

PSYCHOLOGY

Androgen Deprivation Alters Attention to Sexually Provocative Visual Stimuli in Elderly Men



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ABSTRACT

Introduction: Testosterone is known to regulate male sexual interest, but the exact way that androgens influence men's sexual cognition remains unclear.

Aim: To investigate the influence of androgen deprivation (AD) on visual responses to sexually suggestive stimuli in men treated for prostate cancer with AD therapy.

Methods: Patients with AD-treated prostate cancer, patients with prostate cancer not on AD therapy, and age-matched healthy control participants were exposed to images of male and female runway models fully or minimally clothed. Eye tracking was used to compare looking behavior among groups.

Main Outcome Measures: Proportion of fixations on fully clothed vs minimally clothed models and proportion of fixations on target areas of interest (ie, legs, chest, pelvis, and face) of fully clothed and minimally clothed models were analyzed and compared among groups.

Results: Although men not on AD exhibited a larger proportion of fixations on the minimally clothed compared with the fully clothed images, there was no difference between the 2 image types for men on AD. This was true regardless of whether the images depicted male or female models. Groups did not differ in their fixations to target areas of interest.

Conclusion: These results suggest that testosterone can influence men's visual attention to sexual stimuli; specifically, AD can attenuate the time spent fixated on sexualized targets. **Palmer-Hague JL, Tsang V, Skead C, et al. Androgen Deprivation Alters Attention to Sexually Provocative Visual Stimuli in Elderly Men. *Sex Med* 2017;5:e245–e254.**

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Key Words: Androgen Deprivation; Testosterone; Eye Tracking; Visual Attention; Cognition; Sexual Desire

INTRODUCTION

Men's sexual cognition is presumed to be regulated by hormones, but surprisingly little behavioral research has been done to elucidate this relationship. Although the involvement of

testosterone (T) in men's sexual behavior has been well established,¹ the psychological mechanisms underlying men's sexual motivation have not. In this study, we took a biopsychosocial approach to examine the role of T in the facilitation of sexual desire in men receiving androgen deprivation (AD) therapy for the treatment of prostate cancer (PCa).

A considerable body of evidence implicates T in the facilitation of social interaction, particularly with regard to the evaluation and response to signals of formidability and threat in other men.^{2,3} However, little is known about how T influences the interpretation of cues important for other types of human social behavior, such as sexual attraction and interest. For example, although brief interactions with women lead to increases in T and engagement in risky or "show-off" behaviors in healthy heterosexual men,^{4,5} it is unclear whether T also facilitates the initial cognitive processing of sexual signals. This possibility warrants further study.

T has been routinely associated with sexual responses in men developmentally and in adulthood.^{6,7} In particular, it appears to

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facilitate sexual interest. Decreased interest has been shown in hypogonadal men, and increased interest has been reported in healthy men being treated with experimental T supplements. Importantly, these reports are independent of actual sexual activity, suggesting that in addition to peripheral physiologic processes (eg, sustaining the rigidity of an erection), T is important for the generation and maintenance of sexual arousal and motivation.

Sexual arousal is believed to involve 2 stages of information processing: automatic and controlled.⁸ Automatic processing takes place first and involves rapid, unconscious (ie, involuntary) responses to relevant sexual stimuli. The processing at this stage involves encoding the stimuli and matching the stimuli with existing, meaningful knowledge in memory. Once sexual stimuli are associated with meaning, physiologic (eg, genital) responses are triggered and information proceeds to the next stage. Controlled processing at this stage involves conscious (ie, voluntary) attention toward the stimulus and associated emotional responses. At this point, individuals form a subjective experience of being sexually aroused (or not), because they are aware of the stimulus and their physiologic response to it. This ultimately leads to the coordination of approach (or avoidance) behaviors, facilitating (or hampering) reproduction. Importantly, T could be involved in either or both of these stages.

Eye tracking provides an ideal method for assessing cognitive processing of sexual stimuli. It allows researchers to quantify an individual's visual attention (ie, spatial locations they are looking at), duration of fixation (ie, how long they look), and even pupil dilation.^{9,10} Eye tracking also is relatively simple to use and non-invasive.

Previous research using eye tracking has shown that heterosexual men attend rapidly and specifically to women's bodies, particularly when the models are nude compared with fully clothed.^{9,11,12} In addition, compared with women, men tend to focus their attention on regions of the female body that signal health and fertility, such as the face, breasts, and midriff.^{12–14} Fixation on these areas also correlates with sexual interest as measured by changes in pupil diameter¹² and penile plethysmographic data.¹⁵

Recent studies also suggest important sex differences in processing of visual stimuli. For example, Huberman et al¹⁶ showed that in heterosexual men genital responses positively predicted self-reported arousal from explicit videos depicting women. Further, they found that this effect was mediated by self-reported attention to the stimuli. The influence of self-reported attention was not significant for women, suggesting that T could underlie some cognitive mechanisms associated with sexual arousal. One possibility is in orienting early attention to, or the automatic processing of, sexual cues presented visually. Specifically, Dawson and Chivers¹⁷ found that when viewing sexually explicit films, heterosexual men oriented significantly faster to female than to male targets, whereas heterosexual women did not exhibit a sex-of-target bias. Because automatic processing of sexual

stimuli is believed to activate genital response and subsequent sexual arousal, it is plausible that T facilitates these early actions.

To our knowledge, only 1 study has directly investigated the relation between T and processing of sexual stimuli in healthy men using eye tracking. Rupp and Wallen¹⁸ found that endogenous T levels in healthy young men significantly predicted the amount of time they spent fixated on erotic still images of heterosexual couples engaged in sexual activity. It is important to note that this relation was significant only during the last of 3 test sessions. They suggested that this might have been due to the small sample (N = 15), which likely precluded significance in the prior 2 sessions. In addition, when men who reported using erotica outside the study were compared with men who reported not using it, the link between T and time spent fixated on the images was strengthened. Given the reciprocal relation between T and sexual behavior in men (reviewed by Zitzmann and Nieschlag¹⁹), these results support the hypothesis that T could be directly involved in men's controlled attentional processing of sexual images.

Patients treated for PCa provide an ideal study population for the influence of T on attention to sexual images. This is because approximately half of all patients with PCa at one time or another are offered AD therapy to treat their disease. AD is used as adjuvant therapy to improve the effectiveness of radiotherapy for localized disease or to treat the disease when biochemical markers suggest that it is no longer localized. AD is the main pharmaceutical treatment for PCa and some patients can be on and off AD treatment for years when they are otherwise asymptomatic from the disease itself.

T deprivation in patients with PCa is implicated in sexual dysfunction. Men deprived of androgens consistently exhibit depressed sexual function, decreased sexual interest, and other side effects.^{20–24} Similarly, healthy men with pharmacologically induced hypogonadism report significant decreases in sexual cognition, sexual arousal, and sexual drive.^{25,26} Although it is unclear whether these issues are directly related to T rather than to other circulating hormones (eg, estradiol), restoring baseline T levels leads to full recovery of these functions, whereas restoring baseline estradiol levels does not.²⁵ This suggests a key role for T levels in facilitating sexual interest in men. Aside from 1 recent case study of a man receiving AD as treatment for pedophilia,²⁷ we are unaware of any studies that have directly investigated cognitive processing of sexual stimuli in hypogonadal men. Conversely, men with sexual dysfunction can show decreased visual attention to sexual images,²⁸ demonstrating that altered sexual cognition also can occur in this population.

In the present study, we used eye tracking to evaluate cognitive processing of sexually provocative stimuli in men undergoing AD therapy to treat PCa. We compared the number of gaze fixations and length of time spent fixated on minimally clothed (MC; ie, wearing a sexually provocative swimsuit) and fully clothed (FC; ie, wearing regular, not sexually provocative, clothing) male and female models in men being treated with AD

for PCa (AD group) compared with men with PCa who were not receiving AD (no-AD group). We also included a healthy age-matched male control group (HC group) to preclude the possibility that PCa diagnosis and non-hormonal treatment somehow influence visual attention in older men. We hypothesized that the AD-treated men would exhibit fewer fixations and spend less time fixated on MC images compared with the other 2 groups. To elucidate any meaningful patterns in visual responses among these 3 groups, we also explored the number of fixations the men made to each of the following areas of interest (AOIs): legs, chest, pelvic, and facial regions of the models' bodies. These data were collected using a novel eye-tracking protocol that allowed us to indirectly and inconspicuously quantify visual attention as a proxy for libido.

METHODS

Participants

31 men participated in the study. 8 had PCa and were receiving AD treatment (AD group), 15 had PCa but were not on androgen-suppressing medication (no-AD group), and 8 were healthy controls with no history of PCa (HC group). The HC group was included to control for the unlikely possibility that simply having PCa influenced visual attention. All were fluent in English and reported normal or corrected-to-normal vision. Men with symptomatic metastatic disease were excluded from the study.

Patients with PCa were recruited at cancer support-group meetings in and around our metropolitan area. HC participants were recruited from community groups and seniors' homes in the area. All participants were invited to participate in a study looking at "visual attention and cognition." All participants were unaware of the actual study hypotheses before their eye-tracking

data were collected. Monetary remuneration was not provided; however, participants were reimbursed for transportation and parking costs at the study site on the university campus.

Materials and Design

Stimuli were presented at a resolution of $1,680 \times 1,050$ pixels on the SensoMotoric Instruments (SMI; Teltow, Germany) RED desktop eye tracking system with a sampling rate of 120 Hz, a tracking range of 40×20 cm at a 70-cm distance from the integrated 56-cm (22-inch) monitor, accuracy of 0.4° , and spatial resolution of 0.03° . The system consists of inconspicuous external tracking hardware attached to the bottom of the computer monitor.

To test whether AD affected visual attention to sexual stimuli, we took advantage of a pre-existing protocol that had been used to identify social influences on looking behavior in undergraduates.^{29,30} Visual stimuli were 20 same-sex pairs of colored photos (10 male and 10 female) projected on a desktop computer screen. Each pair contained 1 image depicting an MC runway model and the other depicting an FC runway model (Figure 1). All models were shown walking, facing forward, with their entire bodies visible. Images were obtained through web searches and from freely accessible sources. Because the images were of runway models, we assumed that they would be considered physically attractive to participants. Female and male models were included in the images in accord with the pre-existing study protocol; the inclusion of male models with our predominantly heterosexual sample of men allowed us to assess whether any observed differences in viewing behavior would be independent of sexual orientation.

Image pairs were presented in random order, with each image pair shown to the participant for 10 seconds. FC and MC images



Figure 1. Representative of male and female fully clothed and minimally clothed image pairs.

flanked central fixation by 4.2° (ie, left-right separation between images = 8.4°) and were displayed in a random order that was consistent for all participants. Presentation of FC and MC images on the left and right sides of the screen was counterbalanced. While each participant viewed the image pairs, we recorded the total number of fixations made to the FC and MC images, the duration of each fixation, and the number of fixations each on the legs, chest, pelvic, and face regions (Figure 2).

Psychological and Health Measures

To evaluate any pre-existing comorbidity or psychological distress associated with cancer and its treatment, participants were asked to complete the following 4 commonly used questionnaires:

1. Functional Assessment of Cancer Therapy General (FACT-G),³¹ a 27-item general health and wellness questionnaire
2. Expanded Prostate Cancer Index Composite (EPIC),³² a 50-item measure of overall quality of life that assesses symptoms and associated bother resulting from PCa treatment in the urinary, bowel, sexual, and hormonal domains
3. Sexual Health Inventory for Men (SHIM),³³ a 5-item assessment of sexual dysfunction
4. Center for Epidemiologic Studies Depression Scale (CES-D),³⁴ a 20-item self-report assessment of depressive symptoms

Total scores were calculated for each measure, except for the EPIC, for which totals were calculated separately for each of its urinary, bowel, sexual, and hormonal subscales.

Comfort With Erotic Imagery

To ensure that any visual responses to the images used were not due to surprise, novelty, or embarrassment, we assessed participants' comfort with potentially provocative images of a sexual nature. We asked 2 questions as part of the demographic questionnaire: "How often do you purposefully view erotica?" and "How comfortable are you with erotica?" For the 1st question, participants were asked to circle 1 of 7 choices: never, 1 to 2 times a month, at least once a week, at least twice a week, approximately every 2 days, almost every day, or every day. For data analysis, we quantified these as ranging from 1 (never) to 7 (everyday). For the 2nd question, participants were asked to circle the number that best applied to their level of comfort on a 7-point Likert scale ranging from 1 (very uncomfortable) to 7 (extremely comfortable).

Procedure

After informed consent, participants were told that they would be viewing images on a computer screen. At this time, a deception was used to ensure that participants believed that the study was looking simply at viewing behavior, and participants



Figure 2. Geographic AOIs analyzed for proportion of fixations made to the images. AOIs = areas of interest; FC = fully clothed; MC = minimally clothed.

remained unaware of the true study hypotheses and eye-tracking component of the experimental design. In brief, participants were told that the types of images they would view would be determined randomly by choosing a token from a cup of alternatives (eg, automobiles, food, runway models). They were asked to draw from the cup in haphazard fashion the type of images they would be shown, implying random selection of the stimulus category. However, unbeknown to the participants, the cup contained only tokens for images of runway models.

After category selection, the participants were led to a small room containing a chair, desk, and the computer inconspicuously outfitted with the eye-tracking system. It was crucial that participants were unaware that the direction of their gaze was being monitored to prevent them from biasing their natural viewing behavior in ways they might believe to be more socially acceptable (eg, away from or less often at sexual images).

Once the individual was seated at the desk, the participant was asked to view Ishihara color squares to complete a color-blind test. In actuality, presentation of these stimuli served to calibrate their looking behavior for the SMI eye tracker. Specifically, participants were instructed to follow with their eyes a colored circle that moved among 9 different locations on the screen and then report its color. Once the SMI 9-point calibration was completed, participants were told that they would view the images drawn from the stimulus category that they had selected and that the experimenter would be just down the hall, if they needed any assistance. Each participant was instructed to look at the images presented on the screen as he might normally do. No additional instructions were provided.

Participants completed the psychological and health questionnaires after viewing the images. They were then debriefed, informed of the true nature of the study, and given an opportunity to ask questions. Participants also were given the option to have their data discarded if desired. All study procedures were reviewed by our university research ethics boards.

Data Analysis

Demographic variables and questionnaire scores were compared among groups using a series of 1-way analyses of variance (ANOVAs). Welch correction was used for the EPIC sexual function subscale (EPIC-SF) and the SHIM where homogeneity of variance was violated. Follow-up analyses were conducted with independent-samples *t*-tests as appropriate. Frequency of erotica viewing and comfort with erotica were compared using Kruskal-Wallis tests. Proportion of fixations to the FC or MC image (image type) was examined for the 3 groups (group) over each second of the 10-second exposure interval (time) using a mixed (1 between, 2 within) ANOVA. Similarly, a mixed (1 between, 2 within) ANOVA was used to examine group differences (group) in number of fixations to the MC and FC images (image type) and different regions of those images (ie, face, chest, pelvic and legs; AOI). Interactions were further explored as appropriate.

RESULTS

The cost of concealing the eye calibration process from participants was that we introduced the possibility that some participants might unwittingly spoil the acquisition of their eye movements by changing their head position substantially during the calibration phase at the start of the study and/or during the course of the experiment. Indeed, eye movement data from 3 participants (2 in the no-AD group and 1 in the HC group) were not acquired successfully and their data were excluded from all analyses.

Our final sample consisted of 28 men ranging from 55 to 87 years of age (median = 73). 8 were in the AD group, 13 were in the no-AD group, and 7 were in the HC group. 1 man in the no-AD group reported he was homosexual and 1 man in the HC group reported he was bisexual. Most were in a committed relationship and had been so for at least 30 years (75%). There was no significant difference among groups in age, relationship status, or length of current relationship.

Psychological and Health Characteristics

3 participants did not complete the EPIC questionnaire (1 in the no-AD group and 1 in the HC group did not complete the full questionnaire, and 1 in the AD group completed only the urinary function and hormonal function scales). Scores for the remaining participants on the FACT-G, EPIC, SHIM, and CES-D are listed in Table 1. It is important to note that most (63%) AD-treated participants obtained a score of 0 on the EPIC-SF, indicating substantial sexual dysfunction and decreased variability in the data for this group. As expected, significant group differences were observed for the EPIC-SF ($F_{2,23} = 4.24, P = .01$) and the SHIM ($F_{2,25} = 4.79, P < .01$), confirming that AD treatment had a negative effect on men's sexual function. Follow-up comparisons showed that, for the EPIC-SF, the AD group (mean = 4.75, SD = 10.27; 95% CI = -3.83 to 13.34) scored significantly lower than the no-AD group (mean = 31.87, SD = 23.95; 95% CI = 16.66-47.09; $t_{15,99} = -3.47; P < 0.01$), and that the difference between the AD and HC groups approached significance (mean = 30.87, SD = 27.32; 95% CI = 2.20-59.54; $t_{6,07} = -2.23; P < .07$). Similarly, the AD group (mean = 5.38, SD = 2.20; 95% CI = 3.54-7.21) scored significantly lower than the no-AD group (mean = 12.00, SD = 7.60; 95% CI = 7.41-16.60; $t_{15,01} = -2.95; P = .01$) and the HC group (mean = 14.00, SD = 4.47; 95% CI = 9.86-18.14; $t_{13} = -4.84; P < .001$) on the SHIM.

Although the group difference for the EPIC urinary function subscale approached significance ($F_{2,22} = 2.80, P = .08$), post hoc analyses showed no significant differences among groups ($P > .10$ for all comparisons). No additional significant differences were found for any of the remaining psychological and health questionnaires ($P > .15$ for all comparisons).

Table 1. Descriptive statistics for psychological and health questionnaire scores

Measure	AD		No-AD		HC		P value
	Mean	SD	Mean	SD	Mean	SD	
FACT-G	83.29	12.44	84.17	12.97	71.32	19.01	.16
EPIC domains							
Urinary function	93.37	6.84	77.27	19.55	90.30	13.61	.08
Urinary bother	81.25	20.00	63.99	26.40	77.38	12.09	.21
Bowel function	84.38	34.26	86.91	7.96	89.05	9.76	.91
Bowel bother	85.72	25.61	82.44	17.06	88.69	9.15	.80
Sexual function	4.75	10.27	31.87	23.95	30.87	27.32	.03*
Sexual bother	28.91	39.67	54.17	34.27	50.00	45.59	.36
Hormonal function	81.43	18.64	87.50	13.29	89.17	12.81	.60
Hormonal bother	79.17	22.82	92.01	8.97	88.20	11.31	.19
SHIM	5.38	2.20	12.00	7.60	14.00	4.47	.02*
CES-D	7.13	7.51	9.31	5.54	13.14	11.10	.33

AD = prostate cancer with androgen deprivation therapy; CES-D = Center for Epidemiologic Studies Depression Scale; EPIC = Expanded Prostate Cancer Index Composite; FACT-G = Functional Assessment of Cancer Therapy General; HC = healthy control; No-AD = prostate cancer without androgen deprivation therapy; SHIM = Sexual Health Inventory for Men.

*Statistically significant.

Comfort With Sexual Imagery

Most participants did not view erotica frequently (AD: median = 1.00, range = 2.00; no-AD: median = 1.00, range = 2.00; HC: median = 1.50, range = 2.00), and there were no differences among groups ($P > .15$). There also was no significant difference among groups in their level of comfort with erotic material (AD: median = 2.00, range = 4.00; no-AD: median = 2.00, range = 3.00; HC: median = 2.00, range = 4.00; $P > .90$). Thus, we could be confident that any differences in viewing behavior did not reflect pre-existing differences in current exposure to, or comfort with, sexually provocative images.

Viewing Behavior

Looking at FC vs MC Images

To explore group differences in patterns of viewing behavior for FC and MC images over time, we examined the effect of treatment group (group) on the proportion of total fixations to the FC and MC images (image type) at each second of the 10-second exposure interval per image pair (eg, second 1, second 2, etc; time) and their interactions using a mixed (1 between, 2 within) ANOVA. This analysis showed a significant main effect of image type ($F_{1,25} = 23.06$, $P < .0001$, $\eta^2 = 0.48$), reflecting that MC images (mean = 0.298, SD = 0.007; 95% CI = 0.283–0.313) were looked at more than FC images (mean = 0.202, SD = 0.007; 95% CI = 0.187–0.217). Critically, however, this main effect was qualified by a reliable group-by-image type interaction ($F_{2,25} = 4.31$, $P = .03$, $\eta^2 = 0.26$), which remained significant when data from the 2 non-heterosexual participants were excluded ($F_{2,25} = 4.23$, $P = .03$, $\eta^2 = 0.27$). To ensure that there were no effects of the

sex of the model depicted in the images, we also analyzed the interaction among group, image type, and sex of model. This interaction effect was not significant ($F_{2,25} = 3.03$, $P = .742$), suggesting that looking behavior was not appreciably influenced by whether the model was male or female. No other effects were significant.

To isolate the source of the key group-by-image interaction, we conducted 2 planned contrasts. The first analysis compared the AD and no-AD groups using image type and sex of the model in the image (male or female) as within-subject factors. This mixed ANOVA showed the same pattern of results as before: a significant main effect of image type ($F_{1,19} = 9.63$, $P < .01$, $\eta^2 = 0.46$) and a significant group-by-image type

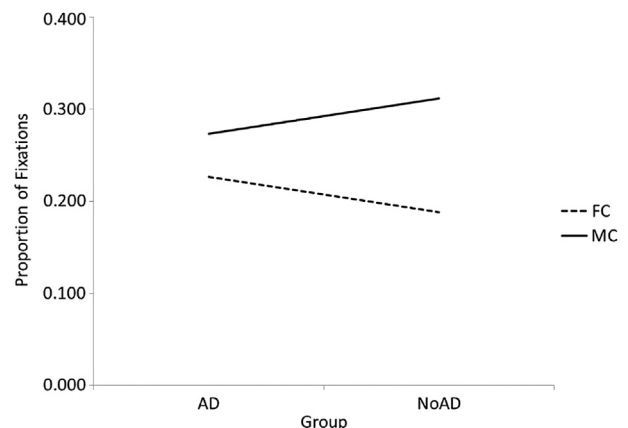


Figure 3. Interaction effect of group (AD vs NoAD) by image type (FC vs MC) on proportion of fixations to the images. AD = prostate cancer with androgen deprivation therapy; FC = fully clothed; MC = minimally clothed; NoAD = prostate cancer without androgen deprivation therapy.

interaction ($F_{1,19} = 6.61$, $P = .02$, $\eta^2 = 0.08$). As shown in Figure 3, this interaction reflects the fact that although the no-AD group looked at the MC images more (mean = 0.312, SD = 0.011; 95% CI = 0.289–0.334) than the FC images (mean = 0.188, SD = 0.011; 95% CI = 0.166–0.211), this was not the case for the AD group. No other effects were significant. The second mixed ANOVA showed that the viewing behavior of the no-AD group at baseline was comparable to that of the HC group, which confirmed our expectation that PCa would not alter men's visual attention. There was a significant effect of image type ($F_{1,18} = 76.16$, $P = .0001$, $\eta^2 = 0.81$), reflecting a preference for viewing the MC images, but no significant variation in this viewing behavior among groups or as a function of the of the model's sex ($F < 1$ for all comparisons).

Fixations to Areas of Interest

Table 2 presents the proportion of fixations to the legs, chest, pelvic, and facial AOIs for the FC and MC images for the AD, no-AD, and HC groups. When these were subjected to a mixed (1 between, 2 within) ANOVA with image type (FC vs MC) and AOI (legs, chest, pelvic, and facial) as within-subject factors, there was a main effect of AOI ($F_{3,23} = 12.67$, $P < .001$, $\eta^2 = 0.62$), reflecting that chests were looked at the most and legs were looked at the least, with faces and pelvic regions falling in the middle (face 0.29 = chest 0.35 > pelvis 0.22 > legs 0.14). This AOI main effect was qualified by an AOI-by-image type interaction ($F_{3,23} = 29.13$, $P < .0001$, $\eta^2 = 0.79$), reflecting that, compared with FC images, looks to the face decreased and looks to the pelvic region increased when the image was MC. This interaction was not qualified by group ($F < 1$), and no other effect was significant.

DISCUSSION

Men who were hypogonadal from AD treatment exhibited altered cognitive processing of sexual visual stimuli compared with men in the no-AD and HC groups. Specifically, we found that men in the AD group failed to demonstrate the preferential bias to fixate on an MC image that was evident for the no-AD and HC groups. Although our sample was small, our ability to identify these effects suggests they could be large. However, replication in future studies with larger samples is needed to expand on the specificity and magnitude of our findings.

Our objective results obtained from a blinded experimental design parallel those obtained from subjective reports of sexual function. Men in the AD group scored significantly lower than those in the no-AD and HC groups for the 2 measures, indicating decreased sexual function (ie, self-reported ability to initiate and maintain erections, engaging in intercourse). Although we did not observe significantly lower scores in the AD group on the EPIC sexual bother subscale, indicating these men did not feel bothered by their sexual dysfunction, scores were indeed lower in this group. Further, we recognize that our groups

Table 2. Descriptive statistics for proportion of fixations to leg, chest, groin, and face regions for MC and FC images

Group	MC		FC	
	Mean	SD	Mean	SD
Legs				
AD	0.11	0.06	0.11	0.09
No-AD	0.17	0.12	0.19	0.11
HC	0.12	0.08	0.13	0.08
Chest				
AD	0.33	0.09	0.32	0.12
No-AD	0.34	0.10	0.39	0.15
HC	0.38	0.19	0.36	0.18
Pelvis				
AD	0.27	0.06	0.17	0.04
No-AD	0.32	0.10	0.19	0.11
HC	0.23	0.08	0.12	0.04
Face				
AD	0.29	0.10	0.41	0.15
No-AD	0.17	0.11	0.23	0.13
HC	0.27	0.11	0.39	0.12

AD = prostate cancer with androgen deprivation therapy; FC = fully clothed; HC = healthy control; MC = minimally clothed; No-AD = prostate cancer without androgen deprivation therapy.

could differ on some other characteristic that alters their visual attention patterns (eg, anxiety, fatigue, affect), but the pilot nature of this study precluded our ability to measure these. It will be important to determine whether subjective experience correlates with eye-tracking results (ie, objective measures of processing sexual images) in future studies with a larger sample.

Our results suggest that T-deprived men exhibit viewing patterns that differ significantly from those of men with presumably typical baseline T levels, but classification of this result remains elusive. Previous research has shown that men and women spend more time looking at sexy compared with non-sexy images,^{9,11,12} and given that women exhibit considerably lower endogenous levels of T than men, our results suggest that a threshold level of T (for men and women) might be required to initiate visual attention to sexually relevant images.

Some studies have shown that men first look at, and spend more time looking at, faces of sexy and non-sexy images.¹² In contrast, others have shown that men fixate proportionately less on the face than on the body when the images are sexualized or nude.^{11,13,14} Although it might be expected that AD-treated men would look less at the pelvis and breasts compared with men in the 2 non-AD groups (ie, no-AD and HC), we did not observe group differences for preferential viewing of specific AOIs. One possible explanation for these discrepancies is that the stimuli used in our study represented material that was especially novel for our elderly participants, causing them overall to focus more on sexually relevant areas (ie, chest, pelvis) rather than other areas, such as faces. Rupp and Wallen¹⁸ suggested that T might be necessary only for sexual cognition over and above that which

is modulated by general arousal mechanisms. Lack of power to detect these effects in our pilot study is likely another contributing factor.

It might seem surprising that we did not find statistical differences in eye-tracking patterns when the participants viewed images of male vs female models. It should be noted that images of men vs women were never concurrently displayed, which would have given participants an opportunity to give more attention to images of one sex than the other.

In addition to increasing our understanding of the role of T in men's visual attention to sexual images, the present eye-tracking results could help us predict how AD affects the lives of its users. Some of these relations are well known because AD correlates with patients' subjective assessment of their libido,^{35,36} but further elucidation of other, less well-known, effects of AD would be welcomed. This would include understanding displays of emotionality, such as the empathetic tearfulness that is more common for women than for eugonadal men, but also increased in AD-treated men.^{20,37,38} Indeed, AD has an array of feminizing physiologic effects, such as loss of body hair, increased accumulation of subcutaneous fat, and some gynecomastia, depending on the drugs used to block T.²⁴

Our results have clinical implications for helping patients and their partners understand and adapt to the side effects of AD therapy. They also have implications to ensuring that patients can make informed decisions when electing AD as a treatment. The psychological impact of AD therapy is substantial and influences not only the patients directly but also their partners indirectly.^{20,39} However, patients and their partners are general poorly informed about the side effects of AD therapy.^{23,40}

Lack of knowledge of the side effects of AD therapy can lead to conflicting coping strategies between patients and partners, which can erode their spousal bond.²⁴ Navon and Morag⁴¹ noted that men whose physical and psychological functions are affected by AD therapy often contend with these difficulties through disguise, diversion, and avoidance strategies. Kornblith et al³⁹ noted that distress for the partners arises from problems in communication. Specifically, men typically have little desire to discuss disease-related issues, whereas their spouses have a great need to discuss them. Similarly, Kim et al⁴² noted patient's wives (no relevant data are available on same-sex couples) might perceive that they have been abandoned emotionally, leading to feelings of deficiency on their own behalf, when communication with their husbands is lacking. For the patients themselves, Roesch et al⁴³ reported that avoidance coping in men with PCa can have serious negative effects on not only their psychological adjustment but also their physical health.

Our finding that AD therapy alters men's reflexive attention to visual images of others is subtle and profound. Informing patients and their partners about this effect can be a step toward arming them with concordant information on the ways that AD therapy influence the patients' attention to and interaction with

others. Others have flagged the ethical responsibility clinicians have to educate patients about the cognitive effects of AD therapy (eg, ⁴⁴). Our findings reinforce that concern.

Our study is the first to provide objective data showing that AD alters men's visual attention to images of other human beings in a quantifiable fashion. These data also establish that our eye-tracking protocol provides a way to assess inconspicuously and covertly visual attention as a proxy for libido, independent of an individual's sexual orientation.

These results also might have implications to assessing objectively the effectiveness of AD as a treatment for undesirable paraphilias. The eye-tracking protocol used in this study can be administered easily and in a blinded fashion, which is not possible with other physiologic assessment protocols of sexual interest, such as measuring pupil diameter¹² and penile tumescence with plethysmography.¹⁵

LIMITATIONS

A major limitation of this research is that the hormonal status of our participants was not directly assessed. We assumed that the no-AD and HC groups would exhibit T titers within the normal range for men of their age. We also assumed that the men who reported being on AD did in fact have their T levels suppressed below what is normal for men of their age and into the castrated range. Similarly, we were unable to rule out the possibility that decreases in other hormones, such as luteinizing hormone, follicle-stimulating hormone, and estradiol, might have affected the cognitive processing observed in our AD-treated men. In future studies, analysis of circulating hormone levels will be crucial.

We also do not know the extent to which other factors, such as age and sexual orientation, might have affected our results independent of hormonal status. It is known that older patients with PCa report less bother from the sexual side effects of PCa treatments,²² but our sample was too small to correlate individual questionnaire scores with decreased attention to MC images in the men's eye-tracking data. Similarly, one must treat with caution our finding that the eye-tracking data for self-reported homosexual men did not differ from their treatment groups. For example, we do not know whether a larger sample would have shown a statistical difference in visual attention based on sexual orientation. To refine the present results, future studies should include not only a large sample but also endocrinologic data on the participants.

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