Gender-dependent differences in sensation seeking and social interaction are correlated with saliva testosterone titre in adolescents

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Abstract

OBJECTIVES: In the present study, we tested the hypothesis that gender – dependent differences in novelty seeking, leadership, and sympathy might correlate with testosterone titre. Since several studies report that the impact of testosterone on personality traits is more visible under emotional challenging situations, we harvested saliva testosterone upon an anticipated stressor (academic examination) and under basal conditions.

SETTING AND DESIGN: 19 female and 23 male adolescents (17 to 19 years of age) completed standardized questionnaires on sensation seeking, anxiety, and social interaction. Two weeks later, they had to write an anticipated, rigorous examination in mathematics in their school. Before and after the examination, saliva had been harvested from each subject and testosterone titre has been estimated.

METHODS: Saliva testosterone was quantified using a luminescence immunoassay (LIA). Each subject completed questionnaires on sensations seeking according to Zuckerman (SSS – V), anxiety (STAI), and social interactions.

RESULTS: Both genders showed an increase in their testosterone titre shortly after examination or announcement of test scores. A Spearman correlation coefficient indicated a significant correlation between testosterone titre and sensation seeking subscales in female but not in male subjects. Analysis of social interactions revealed that peers regarded male subjects, who had high testosterone titres, as leaders but not as likeable individuals, whereas they regarded female subjects, who had high testosterone titres, not as leaders but as highly likeable individuals.

CONCLUSION: Theses findings strongly suggest that testosterone has gender specific effects on novelty seeking, dominance, and sympathy.

ORIGINAL ARTICLE

Introduction

In humans, testosterone titre has been associated with transient individual states as well as with stable individual traits [1, 2, 3, 4, 5]. One emerging picture is that emotional challenging situations, like anticipation of physical or mental competitions, are preceded by an increase in testosterone titre, whereas after the competition, testosterone titre stays elevated in the winner, but declines in the looser [6, 7, 8]. Observers of sport events show similar fluctuations in their testosterone titre as active participants. Before the game, sport observers show an increase of their testosterone titre, but, after the game, the testosterone titre stays elevated in fans of the victorious team and declines in supporters of the defeated team [9].

Despite an avalanche of data on the impact of testosterone on personality traits, there is still a debate whether testosterone is the cause or the result of distinct personality traits, like dominance and sensations seeking [1, 10]. Several findings on primates suggest that testosterone titre fluctuations correlate with personality traits, like dominance, under stressful conditions but not under basal conditions [11]. Interestingly, emotional labile personalities show larger fluctuations in testosterone secretion than emotional stable personalities [12]. These studies underscore the importance of hormone sampling under distinct emotional challenges. Therefore, we harvested saliva several times from subjects under distinct emotional challenges (written examination versus basal conditions) and correlated the impact of testosterone titre on sensation seeking according to Zuckerman, leadership, and sympathy.

Our observations indicate that testosterone titre correlates with sensation seeking subscales in female but not in male adolescents. Furthermore, our data suggest that male adolescents, who had high testosterone titres, ranked high in dominance but belonged to the least likeable subjects. Surprisingly, female adolescents, who had a high testosterone titre, got low scores in their leadership qualities, but belonged to the most likeable subjects in their classes.

Material and Methods

42 adolescent pupils (19 females, 23 males; 17 to 19 years of age; Caucasian only) from a local High School ("Gymnasium") in Salzburg, Austria, participated in this study. Saliva samples were harvested 14, two, and one days before the examination, on the day of examination (shortly before and after the test), and one day after the examination.

Saliva samples were harvested either using salivette tubes containing a polyester wool swab (Sarstedt, Wiener – Neudorf, Austria) or the sputum was collected in a glass tube. Immediately after harvesting, the samples were stored on ice for a maximum of two hours, centrifuged at 4500 rpm for fifteen minutes, and stored at – 20 ° C until quantification for testosterone. Testosterone titre in saliva was quantified using a LIA. The LIA for testosterone was purchased form IBL (Hamburg, Germany). Each subject was classified as having a high or a low testosterone titre using a median split method.

To evaluate individual differences in thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility, we used the fifth version of Zuckerman's sensation seeking subscales (SSS – V). STAI (state – trait – anxiety – inventory), a self report assessment device, was used to measure both temporary anxiety (state anxiety) as well as a disposition to respond to challenging situations with anxiety (trait anxiety). High scores on the subscales indicate more state and trait anxiety, respectively. Quantification of social interactions was used to identify dominant and sympathetic individuals, respectively. Dominant individuals (leaders) have been characterized by three factors: (1) develop effective ideas to meet a challenge, (2) can structure processes used for decision making, and (3) to motivate others to attain a group goal [13]. According to these three factors, students had to name three peers whom they regard as most effective leaders and one peer whom the regard as a most ineffective leader. Sympathy was evaluated using three questions: (1) "With whom of your peers would you like to spend your leisure time?" (2) "With whom of your peers would

Table 1. State of anxiety before and after a written examination using STAI – G / X1. State of anxiety was evaluated 14 days, two days, and one day before a written examination (0), as well as one day after a written examination and on the day of announcement of test scores (+ 7 days).

	– 14 days	– 2 days	– 1 day	0 (exam)	+ 1 day	+ 7 days
female	40.13 ± 7.40	50.29 ± 11.80	50.75 ± 9.66	57.75 ± 6.25	35.71 ± 8.26	54.29 ± 6.73
male	31.36 ± 5.87	38.46 ± 9.80	36.30 ± 9.22	44.00 ± 9.06	31.13 ± 8.94	43.82 ± 12.22

Table 2. Total and subscale scores of Zuckerman's SSS – V for female and male students (mean ± SED).

	Total score	DIS	BS	ES	TAS
Women (n = 8)	23.50 ± 6.866	6.38 ± 2.264	4.13 ± 1.642	6.13 ± 2.167	6.88 ± 2.532
Men (n = 11)	27.73 ± 5.533	6.45 ± 2.382	5.00 ± 1.897	6.91 ± 1.868	9.36 ± 1.027

DIS: Disinhibition; BS: Boredom Susceptibility; ES: Experience Seeking; TAS: Thrill and Adventure Seeking

Table 3. Correlation between saliva testosterone titre and sensation seeking subscale scores and total score (Spearman correlation coefficient)

	– 14 days	– 1 day	0 (before)	0 (after)	+ 1 day	+ 7 days (before)	+ 7 days (after)
Girls (n = 8)							
DIS	– 0.67	– 0.60	– 0.27	– 0.78*	– 0.11	– 0.71	– 0.03
BS	– 0.33	0.16	– 0.72*	– 0.20	– 0.56	– 0.58	– 0.21
ES	– 0.88*	– 0.04	– 0.42	– 0.21	0.30	– 0.52	0.03
TAS	– 0.13	– 0.18	– 0.21	– 0.58	– 0.81*	– 0.13	0.41
Boys (n = 11)							
DIS	0.08	– 0.31	– 0.42	0.41	0.28	0.07	– 0.47
BS	0.24	– 0.22	– 0.36	0.08	0.02	– 0.21	– 0.42
ES	0.12	– 0.56	– 0.36	0.01	0.15	– 0.56	– 0.03
TAS	– 0.10	– 0.15	– 0.49	0.54	– 0.21	0.22	– 0.20

Saliva has been harvested 14 days and 1 day before a written examination, shortly before and after the examination, one day after the examination and before and after of the hand out of the evaluated examinations. * denotes a significant correlation ($p < 0.05$).

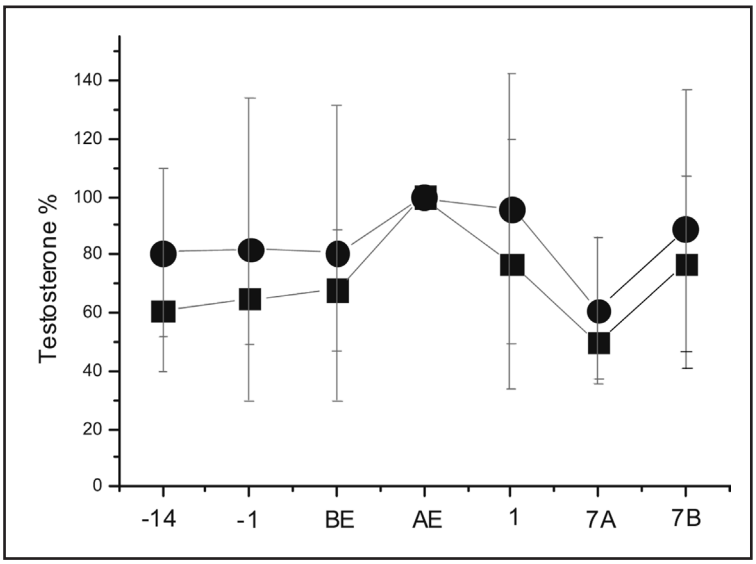

Figure 1. Normalized testosterone titre (mean upon an anticipated written examination. There was no significant difference between baseline (14 days [-14] and one day [-1] before the examination) and shortly before the examination [BE]. However, there was a significant difference between baseline and shortly after the examination (AE) or before (7B) announcement (7A) of the grades.

you like to share a room on a school excursion for several days?" (3) "With whom of your peers would you like to go to a party?" Again, the students had to name three peers with whom they would like to share these activities and one peer with whom they would not like to share these activities. Leadership or sympathy were calculated using ES = OV / N – 1 and RS = OR / N – 1, respectively (ES: election state; OR: obtained rejections; OV: obtained votes; RS: rejections state). The questionnaires (SSS – V; STAI) were handed out to students two weeks before an anticipated written examination.

Statistical significance on correlation between psychometric or sociometric data and testosterone titre were determined with a Mann – Whitney U test and a Spearman correlation coefficient.

Results

Anxiety increases before an anticipated written examination

Anticipation of an academic examination is accompanied by an increase in anxiety in pupils. To estimate individual anxiety, we compared anxiety rating (STAI – G / X1) before and after a written examination as well as before announcement of test scores (Table 1). Relative to baseline anxiety level, we observed an increase in anxiety by about 40 % in female and male adolescents before the written examination, and by 35 % in female and about 40 % in male adolescents before announcement of test scores. In addition to transient anxiety state measurements, we found gender – dependent differences in anxiety trait as measured with STAI – G / X2. Female subjects (43.75 ± 9.80, n = 9) scored higher than male subjects (32.27 ± 7.64, n = 11).

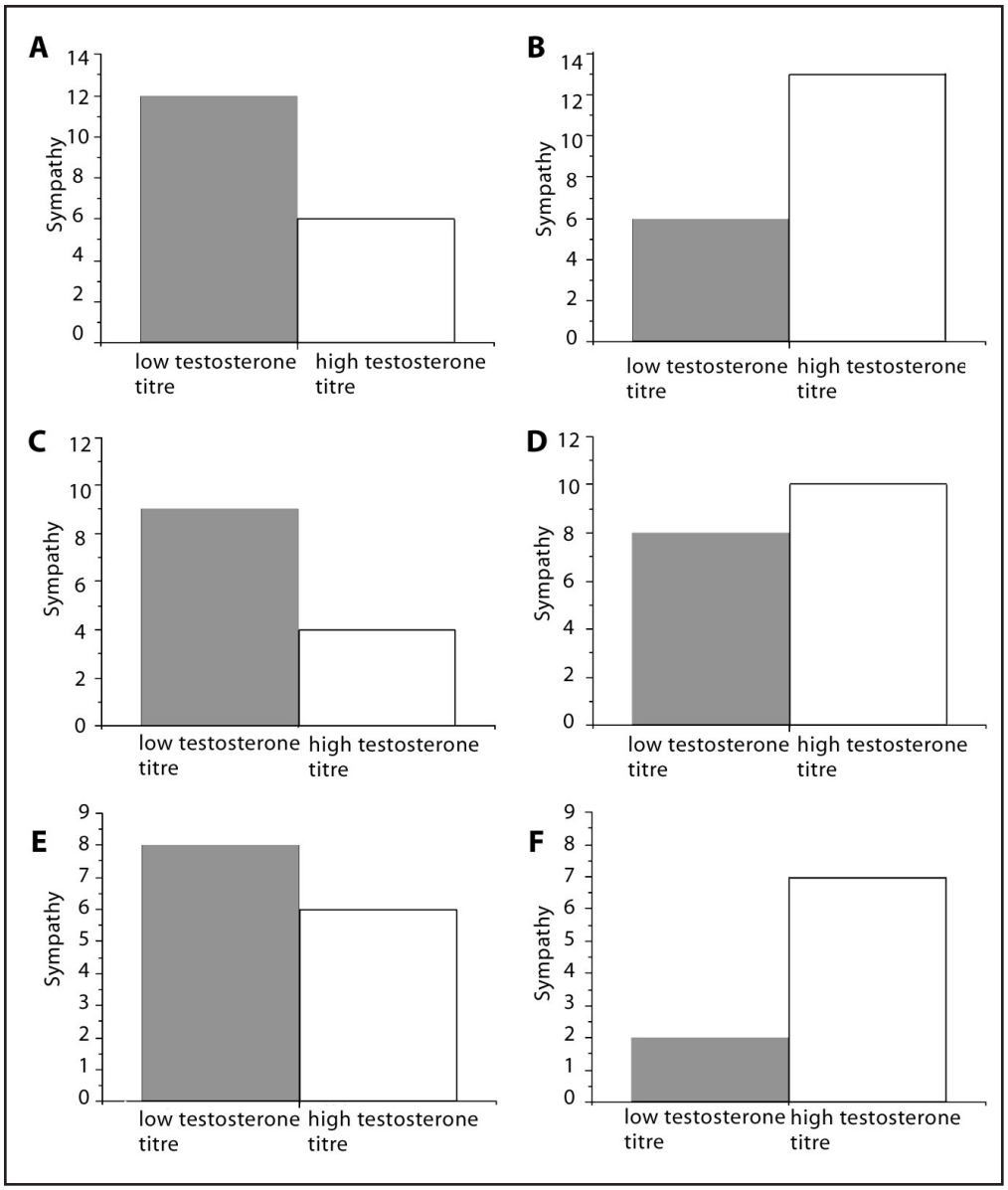

Figure 2. Sympathy scores and testosterone titre Adolescents have been assumed as high in testosterone when their testosterone titre has been above the median and low in testosterone when their testosterone titre has been below the median (basal conditions). The graphs show the results of three independent evaluations of sympathy in three distinct classes and testosterone in three distinct school classes. Note that a high score in sympathy correlates with a low perception of likeability by the peers. In all three classes, boys (B), (D), (F) (n = 23) with a high saliva testosterone titres are not likeable by their peers (not significant at < 0.05), whereas girls (A), (C), (E) (n = 19) with high testosterone titres are likeable by their peers (significant at < 0.05).

Saliva testosterone titre changes before and after an anticipated written examination depends on gender

To assess gender specific variability of the testosterone response upon a written examination, the mean value was computed, normalized, and plotted as function of sampling time (Fig. 1). Male students did not show an increase in their testosterone titre, whereas female students showed a slight increase in their testosterone level shortly before the examination when compared to the testosterone titre one day before the examinations. Female and male subjects showed the largest increase in their testosterone titre above baseline shortly after the written examination and after announcement of test scores. However, in contrast to female subjects, male students showed a prolonged testosterone response, which was still elevated on the day after the examinations.

Association of testosterone titre with sensation seeking subscales

Since we found individual variability in anxiety, dominance, and sensation seeking scores as well as in saliva testosterone titre, we evaluated the correlation between these variables. Although we found gender specific pattern in anxiety and testosterone response upon written examinations, these variables did not correlate significantly. Next, we compared saliva testosterone titre with SSS – V in female and male adolescent students before and after a written examination (Table 3). Taken female and male subjects together, the correlation coefficient was not significant. In contrast, when genders were analysed separately significant correlations were detectable. Male subjects did not show a significant correlation between testosterone and total SSS – V or each of the subscales, whereas female subjects showed a significant correlation between testosterone titre and each of the subscales.

However, significance of correlation depended on the time of sampling in relation to the examination.

To examine correlations between testosterone titre and sympathy or dominance, same sex groups were combined and a Mann – Whithney test were calculated. Figure 2 shows that male subjects with high testosterone titre, defined as testosterone titre above median, and individuals with low testosterone, defined as testosterone titre below median (under basal conditions), got a higher sympathy score by their peers than subjects with a testosterone titre below the median. A high sympathy score indicates less likeability by peers. In female subjects, high testosterone titre was correlated significantly ($p < 0.05$) with low sympathy scores. Dominance scores were significantly higher ($p < 0.05$) in male subjects with a testosterone titre above the median compared to subjects with testosterone titres below the median. The opposite correlation was found in female subjects, where individuals with a testosterone titre below the median were the most dominant subjects.

Discussion

Previous studies have shown that men respond to stressors with a "flight or fight" response whereas women respond to challenging situations with a "tend and befriend" response [14]. In the present study, we report on a comparable correlation between testosterone titre and sympathy. Peers regarded male classmates, who had a testosterone titre above the median, as leaders but not as likeable individuals. However, they classified female classmates, who had a testosterone titre above the median, not as leaders, but as very likeable individuals. Furthermore, female subjects showed significant correlations between testosterone titre and sensation seeking subscales, whereas male subjects did not.

Human adolescents score highest in sensation seeking relative to children and adults [15, 16], which may lead to an increased risk of drug abuse [17]. However, reports on the association between novelty seeking and testosterone titre are inconsistent. While some studies describe a positive correlation, others did not find a correlation between testosterone and novelty seeking [3, 4, 5, 18, 19, 20]. Although these discrepancies may be due to different paradigms used to evaluate novelty seeking, similar discrepancies have been reported using only one type of paradigm, e.g. sensation seeking according to Zuckerman. Previous investigations on the correlation between sensation seeking according to Zuckerman and testosterone reported either an association in men but not in women [4] or did not find a correlation in either sex [5]. We have observed a correlation between testosterone titre and sensation seeking subscales according to Zuckerman in female but not in male adolescents. Inconsistencies on reports on correlation between personality traits and testosterone titre may also depend on the emotional sate of the subject at the time of saliva harvesting. Interestingly, in savannah baboons, Sapolsky reported a correlation between testosterone and aggression or dominances only under social instability and ecological stress [11]. Similar results have been reported in humans, where social unstable conditions affect testosterone titre, like a decrease in testosterone titre around marriage but an increase in testosterone titre around divorce [21]. Thus, it is not completely unexpected that we found in our study significant correlations between testosterone and SSS V under distinct emotional challenging conditions.

A hypothesis of gender – dependent social demands predicts that women focus on interpersonal orientation, whereas men focus on instrumental orientation [14]. According to this model men react to stressors with a "fight or flight" response and women with a "tend and befriend" response. Interestingly, a recent study on pupils showed that girls are more focused on relationships, whereas boys are more focused on achievements [22]. Additionally, recent experiments indicates that inter – individual differences in testosterone relates to association of team mates, but not with dominance [23]. In the present study, we showed a gender – dependent correlation between saliva testosterone titre and the perception of sympathy by peers. Boys having high testosterone titre are less likeable than boys with low testosterone titre, whereas girls having high testosterone titres are highly likeable by their peers. Thus, our findings are in line with the prediction of the "tend and befriend" model [14].

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