women not using hormonal contraceptives. We use gender/sex throughout this paper despite the focus on hormones, because differences cannot knowingly be attributed to biology or gender socialization.

Materials and methods

Health and background questionnaire

This questionnaire contained questions about background and demographics to aid in characterizing the sample, sexual activity and relationships, and possible confounds with hormone measures. Sexual questions had options for individuals to indicate that they were not sexually active with their partners. Sexual activity was defined as activity where the participant's genitals (e.g. penis, clitoris, vagina) were stimulated. Participants were asked to indicate how often they (a) engaged in partnered sexual activity, (b) engaged in masturbation, and (c) experienced orgasm with their partner in the past 7 days, 30 days (on average per week), and six months (on average per week). Self-reported frequencies over the past week, month, and 6 months were highly and significantly correlated for the three variables (ranging from correlations of .43 to .84); as such, we used responses from the past week to minimize the number of analyses and control error inflation. For these and other analyses, both women and men demonstrated variability in their sexual experiences. Participants who selected the N/A response were not included in the relevant analyses.

Orgasm Checklist (Mah and Binik, 2002)

The Orgasm Checklist has two separate lists to characterize orgasms: (1) solitary masturbation, and (2) partnered sexual activity (participants are asked to indicate how they had this orgasm with their partner through five options including a self-listing option). The checklists are otherwise the same though the instructions differ. In each case, participants are instructed to recall their most recent orgasm. Participants are given the opportunity to indicate that they have never experienced either type of orgasm and are then instructed to skip the questionnaire. Participants who have experienced the relevant orgasm are asked to indicate how well each word from a list of 40 options characterizes that orgasm using a 6-pt scale from '0' = 'does not describe it at all' to '5' = 'describes it perfectly'. The 40 items make up 10 Components, which themselves make up three Dimensions (Evaluative, Affective, Sensory). The Orgasm Checklist has high reliability for women and men in the solitary and partnered contexts (Cronbach's $\alpha = .88$–$.92$) (Mah and Binik, 2002) and has been validated in nonclinical populations of younger men and women (e.g. Mah and Binik, 2002, 2005).

Hurlbert Index of Sexual Assertiveness (Hurlbert, 1991)

This index contains 25 brief statements regarding comfort with one's sexual activity, sexuality, sexual body, and ability to communicate sexually. Participants indicate how well each statement characterizes them on a five point scale from '0' = 'all of the time' to '4' = 'never'. The index was originally designed for people with current sexual partners, so we adapted the instructions such that single people could consider their last sexual partner. Participants who had never been sexually active with a partner were instructed to skip this questionnaire. The index was tested on a nonclinical sample of premenopausal younger women (18–31 yrs), who were divided based on a median score of 73 into demographically matched high and low scoring women (Hurlbert, 1991). As would be expected, more

sexually assertive women reported more frequency of sexual activity, orgasms, sexual desire, and sexual satisfaction.

Sexual Desire Inventory (SDI, Spector et al., 1996)

The SDI was adapted by the addition of one question: "During the last month, how often have you had sexual thoughts?". The adapted SDI consists of 15 questions. Participants indicate the strength and frequency of sexual desire over the past month on an 8-point scale. For strength, the scale ranges from '1' = 'no desire' to '7' = 'strong desire'. For frequency, the scale ranges from '0' = 'not at all' to '7' = 'many times a day'. The inventory provides a total SDI score and two subscales (dyadic and solitary SDI). The SDI was used in analyses as a possible mediator between orgasms and hormones. The SDI has been used and validated in previous studies of sexual desire in nonclinical samples of women and men of various ages (e.g. Spector et al., 1996; Spector and Fremeth, 1996; King and Allgeier, 2000), including hormone–desire studies (e.g. van Anders et al., 2007a; 2009). The SDI has test–retest reliability over 1 month of .76 (Carey, 1995).

Saliva samples

Participants provided unstimulated saliva samples by spitting into 17 mL polystyrene tubes after rinsing their mouths with water; samples were frozen until assay. Hormones (E, T) were assayed at the Core Biomarkers Lab at Yerkes Primate Research Center, Emory University, via radioimmunoassay. For E, the assay range was 1–32 pg/mL; the inter-assay coefficients of variation were 7.8% at .107 μg/dL, 5.48% at 1.071 μg/dL, and 10.21% at .20 μg/dL; the intra-assay coefficient of variation was 10.35% at .22 μg/dL. For T, the assay range was 2–500 pg/mL; the inter-assay coefficients of variation were 19.16% at 5.03 pg/mL, 15.08% at 170.81 pg/mL, and 16.40% at 25.31 pg/mL; the intra-assay coefficient of variation was 3.41% at 26.89 pg/mL. There were some participants for whom assay results were unavailable, generally because of low sample quantity.

Men exhibited hormone values within expected ranges for T (mean = 88.11, SD = 42.21, range = 14.02–187.77) and E (mean = 4.09, SD = 2.81, range = .50–12.92). Women also exhibited levels within expected ranges for T (mean = 22.29, SD = 4.20, range = 2.35–56.69) and E (mean = 4.20, SD = 3.04, range = .50–12.48). These ranges do not include outliers (listed under analyses).

There are both advantages and disadvantages to salivary sampling relative to blood sampling of hormones. Salivary sampling is less invasive, less likely to trigger any sort of stress response associated with venipuncture, and poses less (if any) of a biohazard. Salivary sampling is newer and also less widely-used than serum sampling. Still, saliva samples are increasingly prevalent especially in biobehavioral research, and are arguably the norm in this domain. Salivary assays are well-established and validated; e.g. salivary T correlates well with free serum (Khan-Dawood et al., 1984; Granger et al., 2004; Magrini et al., 1986; Swinkels et al., 1988) or total serum (Granger et al., 2004; Shirtcliff et al., 2002) though there are some conflicting results that raise the possibility that the use of salivary T in tests of hormone–behavior relationships may lead to an underestimation of effects in women that can be ameliorated with the use of larger samples of women (Granger et al., 2004). Salivary hormones represent the "bioavailable" fraction, i.e., the portion that is un- or weakly bound to albumin and able to travel to receptors in the body (Quissell, 1993).

Procedure

Participants were part of a larger study addressing methodological investigations and immune–hormone interactions approved by the institutional review board (IRB), and designed specifically to include this orgasm–hormone examination. Testing occurred between 13:00 and 18:00 h to avoid the notably high and rapidly declining steroid levels associated with waking and/or the morning (Khan-Dawood et al., 1984; Axelsson et al., 2005). There are also seasonal rhythms in hormones in both men and women, with T highest in the fall, and lowest in the spring (van Anders et al., 2006); these should not confound any of the analyses, but identifying seasonality may be important. As such, participants were tested between January and April 2008. Women were tested at all phases of their menstrual cycles. As suggested by previous research (Dabbs and de La Rue, 1991), cycle phase does not need to be controlled in studies with T unless cycle phase is of particular interest. In contrast, E changes over the cycle, with a high but brief preovulatory peak and a gradual increase then decrease during the luteal phase. Given the exploratory nature of the present study, menstrual cycle phase was not controlled.

Participants provided a saliva sample and completed a questionnaire packet, which included the Health and Background Questionnaire, the Orgasm Checklist (Mah and Binik, 2002), the Sexual Desire Inventory (Spector et al., 1996), and the Hurlbert Index of Sexual Assertiveness (Hurlbert, 1991). Participants then received either credit or reimbursement depending on participation status.

Analyses

Outliers

There were several hormone outliers (over 3 SD from the mean as well as visually) who were excluded from analyses with those variables; some of these included extreme outliers that likely resulted from blood or food contamination. For men, there were four T outliers and eight E outliers (including four too high to be read). For women, there were 12 T outliers and 12 E outliers (including six too high to be read). The outliers did not appear to differ from nonoutliers on the various measures in the study, indicating that excluding them did not confound analyses. Though there appear to be many outliers, not all of which can be explained by possible blood contamination, the number of outliers per sample and per hormone in men (e.g. four T outliers from 91 men) is generally in line with previous studies (though the number of E outliers is higher); outlier number appears higher likely because there were more samples with two hormones measured in this study compared to other recent studies.

Statistics

We analyzed data with the Statistical Package for the Social Sciences (SPSS) v. 16.0.1. We assessed associations via correlations, and group differences via analyses of variance (ANOVAs). We controlled for error/variability by conducting partial correlations and analyses of covariance (ANCOVAs); the variables we controlled for were age (e.g. Burger et al., 2000), body mass index (BMI) (e.g. Wabitsch et al., 1995), and sampling time (e.g. Axelsson et al., 2005), all of which may be confounded with T, E, and/or the variable of interest and are commonly used covariates in human biobehavioral research with hormones.

Results

Orgasms and hormones

Past experience of orgasm

Participants were asked to report whether they had experienced orgasms with masturbation or partnered sexual activity on the Orgasm Checklist (Mah and Binik, 2002). Twenty women reported no past orgasms with masturbation, and two women did not respond. Seven women reported no past orgasms with partnered sexual activity, and 13 women did not respond (who presumably had never been sexually active with a partner and thus skipped the questionnaire as instructed). There were no significant differences in T or E between the women who reported past orgasms or no past orgasms with masturbation or partnered sexual activity. All men reported past orgasms with masturbation, and all but one reported

past orgasms with partnered sexual activity (who presumably had never been sexually active with a partner and thus skipped the questionnaire as instructed). Participants who had not experienced the solitary or partnered orgasms did not complete the solitary or partnered Orgasm Checklist, respectively.

We also conducted analyses to confirm the previous findings of correlations between T and frequency orgasms in women. There was a trend for a correlation, $r(37)=.26$, $p=.095$, that became significant when only women experiencing orgasms in the past week were included, $r(32)=.38$, $p=.025$. Controlling for age, BMI, and time of sampling did not change this pattern of results, except to slightly decrease the magnitude of the correlations and change this significance to a trend, *partial* $r(29)=.35$, $p=.054$. There were no significant correlations between E and frequency of orgasms in all women, $r(38)=.14$, p .396, or women who experienced orgasms, $r(31)=.10$, $p=.587$. There were also no significant correlations between T and frequency of orgasms in all men, $r(40)=-.19$, $p=.24$, or men who experienced orgasm in the past week, $r(36)=-.23$, $p=.164$, or between E and frequency of orgasms in all men, $r(38)=.23$, $p=.158$, or men who experienced orgasm in the past week, $r(34)=.2$, $p=.189$. Controlling for age, BMI, and time of day did not change this pattern of results.

Orgasm Checklist

We first conducted partial correlations (controlling for age, BMI, and sampling time) with the Dimensions and gonadal hormones; when statistical significance or trend level was reached for the Dimension, we conducted post hoc analyses with the contributing Components. Similarly, when statistical significance or trend level was reached for the Component, we conducted further post hoc analyses with the contributing Items. For women, please see Table 1 for significant or trend level partial correlations.

Men. In men, there were no significant partial correlations between T or E and the Partnered or Solitary Orgasm Dimensions.

Testosterone in women. In women, T was significantly correlated with the Partnered Evaluative Dimension (see Fig. 1a), so we checked which two contributing Components (Pleasurable Satisfaction; Relaxation) were correlated with T. T was significantly correlated with the Partnered Relaxation Component, but not the Partnered Pleasurable Satisfaction Component (see Fig. 1b). The Partnered Relaxation Component was made of three Items (Peaceful, Soothing, Relaxing), and all three were significantly correlated with T (see Fig. 1c). Results were similar for the Solitary Evaluative Dimension. Please see Table 1 for statistics.

Table 1
Partial correlations between testosterone (T) and estradiol (E) and Orgasm Checklist (Mah and Binik, 2002) parameters in women reaching statistical significance or trend.

Context Dimension Component Item	T	E
Partnered		
Evaluative	$r(44)=.38$, $p=.009$	
Relaxation	$r(44)=.46$, $p=.001$	
Relaxing	$r(45)=.39$, $p=.007$	
Peaceful	$r(44)=.46$, $p=.001$	
Soothing	$r(45)=.42$, $p=.003$	
Solitary		
Evaluative	$r(51)=.24$, $p=.082$	
Relaxation	$r(52)=.35$, $p=.010$	
Relaxing	$r(52)=.25$, $p=.072$	
Peaceful	$r(52)=.32$, $p=.018$	
Soothing	$r(52)=.36$, $p=.008$	
Sensory		$r(46)=.29$, $p=.049$
Building		$r(46)=.28$, $p=.058$
Building		$r(46)=.38$, $p=.008$
Flooding		$r(46)=.36$, $p=.012$
Flooding		$r(46)=.47$, $p=.001$
Flushing		$r(46)=.36$, $p=.012$
Flushing		$r(46)=.31$, $p=.030$
Spreading		$r(46)=.31$, $p=.030$

Note. There were no significant correlations between gonadal hormones and Orgasm Checklist parameters in men.
Covariates were age, BMI, and time of sampling.

Estradiol in women. E was significantly correlated with the Solitary Sensory Dimension, so we checked which six contributing Components (Building; Flooding; Flushing; Spurting; Throbbing; General Spasms) were correlated with E. Two of the Solitary Components (Flooding; Flushing) were significantly correlated with E, and there was a trend for Building to be correlated with E. The Solitary Flooding Component is made of two Items (Flowing; Flooding), and only Flooding was significantly correlated with E. The Solitary Flushing Component is also made of two Items (Flushing; Spreading) and both were significantly correlated with E. The Building Component is also made of two Items (Building; Swelling), and only Building was significantly correlated with E. Please see Table 1 for statistics.

Sexual frequency and desire as potential confounds. To check whether the significant correlations reported above were secondary to factors relating to sexual activity or desire, we conducted additional partial correlations. Adding partnered sexual activity as a covariate made the correlation between T and the Partnered Evaluative Dimension larger and more significant, *partial* $r(32)=.46$, $p=.006$, but did not change any other correlations in the Partnered Orgasm context. Controlling for dyadic SDI did not change any correlations in the Partnered Orgasm context.

Adding masturbation frequency as a covariate reduced the association between T and the Solitary Evaluative Dimension to nonsignificance, *partial* $r(49)=.23$, $p=.105$ and also reduced the association between E and the Solitary Sensory Dimension to a trend again, *partial* $r(44)=.26$, $p=.088$, but did not change any other correlations in the Solitary Orgasm context. Adding solitary SDI as a covariate reduced the correlation between E and the Solitary Sensory Dimension, *partial* $r(45)=.21$, $p=.159$, but did not change any other correlations in the Solitary Orgasm Context.

Hormones and sexual assertiveness

Hurlbert sexual assertiveness scale and hormones

There were no significant correlations between sexual assertiveness and women's T, $r(52)=.09$, $p=.517$, or E, $r(46)=.17$, $p=.249$, or with men's T, $r(69)=-.12$, $p=.315$, or E, $r(63)=.11$, $p=.371$. Controlling for age, sampling time, and BMI or conducting correlations only in nonsingle participants did not change this pattern. These results do not provide support for the hypothesis that T is correlated with more sexual assertiveness.

Sexual assertiveness was correlated with frequency of partnered orgasms during the past week for all participants, $r(103)=.22$, $p=.022$, with a trend for a correlation in women alone, $r(58)=.23$, $p=.079$, but no significant correlation in men alone, $r(43)=.20$, $p=.198$, though all correlations were near in size.

Hormones and sexual desire

Though the study was not designed to assess hormone–desire associations, we were able to conduct these analyses. In women, T was not significantly correlated with Solitary SDI, $r(59)=-.01$, $p=.959$, Dyadic SDI, $r(60)=.18$, $p=.16$, or Total SDI, $r(60)=.16$, $p=.204$. Controlling for age, time of sampling, and BMI did not change this pattern of results. E was significantly correlated with women's Total SDI, $r(54)=.32$, $p=.016$, but not Solitary SDI, $r(54)=.21$, $p=.114$, or Dyadic SDI, $r(54)=.19$, $p=.162$. Controlling for age, time of sampling,

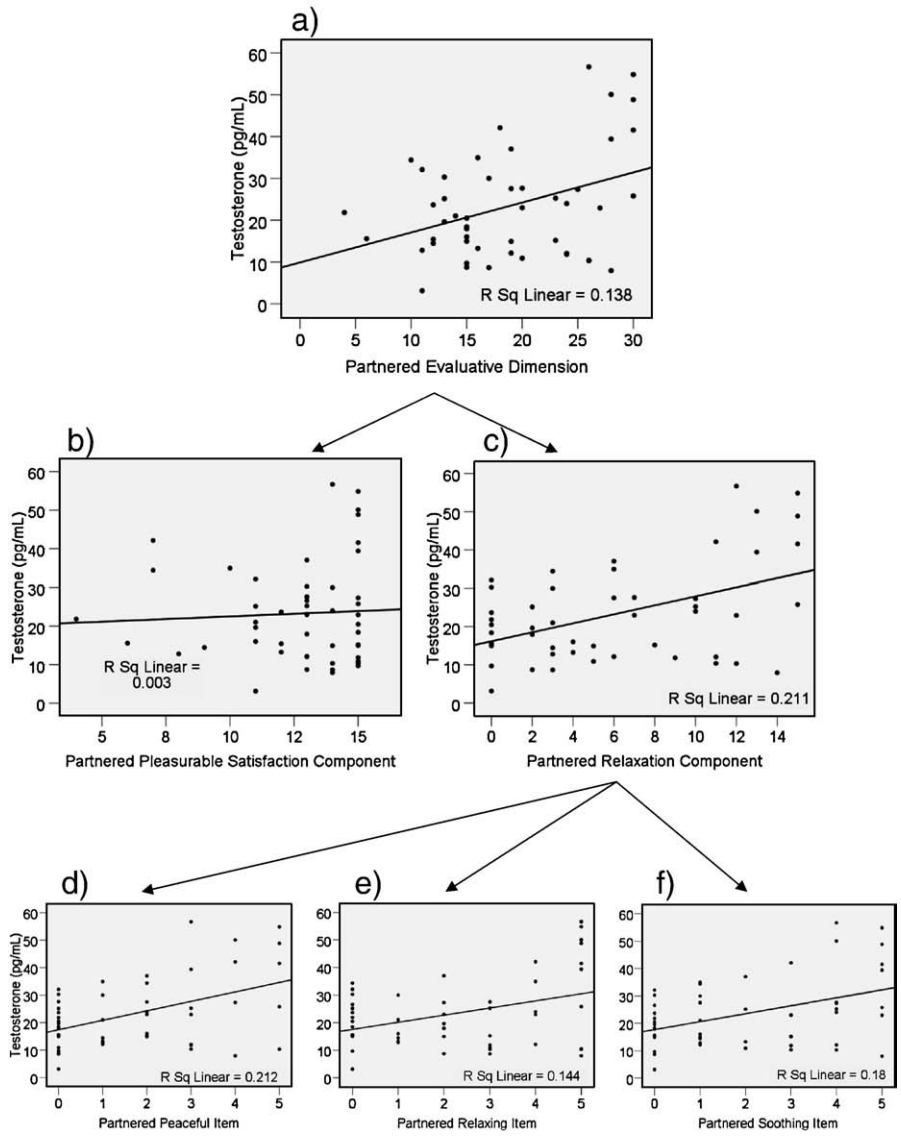

Fig. 1. Correlations between testosterone (pg/mL) and scores on the Partnered Orgasm Checklist (Mah and Binik, 2002) in women. (a) Evaluative Dimension*; (b) Pleasurable Satisfaction Component; (c) Relaxation Component*; (d) Peaceful Item*; (e) Relaxing Item*; (f) Soothing Item*. Arrows indicate post hoc correlations after significant omnibus correlation. '*' indicates a significant correlation at $p<.05$. Correlations were similar for the Solitary Dimension and contributory Components and Items.

and BMI made the correlation between E and Total SDI slightly stronger, *partial* $r(51)=.34$, $p=.34$, $p=.012$, and the correlation between E and Solitary SDI a trend, *partial* $r(51)=.24$, $p=.079$.

In men, T was significantly correlated with Solitary SDI, $r(77)=.25$, $p=.025$, and a trend for Total SDI, $r(78)=.19$, $p=.095$, but was not significantly correlated with Dyadic SDI, $r(78)=.10$, $p=.371$. There were no significant correlations between E and Solitary SDI, $r(71)=-.03$, $p=.817$, Dyadic SDI, $r(72)=-.08$, $p=.489$, or Total SDI, $r(72)=-.09$, $p=.457$. Controlling for age, time of sampling, and BMI did not change this patterns of results.

Discussion

Some past evidence has shown that healthy premenopausal women's T is correlated in a trait-like way with orgasm occurrence, frequency, and experience (Bancroft et al., 1983; Mantzoros et al. 1995; van Anders et al., 2007a; 2009), but these associations have not been clearly characterized. Accordingly, we tested two hypotheses to explore T–orgasm associations: women with higher T (1) experience orgasms that are more positive; and/or (2) are more sexually assertive. We conducted exploratory analyses of E based previous orgasm links (e.g. van Anders et al., 2009), and we included men to explore possible associations. Results confirmed previous correlations between orgasm frequency and T in women (van Anders et al., 2007a), and provided support for Hypothesis 1 in women, that higher T is associated with more positive orgasm experiences in women. There was no support for the second hypothesis, that higher T would be associated with more sexual assertiveness.

These analyses with women are among the first to show that T is correlated with perceptions of relaxing, soothing, and peaceful experiences during partnered orgasms (via the Orgasm Checklist, Mah and Binik, 2002). These associations were not explained by frequency of partnered sexual activity or level of dyadic sexual desire. Correlations in the solitary orgasm context were similar, though analyses indicated that masturbation frequency may account for them. The association between T and the Evaluative but not Sensory or Affective Dimensions of the Orgasm Checklist is suggestive that orgasm–T links in women may be related to perceptions of psychological rather than genital experiences of orgasm. There was also novel evidence in women that E was associated with perceptions of flooding, flushing, spreading, and building during solitary orgasms, and there was some indication that this was accounted for by variation

in masturbation frequency and solitary sexual desire. The association between E and the Sensory but not Evaluative or Affective Dimensions of the Checklist is suggestive that orgasm–E links in women may be related to perceptions of physical rather than psychological experiences of orgasm.

Our conclusion that T is linked with psychological and E with physical experiences during orgasm accords with extant conceptualizations of T being linked to psychological constructs like sexual desire (e.g. Bachmann, 2002), and E more to physical constructs like vaginal lubrication (Traish et al., 2002). Of course (and see Mah and Binik, 2005, for further discussion), genital arousal and desire can influence each other, and evidence does link T with some genital parameters (e.g. genital wetness, van Anders et al., 2009; increased genital arousal, Traish et al., 2007) and E with some psychological parameters (e.g. increased neural responses to erotic stimuli, Archer et al., 2006). Interestingly, some research has shown divergence between physical vs. psychological sexual arousal (e.g. Suschinsky et al., in press), so there already is evidence that sexual parameters can be differentiated along these lines. However, van Anders et al. (2009) did not find evidence of associations between T and psychological sexual arousal as one might predict based on this dichotomy.

The results with E highlight the need to address context as the Solitary but not Partnered Sensory experiences were correlated with E. Clinical research has found that E administration does not appear to increase women's orgasms (for a review, see Meston et al., 2004) presumably in the partnered context that most clinical sexuality research is conducted. It may be that a partner introduces sensations or contexts that qualitatively change the orgasm experience, or it may be that partnered sexual activity reduces the opportunity to experience or focus on sensations, such that hormonal associations become less apparent or nonexistent. As such, our novel finding of E-Sensory Orgasm experiences has implications for conceptualizing experiences of orgasms, how partner presence affects the experience, and what contextual factors may modulate hormone–behavior associations.

Results with T also have implications and point to future avenues of research. T and relaxing experiences of orgasms were correlated in women; does orgasm-related relaxation increase T or do higher T women find orgasms more relaxing because they are more stressed pre-orgasm? Are the rewarding effects of T found in other species (e.g. Wood, 2004) related to 'relaxation' or alleviation of stress in some way? And, do higher T women have different neural responses during orgasm associated with heightened experience of relaxation and peacefulness? Neither researchers nor laypeople typically associate T with relaxation or peacefulness, so these associations may also lead to reconceptualizing T. Indeed, T-relaxation links may in part explain a past finding of increased T post-cuddling as well as post-intercourse (van Anders et al., 2007a,b).

We also hypothesized that T and sexual assertiveness would be linked based on past evidence, though mixed, of associations between T and assertiveness or confidence (e.g. Cashdan, 1995), but no correlation was apparent between T and sexual assertiveness in our study. One limitation is that we adapted the measure so that single people could consider a past relationship, but the sexual assertiveness questionnaire was designed for partnered women. Correlations within nonsingle and single participants were similarly nonsignificant, and Cronbach's alphas were high within single and nonsingle men and women, suggesting similar and high internal consistency for single and nonsingle women and men.

We were able to conduct post hoc analyses on hormone–desire associations (via the SDI, Spector et al., 1996). Findings showed correlations between E and women's desire (total; perhaps solitary), but no correlations with T. The literature is mixed on T–desire associations in healthy premenopausal women, with evidence of significant correlations (e.g. van Anders et al., 2007a; 2007b; Van Goozen et al., 1997) and null associations (e.g. van Anders and Hampson, 2005; Alexander et al., 1990). Some limited evidence has linked women's E with desire via the FSFI but not the SDI (van Anders et al., 2009), so these results are among the first to indicate E–desire links in women via the SDI. There were also links between T and men's desire (solitary; perhaps total), but no correlations with E. Studies have rarely addressed T–desire links in healthy men, but some studies show no significant correlations (e.g. van Anders et al., 2007b). These results add to the body of mixed evidence of hormone–desire associations in healthy women and men. At present, the reasons for diverging associations are unknown, but may relate to sampling issues (e.g. studies with more sexually experienced or comfortable women) or other putated or unidentified factors (for a discussion of these complexities, see Bancroft, 2002; 2005).

Why were there no correlations between men's orgasm experiences and gonadal hormones? There was wide variability in men's scores on the Orgasm Checklist, so constricted range cannot explain the null associations. Bancroft (2005) suggests that sexuality–T research in men may be subject to a threshold effect whereby only men with clinically and atypically high or low levels show alterations in sexual parameters. So, whereas men may exhibit a step-like association, women may exhibit a continuous association. T ranges in men are larger absolutely, but smaller relative to women's ranges, so perhaps men's lower variability in T may account for the lack of significant associations. Past research has also shown associations between T and some sexual parameters in men but not women, while other parameters show links in women but not men. For example, sexual activity strongly and immediately increases women's T (van Anders et al., 2007a) but has no or weak or delayed effects on men's T (e.g. Lee et al., 1974; Dabbs and Mohammed, 1992). In contrast, viewing erotic stimuli reliably increases men's T (e.g. Rowland et al., 1997) but not women's T (Heiman et al., 1991; van Anders et al., 2009).

There are methodological issues meriting consideration. The first is that a relatively large number of women in the sample, though recruited specifically for a study concerning sexuality, had not orgasmed or masturbated recently. This may not be entirely uncharacteristic of young women volunteering for hormone–sexuality studies. For example, Richters et al. (2006) found in a national survey of adults (16–59) that women experienced orgasm in 69% of their last sexual encounters, and Laumann et al. (1994) reported that 29% of women always (vs. less frequently) experienced orgasms with their partner. Given that the women in this study were younger and at earlier stages in their sexual careers, the proportions experiencing recent orgasms or masturbation fall into the patterns suggested by these past studies. Another issue is that the sample was predominantly heterosexually-identified, and results, as such, cannot be understood to generalize to GLBQ-identified individuals since partner-related results may be confounded with gender/sex of partner (i.e. that women had men partners, and men had women partners). The sample was, however, diverse in other ways, including ethnicity and employment status, and to a much lesser extent religion. An additional limitation is the preliminary nature of these data and associations; replication is clearly needed, especially of which factors (e.g. sexual activity? sexual desire?) might mediate hormone–orgasm perception links. One more limitation when considering the findings with E (but not T per se: Dabbs and de La Rue, 1991) is that menstrual cycle phase was not controlled. Though this would not affect the pattern of significant findings, the variation in E due to cycle phase may have obscured some other potential associations, or menstrual cycle phase may moderate hormone–orgasm perception links. Future directions building on this exploratory study may include attention to menstrual cycle as a moderator and/or source of variance.

Evidence from the present study support the need to incorporate psychological and biological measures into bio-sexuality research as suggested by Mah and Binik (2001) among others. And, results from

this study have methodological implications for Mah and Binik's Orgasm Checklist (2002). Evidence from this study is suggestive that the analyses should be conducted with the three major Dimensions, but also with the contributory Components and Items once omnibus significance is determined. And, results indicate that some of Components (e.g. Evaluative) may be more internally consistent than others (e.g. Sensory), at least when considering hormone associations. Thus, one benefit of conducting sexual research with both psychological and physiological measures is understanding, e.g., how hormones might be associated with specific aspects of sexuality; another benefit is considering psychological scales from additional angles resulting from incorporation of physiological measures.

Results from the present study indicate novel associations between hormones and orgasms that relate to perceptions of orgasm experiences in women. Findings thus add to a growing body of literature showing T– and E–sexuality associations in healthy individuals, especially women. With neither intention nor desire to revisit mind/body dualisms, results nonetheless are suggestive that T might be more strongly linked to perceptions of psychological experiences of orgasm, and E might be more strongly linked to physiological perceptions of experiences of orgasm in women. As such, future research may focus less on 'what an orgasm is' and more on concordant or parallel physiological correlates of diversely-experienced orgasms.

Acknowledgments

This research was conducted while SMvA was an Assistant Professor in the Department of Psychological and Brain Sciences at Indiana University Bloomington, and an Assistant Research Scientist at the Kinsey Institute for Research in Sex, Gender, and Reproduction. We would like to acknowledge the help of C. Allard, J. Brenay, K. Johnson, S. Josway, K. Reinecke, and B. Rupert in data collection and entry. We would also like to acknowledge A. Stewart and G. van Anders for reading earlier drafts of this manuscript, and K. Mah for providing the Orgasm Checklist.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.yhbeh.2009.04.007.

References

Alexander, G.M., Sherwin, B.B., Bancroft, J., Davidson, D.W., 1990. Testosterone and sexual behavior in oral contraceptive users and nonusers: a prospective study. Horm. Behav. 24, 388–402.
Alexander, J.L., Kotz, K., Dennerstein, L., Kutner, S.J., Wallen, K., Notelovitz, M., 2004. The effects of postmenopausal hormone therapies on female sexual functioning: a review of double-blind, randomized controlled trials. Menopause 11, 749–765.
Archer, J.S., Love-Geffen, T.E., Herbst-Dam, K.L., Swinney, D.A., Chang, J.R., 2006. Effect of estradiol versus estradiol and testosterone brain-activation patterns in postmenopausal women. Menopause 13, 528–537.
Axelsson, J., Ingre, M., Skerstedt, T., Holmback, U., 2005. Effects of acutely displaced sleep on testosterone. J. Clin. Endocrinol. Metab. 90, 4530–4535.
Bachmann, G.A., 2002. The hypoandrogenic woman: pathophysiologic overview. Fertil. Steril. 77, S72–S76.
Bancroft, J., 2002. Sexual effects of androgens in women: some theoretical considerations. Fertil. Steril. 77, S55–S59.
Bancroft, J., 2005. The endocrinology of sexual arousal. J. Endocrinol. 186, 411–427.
Bancroft, J., Sanders, D., Davidson, D., Warner, P., 1983. Mood, sexuality, hormones, and the menstrual cycle. III. Sexuality and the role of androgens. Psychosom. Med. 45, 509–516.
Blaicher, W., Gruber, D., Bieglmayer, C., Blaicher, A.M., Knogler, W., Huber, J.C., 1999. The role of oxytocin in relation to female sexual arousal. Gynecol. Obstet. Invest. 47, 125–126.
Burger, H.G., Dudley, E.C., Cui, J., Dennerstein, L., Hopper, J.L., 2000. A prospective longitudinal study of serum testosterone, dehydroepiandrosterone sulfate, and sex hormone-binding globulin levels through the menopause transition. J. Clin. Endocrinol. Metab. 85, 2832–2838.
Carey, M.P., 1995. Test–retest reliability of the Sexual Desire Inventory. Unpublished raw data.
Carmichael, M.S., Humbert, R., Dixen, J., Palmisano, G., Greenleaf, W., Davidson, J.M., 1987. Plasma oxytocin increases in the human sexual response. J. Clin. Endocrinol. Metab. 64, 27–31.
Cashdan, E., 1995. Hormones, sex, and status in women. Horm. Behav. 29, 354–366.
Cayan, F., Dilek, U., Pata, O., Dilek, S., 2008. Comparison of the effects of hormone therapy regimens, oral and vaginal estradiol, estradiol + drospirenone and tibolone, on sexual function in healthy postmenopausal women. J. Sex. Med. 5, 132–138.
Dabbs Jr., J.M., de La Rue, D., 1991. Salivary testosterone measurements among women: relative magnitude of circadian and menstrual cycles. Horm. Res. 35, 182–184.
Dabbs Jr, JM, Mohammed, S., 1992. Male and female salivary testosterone concentrations before and after sexual activity. Physiol. Behav. 52, 195–197.
Exton, M.S., Bindert, A., Krüger, T., Scheller, F., Hartmann, U., Schedlowski, M., 1999. Cardiovascular and endocrine alterations after masturbation-induced orgasm in women. Psychosom. Med. 61, 280–289.
Exton, M.S., Krüger, T.H., Bursch, N., Haake, P., Knapp, W., Schedlowski, M., Hartmann, U., 2001. Endocrine responses to masturbation-induced orgasm in healthy men following a 3-week sexual abstinence. World J. Urol. 19, 377–382.
Exton, N.G., Truong, T.C., Exton, M.S., Wingenfeld, S.A., Leygraf, N., Saller, B., Hartmann, U., Schedlowski, M., 2000. Neuroendocrine response to film-induced sexual arousal in men and women. Psychoneuroendocrinology 25, 187–199.
Giraldi, A., Marson, L., Nappi, R., Pfaus, J., Traish, A.M., Vardi, Y., Goldstein, I., 2004. Physiology of female sexual function: animal models. J. Sex. Med. 1, 237–253.
Granger, D.A., Shirtcliff, E.A., Booth, A., Kivlighan, K.T., Schwartz, E.B., 2004. The "trouble" with salivary testosterone. Psychoneuroendocrinology 29, 1229–1240.
Grant, J., France, J.T., 2001. Dominance and testosterone in women. Biol. Psychol. 58, 41–47.
Hurlbert, D.F., 1991. The role of assertiveness in female sexuality: a comparative study between sexually assertive and sexually nonassertive women. J. Sex Marital Ther. 17, 183–190.
Heiman, J.L., Rowland, D.L., Hatch, J.P., Gladue, B.A., 1991. Psychophysiological and endocrine responses to sexual arousal in women. Arch. Sex. Behav. 20, 171–186.
Khan-Dawood, F.S., Choe, J.K., Dawood, M.Y., 1984. Salivary and plasma bound and "free" testosterone in men and women. Am. J. Obstet. Gynecol. 148, 441–445.
King, B.E., Allgeier, E.R., 2000. The Sexual Desire Inventory as a measure of sexual motivation in college students. Psych. Rep. 86, 347–350.
Kinsey, A.C., Pomeroy, W.B., Martin, C.E., Gebhard, P.H., 1948. Sexual Behavior in the Human Male. WB Saunders, Philadelphia.
Krüger, T.H., Haake, P., Chereath, D., Knapp, W., Janssen, O.E., Exton, M.S., Schedlowski, M., Hartmann, U., 2003. Specificity of the neuroendocrine response to orgasm during sexual arousal in men. J. Endocrinol. 177, 57–64.
Laumann, E.O., Gagnon, J.H., Michael, R.T., Michaels, S., 1994. The Social Organization of Sexuality: Sexual Practices in the United States. University of Chicago, Chicago.
Lee, P.A., Jaffe, R.B., Midgley, A.R., 1974. Lack of alteration of serum gonadotropins in men and women following sexual intercourse. Am. J. Obstet. Gynecol. 120, 985–987.
Magrini, G., Chiodini, G., Rey, F., Felber, J.P., 1986. Further evidence for the usefulness of the salivary testosterone radioimmunoassay in the assessment of androgenicity in man in basal and stimulated conditions. Horm. Res. 23, 65–73.
Mah, K., Binik, Y.K., 2001. The nature of human orgasm: a critical review of major trends. Clin. Psychol. Rev. 21, 823–856.
Mah, K., Binik, Y.K., 2002. Are all orgasms alike? Evaluating a two-dimensional model of the orgasm experience across sex and sexual content. J. Sex Res. 39, 104–113.
Mah, K., Binik, Y.K., 2005. Are orgasms in the mind or the body? Psychosocial versus physiological correlates of orgasmic pleasure and satisfaction. J. Sex Marital Ther. 31, 187–200.
Mantzoros, C.S., Georgiadis, E.I., Trichopoulos, D., 1995. Contribution of dihydrotestosterone to male sexual behavior. Br. Med. J. 310, 1289–1291.
Mazur, A., Booth, A., 1998. Testosterone and dominance in men. Behav. Brain Sci. 21, 353–363.
Meston, C.M., Levin, R.J., Sipski, M.L., Hull, E.M., Heiman, J.R., 2004. Women's orgasm. Annu. Rev. Sex Res. 15, 173–257.
Quissell, D.O., 1993. Steroid hormone analysis in human saliva. Ann. N. Y. Acad. Sci. 694, 143–145.
Richter, J., de Visser, R., Rissel, C., Smith, A., 2006. Sexual practices at last heterosexual encounter and occurrence of orgasm in a National Survey. J. Sex Res. 43, 217–226.
Rosen, R., Brown, C., Heiman, J., Leiblum, S., Meston, C., Shabsigh, R., Ferguson, D., D'Agostino Jr, R., 2000. The Female Sexual Function Index (FSFI): a multidimensional self-report instrument for the assessment of female sexual function. J. Sex Marital Ther. 26, 191–208.
Rowland, D.L., Heiman, J.R., Gladue, B.A., Hatch, J.P., Doering, C.H., Weiler, S.J., 1987. Endocrine, psychological and genital response to sexual arousal in men. Psychoneuroendocrinology 12, 149–158.
Rupp, H.A., Wallen, K., 2007. Relationship between testosterone and interest in sexual stimuli: the effect of experience. Horm. Behav. 52, 581–589.
Sarrel, P.M., 2000. Effects of hormone replacement therapy on sexual psychophysiology and behavior in postmenopause. J. Womens Health Gend. Based Med. 9, S25–S32.
Shirtcliff, E.A., Granger, D.A., Likos, A., 2002. Gender differences in the validity of testosterone measured in saliva by immunoassay. Horm. Behav. 42, 62–69.
Spector, P., Carey, M.P., Steinberg, L., 1996. The Sexual Desire Inventory: development, factor structure, and evidence of reliability. J. Sex Marital Ther. 22, 175–190.
Spector, P., Fremeth, S.M., 1996. Sexual behaviors and attitudes of geriatric residents in long-term care facilities. J. Sex Mar. Ther. 22, 235–246.
Suschinsky, K.D., Lalumière, M.L., Chivers, M.L., in press. Sex differences in patterns of genital sexual arousal: measurement artifacts or true phenomena? Arch. Sex. Behav.
Swinkels, L.M., Meulenberg, P.M., Ross, H.A., Benraad, T.J., Salivary and plasma free testosterone and androstenedione levels in women using oral contraceptives containing desogestrel or levonorgestrel. Ann. Clin. Biochem. 25, 354–359.

Traish, A.M., Kim, N.N., Munarriz, R., Moreland, R., Goldstein, I., 2002. Biochemical and physiological mechanisms of female genital sexual arousal. Arch. Sex. Behav. 31, 393–400.
Traish, A.M., Kim, S.W., Stankovic, M., Goldstein, I., Kim, N.N., 2007. Testosterone increases blood flow and expression of androgens and estrogen receptors in the rat vagina. J. Sex. Med. 4, 609–619.
Udry, J.R., Talbert, L.M., 1988. Sex hormone effects on personality at puberty. J. Pers. Soc. Psychol. 54, 291–295.
van Anders, S.M., Brotto, L., Farrell, J., Yule, M., 2009. Associations between physiological and subjective sexual response, sexual desire, and salivary steroid hormones in healthy premenopausal women. J. Sex. Med. 6, 739–751.
van Anders, S.M., Hamilton, L.D., Schmidt, N., Watson, N.V., 2007a. Associations between testosterone secretion and sexual activity in women. Horm. Behav. 51, 477–482.
van Anders, S.M., Hamilton, L.D., Watson, N.V., 2007b. Multiple partners are associated with higher testosterone in North American men and women. Horm. Behav. 51, 454–459.
van Anders, S.M., Hampson, E., 2005. Waist-to-hip ratio is positively associated with bioavailable testosterone but negatively with sexual desire in healthy premenopausal women. Psychosom. Med. 67, 246–250.
van Anders, S.M., Hampson, E., Watson, N.V., 2006. Seasonality, waist-to-hip ratio, and salivary testosterone. Psychoneuroendocrinology 31, 895–899.
van Bokhoven, I., van Goozen, S.H., van Engeland, H., Schaal, B., Arsenault, L., Séquin, J.R., Assaad, J.M., Nagin, D.S., Vitaro, F., Tremblay, R.E., 2006. Salivary testosterone and aggression, delinquency, and social dominance in a population-based longitudinal study of adolescent males. Horm. Behav. 50, 118–125.
Van Goozen, S.H.M., Wiegant, M., Endert, E., Helmond, F.A., Van de Poll, N.E., 1997. Psychoendocrinological assessment of the menstrual cycle: the relationship between hormones, sexuality, and mood. Arch. Sex. Behav. 26, 359–382.
Wabitsch, M., Hauner, H., Heinze, E., Böckmann, A., Benz, R., Mayer, H., Teller, W., 1995. Body fat distribution and steroid hormone concentrations in obese adolescent girls before and after weight reduction. J. Clin. Endocrinol. Metab. 80, 3469–3475.
Wallen, K., Zehr, J.L., 2004. Hormones and history: the evolution and development of primate female sexuality. J. Sex. Res. 41, 101–112.
Wood, R.I., 2004. Reinforcing aspects of androgens. Physiol. Behav. 83, 279–289.